FERTIGATION MANAGEMENT TO MAXIMIZE OLEUROPINE CONTENT IN OLIVE LEAVES

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Abstract

This work was conducted for two successive seasons (2015/2016) on Shemlaly 15 years old olive trees (Olea europaea L.) cultivated under semi-arid conditions of Egypt (sandy soil at spacing of 4x5 m) at a private orchard located in Cairo–Alexandria desert road, The tested trees were almost uniform in growth vigor, healthy, subjected to drip irrigation and received the same culturel practices adapted in the region such as fertilization, irrigation, pruning, and hoeing as well as pest management. The main objective of the present research is to investigate the effect of water regimes and fertilization with urea (over than the rates recommended by the Ministry of Agriculture) on Oleuropein content of leaves and pruning residues The treatments were T1 : control (farmer‟s conventional technique of irrigation and fertilization), T2 (75% of ETc by drip + 1% urea), T3 (75% of ETc by drip + 2% urea) T4 (75% of ETc by bubbler + 1% urea), T5 (75% of ETc by bubbler + 2% urea), T6 (60 % of ETc by drip + 1% urea), T7 (60% of ETc by drip + 2% urea), T8 (60% of ETc by bubbler + 1% urea), T9 (60% of ETc by bubbler + 2% urea) and two level of urea (1 and 2kg/100 liter) were injected through the irrigation system during March over than the fertilization rates recommended by the Ministry of Agriculture. Oleuropein content of The leaves and pruning residues were measured at flowering phenological stage.

Key words: Fertigation Management, Oleuropein content.

Sandy soil, urea, irrigation, rezime, plnning , recidues.

SUCCESSIVE MANAGEMENT PROGRAMS FOR THE DEFICIT WATER RESOURCES IN HYDROPONICS AND SOILLESS GREEN FODDER PRODUCTION

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Abstract

Maximization of water use efficiency (WUE) in green fodder production in the arid regions is considered critical issue for overcoming on the limitation of water resources. Therefore, three experiments were executed using electric controller system to manage the deficit water resources inside hydroponics and soilless green fodder production system. Single, double, and triple programs for water management were applied in the first, the second, and the third experiments respectively. Irrigation intervals “4, 6, 8, 10, 12, and14h” and irrigation durations “30, 45, and 60sec.” are used as main variables in these experiments. The consumed water, fresh weight of the produced green fodder, dry matter weight, dry matter percentage, water use efficiency and germination percentage as main indicators. The statistical analysis of the results revealed that water use efficiency values for the best treatment in the first, the second, and the third exponent are 49.11, 79.92 and, 109.01 ”gram of dry matter/liter of water” respectively. Therefore, applying triple successive programs “60 sec. per 6h in the initial period, “45 sec. per 10h in the intermediate period” and “30 sec. per 12h in the final period” is considered the best management of the deficit water resources inside hydroponics and soilless green fodder production systems.

Keywords:– Irigation - water use efficiency - production systems – water management program.

UTILIZATION OF DIFFERENT INCINERATION METHODS FOR SAFE DISPOSING OF POULTRY MORTALITY DUE TO EPIDEMIC DISEASES

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Abstract

Mortality losses are a normal part of poultry production facilities. Producers may have losses due to disease, accidents, inter-animal competition or natural disasters. The producer is responsible for disposing of these mortalities within 48 hours in an environmentally acceptable manner. Safe disposal of carcasses is an important issue for day-to-day, routine management of poultry mortalities to prevent disease transmission and to protect air and water quality. Methods for disposal of poultry carcasses include burial, incineration, composting, and rendering. When there is an outbreak of epidemic disease such as avian influenza or other diseases that can be easily spread, incineration become the first option, where it provides a higher level of bio-security than other mortality management options, carcasses that could potentially spread disease or attract insect pests or vermin are quickly reduced to ash during the incineration process. The main aim of the present research is to select the best available incineration technique (BAIT) for poultry mortality in the small scale commercial farms (10.000-20.000 bird capacity) during any epidemic disease outbreak. Three incineration methods (Open air burning - Air curtain burning –Fixed facility incinerator) were evaluated according to burning time, fuel consumption, cost, environmental impact and biosecurity (presence of pathogens in burning remnants). All methods were tested by using thee sample of broiler (20, 32 and 42 day old) and one sample of layer (112 day old) with size of (25 kg) for each. Based on the test results; the best available technique for the small scale commercial and house hold farms was air curtain incineration.

Keywords: avian influenza H5N1, Air curtain incineration, Biosecurity.

RICE STRAW RECYCLING FOR DEVELOPING THE HYDROPONICS SPROUTED BARLEY PRODUCTION AND CONSERVING THE ENVIRONMENT

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Abstract

Open-field burning of the rice straw is clearly practiced and considered a significant source of air pollutants. Increasing the quantity and conserving the quality of the hydroponics sprouted barley are considered critical issue for feeding the large animals and executing food security. Therefore, the main objective of this research is recycling of the rice straw as “a bio-media” for developing the hydroponics sprouted barley production and conserving the environment. Randomize complete block design experiment was executed through (27) treatments. Three types of rice straw media "rough media (less than 7.5cm), medium media (less than 5cm), and fine media (less than 2.5cm); three ratio between rice straw weigh to dry grains weight "25,50, and 75" (%); and three periods of growth life durations “8, 10, and 12 days” were applied. Statistical analysis processes of the results revealed that using medium rice straw media (less than 5cm), with ratio of 50%, and periods of 10 days is considered the beast treatment. In view of this result overcoming on the open-field burning of the rice straw through its recycling as a bio-media for growing the hydroponics sprouted barley production is discussed.

Keywords: environment–trails design- statistical analysis.

FACTORS AFFECTING PRODUCING BIO-MASS BRIQUETTES USING RICE STRAW

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Abstract

Rice straw; husk and bagasse are a lignocellulose biomass materials not optimally used by farmers in Egypt and potentially become environmental pollutant. A new technique to convert these residues into bio-solid fuel production through briquetting process was introduced. The briquettes are processed based on rice straw blending with rice husk or bagasse in a hexagonal briquetting die shape, using screw press heated die briquetting machine "binder less technique" which imported from china and has become widespread in Egypt. The controllable factors used in this study consisted of the following: (1) the hot pressing temperature (180, 220, 260 and 300 °C), (2) rice straw particle size (10–5mm, 5–2mm, and < 2mm), while the particle size of rice husk and bagasse was less than 1 mm and (3) the percentage ratio of rice straw to rice husk and bagasse in a briquette (100/0, 80/20, 60/40 and 0/100). The briquettes properties are quite good with good resistance to mechanical disintegration. The briquettes have densities 8 -10 times more than as received biomass. This makes for easier handling & transportation. All these factors make briquettes one of the most attractive forms of biomass based energy. Overall, converting rice straw blending with rice husk into briquettes has increased its calorific value is about 17.4 MJ/kg and reduced moisture content to a minimum of 7.7%. The garnering of knowledge in the briquetting process provides a path to increase the use of this resource. Rice straw briquettes can become an important renewable energy source in the future.

Keywords: Rice husk; Bagasse; Biomass briquette; binder, density;

EFFECTIVENESS OF USING NATURAL SORBENT FOR REMOVING OIL FROM WASTE WATER

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Abstract

WAste water contains a large variety of contaminants, including oil and grease. The failure of some of the conventional wastewater treatment plants is mainly because of presence of excess oil and grease. It was the objective of this investigation to find and identify the most effective sorbent materials for removing oil from waste water. Twelve natural sorbent materials belonging to three categories: organic plant byproduct (Flax, Jute rebif , rice husk, rice straw, wheat straw, corn cub, garlic peel, palm carnival and cane bagasse); organic animal byproduct (wool and goat hair) and polypropylene fibers (DEUREX@ WF5010). Some of the properties evaluated were oil and water sorption capacity, oil retention, buoyancy retention with and without absorbed oil, reusability and biodegradable. Of all the materials evaluated the wool, rice straw and corn cub respectively showed the best overall properties for removing oil spilled on waste water. The lowest natural organic material for the removing oil properties was palm carnival. Polypropylene fibers showed a relatively high sorption capacity but it was very expensive and poor in reusability and biodegradable point of view.

Keywords: Oil, Polypropylene, Adsorption.

EFFECT OF SOME ORGANIC FERTILIZATION METHODS ON COWPEA CROP YIELD UNDER DRIP IRRIGATION SYSTEM

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Abstract

Effect of some organic fertilization methods on cowpea crop yield under surface drip irrigation system was studied. The vegetative potato tops were applied as an organic fertilizer. The experiment was established and designed statistically as a split plots with three replications. The main plots were located for the organic fertilization method treatment with levels of completed conformation tops, chopped tops and mulched tops, comparing with bereaved of organic fertilization. The sub-plots were involved the water regime under deficit irrigation treatment levels of 70, 80, 90 and 100% from actual cowpea irrigation requirements. The obtained results showed that the chopped potato tops accompanied with 100% actual cowpea irrigation requirements achieved more desirable soil characteristics, higher cowpea seed yield of 948 kg/fed and higher water use efficiency of 0.60 kg/m^3. So, it is recommended to apply the chopped potato tops under drip irrigation system.

INTRODUCTION

Cowpea is considered as one of the most important legume crops all over the world. It could be used as green pods for fresh market or dry seeds. Cowpea seedcontains high percent of protein reached up 24.8%, added to carbohydrate reached up to 63.6%. So, it is currently used in human feeding. Moreover, cowpea residues serve as a filling material for animal feed. Also, cowpea planting improves the soil properties (Directorate of Plant Production, 2011).

The effect of water deficit on cowpea growth and yield depends upon the degree of stress and the development stage at which the stress occurs. The variation of deficit irrigation timing and amount along the growing season of different growth stages might increase yield due to the change with dry matter between vegetative and reproduction organs (Aboamera, 2007). Since cowpea is a row crop, it is best suited to grow under drip irrigation system to achieve a good water application uniformity so as to improve soil moisture uniformity which would in turn contribute to increase in crop yield when there is water scarcity (DeTar and Funk, 2005). Also, drip irrigation helps to save water and fertilizer at the same time and decreases energy requirements (Anu Varughese *et al*., 2014).

Modern agriculture depends to great extent on chemical fertilizers application for crop production which certainly provide quick results, but in long-run contributed to soil deterioration, environmental pollution and health hazards (Savci, 2012). While, organic fertilization . plays a vital role to bring stability and sustainability to agriculture and also avoid over dependence of chemical fertilizers. Nowadays, consumer preference is more for organically grown produce because they are free of toxic residues and have concern for environment. Crop residues are a good source for organic fertilization which helps to improve soil properties. Combined use of crop residues and chemical fertilizer could narrow down the negative nutrient balance substantially; besides improving the soil fertility in many cropping system (Ahmed and El-Zaawely, 2010 and Yoganathan *et al*., 2013). Also, organic mulch adds nutrients to soil when decomposed by microbes and helps in carbon sequestration. In addition, it can conserve soil water and decrease temperature because it increases residue accumulation and reduces soil disturbance on the soil surface (Zhang, *et al*. 2009; Abd El-Kader *et al*., 2010; Khalifa and El-Nemr, 2011 and Adebimpe *et al*., 2017). So, this study aims finding out the effect of some organic fertilization methods on cowpea crop yield under surface drip irrigation system.

MATERIALS AND METHODS

Experimental site and soil characteristics:

During 2016 summer season, a field experiment of 1 feddan (70 x 60 m)was carried out at El-Damayra Village, El-Dakhlia Governorate, Egypt, where as the preseeding crop was Sponta potato variety. According to El-Serafy and El-Ghamry (2006), tables (1, 2, 3, 4 and 5) presented the experimental site soil mechanical analysis, some soil characteristics, some soil hydrophysical characteristics, some vegetative potato tops characteristics and irrigation water chemical analysis, respectively.

Table (1): The experimental site soil mechanical analysis.

Soil layer depth, m	Sand, %			Silt, %	Clay, %	Soil texture class
	coarse, %	fine, %	total, %			
0-0.15	5.70	6.60	12.30	40.20	47.50	Silty clay loam
0.15-0.30	3.80	7.80	11.60	39.10	49.30	Silty clay loam

Table (2): Some soil characteristics of The experimental site.

Soil layer depth, m	Moisture content (d.b.), %	Bulk density, g/cm^3	Organic carbon, %	pH, 1:2.5	Ec,dS/m	Available N, ppm	Available P, ppm	Available K, ppm
0-0.15	18.00	1.45	1.44	7.82	5.23	28.55	15.45	325.29
0.15-0.30	19.55	1.40	1.38	7.71	5.11	26.70	14.00	320.00

Table (3): Some soil hydrophysical characteristics of The experimental site.

Soil layer depth, m	Field capacity, Wt/wt%	Wilting point, Wt/wt%	Available water, mm	Infiltration rate, mm/h
0-0.15	12.45	6.55	5.90	22
0.15-0.30	11.55	7.40	4.15	25

Table (4): Some characteristics of Vegetative potato tops.

Moisture content (d.b.), %	Ash, %	Organic matter, %	Organic carbon, %	Total N, %	Total P, %	Total K, %	C:N
18.85	10.20	73.51	32.90	0.65	0.88	2.00	50.61:1

Table (5): Irrigation water chemical analysis of The experimental site.

Ph, 1:2.5 (susp.)	Ec, dS/m	Total soluble salts, ppm	Soluble anions, ppm				Soluble cations, ppm				SAR
			CO3	HCO3	Cl	So4	Ca	Mg	Na	K	
68.17	4.48	1885.04	0.03	489.43	750.32	222.52	5.64	102.37	304.57	10.16	3.50

Agricultural practices:

Potato tops application:

The following vegetative potato tops forms with a rate of 10.84 Mg/fed were applied as organic fertilization methods.

1. Completed conformation tops which were manually broadcasted uniformly upon the soil surface.
2. Chopped tops which were obtained using a mounted forage chopper. The chopper consists of a gathering unit to pick up windrowed material, a conveying and feed mechanism to compress and hold the material and a cutter head which is attached with 12 knives that rotate at 1250 rpm (28.80 m/s peripheral speed) which was obtained by operating the tractor PTO at a speed of 1200 rpm, and adjusting the gearbox position.
3. Mulched tops which were manually broadcasted uniformly to cover the soil surface just after sowing irrigation.

Minimum tillage:

Minimum tillage was conducted at 0.15 m depth using a mounted rotary plough of 24 L-shape blades which are arranged on the total machine width (1.55 m). It was operated at rotary speed of 145 rpm (2.41 m/s peripheral speed) which was obtained by operating the tractor PTO at a speed of 540 rpm, and adjusting the gearbox position.

Planting:

A mounted pneumatic planter was used to plant the selected cowpea seeds of Karem 7 variety with a rate of 10 kg/fed at 0.03 m depth, 0.60 m row spacing and 0.15 m hill spacing apart along the same furrow. A 2 WD tractor of 45 kW power was used to operate the forage chopper, the rotary plough and the planter at 5.80, 4.80 and 5.25 km/h forward speed, respectively. The operating speeds were achieved by selecting appropriate gears, adjusting tractor engine throttle at the maximum position at adjusting the engine speed around 75-80%.

Drip irrigation system:

Daily irrigation and alternate day fertigation was applied Using a surface drip irrigation system. It was constructed and installed in the experimental site after cowpea planting. The irrigation network consisted of the following components:

1. Control head: It is located at the water source supply. It included the following parts:
   a. Centrifugal pump of 45 m^3/h discharge and 380 kPa pressure head. It is driven using an electric engine of 15 kW power.
   b. Screen filter of 120 mesh.
   c. Back flow prevention device.
   d. Pressure regulator.
   e. Pressure gauges.
   f. Flow-meter.
   g. Control valves.
   h. Injection pump.
2. Main line: A P PVC pipe of 0.075 m diameter was buried at 1 m depth beneath the soil surface. It conveys the water from the source to the manifold lines.
3. Manifold lines: PVC pipes of 0.05 m in diameter were connected to the main line through the control valves.
4. Bulb valves: T shape valves are used after 0.30 m from the beginning of each lateral to control water entry through the laterals.
5. Lateral lines: PE tubes of 0.016 m in diameter were connected to the manifolds through beginnings stalled on manifolds lines. The lateral spacing is 12 m. The lateral line spacing was 0.60 m (one lateral per planting row).
6. Emitters: GR type emitter are located at 0.30 m along apar the lateral. The emitter nominal discharge is 4 L/h (actual is 3 L/h) at 150 kPa operating pressure.

All other practices were applied as recommended by Ministry of Agriculture and Land Reclamation (207).

Experimental design and treatments:

The experiment was established and designed statistically as a split plots with three replications. The main plots were located for the organic fertilization method treatment that included levels of completed conformation tops, chopped tops and mulched tops, comparing with bereaved of organic fertilization. The sub-plots were involved the water regime under deficit irrigation treatment that included levels of 70, 80 90 and 100% of actual cowpea irrigation requirements.

Measurements:

Implement performance:

1. **Implement actual field capacity (*AFC*):**

   It is determined as cited by Srivastava *et al*. (2006) as follows:

$$AFC = \frac{1}{ATT} \text{ ,fed/h} \quad (1)$$

Where: *ATT* is the actual total time required for accomplishing one fed, hrs.

2. **Tractor wheel slip (*S*):** It is determined as cited by Srivastava *et al*. (2006) as follows:

$$S = \frac{V_1 - V_2}{V_1} \times 100 \ \% \quad (2)$$

Where: V_1 is the machine forward speed without load, m/s.
V_2 is the machine forward speed with load, m/s.

3. **Soil mean weight diameter (MWD):**

According to **Dimoyiannis (2009), s**oil samples were taken 48 hrs after sowing irrigation using a sampler box of 0.50 x 0.20 x 0.20 m in length, width an height, respectively. The soil crumbles were sieved using a set of sieves of 2, 5, 10, 20, 50 and 100 mm mesh whole diameter. The soil mean weight diameter is determined as follows:

$$MWD = \frac{1}{w} \text{ x } (2A + 5\,B + 10\,C + 20\,D + 50\,E + 100\,F)\text{, mm} \quad (3)$$

Where: $A + V + ... + G$ is weight of separated soil by the set, kg.
$W = A + B + C + D + E + F$, kg.

4. **Planter wheel skidding (sk):**

   It is determined as cited by **Srivastava *et al.* (2006)** as follows:

$$sk = \frac{L - 3.14D}{L} \times 100\text{ , \%} \quad (4)$$

Where: *L* is the actual distance per one planter wheel revolution, m.
D is the diameter of the planter wheel, m.

5. **Plant distribution uniformity:**

As cited by ASAE (2004), the plant distribution uniformity is estimated as the coefficient of variation (*c.v.*) from average number of plants at unit area through longitudinal direction as follows:

$$cv = \frac{\sigma_n}{S_r} \times 100\text{ , \%} \quad (5)$$

Where: σ_n is standard deviation of seed spacing along the same row, m.
S_r is recommended seed spacing along the same row, m.

6. **Implement specific energy requirements:**

a. **Forage chopper and rotary plough:**

According to Ismail (2007), the equivalent tractor PTO power is estimated as follows:

$$Equivalent\ \text{PTO power} = \frac{Px\ \eta_m}{0.80}\ \text{, kW}$$

Where: 0.80 is PTO loading per the maximum tractor PTO power.

η_m is tractor engine mechanical efficiency (considered to be 80 % for diesel engine).

$$\text{Specific energy requirements} = \frac{3.61 x equivalent\ \text{PTO}\ power}{AFC}\ \text{, MJ /fed} \quad (6)$$

Where: 3.61 is coefficient of conversion from kW.h to MJ.

b. Planter:

As cited by ASAE (2003), the auxiliary tractor of 82.8 kW power pulled the tractor-drawn planter combination upon the experimental soil surface. The draught force is measured as the horizontal component of the force between the driving tractor and the tractor -planter combination using a spring dynamometer. The traction force required for the drawn implement is estimated as the difference between the dynamometer reading and the pulling resistance of the 45 kW tractor, which is estimated by pulling the tractor alone on the experimental soil surface. Then, the power required (*P*) for operating the is calculated as follows:

$$P = TF\ x\ S\ x\ \eta_m\text{, kW}$$

Where: *TF* is traction force, kN.

$$TF = S_w\ \text{x}\ \vartheta,\ kN.\quad \text{P} = \frac{TFxS}{c}$$

Where: S_w is specific work, kN.m/m3;

ϑ is volume of tilled soil, m^3 and

S is actual tractor forward speed, m/s.

Total amount of irrigation water:

According to Simonne and Dukes (2010), the total amount of irrigation water (TIW) is determined as follows:

$$TIW = \frac{LR + CR}{\eta A} m^3 / fed \quad (7)$$

Where: *LR* is leaching requirements, m^3/fed;

CR is crop water requirements, m^3/fed. and

η is irrigation system efficiency, %.

$\eta = K_1$ (emitter uniformity coefficient) x K_2 (drip irrigation efficiency coefficient).

Where: *A* is irrigated area, fed.

LR is estimated as follows:

$$LR = \frac{ECi}{EC_d}$$

Where: EC_i is irrigation water electrical conductivity, dS/m. and

EC_d is drainge water electrical conductivity, dS/m.

The net crop water requirements and the irrigation interval (*II*) are calculated as follows:

$WHC = (FC - PWP)\, \rho_b \,.\, D,$ m

$$Max.CR = \frac{MAD.WHC}{100}, \text{ mm}$$

$$MaxCR = \frac{Maxg.w.r}{\eta}, \; mm$$

$$II = \frac{Max\ .CR}{Etcrop}, \; day$$

$$ET = ET_0 \times k_c, \; mm/day$$

here: WHC. is soil water holding capacity, mm.

FC is soil field capacity, %.

PWP is soil permanent wilting point, %.

ρ_b is soil bulk density, g/cm^3.

D is effective root zone depth, m.

MAD is management allowable deficit,mm/m.

Max. g.w.r is maximum gross water requirements, mm.

ET is net crop water requirements, mm.

ET_0 is potential evapotranspiration, mm/day.

K_c is crop factor.

Et_0 is calculated according to the data recorded by Kafr Ssad weather station, Domiat *Governorate* which is affiliated to the Central Laboratory for Agricultural Climate, Agriculture Research Center, Ministry of Agriculture and Land Reclamation.

Soil characteristics:

At harvest, as cited by El-Serafy and El-Ghamry (2006), soil organic carbon, soil pH, soil infiltration rate and available soil macronutrients concentration are determined.

Cowpea seed yield:

At harvest, across each experimental unit, an area of 1 m^2 is selected randomly to determine cowpea seed yield which is calculated on basis of 14% moisture content (d.b.).

Water use efficiency (*WUE*):

$$WUE = \frac{\text{seed yield, kg/fed.}}{\text{applliedirrigation water amount, m}^3\text{/fed.}} \; \text{kg/m}^3 \qquad (8)$$

Data Analysis:

SPSS (Version 20.0) computer software package is used to employ the analysis of variance test and the LSD tests for cowpea seed yield data. Also, microsoft Excel 2016 computer software is used to employ the simple regression and correlation analysis to represent the relation between cowpea seed yield and actual cowpea irrigation requirements.

RESULTS AND DISCUSSION

Implement Performance:

Table (6) shows the used forage chopper performance.

Table (6): Forage chopper performance.

Field capacity, fed/h	Tractor wheel slip, %	Specific energy requirements, MJ/fed
1.75	4.55	11.05

Data in Table (7) display the completed tops accomplished unacceptable rotary plough performance. It achieved the lower field capacity value of 0.88 fed/h and the higher value of tractor wheel slip of 6.45%. It is illustrated that the completed tops obstructs the implement and twines at the plough blades. Then, the completed tops maximizes the adhesion between the tractor wheels and the soil surface, resulting in more tractor wheel diving, consuming more time for accomplishing the unit area. The completed tops achieved the higher soil mean weght diameter value of 45 mm. It is illustrated that the completed tops increase the resistance of soil cutting and breaking down which increases the friction between the plough blades and the soil clods, resulting in pulverizing soil clods of larger size. The completed tops expended higher specific energy requirements value 28.55 MJ/fed. It is due the higher tractor wheel slip which leads to insufficient traction. So, the full engine power cannot be used.

Table (7): Effect of some organic fertilization methods on rotary plough performance.

Organic fertilization method	Field capacity, fed/h	Soil mean weight diameter, mm	Tractor wheel slip, %	Specific energy requirements, MJ/fed
Complete tops	0.88	45	6.45	28.55
Chopped tops	0.92	43	6.10	26.50
Before tops Mulched	0.98	40	6.00	24.00

Table (8) demonstrates that applying the completed tops complemented the lower seed drill field capacity value of 1.98 fed/h, the higher tractor wheel slip value of 3.35% and the higher implement wheel skidding value of 2.80%. It is attributed to the lower degree of seed drill stability upon the soil surface that occurs due to the completed tops which obstructs the implement and twines at the furrow openers. Then, the implement utilizes more time for accomplishing the unit area. Also, the adhesion between the tractor wheels and the soil surface increases that leads to the higher value of tractor wheel slip. In addition, the seed drill vibration increases, resulting in lower contact area between the seed drill wheel and the soil surface. The completed tops achieved the moderate plant distribution uniformity value of 94%. It is due to the larger size of the soil clods that increases the seed kinetic energy, resulting in lower seed rolling motion. Then, the accuracy of seed deposition decreases. It expended the higher specific energy requirements of 1.28 MJ/fed. It is due to the proportion of the tractor wheel slip with the energy consumed.

Table (8): Effect of some organic fertilization methods on planter performance.

Organic fertilization method	Field capacity, fed/h	Tractor wheel slip, %	Seed drill wheel skidding, %	Plant distribution uniformity, %	Specific energy requirements, MJ/fed
Complete tops	1.98	3.35	2.80	94	1.28
Chopped tops	2.12	3.05	2.00	96	1.05
Before tops mulching	2.25	3.00	1.70	93	1.20

Through Tables (6 to 8), it is revealed that the chopped tops application utilized more time of 2.02 hrs. for accomplishing the unit area. Also, it required higher specific energy requirements of 38.60 MJ/fed.

Total Amount Of Irrigation Water:

Fig. (1) transposes that the chopped potato tops accompanied with 70% actual cowpea irrigation requirements required the lower irrigation water amount of 1106 m^3/fed. the chopped potato tops saved the total irrigation water amount by 2.80, 2.16 and 11.48% of that required by the completed tops, mulched tops and the bereaved of organic fertilization, respectively. this finding is illustrated that the organic fertilization enhances to improve the soil structure, resulting in increasing of water retention that impedes the infiltration process and increases the soil moisture accumulation, resulting in the increase of soil water holding capacity. the higher effect of the chopped tops on saving water irrigation amount is due to the higher specific surface area which accumulates more amount of the soil water.

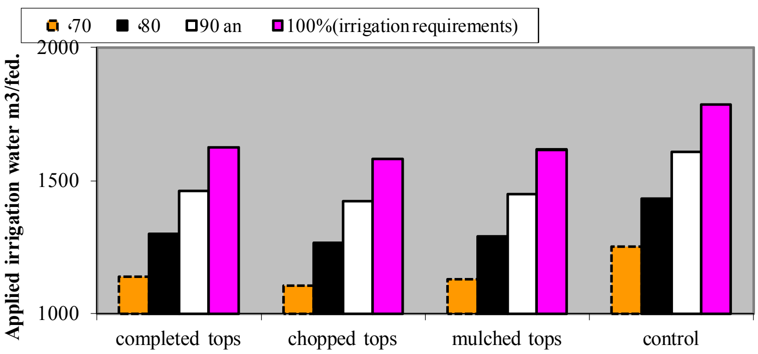

Fig. (1): Effect of organic fertilization method on total amount of irrigation water under different levels of actual irrigation requirements.

Soil Characteristics:

Through Figs (2 to 6), it is shown that the chopped potato tops accompanied with 100% actual cowpea irrigation requirements achieved more desirable soil characteristics. It recorded higher soil organic carbon value of 2.84%, lower soil pH value of 7.35, lower soil infiltration rate value of 14.55 mm/h and higher soil N, P and K concentration values of 36, 18 and 345 ppm, respectively. This tendency may be explained that the rotary plough incorporates more amount of the chopped tops with the finer size into the soil voids. Then, the decomposition of the retained chopped tops in the voids between soil particles sticks one to another, creating smaller pores, offering greater resistance to gravity, where they can impede the infiltration process, resulting in lower value of soil pH, enhancing the biological process in which microorganisms decompose the soil organic material, consuming oxygen and producing carbon dioxide, water and heat into the soil and releasing more amount of soil N, P and K.

The figures show that the soil characteristics relate strongly with the soil moisture content which is negatively proportional to the soil pH, consequently, the releasing and the availability of macronutrients increases.

It is clear that the soil characteristics at the surface layer are more desirable than that of the sub-surface layer. It may be explained that the soil organic carbon content at the surface soil layer is higher than that at the sub-surface layer due to the increase in the biological activity of the surface layer as a result of higher porosity, aeration and water retention.

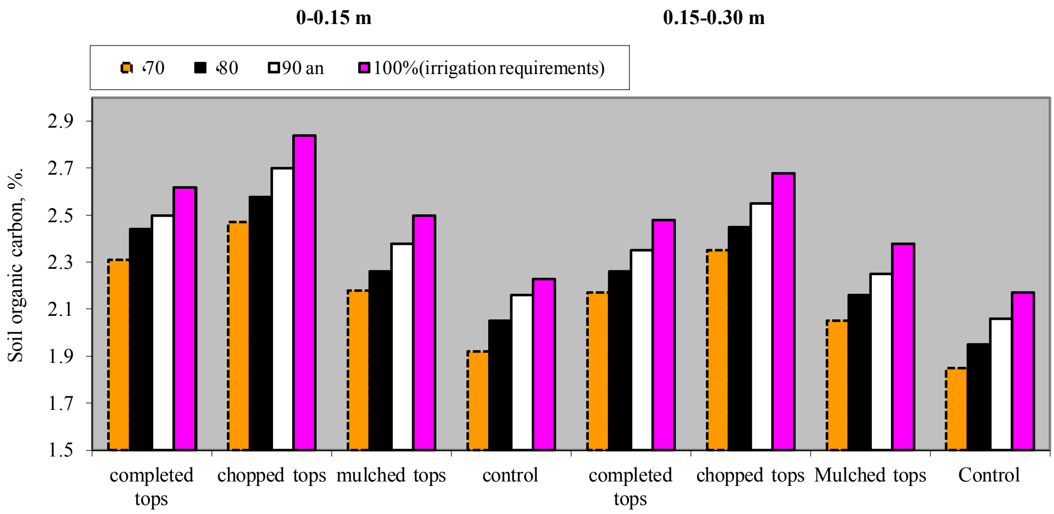

Fig. (2): Effect of organic fertilization method on soil organic carbon under different levels of actual irrigation requirements.

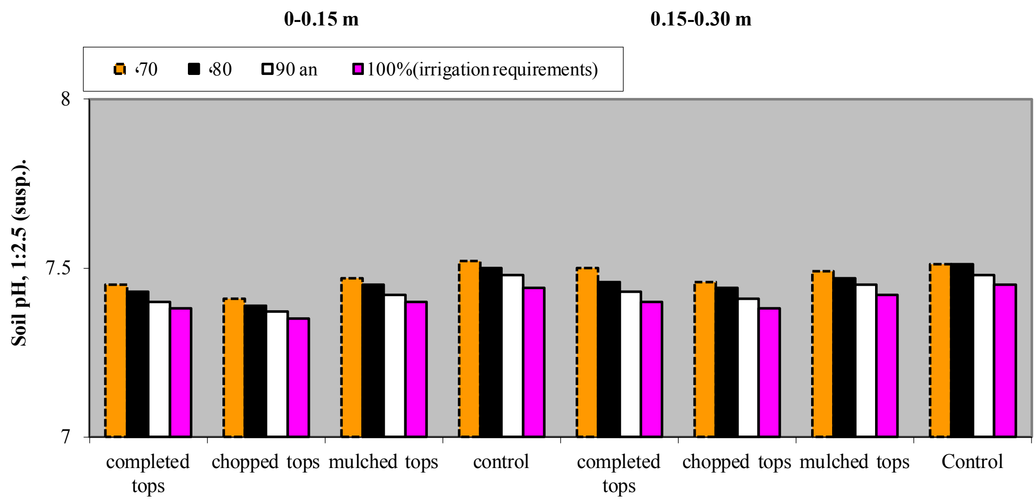

Fig. (3): Effect of organic fertilization method on soil pH under different levels of actual irrigation requirements.

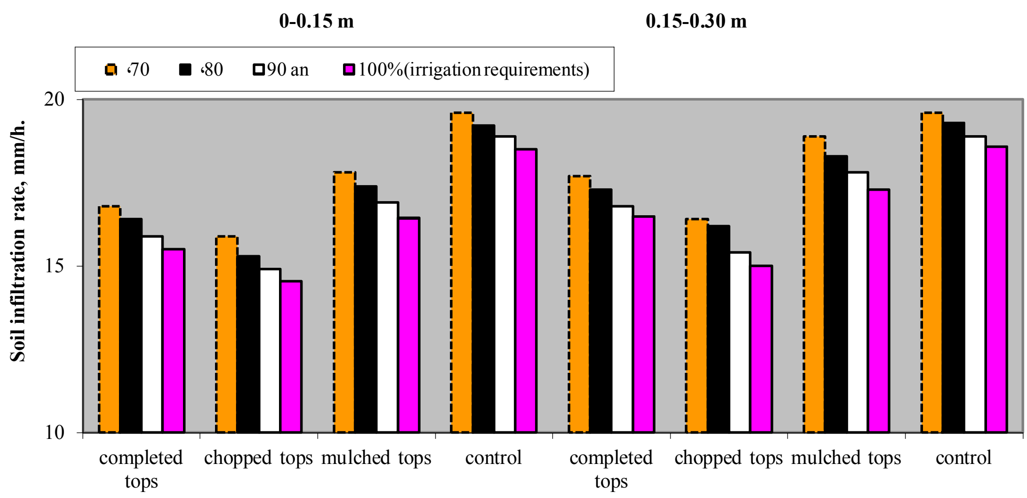

Fig. (4): Effect of organic fertilization method on soil infiltration rate under different levels of actual irrigation requirements.

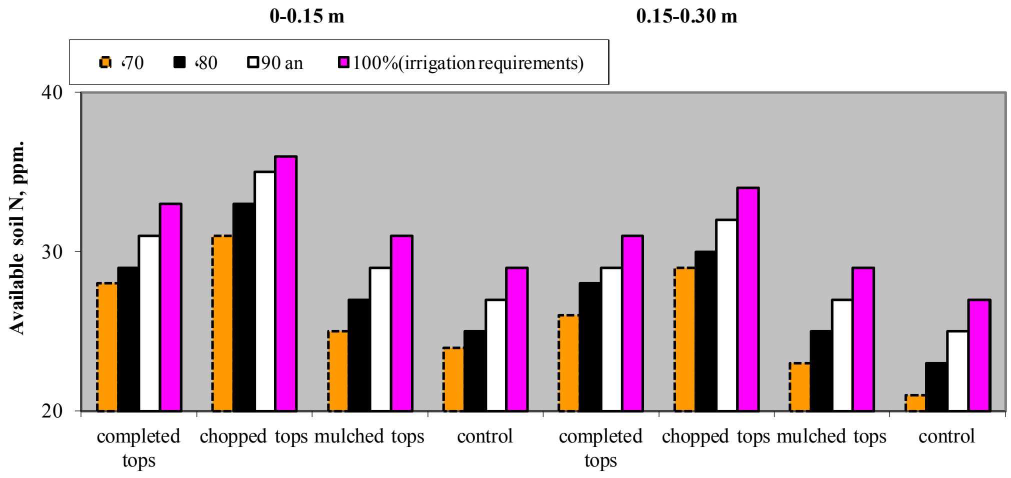

Fig. (5): Effect of organic fertilization method on available soil N concentration under different levels of actual irrigation requirements.

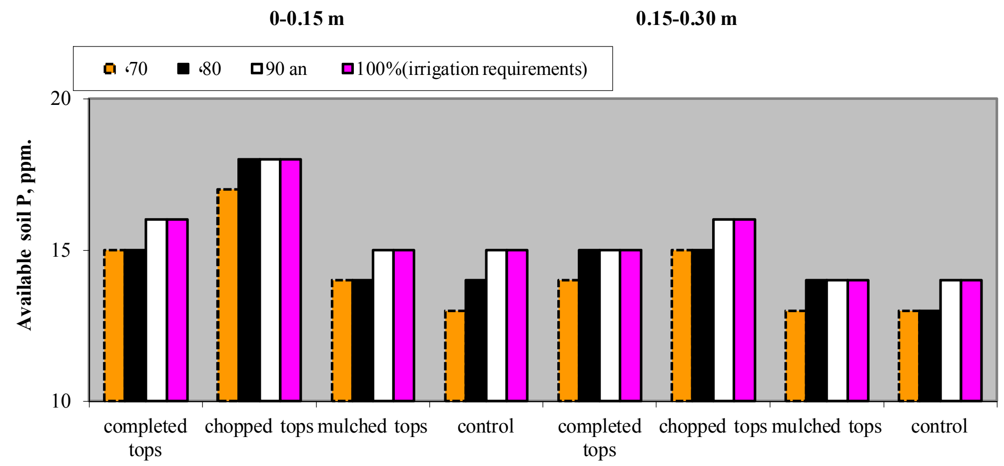

Fig. (6): Effect of organic fertilization method on available soil P concentration under different levels of actual irrigation requirements.

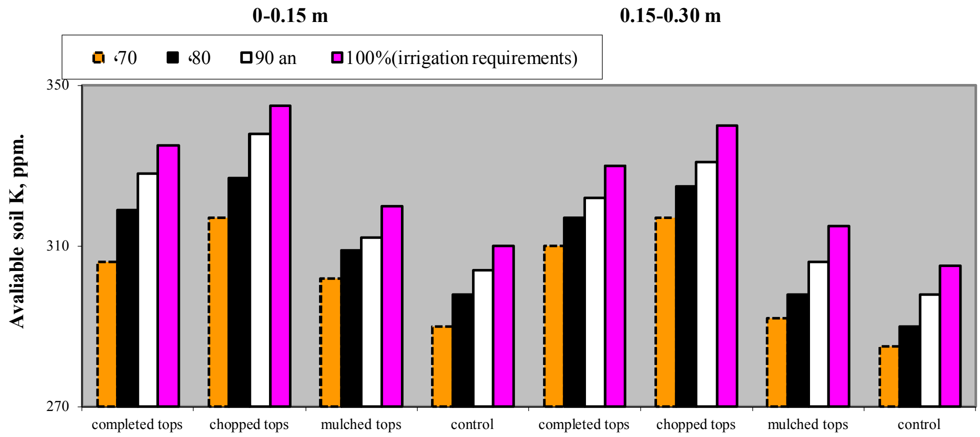

Fig. (7): Effect of organic fertilization method on available soil K concentration under different levels of actual irrigation requirements.

Cowpea seed yield:

Fig. (8) reveals that the higher cowpea seed yield of 948 kg/fed was observed with the chopped potato tops accompanied with 100% of cowpea actual irrigation requirements. While, the lowest yield of 613 kg/fed was found with bereaved of organic fertilization attended with 60% of actual irrigation requirements. The figure shows that cowpea seed yield was found to be linearly related to actual irrigation requirements. It is due to the plant extract from root zone without suffering water stress in the readily available water. Then, the supply of water is present in the soil profile and there is no precipitation occurs. Also, drought stress can significantly affect the total biomass produced of crops and that water stress can reduce crop yield by reducing CO^2 assimilation area and leaf number and total leaf area. In addition, data indicate that cowpea seed yield was affected significantly by the applied organic fertilization, especially, the chopped potato tops. This finding is due to the desirable soil characteristics through organic matter decomposition by soil micro organisms, resulting in the increase of nutrients solubility and nutrient availability to the plants that enhance plant growth and development.

The analysis of variance test indicated that there is a significant difference in cowpea seed yield due to the organic fertilization methods and actual irrigation requirements. LSD test at 0.05 level shows that the chopped potato tops accompanied with 100% irrigation requirements achieved higher cowpea yield among the other treatments.

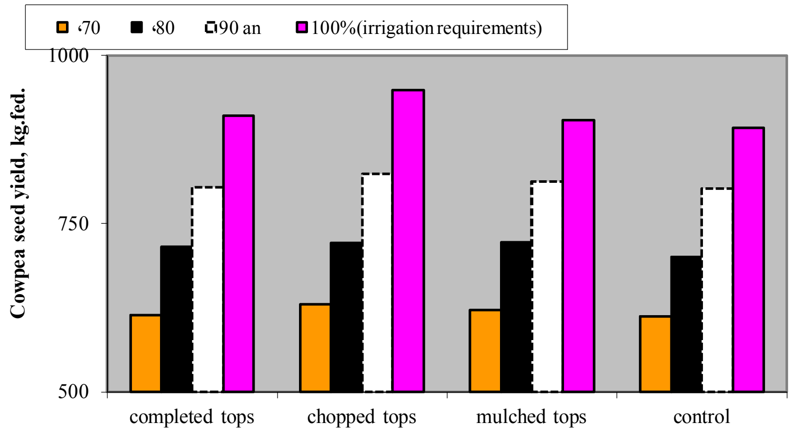

Fig. (8): Effect of organic fertilization method on cowpea seed yield under different levels of actual irrigation requirements.

The regression analysis revealed that there is a significant highly positive effect between cowpea seed yield (y) and actual irrigation requirements (x) under different organic fertilization methods as follows:

Completed potato tops: $y = 97.56\ x + 807$ ($R^2 = 0.999$)

Chopped potato tops : $y = 105.59\ x + 840.17$ ($R^2 = 0.995$)

Mulched potato tops : $y = 93.50\ x + 807.50$ ($R^2 = 0.999$)

Control : $y = 94.05\ x + 807.10$ ($R^2 = 0.999$)

Water Use Efficiency:

Fig. (9) reveals that the chopped tops accompanied with 100% of cowpea irrigation requirements recorded the higher water use efficiency value of 0.60 kg/m^3. The chopped tops increased the water use efficiency by 106, 106 and 116% from that was recorded by the comleted tops, mulched tops and the bereaved of organic fertilization, respectively.

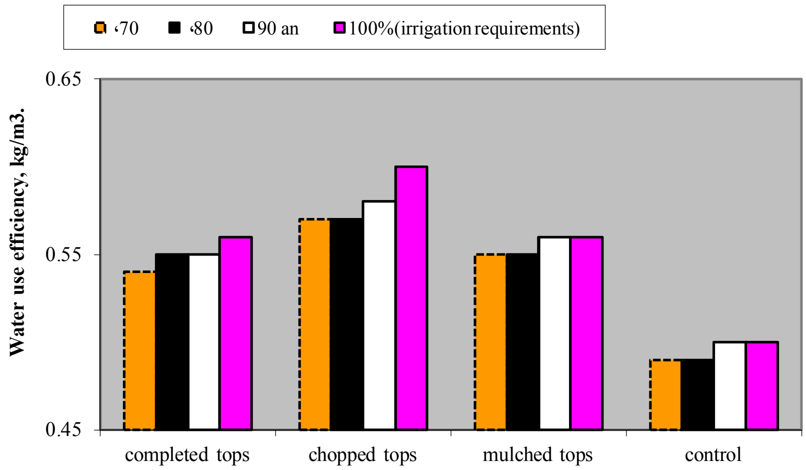

Fig. (9): Effect of organic fertilization method on water use efficiency under different levels of actual irrigation requirements.

CONCLUSION

The obtained results of this study could be concluded as follows:

1. Application of the chopped potato tops utilized more time and required higher specific energy for accomplishing the unit area.
2. Application of the chopped potato tops improved the soil characteristics.
3. Application of the chopped potato tops accompanied with 70% actual cowpea irrigation requirements required the lower irrigation water amount.
4. Application of the chopped potato tops accompanied with 100% of cowpea actual irrigation achieved the higher cowpea seed yield and the higher water use efficiency.

Finally, it is recommended to apply of the chopped potato tops accompanied with 100% of cowpea actual irrigationto achieved the higher cowpea seed yield and the higher water use efficiency.

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تأثير بعض طرق التسميد العضوي على إنتاج محصول اللوبيا تحت نظام الري بالتنقيط

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معهد بحوث الهندسة الزراعية - مركز البحوث الزراعية بالجيزة.

أجريت هذه الدراسة بقرية الدمايرة بمحافظة الدقهلية بجمهورية مصر العربية خلال الموسم الصيفي 2016، وذلك للوقوف على تأثير بعض طرق التسميد العضوي على إنتاج محصول اللوبيا تحت نظام الري بالتنقيط السطحي. وقد صممت التجربة إحصائياً ونفذت في القطع الثانويه في ثلاث مكررات، حيث أن القطع الرئيسة تضمنت معاملة التسميد العضوي بمستويات حراثة عروش البطاطس وحراثة عروش البطاطس بعد فرمها وتغطية سطح التربة بعروش البطاطس بالمقارنة مع عدم التسميد العضوي، وقد إشتملت القطع الشقية على معاملة الإحتياجات المائية للوبيا بمستويات 70 و80 و90 و100%. وقد أوضحت النتائج أن معاملة التسميد بعروش البطاطس بعد فرمها المقترنة بالإحتياجات المائية للوبيا بمقدار 100% قد حققت أفضل خواص للتربة وأعلى إنتاج لمحصول بذور اللوبيا بمقدار 948 كجم/فدان وأعلى قيمة لكفاءة إستخدام مياه الري بمقدار 0.60 كجم/م3، ولذا فإنه يوصى باستخدام التسميد العضوي بعروش البطاطس تحت نظام الري بالتنقيط.

MANAGEMENT OF SPRINKLER IRRIGATION SYSTEM FOR RICE CROP PRODUCTION

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Abstract

Nowadays, Egyptian farmers cultivate about 1.35 million Feddan under flooding conditions, which consume about 18% of the total water resources resulting in higher decrement percentages in available irrigation water and lower water productivity, which synchronized in the same time with the irrigation water shortage problem in Egypt. Therefore, the present study was carried out to study the effect of using sprinkler irrigation system on rice crop production and irrigation water applied for two rice cultivars (Giza 178 and Egyptian hybrid 1) under different planting methods in clay soil comparing with flooding irrigation to save irrigation water and maintaining the rice productivity.

The sprinkler irrigation system was applied with three levels of submerged irrigation depth after saturation namely;1cm (SD1), 3cm (SD3) and 5cm (SD5) compared with flooding irrigation method at recommended submerged irrigation depth after saturation 5cm (FD5), under three different planting methods namely; drilling planting, hand transplanting and regulating transplanting using two rice cultivars namely; Giza 178 (G178) and Egyptian Hybrid 1(H1).The field experiments were done at research farm of Rice Mechanization Center (RMC), Meet El-Deeba, Kafr El-Sheikh Governorate, Egypt during the summer seasons 2015 and 2016.The experimental results indicated that:

- Using sprinkler irrigation system at 5 cm submerged irrigation depth after saturation SD5 saved about 9.92, 6.84 and 12.01% of total applied water comparing with flooding irrigation FD5 treatment when using regulating, drilling and hand methods, respectively.
- Regulating method gave the lowest total applied water, while drilling method gave the highest total applied water for both rice cultivars G178 and H1.
- Irrigation systems and planting methods had a significant effect on the total rice grain yield. Increasing submerged irrigation depth increased the total rice grain yield for two rice cultivars. Regulating method under FD5gave the highest grain yield (3800 and 4200kg/fed) for both rice cultivars G178 and H1, respectively. While drilling method under SD1gave the lowest grain yield (1680 and 1863 kg/fed. for both rice cultivars G178 and H1, respectively.
- Increasing submerged irrigation depth decreased water productivity for two rice cultivars. Regulating method gave the highest water productivity (0.802 and 0.821.) for G178 and H1, respectively under SD1. While, drilling method gave the lowest water productivity (0.345) for G178 under FD5 and (0.410) for H1 under SD5.
- Increasing submerged irrigation depth increased yield components (Plant height (cm), panicle length (cm), straw yield (kg/Fed.), number of panicles/m^2 and weight of 1000 grain (g)) for two

rice cultivars but the increment percentages decreased with increasing submerged irrigation depth. Regulating method gave the highest yield components, while drilling method gave the lowest yield components.

- Increasing submerged irrigation depth increased grain quality but the increment percentages decreased with increasing submerged irrigation depth. Regulating method gave the highest grain quality, while drilling method gave the lowest grain quality.

INTRODUCTION

Said *et al*. (1995) reported that increasing submersion depth after saturation over than 5 cm could be considered waste water. Kumar *et al*. (1997) reported that reflooding rice field to 5 cm depth after saturation increased grain yield and irrigation water use efficiency comparing with reflooding to 2.5 and 10 cm depth after saturation. Moursi (2001) compared three levels of submerged irrigation depth after saturation 2.5, 5 and 7.5 cm for 3 rice cultivars (Giza 171, Giza 177 and Sakha 101), the results indicated that, total applied water and grain yield increased with increasing water depth while irrigation water use efficiency decreased. The results showed that the difference in grain yield between depths 5 and 7.5 cm was not significant.

Three rice cultivars in 1983 and six cultivars in 1984 under flood vs sprinkler irrigation systems were evaluated; Sprinkler irrigation consisted of three weekly applications of 0.038 m water. They found that grain yield under sprinkler irrigation vs flood irrigation was 4448 kg ha^{-1} vs. 7139 kg ha^{-1}and5901 kg ha−1 vs. 7846 kg ha−1 in years 1983 and 1984 respectively (Westcott and Vines 1986).Evaluated 12 rice cultivars under flood and three levels of sprinkler irrigation (100, 50, and 25% of estimated evapotranspiration (ET_e)) were conducted for 3 years (1982–1984) on a clay soil. The results indicated that, flooded rice treatment exceeded total applied water by 331 to 571 mm comparing with 100% ET_e sprinkler irrigation treatment. Sprinkler irrigation treatment 100% ET_e reduced plant height by 0.09 to 0.28 m and reduced the yield more than 20% comparing with flooded rice treatment. Therefore sprinkler irrigation does not appear to be a viable alternative to conventional flood irrigation in traditional rice-growing areas (McCauley1990).

Cultivated rice in clay loam soil under flooding irrigation (continuous and intermittent) and sprinkler irrigation (1.0 ET_P and 1.5ET_P). The results indicated that sprinkler irrigation and intermittent flooding increased WUE by 20 to 60% comparing with continuous flooding. Using sprinkler irrigation system decreased grain yield and increased percentage of unfilled grain (Vijayakumar *et al*., 2004). Daily sprinkler irrigation at 4 depths (7, 14, 21 and 28 mm/day) compared with flooding irrigation at submerged depth (8-10 cm). The results showed that, increasing sprinkler irrigation depths caused significant increase in total applied water, leaf area index and dry matter weight. There is no significant difference in total applied water between flood irrigation and sprinkler irrigation at depth 28 mm/day (Al-Mashhadani *et al*., 2006). Also, Stevens *et al*. (2012) reported that 1- sprinkler irrigation for rice production can be a water saving alternative to conventional flood irrigation. 2- Hybrid rice lines usually produce more tillers and have greater blast resistance than inbred rice cultivars under center pivot irrigation.3- Hybrids are better suited for sprinkler irrigation than inbreds because of their vigorous root growth. Because almost all rice in USA is produced with continuous flood irrigation, little information addresses irrigation scheduling for rice; however, successful production without a continuous flood will require timely irrigation. The findings suggest that sprinkler irrigated rice performed equally well under a range of irrigation management, additional research is needed to validate these trends and develop improved guidelines for producers (Vories *et al*., 2017).

Rice grain yield and Water use efficiency under furrow and flooding irrigation systems were compared for three years in silt clay soil. Flooding irrigation system for three years increased rice production while decreased water use efficiency comparing with furrow irrigation system. Mean of rice grain yield was 7.04 and 5.95 Mg $ha^{-1}$for Flooding and furrow irrigation systems respectively, while water use efficiency was 3.26 and 9.09 kg ha^{-1} mm^{-1} for two irrigation systems respectively (Vories *et al*., 2002). Continuous flooding consumed amount of irrigation water higher than continuous saturation. On the other hand, continuous saturation recorded the highest water productivity and minimum rice yield (El-Refaee *et al*., 2005). In the same year, Vories *et al.* (2005) compared conventional flooding with multiple-inlet approach to investigate its effect on water being pumped for rice production under scale fields. Their results showed that the multiple-inlet method required 24% less irrigation water than conventional flooding and produced 3% more yield and 36% higher irrigation water use efficiency.

El-Bably *et al.* (2007) reported that submerged depths of 10 and 7 cm significantly increased rice grain yield and yield component comparing with submerged depth of 4 cm. Submerged depth of 4 cm increased field water use efficiency by 16.6% and 49.7% more than submerged depths of 7 and 10 cm, respectively. However, Badawy (2011)recommended submerged irrigation depth 4-5 cm after saturation under continuous flooding for cultivar Egyptian hybrid1 due to improve growth characteristics, yield and yield component. He reported that hulling, milling and head rice percentage were not affected significantly with irrigation levels. In the same year, Darwesh (2011) concluded that using rice transplanting method saved irrigation water and increased grain yield comparing with broadcasting method for cultivars Giza 177 and Egyptian hybrid1. Irrigating with traditional irrigation depth gave highest grain yield for Egyptian H1 comparing with irrigation with 0.75% of traditional irrigation depth, while for Giza177 irrigation with 0.75% of traditional irrigation depth gave the highest grain yield comparing with traditional irrigation depth.

El-Saka (2013) studied the effect of three irrigation intervals (continuous flooding, irrigation every 6 and 12 days for cultivar Egyptian H1. The obtained results indicated that increasing irrigation intervals decreased total applied water and grain yield. Milling characters (hulling, milling and head rice) were affected by irrigation intervals. El-Ekhtyar (2014) studied the effect of three irrigation intervals 3, 6 and 9 days on yield of Giza 179 rice cultivar. His results indicated that the growth characteristics as well as grain yield and its attributes were significantly affected by irrigation intervals. The optimum water use efficiency was obtained at 6 days irrigation intervals, while 9 days irrigation intervals gave the highest of water save and yield reduction. Takayoshi *et al* (2016) reported that worldwide increasing water demands have made alternate wetting and drying (AWD) technology where rice paddies are intermittently irrigated, except during the rooting and flowering stages.AWD procedure ("safe-AWD") follows strict standards, whereby paddy fields are watered up to 5 cm and then re-watered when the water level naturally declines to 15 cm below the soil surface. With AWD technology total applied water reduced by 15%-40% comparing with continuous flooding irrigation with no major negative impact on yield.

Rice is the staple food for more than half of the world`s population, and it is consider a major food crop in Egypt which, planted in an area about 1.35 million Feddan in the 2015 season (Annual Rice Technical Recommendations 2016). Nevertheless, it still grown under flooding conditions which consumes about 18% of the total water resources (Badawy *et al*., 2002) may be due to applying much higher amount of water (1900 mm) comparing with other summer crops such as cotton (1380 mm) and maize (1000 mm) (FAO, 2003). This results leading to higher decrement percentages in available irrigation water and lower water productivity which synchronized in the same time with the irrigation water shortage problem in Egypt, where the irrigation water is relatively limited and insufficient for both reclamation and irrigation purposes. From this point of view it was necessary to study applying other irrigation systems to save irrigation water and maintaining the productivity of rice. Therefore, the present study was carried out to realized the following main objectives: 1) studying the effect of sprinkler irrigation system on rice crop production and irrigation water applied for two rice cultivars (Giza 178 and Egyptian hybrid 1) in clay soil comparing with flooding irrigation, 2) optimum management for sprinkler irrigation system to improve rice yield and decrease irrigation water, 3) evaluate the interaction of different planting methods and irrigation systems on irrigation applied water and rice grain yield.

MATERIALS AND METHODS

Experimental layout:

The field experiments were carried out at the research farm of Rice Mechanization Center (RMC), Meet El-Deeba, Kafr El-Sheikh Governorate during the sowing cultivation summer seasons of 2015 and 2016. The experimental field was prepared using the traditional preparing method of chisel plow (20 cm depth, one pass) + wooden level (1 pass).All agricultural practices were done according to the agronomy recommendations for all treatments under study. Both rice cultivars were drilled in May 28, 2015 and May 30, 2016 at the same date of nursery prepared for transplanting and were harvested in October 12, 2015 and October 10, 2016.Some of soil physical properties and mechanical soil analysis of the experimental field were conducted according to standard procedures and tabulated in Table 1.

Table 1: Mechanical soil analysis and some physical properties of experimental field.

Soil depth, cm	Particle size distribution			Soil texture	Physical properties		
	Sand,%	Silt, %	Clay,%		Field	Permanent	Bulk
0-15	10.42	31.25	58.33	Clay	44.80	21.36	1.10
15-30	13.00	32.00	55.00	Clay	41.45	21.40	1.22
30-45	12.00	29.00	59.00	Clay	39.00	21.00	1.28
45-60	12.00	28.00	60.00	Clay	37.40	20.85	1.31

Sprinkler Irrigation network:

Sprinkler irrigation system under study consisted of centrifugal pump (3 inch inlet and outlet diameters and 30 m^3/h discharges) driven by 3.75kW internal combustion engine, back flow prevention device, pressure gauges, flow-meter control valves, mainline, lateral lines and sprinklers. Main line was high density polyethylene (HDPE) pipes with 75 mm outer diameter, lateral lines were poly vinyl chloride (PVC) pipes with 32 mm outer diameter which connected to the main line by 32 mm control valves. Plastic impact angle sprinkler ½ inch diameter 750 ℓ/h discharge, 18m diameter of throw at 1.25 bar pressure head and 27°trajectory angle was used. The laterals and sprinklers were fixed in square layout, at 9m distance between sprinklers and 4 sprinklers were used to irrigate every treatment.

Study variables:

a- Irrigation system: two different irrigation systems, Sprinkler irrigation system and conventional flooding irrigation. The sprinkler irrigation system was applied with three different submerged irrigation depths after saturation namely; 1cm (SD1), 3cm (SD3) and 5cm (SD5). However, the conventional flooding irrigation was applied with 5cm submerged irrigation depth after saturation (FD5).

b- Planting method: three different planting methods, drilling planting, hand transplanting and regulating transplanting.

c- Rice cultivar: two rice cultivars have same life period (130 days) were used namely; Giza 178 (G178) and Egyptian Hybrid 1(H1).

The experimental field was divided to 12 plots have the same area $81m^2$ (9 × 9m). Two meters wide borders between plots were used to avoid lateral water movement between plots, every plot was divided into to two parts for two rice cultivars. The experimental field layout and study treatments distribution are shown in Fig.1.

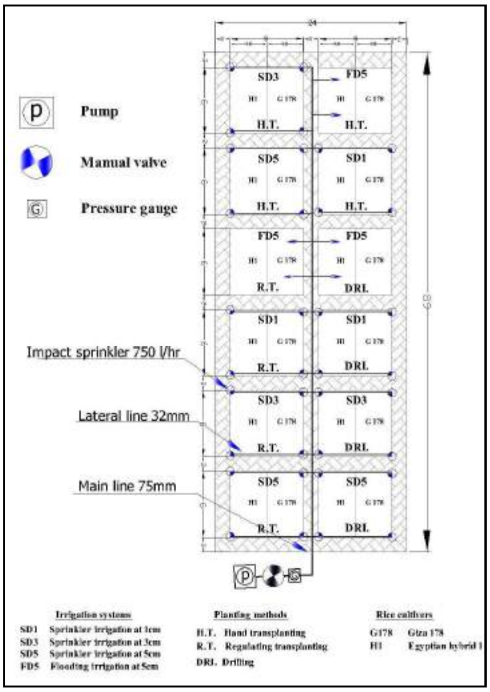

Fig. 1: The experiment field of layout and treatments distribution.

The experimental field layout for each rice cultivar was arranged in split plot design and the statistical analysis was carried by Co-Stat program for windows.

Measurements:

Total applied water

The mean values of total applied water for sprinkler irrigation system under different treatments comparing with conventional flooding irrigation system under study were measured and recorded for each study treatment during two growing seasons

Crop yield and its components

At harvesting time, rice grain yield, kg/fed and some yield components such as straw yield, kg/fed; plant height, cm; panicle length, cm; number of panicle/m^2;and weight of 1000 grain, g were measured, calculated and recorded for all given treatments under study.

Water productivity

Water productivity (WP), kg/ m^3 was calculated as following:

$$\mathrm{WP} = \frac{\text{Total grain yield, } \left({}^{kg}/_{fed} \right)}{\text{Total applied irrigation water, } \left({}^{m^3}/_{fed} \right)} ---------- (1)$$

Grain quality:-

After rice harvesting, five samples were taken randomly from each treatment under study to determine grain quality. Hardness of rice grains was tested by using the hardness device, Model (*#174886 kiya seisakusho* LTD). However, the milling quality of rough rice was evaluated in terms of total milling yield and percentage of broken rice. For each treatment 125gm of rough rice sample was husked using Satake rubber roll husker, Model (ST-50) and polished using Satake rice polisher, model (SKD-DBKK). A laboratory grader, Model (TRG-05A) was used for separating head rice from the broken rice. Total milled rice recovery and broken rice percentage were measured using the following equation:

$$\text{Milling Recovery, \%} = \frac{\text{Mass of milled rice}}{\text{Mass of rough rice sample}} ---------- (2)$$

$$\text{Broken rice, \%} = \frac{\text{Mass of broken grains}}{\text{Mass of rough rice sample}} ---------- (1)$$

RESULTS AND DISCUSSION

Total applied water:-

The effect of different planting methods and the irrigation system with its submerged irrigation depths after saturation for both rice cultivars under study on the total applied water are shown in Fig.(2). The obtained results indicated that, irrigation system with its submerged irrigation depth after saturation and planting method had highly significant effect on the total applied water. Using flooding irrigation system at 5 cm submerged irrigation depth after saturation increased the total applied water comparing with sprinkler irrigation system at any given submerged irrigation depth and planting method. However, using sprinkler irrigation system, increasing submerged irrigation depth, increased total applied water under different planting methods. Using regulating transplanting method gave the lowest total applied water followed by hand transplanting method, while drilling planting method gave the highest applied water under any given irrigation treatment. Increasing submerged irrigation depth from 1cmto 3cmincreased the total applied water by about29.55%atregulating transplanting method comparing with 36.2and 31.51% at drilling and hand transplanting methods, respectively. However increasing submerged irrigation depth from 3cmto 5cmincreasedthe total applied water by 22.02% at regulating transplanting method comparing with 19.31 and 21.18% at drilling and hand transplanting methods, respectively.

In other words, it could be cleared that, using sprinkler irrigation system with submerged irrigation depth5cmsaved about 9.92, 6.84 and 12.01% of the total applied water under regulating transplanting, Drilling and hand transplanting methods, respectively comparing with flooding irrigation system.

The highest value of the total applied water was 6977m^3/fed. obtained under flooding irrigation system under drilling planting method, while the lowest value 3533 m^3/fed. was obtained under sprinkler irrigation system with its submerged irrigation depth of 1cmand regulating transplanting method as shown in Fig. (2). In regards of the total applied water for both rice cultivars under study G178 and H1, it could be cleared that whereas two rice cultivars have the same duration period (130 days) thus, the total applied water for two cultivars were the same.

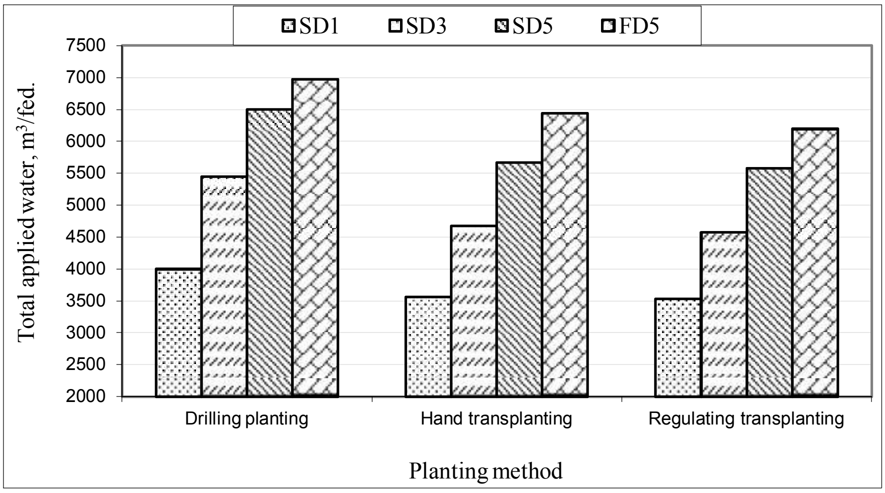

Fig. (2): Effect of irrigation system with its submerged irrigation depths and planting methods on the total applied water.

3.2. Grain yield:-

The effect of irrigation system with its submerged irrigation depths and planting methods on the total grain yield are shown in Fig. (3). The obtained results indicated that, the irrigation system with its submerged irrigation depths and planting methods had significant effect on the total rice grain yield. Using regulating transplanting method gave the highest grain yield at any given irrigation system with its submerged irrigation depth under study for both rice cultivars G178 and H1. While, drilling planting method gave the lowest grain yield at any given irrigation system with its submerged irrigation depth for both rice cultivars G178 and H1. Under sprinkler irrigation system, increasing submerged irrigation depth increased the total rice grain yield for two rice cultivars.

Increasing submerged irrigation depth from 1cm to 3cm increased rice grain yield by about 19.05, 16.48 and 12.35% when applied planting methods of drilling planting, hand transplanting and regulating transplanting, respectively for G178 cultivar comparing with24.8, 18.34 and 13.10% when applied planting methods of drilling planting, hand transplanting and regulating transplanting, respectively for H1 rice cultivar. Increasing submerged irrigation depth from 3cm to 5cm increased rice grain yield by about 12.50, 14.22 and 10.68% when applied planting methods of drilling planting, hand transplanting and regulating transplanting, respectively for G178 cultivar comparing with about 14.54, 13.59 and 10.52% when applied planting methods of drilling planting, hand transplanting and regulating transplanting, respectively for H1 rice cultivar.

Under submerged irrigation depth 5cm, sprinkler irrigation (SD5) decreased grain yield of G178by about 6.64, 8.82 and 7.24% comparing with flooding irrigation system (FD5) when using different planting methods drilling planting, hand transplanting and regulating transplanting, respectively. However, H1 grain yield decreased by about 9.67, 8.86 and 13.79% under the same previous mentioned conditions. From the results it could be concluded that the highest grain yield were3800and 4200kg/fed. for G178 and H1, respectively obtained under flooding irrigation and regulating transplanting, while the lowest grain yield was 1680 and 1863kg/fed. for G178 and H1 respectively this obtained under sprinkler irrigation system with its submerged irrigation depth 1cm and drilling planting method.

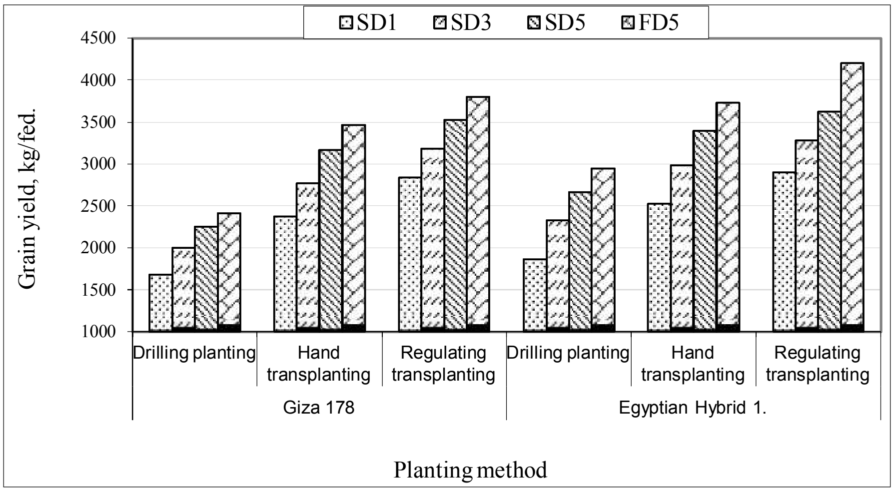

Fig. (3): Effect of irrigation system with its submerged irrigation depth after saturation and planting method on rice grain yield for two rice cultivars of Giza 178 and Hybrid 1.

3. 3.Water productivity:-

The effect of irrigation system with its submerged irrigation depths and planting methods on water productivity are shown in Fig. (4). The obtained results indicated that, the irrigation system with its submerged irrigation depths and planting methods had significant effect on the water productivity. Using regulating transplanting method gave the highest water productivity at any given irrigation system with its submerged irrigation depth under study for both rice cultivars G178 and H1. While, drilling planting method gave the lowest water productivity at any given irrigation system with its submerged irrigation depth for both rice cultivars G178 and H1. Under sprinkler irrigation system, increasing submerged irrigation depth decreased water productivity for two rice cultivars.

Increasing submerged irrigation depth from 1cm to 3cm decreased water productivity by about12.59, 11.43 and 13.28% when applied planting methods of drilling, hand transplanting and regulating transplanting methods, respectively for G178 cultivar comparing with about 8.37, 10.02 and 12.70% when applied planting methods of drilling, hand transplanting and regulating transplanting methods, respectively for H1 rice cultivar. Increasing submerged irrigation depth from 3cm to 5cm decreased water productivity by about5.71, 5.74 and 9.30% when applied planting methods of drilling, hand transplanting and regulating transplanting methods, respectively for G178 cultivar comparing with about 4.00, 6.27 and 9.43% when applied planting methods of drilling, hand transplanting and regulating transplanting methods, respectively for H1 rice cultivar.

Using sprinkler irrigation of 5cm submerged irrigation depth decreased water productivity for G178 by about 0.21, 3.50 and 2.89% comparing with flooding irrigation system under drilling, hand transplanting and regulating transplanting methods, respectively. However, water productivity for H1 decreased by about 3.13and3.45% comparing with flooding irrigation system under drilling and hand transplanting methods and increased by about 4.37%with regulating transplanting method.

The results showed that, under submerged irrigation depth of 5cm, there is no significant difference in water productivity values between sprinkler and flooding irrigation systems. Also, the highest water productivity values of 0.802 and 0.821wereobtainedfor G178 and H1, respectively under sprinkler irrigation system with its submerged irrigation depth of 1cm and regulating transplanting method. While the lowest water productivity of 0.345 for G178 was obtained under flooding irrigation and drilling method. The corresponding value of the lowest water productivity of 0.410for H1 was obtained under sprinkler irrigation system with its submerged irrigation depth of 5cm and drilling planting method.

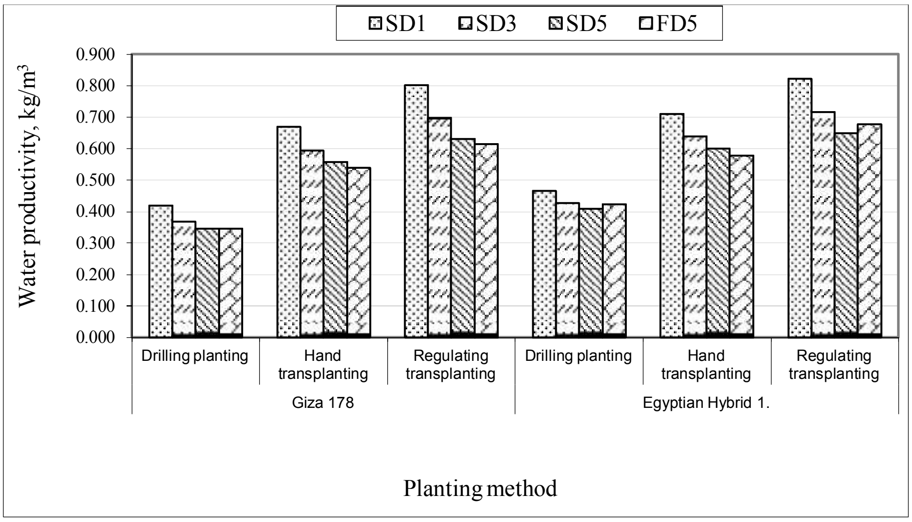

Fig. (4): Effect of irrigation system with its submerged irrigation depth after saturation, and planting method on water productivity for two rice cultivars of Giza 178 and Hybrid 1.

3.4. Yield components:-

Effect of irrigation system with its submerged irrigation depth after saturation and planting method on yield components (plant height, panicle length, straw yield, number of panicles/m^2 and weight of 1000 grain)for two rice cultivars Giza 178 and Egyptian Hybrid 1 are listed in Table (2). The obtained results indicated that, increasing submerged irrigation depth increased plant height and yield components values, but the increment percentages decreased with increasing submerged irrigation depth. Regulating transplanting method gave the highest yield components, while drilling planting method gave the lowest yield components. The maximum plant heights were 83 and 94cm for Giza 178 and Egyptian Hybrid 1 cultivars, respectively under flooding irrigation and regulating transplanting, while the lowest plant heights were 60.8 and 71.3cm under sprinkler irrigation system with its submerged irrigation depth 1cm and drilling planting method.

Under sprinkler irrigation system the highest plant heights were 81 and 89cm for Giza 178 and Egyptian Hybrid 1 cultivars, respectively obtained at submerged irrigation depth 5cm and regulating transplanting method. Highest straw yield were 2930 and 3410kg/fed. for G178 and H1 cultivars, respectively under flooding irrigation and regulating transplanting method. While, the lowest straw yield were 1159 and 1360kg/fed. under sprinkler irrigation system with its submerged irrigation depth 1cm and drilling planting method. Flooding irrigation and regulating transplanting method gave the highest values of panicle length, number of panicles/m^2 and weight of 1000 grains for two rice cultivars (20.3, 477 and 22.65 respectively) for G178 and the corresponding values for H1 were 22.2, 488 and 24.85 respectively. While using sprinkler irrigation with its submerged irrigation depth 1cm and drilling planting method gave the lowest values of 16.2, 319 and 20.55 respectively forG178 and the corresponding values for H1 were 16.4, 352 and 21.05 respectively.

Table 2: Effect of irrigation system with its submerged irrigation depth after saturation and planting method on the yield components for two rice cultivars of Giza 178 and Egyptian Hybrid 1.

Planting method	measurement	G 178				EH1			
		SD1	SD3	SD5	FD5	SD1	SD3	SD5	FD5
Drilling planting	Plant height (cm)	60.8	66.5	69.4	70.3	71.3	73.0	74.3	75.0
	Straw yield, kg/fed.	1159	1512	1613	1680	1360	1780	1840	1960
	Panicle length, (cm)	16.2	16.7	17.9	18.2	16.4	17.6	18.3	18.4
	No. of panicles/m^2	319	371	393	424	352	389	414	428
	Weight of 1000 grain (g)	20.55	20.8	21.05	21.25	21.05	21.85	22.6	23.08
Hand transplanting	Plant height (cm)	69	75	78	81	79	84	87	90
	Straw yield, kg/fed.	1915	2520	2770	2898	2048	2886	3100	3176
	Panicle length (cm)	17.2	18	18.8	20.1	17.5	19.6	21	21.2
	No. of panicles/m^2	359	412	435	458	376	423	449	468
	Weight of 1000 grain (g)	21.05	21.6	21.85	22.05	22.65	23	23.85	24.2
Regulating transplanting	Plant height (cm)	72	78	81	83	80	85	89	94
	Straw yield, kg/fed.	2016	2650	2800	2930	2370	3096	3320	3410
	panicle length (cm)	18.4	19.8	20	20.3	20.5	21	22.1	22.2
	No. of panicles/m^2	370	426	464	477	382	447	486	488
	Weight of 1000 grain (g)	21.35	21.95	22.2	22.65	23.15	23.65	24.25	24.85

Rice grain quality:-

Effect of irrigation system with its submerged irrigation depth after saturation and planting method on rice grain quality(milling recovery,%;head yield,%;broken grains,% and hardness, kg) for two rice cultivars Giza 178 and Hybrid 1 are listed in Table (3).The results indicated that, increasing submerged irrigation depth increased grain quality (increased milling recovery,%;head yield,% and hardness, kg and decreased broken grains,%)but the increment percentages decreased with increasing submerged irrigation depth. Regulating transplanting gave the highest grain quality, while drilling planting gave the lowest grain quality. Also, the results indicated that, for G178 cultivar there is no significant difference in grain quality values between flooding irrigation and sprinkler irrigation with its submerged irrigation depth 5cm. For two rice cultivars G178 and H1the highest grain quality values were obtained at flooding irrigation and regulating transplanting method, while the lowest grain quality values were obtained at sprinkler irrigation with its submerged irrigation depth 1cm and drilling planting method.

Table (3): Effect of irrigation system with its submerged depths after saturation (D), and planting method on rice grain quality for two rice cultivars of Giza 178 and Hybrid 1.

Planting method	Measurement	G 178				EH1			
		SD1	SD3	SD5	FD5	SD1	SD3	SD5	FD5
Drilling planting	Milling recovery, %	71.1	74.2	76.5	77.4	73	74.7	77.2	78.1
	Head yield, %	59.9	65.2	67.9	69.1	64.2	67.5	70.5	71.8
	Broken kernels, %	11.2	9	8.6	8.3	8.8	7.2	6.7	6.3
	Hardness, kg	4.9	5.4	5.6	5.7	5.1	5.8	6	6.2
Hand transplanting	Milling recovery, %	72.7	76.5	77.6	78.1	76.2	78.3	78.9	79.1
	Head yield, %	64	68	69.8	72.1	70.1	73.1	74.6	75.3
	Broken kernels, %	8.7	8.5	7.8	6	6.1	5.2	4.3	3.8
	Hardness, kg	5.3	6.1	6.4	6.6	5.5	6.6	6.9	7.1
Regulating transplanting	Milling recovery, %	73.1	76.8	78.5	79.1	76.8	78.8	79.6	80.4
	Head yield, %	65.9	69.9	71.7	72.8	71.4	74.7	75.9	77.2
	Broken kernels, %	7.2	6.9	6.8	6.3	5.4	4.1	3.7	3.2
	Hardness, kg	5.7	6.4	6.8	7	6.1	6.8	7.1	7.3

CONCLUSION

- Flooding irrigation system increased the total applied water comparing with sprinkler irrigation system at any given submerged irrigation depth and planting methods.
- Increasing submerged irrigation depth increased the total rice grain yield and decreased water productivity.
- Yield components and grain quality increased by increasing submerged irrigation depth for two rice cultivars, but the increment percentages decrease with increasing submerged irrigation depth.
- Regulating transplanting method gave the lowest value of total applied water and the highest values of grain yield, yield components, grain quality and water productivity, while drilling planting method gave the highest value of total applied water and the lowest values of grain yield, yield components, grain quality and water productivity for both rice cultivars.

- The findings suggest that there is a need to additional research to develop sprinkler irrigation management to improve rice productivity and decrease amount of irrigation water as possible.

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إدارة نظام الري بالرش لإنتاج محصول الأرز

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يعتبر الأرز هو محصول الغذاء الرئيسي فى مصر وأكثر من نصف سكان العالم ، حيث تم زراعة حوالى 1.35 مليون فدان في عام 2015. ومع ذلك، فإنه لا يزال يتم زراعته بطريقة الغمر التي تستهلك 18٪ من إجمالي الموارد المائية مما يؤدي إلى ارتفاع نسب التناقص في مياه الري المتاحة وانخفاض إنتاجية ماء الري تزامنا في الوقت نفسه مع مشكلة نقص مياه الري الحالية في مصر، لهذا كان لابد من دراسة تطبيق نظم رى أخرى لتوفير مياه الرى والمحافظة على إنتاجية محصول الأرز من خلال تحقيق الأهداف الرئيسية التالية : 1) دراسة تأثير نظام الري بالرش على إنتاجية محصول الأرز ومياه الري باستخدام صنفين من الأرز (جيزة 178 و هجين مصري 1) في التربة الطينية مقارنة بطريقة الري بالغمر، 2) الإدارة المثلى لنظام الري بالرش لتحسين إنتاجية الأرز وتخفيض استهلاك مياه الري، 3) دراسة تأثير التفاعل بين طرق الزراعة المختلفة وأنظمة الري على كمية مياه الري المضافة وإنتاجية محصول الأرز.

لذا تم إجراء تجربة حقلية بالمزرعة البحثية بمركز ميكنة الأرز بميت الديبة بمحافظة كفر الشيخ خلال موسمي 2015 و 2016 بهدف دراسة تأثير نظام الري بالرش على إنتاجية محصول الأرز كنظام بديل لنظام الغمر لصنفي جيزة 178 وهجين مصر 1.تم تطبيق نظام الري بالرش بثلاث مستويات تبعا لعمق الماء المضاف فوق سطح التربة بعد التشبع وهي(1سم ،3سم، 5سم) مقارنة بنظام الري بالغمر عند عمق 5سم بعد التشبع (العمق الموصى به) مع ثلاث طرق للزراعة هي (التسطير – الشتل اليدوي – الشتل المنتظم).

<u>كانت أهم النتائج المتحصل عليها كالتالي:-</u>

- أدى استخدام نظام الري بالرش عند عمق 5 سم فوق سطح التربة بعد التشبع إلى خفض كمية ماء الري الكلية المضافة بنسبة 9.92، 6.84، 12.01**%** مقارنة بالري بالغمر عند استخدام طرق الزراعة المختلفة الشتل المنتظم والتسطير والشتل اليدوى على التوالى .
- استخدام طريقة الشتل المنتظم أعطى أقل كمية ماء ري مضافة مقارنة بطريقة الزراعة بالتسطير التى أعطت أكبر كمية ماء ري مضافة.
- كان لاستخدام نظام الرى بالرش وطرق الزراعة تأثير معنوى على إنتاجية المحصول حيث أعطى الشتل المنتظم أعلى إنتاجية (3800 ،4200كجم/فدان) عند الري بالغمر للصنفين جيزة 178 وهجين مصر 1 على التوالي بينما أعطى التسطير أقل إنتاجية (1680، 1863 كجم/فدان) عند الري بالرش لعمق 1سم للصنفين على التوالي .
- أدت زيادة عمق الماء المضاف فوق سطح التربة بعد التشبع إلى انخفاض قيمة إنتاجية ماء الري لكلا الصنفين. وقد أعطى الشتل المنتظم أعلى قيمة لإنتاجية ماء الري (0.821، 0.802) للصنفين جيزة 178 وهجين مصر 1 على التوالي عند الري بالرش لعمق 1سم بينما أعطى التسطير أقل قيمة (0.345) للصنف جيزة 178 عند الري بالغمر و(0.410) للصنف هجين مصر 1 عند الري بالرش لعمق 5سم.
- زادت قيم مكونات الإنتاجية (ارتفاع النبات، طول السنبلة، إنتاجية القش، عدد السنابل /م2، وزن 1000 حبة) لكلا الصنفين بزيادة عمق الماء المضاف فوق سطح التربة بعد التشبع وقد أعطى الشتل المنتظم القيم الأعلى لارتفاع النبات ومكونات الإنتاجية بينما أعطى التسطير القيم الأقل.
- زادت قيم جودة الحبوب لكلا الصنفين بزيادة عمق الماء المضاف فوق سطح التربة بعد التشبع حيث زادت نسبة صافي التبييض**%** ونسبة الحبوب السليمة**%** وقيمة الصلابة كجم وانخفضت نسبة الحبوب المكسورة**%** وقد أعطى الشتل المنتظم القيم الأعلى لجودة الحبوب بينما أعطى التسطير القيم الأقل.

THE RELATIVE IMPACT OF OPTIMUM IRRIGATION SCHEDULING ON IMPROVING BARLEY PRODUCTIVITY IN THE NORTH WESTERN COAST

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Abstract

This paper presents the findings of the effect of irrigation scheduling methods on barley grain and straw yields, yield components (spike length, no. of kernels, kernels weight/spike, and 1000-kernel weights), amount of applied irrigation water, ~~use~~ and water productivity. The field experiments were carried out at Bahry El-Methaq region (altitude: 7m above sea level, latitude: 29°0'0" N, and longitude: 31°7'0" E), Bourg El-Arab, Alexandria Governorate, Egypt during the two successive winter seasons of 2015/2016 and 2016/2017. Three irrigation scheduling methods (canopy temperature (CT) based on crop water stress index (CWSI), water-balance approach (WB), and soil water tension (SWT) approach) were tested against two farmer practices low application efficiency (LAE) and rain-fed with no manual irrigation except two irrigation at sowing (RF). A randomized complete blocks design (RCBD) with four replicates was used to conduct the field experiment. Results indicated that, the average values of the amounts of applied irrigation water (AIW) were 1515.78, 1537.37, 1403.91, 1788.37 and 625.21 m^3/fed for the (WB), (SWT), (CT), (LAE) and (RF) treatment, respectively. The efficiency of irrigation schedule (EIS) results varied inversely with irrigation scheduling methods, where EIS increased from 56.96 to 94.65% in the first season and from 63.67 to 95.61% in the second season for the LAE treatment and the RF treatment, respectively Average grain yield values of 2.25, 2.25, 2.27, 2.25 and 0.4 ton/fed and average values of straw yield values of 4.34, 4.26, 4.2, 4.1 and 0.75 ton/fed were recorded for the WB, SWT, CT, LAE and RF respectively The results showed that, the average values of CWP values were 1.48, 1.46, 1.62, 1.25 and 0.63 kg grain/m^3 water, and were 2.86, 2.77, 2.99, 2.29 and 1.16 kg straw/m^3 for the WB, SWT, CT, LAE and RF treatments, respectively. Under the experimental conditions, the CT proved to be the best method that produced the highest water productivity values compared with the other methods.

Keywords: Water-balance, soil-water tension, canopy-temperature, Water productivity .

INTRODUCTION

In Egypt, the old lands represent the largest irrigated area spreading over 2.25 million ha (5.36 million feddan), are irrigated by traditional surface irrigation systems and new reclaimed lands cover 1.05 million ha (2.5 million feddan). Reclamation of these lands started in the early 1950s and is continuing. Nearly 2.8 million ha (6.7 million feddan) depend on rainwater. Almost 6% of this land area, which lies mostly along the north coast, is fit for traditional cultivation activities. The Nile is the main source of irrigation water, but in some desert areas underground water is used. Sprinkler and drip irrigation regimes are practiced Also, Egypt is facing major constraints with respect to its water resources one of them is a fixed water supply and rocketing population growth. Therefore, must be exploited every drop of water from its sources, especially rainwater, which provides an overall volume of 1.3 billion m3/year (ICARDA, 2011).

The northern coast of Egypt extends for about 1,050 km along the Mediterranean Sea from the eastern side of the Sinai Peninsula at the Egypt-Gaza border to the western village of Sallum at Egypt's border with Libya. It is one of the longest Mediterranean coastlines in North Africa. The strips which lies between Alexandria and village of Sallum extends for about 550km with inland depth varies from 2 to 35km from the Mediterranean Sea called North Western Coast. Rain fall rate varies in this area ranging from 130 to 150 mm in the northwestern coast and from 80 mm (west of Al-Arish) to 280 mm (at Rafah) in the northeast. This rate decreases after 20 km south of the Mediterranean in both areas The rainfall season starts from October until March with about 75% of the precipitating rainfall occurs during the period from November to February. Number of rainy days is about 25 days in the area east of Matrouh, 42 days in the area west of Matrouh and 32 days at El- Sallum area. The most of precipitation is light to medium and the number of heavy rainfall days (10 mm/day) doesn't exceed 4 days. (http://www.emwis-eg.org). Few field crops are cultivated in the rain-fed areas in Egypt, mainly barley and wheat, in addition to few fruit trees (Ouda *et al.*2016). Due to insufficient precipitation rate to meet crop water consumptive use, therefore large grain harvests cannot be expected without supplemental irrigation. Poor water resources and wells must be used to supplement. For scarce of water used in irrigating and save water; scheduling must done.

Irrigation scheduling involved the definition of the time and amount of water application to a crop, according to a management objective (Howell, 1996).

The goal of irrigation scheduling is to make the most efficient use of water and energy by applying the right amount of water to cropland at the right time and in the right place. Proper irrigation scheduling requires a sound basis for making irrigation decisions. Methods of irrigation scheduling are based on soil water measurements, meteorological data or monitoring plant stress (Van der Gulik, 2015).

Proper irrigation management requires a good understanding of a number of factors as soil fertility (crop nutritional requirements), soil-water-plant relationships, crop type, crop sensitivity to water stress, crop growth stages, availability of a water supply, climatic factors that affect crop water use such as rainfall, temperature, humidity, and net radiation and irrigation system capabilities and limitations (Alan 2011).

There are a number of ways to know when irrigation is needed (i.e., when maximum allowable depletion would be reached) and anther ways to estimate how much amount of irrigation water is applied. the ways to know when are feel method, electrical conductivity, tensiometers, neutron moisture probe and canopy temperature, but the ways to estimate how much are evaporation pans, computer programs and water budgeting.

Tensiometers measure the soil water tension that can be related to the soil water content, also are rapid, cheap and easy devices for monitoring the water status of substrate and useful for fertirrigation scheduling (Hodnett *et al*., 1990). Soil tensiometers are instruments to measure directly, without calibration, the soil matric potential between zero and the barometric pressure, but in practice it is functional up to about 85 kPa, allowing monitoring continuously the soil water status for irrigation scheduling and other hydrological applications (Carlos *et al* 2013).

Crop canopy temperature is an indicator of the vegetal response to environmental factors that can stress the plants. Inadequate soil water stresses the plant, causing the plant to transpire at a rate less than the evaporative demand of the atmosphere. The water passing through the leaf surface through transpiration cools the leaves. As water becomes limiting, transpiration decreases and leaf temperature increases. (Ivan, 1993). Whereas, Infrared thermometry has been used as a tool to provide a non-invasive method to detect crop water stress and schedule irrigations (O'Shaughnessy *et al* 2014). Initially the infrared thermometers that were used were hand-held instruments. Measurements made with these portable devices were of temperatures integrated over a small portion of the canopy and usually taken over a short period, i.e. midday, usually between 11:00 am and 14:00 pm (Hattendorf *et al*., 1988; Barbosa da Silva and Rao, 2005). Canopy temperature measurement with infrared thermometers has been an effective tool for irrigation scheduling in semi-arid and arid conditions (Evett *et al*., 2000).

Irrigation scheduling by the water-balance approach is based on estimating the soil water content. This approach is analogous to a checkbook balance. Daily withdrawals are subtracted from the checkbook balance and deposits are added. Should cash-flow scheduling project the balance to drop below some minimum, a special deposit is needed efficiencies compared to all other irrigation techniques used (Broner 2005).

Barley (Hordeum vulgare L) is the fourth most important cereals of the world after wheat, rice and maize.

Barley grown under optimal conditions (well-fertilized, well-irrigated, seeded in standing stubble, pest-free, and uniform and optimum canopy) requires 380 to 430 mm of water per growing season. The main objectives of this study were to test the effect of three irrigation scheduling methods (water balance, soil moisture tension, and canopy temperature) as compared to farmer practice on barley grain and straw yields, yield components amount of applied irrigation water, and water productivity.

MATERIALS AND METHODS

Description of the experimental site:

A field experiment was carried out in a private farm at Bahry El-Methaq region (altitude: 7m above sea level, latitude: 29° 0' 0" N, and longitude: 31° 7' 0" E), Bourg El-Arab, Alexandria Governorate, Egypt, during the two successive seasons of 2014/2015 and 2015/2016. Soil samples from the experimental site were collected to determine some physical properties (particle size analysis, textural class, bulk density (BD), moisture contents at saturation (□$_s$), field capacity (FC), welting point (WP) and available water (AW), and saturated hydraulic conductivity (ks)), as well as some chemical properties (soil reaction (pH), electric conductivity of soil paste (EC_e), Calcium carbonate contents, organic matter (OM), and soluble anions and cations). The measured parameters were determined according to Black *et al*. (1985) and presented in Tables (1 and 2).

Irrigation water was pumped from a deep well near the experimental field. The electrical conductivity (EC) of irrigation water was 5.9 ds m^{-1}, pH was 7.9 and the sodium absorption rate was 9.57.

Table (1). Some physical properties of the soil at the experimental site.

Soil depth (cm)	Particle size distribution (%)			Soil texture class	B.D gcm^{-3}	□$_s$ cm^3cm^{-3}	F.C cm^3cm^{-3}	P.W.P cm^3cm^{-3}	A W cm^3cm^{-3}	ks cmd^{-1}
	Sand	Silt	Clay							
0 – 20	72.05	17.2	10.75	Sandy Loam	1.51	0.47	0.22	0.12	0.11	18.35
20-40	72.85	16.55	10.6		1.53	0.51	0.22	0.11	0.11	16.45
40-60	76.29	14.37	9.34		1.55	0.49	0.22	0.11	0.11	17.38
Aver.	73.73	16.04	10.23		1.53	0.49	0.22	0.11	0.11	17.39

Table (2). Some chemical properties of the soil at the experimental site.

Soil depth (cm)	EC_e dS/m	pH	Total $CaCO_3$ %	O.M	Soluble cations (meq/l)				Soluble anions (meq/l)			
					Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	CO_3^{2-}	HCO_3^-	SO_4^{2-}	Cl^-
0–30	8.3	7.5	35.5	0.7	23.2	4.1	15.0	1.2		6.0	27.0	10.5
30–60	8.5	7.5	36.2	0.7	24.2	4.3	17.0	1.0		8.0	28.0	11.0
Aver.	8.4	7.5	35.9	0.7	23.7	4.2	16.0	1.1	-	7.0	27.5	10.8

The experimental field area was fertilized with 150kg/fed of supper phosphate fertilizer then the soil was tilled by using the disc harrow machine to mix the fertilizer. Nitrogen fertilizer was applied three time, with nitrogen applied as UREA at 150 kg/fed plus potassium fertilizer at rate of 25 kg K/fed, before the expulsion of the kernels. The soil was then twice perpendicularly plowed by chisel blade plow. Barley grains (var. Giza 2000) were sown at the rate of 50 kg/fed on 6 and 10 Dec. and were harvested on 23 and 28 Apr in the first and second seasons, respectively. A pre-sowing irrigation of 20 mm was applied to all treatments to ensure better germination

Irrigation system:

A fixed sprinkler irrigation system was used to conduct the field experiment. The components and specifications of the irrigation system are summarized at Table (3).

Table 3. The components and specifications of sprinkler irrigation system at the experiment site.

Component	Specification	Component	Specification
Sprinkler type	Aqua (Indian)	Wetting diameter (m)	46.4
Nozzle size (mm)	ø 10.30 × 5.60	PVC. lateral diameter(mm)	90
Raiser height	120cm	laterals operating together	2
Steel riser diameter (mm)	33.4	PVC main line diam. (mm)	125
Working pressure (kPa)	350	Pump discharge (m^3/h)	72
Ave. sprinkler discharge (m^3/h)	9	Pump pressure head (kPa)	540
Sprinkler spacing (m)	18 ×18	Power of elect. motor (kW)	18.5
No. of sprinklers per lateral	4	Motor pump speed (rp.)	1450

The discharge from the sprinkler jet was volumetrically measured by placing two flexible hoses over the sprinkler nozzles and receiving the flowing water in calibrated containers (20 liters). The time to fill the container was recorded by digital stop watch, and the discharge was calculated as m^3/h. The sprinkler base pressure was measured using a hypodermic needle assembly and dial pressure gage as indicated by the ASAE standard (1988). The revolution time of sprinkler ~~is~~ necessary for determining minimum suitable time of experimental run. Sprinkler revolution time was measured by recording the time of ten revolutions and calculates the average time for one revolution. In this study, 60 minutes for each run were used in the experiments. The evaporation losses were measured by evaporation pan.

Experimental design and tested treatments:

A randomized complete block design (RCBD) with four replicates was used in this investigation. Four irrigation treatments including three irrigation scheduling techniques and farmer practice were tested. The treatments are:

a) Canopy Temperature based scheduling method (CT).
b) Soil water tension based scheduling method (SWT).
c) The Water Balance Approach based scheduling method (WB).
d) Two farmer irrigation practices, (one of them with a low application efficiency (LAE) (more water applied than needed), other rain-fed with no manual irrigation except two irrigation at sowing(RF)) was set as control treatment in both growing seasons

Irrigation scheduling methods:

Canopy temperature based scheduling method (CT):

The methodology of Idso *et al*. (1981) was used in this study. The methodology was developed for quantification of plant water stress index (CWSI) using the infrared thermometer for temperature measurements The crop water stress index (CWSI) is calculated based on the relationship between vapor pressure deficit (VPD) and canopy-air temperature differences (T_c-T_a) as follows:

$$CWSI = \frac{(T_c - T_a)_M - (T_c - T_a)_L}{(T_c - T_a)_U - (T_c - T_a)_L} \qquad (1)$$

where:

T_a air temperature (°C)

T_c canopy temperature (°C)

$(T_c - T_a)_M$ the measured difference temperature (°C)

$(T_c - T_a)_L$ the lower limit base line (non-water stressed condition)(°C)

$(T_c - T_a)_U$ the upper limit base line (water stressed condition) (°C)

$$(T_c - T_a)_L = a - b \times VPD \qquad (2)$$

$$(T_c - T_a)_U = a - b \times VPG \qquad (3)$$

VPD the vapor pressure deficit (kPa) and calculated as:

$$VPD = e_S - e_a \qquad (4)$$

e_S saturation vapor pressure at T_{air} (kPa) and calculated by Teten formula in FAO 56 as:

$$e_S\,(Tair) = 0.611 \times \exp\left[\frac{17.27 \times Tair}{237.3 + Tair}\right] \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

e_a actual vapor pressure of air (kPa), calculated as:

$$e_a = e_S\,\left(\frac{RH_{mean}}{100}\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

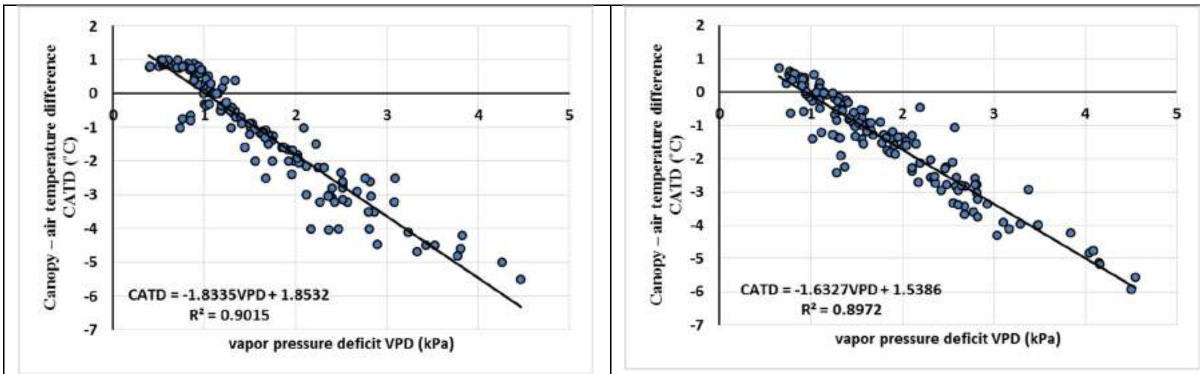
The a and b coefficients are the intercept and the slope of the linear relationship between CATD and VPD

VPG vapor pressure gradient (kPa) for possible maximum temperature, calculated as:

$$VPG = e_{S(Tair)} - e_{S(Tair+a)} \ldots\ldots\ldots\ldots\ldots\ldots (7)$$

$e_{S(Tair)}$, $e_{S(Tair+a)}$ are the saturated vapor pressure of air temperature and air temperature plus a constant, respectively.

The developed relation between (Tc - Ta) and vapor pressure deficit using the meteorological data at the experimental site is illustrated in Fig. 1. The equations for canopy air temperature difference (CATD) used under this experimental conditions were given determined as: CATD =1.8532 -1.8335VPD, and CATD = 1.5386 -1.6327 VPD for first and second season, respectively



1st season **2nd season**

Fig. 1. The relationship between the canopy-air temperature difference and the vapor-pressure difference at the experimental site.

The infrared thermometer (model 2, Plant Stress Monitor; Serial Number 870193, Manufacturer Standard Oil Engineered Materials Co, Canton, Massachusetts, USA) were used to measure crop canopy temperatures, the accuracy was ±1.0°C. Measurements were done at an angle of approximately 45° to the horizontal in a range of directions such that they covered different regions of the plot and integrated many leaves. The data were collected two to three times per week when skies were clear between 10 a.m. and 2 p.m. hours, taking into consideration to always sample the sunlit of the crop and ensure to point the gun at foliage not at the bare soil or the sky above the crop canopy by 10-30cm.A relationship between CWSI and soil moisture content was developed fig. 2. to determine the amount of applied water based on this method.

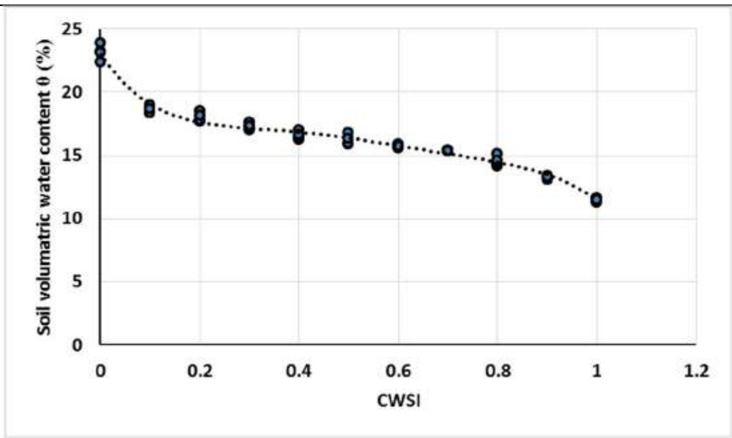


Fig. 2. The relationship between crop water stress index (CWSI) and soil moisture content at the experimental site

CWSI should progress from zero for (non-stressed plants) transpiring at potential rates, to 1 for (severely stressed plants) that are not transpiring (Idso etal1981). In this study, it was found that irrigation was approximately applied when the value of CWSI reached value of 0.7 and soil water level was brought to field capacity

Soil water tension based scheduling method (SWT):

Soil water tension was measured by tensiometers and related to the soil water content. The previous relationships were plotted as in Fig. 3. A six order polynomial equation was developed to relate soil water tension (cbar) and volumetric water content. The equation is used to predict the soil water content.

$$\theta = 5E\text{-}09\Psi^6 - 2E\text{-}06\Psi^5 + 0.0002\Psi^4 - 0.0137\Psi^3 + 0.4633\Psi^2 - 7.5207\Psi + 64.966 \quad \ldots\ldots\ldots\ldots(8)$$

Where:

Ψ soil water tension (-m)

Θ volumetric soil water content (m^3m^{-3})

(a) (b)

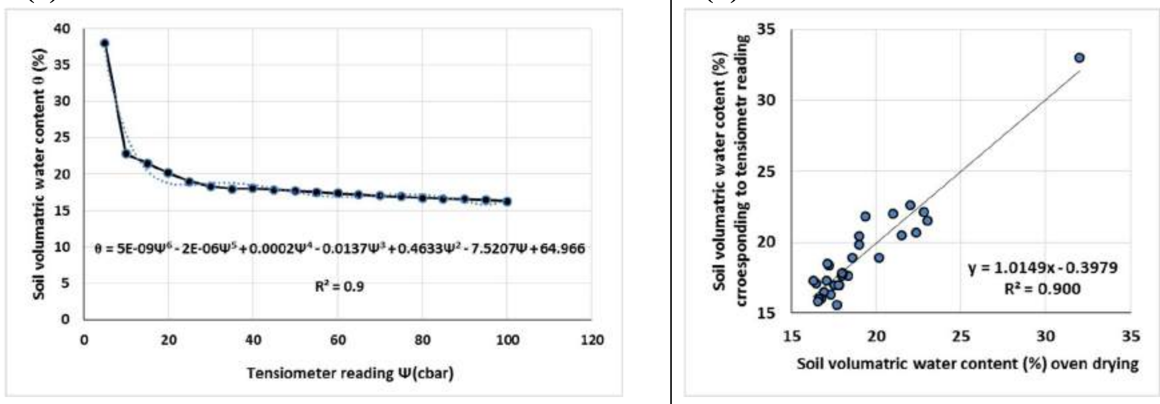


Fig. 3. Soil moisture versus water tension for the soil at the experimental site(a), soil moisture tensiometer calibration curve (b)

Soil moisture data collected through tensiometers has been calibrated with reference to oven drying method. Two tensiometers were placed in the area irrigated by the first lateral of the sprinkler system, and irrigation begins once the tensiometer reading reaches the triggered level. Since the depth of effective root zone of the barley was taken as 60cm, the first tensiometer was installed at 30cm from soil surface to reach the trigger level to begin the irrigation event (trigger level for sandy loam and rooting depth 60cm equals 30 -40cbar), this range corresponds to 50% available water depletion. While, the second tensiometer was installed at 60 cm below the soil surface. The triggered level to stop the irrigation event for sandy loam and rooting depth equals 10cbar (Van der Gulik *et al*., 2005). Irrigation stops as soon as the root zone is rewetted to field capacity and the reading of the lower tensiometer start to decrease to 10 cbar.

The Water Balance Approach based scheduling method (WB).

The water storage in the effective root zone was estimated by using the water balance equation expressed by Abrahao *et al*. (2011) as:

$$\Delta S = (P + I) - (ETa + Ds + EWDL) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (9)$$

where:

ΔS	Soil water storage (mm).
P	Precipitation rate (mm).
I	Irrigation depth (mm).
ETa	Actual evapotranspiration (mm).
Ds	Soil drainage (mm).
$EWDL$	Losses due to evaporation and wind drift of sprinkler irrigation (%)

The amount of irrigation water (*I*) was calculated based on the pre-irrigation soil water content (SWC) in 60 cm soil depth according to James (1988) as:

$$I = 100\left(\frac{R_z(\theta_f - \theta_i) + ETa + LR - P_e}{\eta}\right) \quad \text{.............................}(10)$$

Where:

η	overall efficiency of irrigation (%)
LR	leaching requirement
R_z	effective root depth
θ_f *and* θ	soil water content by volume at end (final) and beginning (initial) of the time between irrigations, respectively (m^3m^{-3})

Soil water contents were computed according to James (1998) by the following equation:

$$\theta_i = \theta_{i-1} - \left(\frac{ETa}{R_z \times 10 \times (1 - LR)}\right) \quad \text{.............................}(11)$$

where:

θ_i, θ_{i-1} soil water content by volume at end of day i (final) and day i-1 respectively (m^3m^{-3})

The barley effective root depth was estimated during the crop growing seasons according to Borg and Grimes (1986) formula as follows:

$$R_z = R_{d\max}\left(0.5 + 0.5\sin\left(\frac{3.03D_{as}}{D_{R\max}} - 1.47\right)\right) \quad \text{.............................}(12)$$

Where:

R_{dmax}	the maximum root depth 0.9 m for barley crop
D_{as}	the number of days after planting
D_{Rmax}	the number of days for maximum root depth

A percentage of losses was applied to the irrigation volume to quantify the combined losses by evaporation and wind drift was calculated according to Playán *et al*. (2005) as:

$$EWDL = 20.34 + 0.214WS^2 - 2.29 \times 10^{-3} RH^2 \quad \text{.............................}(13)$$

where:

WS	wind speed 2m above the surface (m s^{-1})
RH	relative humidity above ground level (%).

The losses due to soil drainage (*Ds*) was estimated by using the equation expressed by Abrahao *et al*. (2011) as:

$$D_s = \frac{\Delta\theta_z}{\Delta t} = \tau(\theta_s - \theta_{fc})\frac{e^{\theta_z - \theta_{fc}} - 1}{e^{\theta_s - \theta_{fc}} - 1} \quad (14)$$

$$If \quad \theta_z \le \theta_{fc} \quad then \quad D_s = 0, \quad if \quad \theta_z = \theta_s \quad then \quad D_s = \tau(\theta_s - \theta_{fc})$$

where:

$\Delta\theta_z/\Delta t$	decrease in soil water content at depth z, during time step Δt ($m^3m^{-3}day^{-1}$)
τ	drainage characteristics, from 0 to 1, in a free draining soil = 0.4 (dimensionless)
θ_z	actual soil water content at depth z (m^3m^{-3})
θ_s	soil water content at saturation (m^3m^{-3})
θ_{fc}	soil water content at field capacity (m^3m^{-3})

The minimum water content is often varied according to growing stage, especially for deficit irrigation schedule, in this study it was assumed constant along growing season and estimated with the following equation:

$$\theta_c = \theta_{fc} - [(\theta_{fc} - \theta_{wp})d_{rat}] \quad (15)$$

where:

θ_c	critical soil moisture content
θ_{fc}	soil moisture content at field capacity
θ_{wp}	soil moisture content at welting point
d_{rat}	depletion ratio taken as 60%

Efficiency irrigation schedule (*EIS*, %)

The *EIS* is expressed as a percentage and computed as the ratio between the irrigation water effectively used by the crop, meaning the difference between net irrigation (I) and irrigation losses, and net irrigation and was estimated according to Swennenhuis, (2009) by the following equation:

$$EIS = \frac{\sum(I - losses)}{\sum I} \times 100 \quad (16)$$

The actual evapotranspiration (ETa)

The actual evapotranspiration (ET_a) or water requirement of barley crop was calculated as follows:

$$ETa = ETo \times Kc \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. (17)$$

where:

ET_a: crop water requirement or the actual evapotranspiration (mm/day)

ET_o: reference evapotranspiration (mm/day)

K_c : crop coefficient of barley

Barley crop coefficients:

Table 4 shows the crop coefficient values of the barley crop and the length of each growth stage.

Table (4). Length of growth stages and crop coefficient (Kc) for the barley crop (Allen *et al.*, 1998).

Stage	Initial	Development	Mid-season	Late-season
Length growth stage	15	30	65	40
Crop coefficient Kc	0.30	1.15	1.15	0.25

Adjustment of Barley crop Coefficients:

The crop coefficients for initial and mid-season stages are ~~is~~ constant and equal to the Kc value of the growth stage under consideration. While for development and late-season stages, the Kc varies linearly between the Kc at the end of previous stage and Kc at the beginning of the next stage. Therefore, for each day the crop coefficient of development and late-season stages can be estimated according to Allen *et al*. (1998) by using following equation:

$$Kc_i = Kc_{prev} + \left[\frac{\left(i - \sum (L_{prev})\right)}{(L_{stag})} \right] (Kc_{next} - Kc_{prev}) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (18)$$

where:

Kc-i	crop coefficient on day i
i	day number within the growing season.
L-prev	length of the stage under consideration (days).
∑*(Lprev)*	sum of the length of all previous stages (days).
Kcnext	crop coefficient of the next stage
Kcprev	crop coefficient of the previous stage

Leaching requirements (LR):

The leaching fraction needed to be added to irrigation water to avoid salinity buildup in the soil profile was calculated according to Wichelns and Qadir, (2015), and expressed as:

$$LR = \frac{Ec_w}{5Ec_e - Ec_w} \quad \text{.......................................(19)}$$

where:

Ec_e electrical conductivity of the saturation extract soil water. (dS/m)

Ec_w electrical conductivity of the irrigation water (dS/m).

7. Weather data:

The main agro-meteorological data including air temperatures, precipitation, solar radiation, relative humidity, sunshine hours, wind speed (WS), and the calculated potential evapotranspiration (ET), vapor pressure deficit (VPD), and vapor pressure gradient (VPG) during the two barley growing seasons were obtained from a weather stations located 1500 m away from the site. The agro-meteorological data are presented in Table 5. The potential evapotranspiration (ET_o) values were calculated according to Penman-Montieth method (Allen *et al.*, 1998).

Effective rainfall:

The effective rainfall during growing seasons was calculated according the relation suggested by Smith (1992) as follows:

$$P_{eff} = P_{tot}\,(125 - 0.2\,P_{tot}) / 125 \quad \text{for } P_{tot} < 250\text{mm, and} \quad \text{...........................(20)}$$

$$P_{eff} = 125 + 0.1\,P_{tot} \quad \text{for } P_{tot} > 250\text{mm}$$

where:

P_{eff} = effective rainfall, and

P_{tot} = total rainfall

Table 5. Monthly meteorological data, calculated potential evapotranspiration, estimated vapor pressure deficit, vapor pressure gradient.

Month	Temperature (°C)			SR* $MJm^{-2}d^{-1}$	RH* (%)	Rain* (mm)	WS* (km/h)	SSH* (h)	ETo* (mm)	VPD* (kPa)	VPG* (kPa)
	Max	Min	Mean								
Dec. 2015	17.5	6.2	10.9	24.4	52.4	10.2	4.05	7.1	66.25	0.95	-0.25
Jan. 2016	19.6	7.7	12.7	24.9	51.6	74.9	3.15	5.9	78.30	1.10	-0.28
Feb. 2016	21.7	7.7	13.8	25	48.2	71.6	4.2	7.2	75.00	1.35	-0.31
Mar. 2016	24.9	10.5	17.1	26.6	37.2	0	4.2	8.2	121.55	1.98	-0.37
Apr.2016	28.5	13.1	20.5	28.5	31.3	0	4.3	8.6	108.55	2.67	-0.44
Seasonal rainfall (mm)						156.70					
Dec.2016	20.4	8.6	13.6	25.15	50.4	11.6	3.43	5.9	59.90	1.19	-0.24
Jan. 2017	19.2	7.6	12.5	24.72	52.5	96.36	3.32	5.3	76.10	1.06	-0.22
Feb. 2017	21.3	8.8	14.3	25.3	41.64	55.12	3.59	6.4	92.90	1.48	-0.25
Mar. 2017	25.7	10.2	17.2	25.62	35.49	0.28	4.61	8	108.8	2.13	-0.31
Apr. 2017	30.4	14.3	21.8	27.76	29.51	0	4.42	8.8	124.90	3.06	-0.40
Seasonal rainfall (mm)						163.36					

*Solar radiation (SR), relative humidity (RH), sunshine hours (SSH), wind speed (WS), evapotranspiration (ET), vapor pressure deficit (VPD), and vapor pressure gradient (VPG),

The assessment of the irrigation water use

Crop water productivity (WP):

Crop water productivity (WP) with dimensions of (kg m^{-3}) was calculated according to Molden (2003) and expressed as follows:

$$WP = \frac{Y_a}{TAW} \quad \text{....................................(21)}$$

where:

Y_a: the mass of barley yield (Kg $fed.^{-1}$).

TWA: the total amount of water applied (m^3 fed^{-1})

Date analysis:

The obtained data were analyzed using the Costat Statistic Package (version 6.311) for Windows, CoHort Software (2005). Average values from the four replicates of each treatment were interpreted using the analysis of variance (ANOVA) at 0.05 significance level.

RESULTS AND DISCUSSION

Irrigation water applied (IWA):

The amounts of water applied according to three scheduling methods and farmer practice in the two growing seasons are presented in Tables (6 and 7).

Table (6): Irrigation dates of barley according to different irrigation scheduling methods during to the two growing seasons

Date	Season									
	2015/2016					2016/2017				
	WB	SWT	CT	Control		WB	SWT	CT	Control	
				LAE	RF				LAE	RF
06-Dec-15	20.00	20.00	20.00	20.00	20.00					
10-Dec-16						20.00	20.00	20.00	20.00	20.00
16-Dec-15	5.03	5.03	5.03	11.04						
22-Dec-16						6.23	6.23	6.23	8.55	6.23
23-Dec-15	7.60	7.60	7.60	11.59	12.63					
31-Dec-15				13.05						
15-Jan-16				13.20						
25-Jan-16	39.20									
26-Jan-16		45.25		18.53						
30-Jan-16										
01-Feb-16				19.55						
13-Feb-16				20.73						
23-Feb-17						59.25			26.50	
24-Feb-16				22.35						
26-Feb-17							61.80			
01-Mar-17									30.35	
03-Mar-16	75.90									
04-Mar-16		80.55	86.12							
05-Mar-16				24.10						
06-Mar-17						71.96		89.40		
09-Mar-17									34.02	
10-Mar-17							74.07			
13-Mar-16				25.60						
17-Mar-17									38.15	
21-Mar-16				25.83						
24-Mar-17						79.21			42.17	
29-Mar-16				26.56						
01-Apr-16		89.25								
01-Apr-17									42.55	
04-Apr-16			93.16							
05-Apr-16	98.80			30.45						
05-Apr-17							83.56			
08-Apr-17								102.38	44.17	
12-Apr-16				43.92						
No of irrig	6	6	5	15	2	5	5	4	9	2
Total AW	246.53	247.68	211.91	326.50	32.63	236.66	245.67	218.01	286.49	26.23
eff Rain	117.93	117.93	117.93	117.93	117.93	120.68	120.68	120.68	120.68	120.68
total (mm)	364.46	365.61	329.84	444.43	150.56	357.34	366.35	338.69	407.17	146.91
m3/fed	1530.73	1535.56	1385.32	1866.60	632.35	1500.83	1538.66	1422.51	1710.13	617.03
Water Saving %	17.99	17.74	25.78		66.12	12.24	10.03	16.82		63.92

Results showed that, the amounts of irrigation water were 1530.73, 1535.56, 1385.33, 1866.61 and 632.35m^3/fed in the first season, while in the second season the IWA were 1500.83, 1538.66, 1422.50, 1710.57 and 617.03 m^3/fed for the water balance approach-based scheduling method (WB), soil water tension-based scheduling method (SWT), canopy temperature-based scheduling method (CT), low application efficiency (LAE) and rain-fed with no manual irrigation except two irrigation at sowing (RF) respectively. While, the lowest amount of irrigation water applied was recorded with the RF followed by CT treatment, while, the highest value was recorded with LAE in the two seasons.

Average water savings were 15.12, 13.88 and 21.30% for the WB, SWT, and CT scheduling methods, respectively compared with traditional irrigation practices.

Although RF treatment recorded the lowest amount of applied water, and highest value of water saving, we cannot told that it save irrigation water because only about 156.70 and 163.36mm precipitation occurs in the first and second barley growing season (from December to the next April), with effective rain about 117.93 and 120.68mm plus two irrigations therefore the total applied water reached to 150.56 and 146.91mm (about 632.35 and 617.03) for first and second growing season respectively, which is much less than the water requirement of barley (about 260 mm) calculated by the Penman-Monteith equation.

During the first season the irrigation water was applied among 6 irrigations for WB and SWT and 5 irrigations for CT while for LAE among 15 irrigations. In the second season the amount of irrigation water was applied for WB and SWT among 5 irrigations and 4 irrigations for CT while for LAE among 9 irrigations. The RF treatment was received 2 irrigations one pre sowing and other after 10 days in both growing seasons.

From the previous results, the amounts of water applied ranged between 1385.32 and 1866.60 m^3/fed (329.84 and 444.43 mm) which agreed with those reported by Ismail (2002), Allan (2011) and FAO (1979).

Table (7). Components of seasonal applied water for different irrigation scheduling methods.

Irrigation item	Season									
	2015/2016					2016/2017				
	WB	SWT	CT	Control		WB	SWT	CT	Control	
				LAE	RF				LAE	RF
IWA (mm)	203.84	205.59	184.52	261.89	29.70	197.41	204.52	187.55	235.11	23.30
Eff. Rain (mm)	42.69	42.09	27.39	64.61	3.18	39.25	41.15	30.46	51.38	2.93
EWDL (mm)	117.93	117.93	117.93	117.93	117.93	120.68	120.68	120.68	120.68	120.68
Total Irri. (mm)	364.46	365.61	329.84	444.43	150.81	357.34	366.35	338.69	407.17	146.91
m3/fed	1530.73	1535.56	1385.32	1866.60	633.40	1500.83	1538.66	1422.50	1710.13	617.02
Ds (mm)	67.62	70.42	50.47	126.67	5.12	62.33	65.11	55.71	96.53	3.52
losses (mm)	110.31	112.51	77.86	191.28	8.30	101.58	106.26	86.17	147.91	6.45
CU (mm)	254.15	253.10	251.98	253.15	142.51	255.76	260.09	252.52	259.26	140.46
EIS (%)	69.73	69.23	76.39	56.96	94.50	71.57	70.99	74.56	63.67	95.61

The depletion of the soil moisture content along the barley growing season under different irrigation scheduling methods is shown in Fig. (4). In these figures, it is clear that the minimum depletion of the soil moisture content under is about 17% or equals to 50% of the total available soil water where the soil field capacity is 22% and the wilting point is 11%. In some period the moisture content was stable at 22.4% that means rain was fallen in this period. The obtained results indicate that, applying the selected scheduling methods did not cause any water stress on barely crop during the growing season.

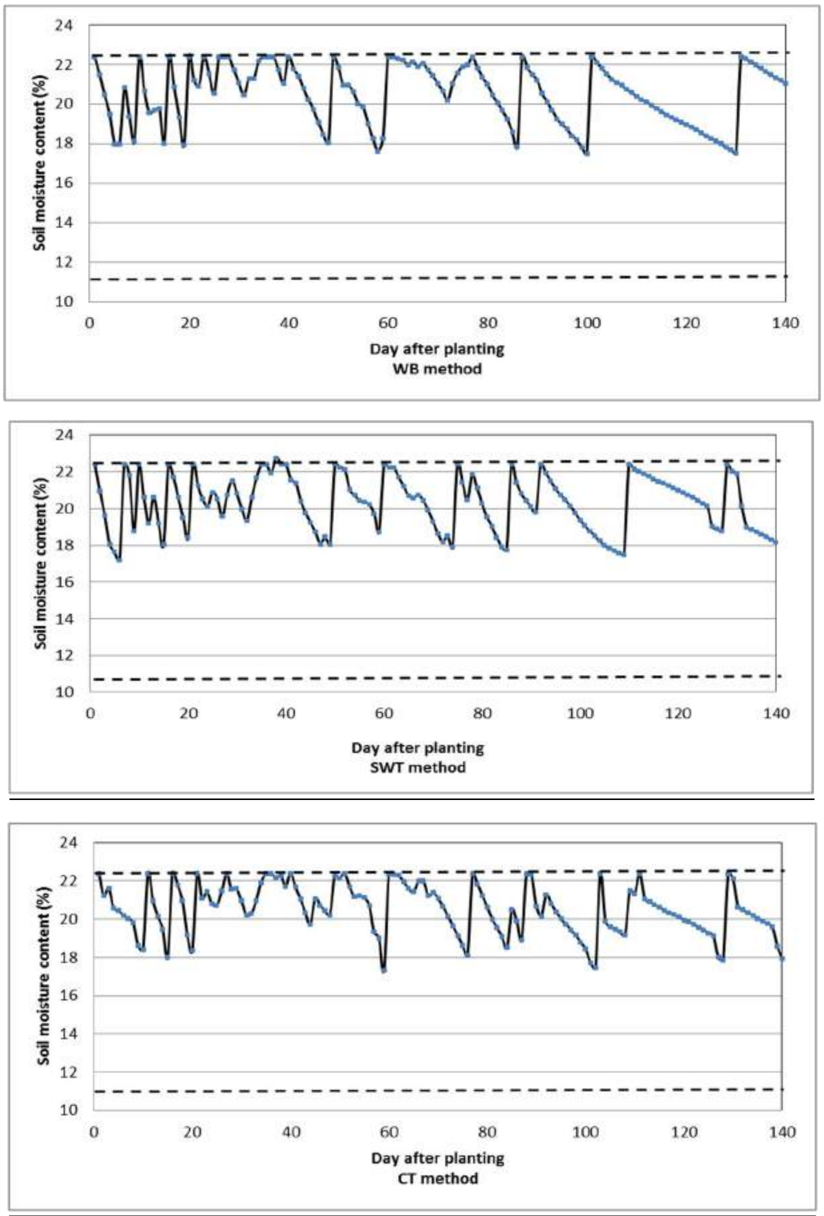


Fig. 4. Daily soil moisture depletion during growing season of barley under the water balance approach-based scheduling method (WB), soil water tension-based scheduling method (SWT), canopy temperature-based scheduling method (CT)

Efficiency irrigation schedule (EIS %):

Results in Table 6 present the efficiency irrigation schedule (EIS), which was calculated as the ratio between the irrigation water effectively used by crop (CU) and net irrigation. The obtained results indicated that, the EIS inversely varied with irrigation scheduling methods, where EIS increased from 56.96 to 94.65% in the first season and from 63.67 to 95.61% in the second season for the LAE treatment and the RF treatment, respectively. Results indicated also that, the three irrigation scheduling methods show low losses due to soil drainage (*Ds*) over the growing season. It is observed that farmer treatment, water applied every week approximately, caused high Ds. Average Ds values were 64.96, 67.77, 53.09, 111.60 and 4.32 mm for the WB, SWT, CT, LAE and RF treatments, respectively.

As a result to number of irrigation and decreasing the amount of irrigation water the results indicated that, the three irrigation scheduling methods show low percentage of losses by evaporation and wind drift (*EWDL*) over the growing season. It is observed that LAE treatment recorded highest cumulative value of EWDL losses and RF the lowest values. Average of EWDL values were 40.97, 41.62, 28.93, 50 and 3.06 mm for the WB, SWT, CT, LAE and RF treatments, respectively.

Barley yields and yield component parameters:

The effect of irrigation scheduling treatments on barley grain and straw yields and yield components are presented in Table 8. The statistical analysis indicated that, there were no significant differences of the WB, SWT, CT and LAE treatments on barley yield and yield components, while there were high significant differences between these treatments and RF treatment. Average grain yield values of 2.25, 2.25, 2.27, 2.25 and 0.4ton/fed and average straw yield values of 4.34, 4.26, 4.2, 4.1 and 0.75 ton/fed were recorded for the WB, SWT, CT, LAE and RF respectively. Obviously, there was no significant effect of the irrigation scheduling methods on any yield component which was reflected on the total yield. The obtained results could be due to no water stress was occurred under the selected scheduling methods in the two seasons but the RF treatment was exposed to high water stress and suffered from major water deficit, therefore the grain yield decreased by 82%.

Table (8). Barley yields and yield component parameters as affected by scheduling methods.

Crop item	Season											
	2015/2016						2016/2017					
	WB	SWT	CT	Control		LSD 0.05	WB	SWT	CT	Control		LSD 0.05
				LAE	RF					LAE	RF	
Spike length, cm	6.4	6.3	6.4	6.3	3.7	0.685	6.4	6.5	6.3	6.4	4.1	0.872
No. of kernels/spike	48.0	46.4	48.0	48.2	25.3	1.550	48.0	47.7	46.5	48.2	29.5	1.774
W. of kernels/spike, gm	2.5	2.5	2.6	2.5	1.1	0.936	2.4	2.4	2.5	2.5	1.4	0.895
1000 kernels weight, gm	53.4	53.9	53.8	54.6	31.7	1.874	53.5	53.6	54.8	5.7	33.0	1.651
Grain yield (ton/fed)	2.3	2.2	2.2	2.2	0.4	1.020	2.2	2.3	2.3	2.3	0.4	1.110
Straw yield (ton/fed)	4.4	4.0	4.3	4.0	0.8	0.941	4.3	4.5	4.1	4.2	0.7	1.030

Crop water productivity (CWP):

Crop water productivity values are used to evaluate the effectiveness of irrigation scheduling methods on maximizing water utilization by barley crop. Values of crop water productivity as affected by the irrigation scheduling treatments are presented in Table 9.

Table 9. Effect of different irrigation scheduling methods on the CWP of barley.

Crop water productivity item	Season											
	2015/2016						2016/2017					
	WB	SWT	CT	Control		LSD 0.05	WB	SWT	CT	Control		LSD 0.05
				LAE	RF					LAE	RF	
Grain yield (kg grain/m^3 water)	1.49	1.45	1.62	1.18	0.61	0. 373	1.48	1.47	1.62	1.33	0.66	0.254
Straw yield (kg straw/m^3 water)	2.88	2.62	3.10	2.13	1.22	0.462	2.85	2.92	2.88	2.47	1.10	0.471

The results showed that, the CWP values were 1.49, 1.42, 1.62, 1.19 and 0.69 kg grain/m^3 water, and were 2.88, 2.62, 3.10, 2.13 and 0.941 kg straw/m^3 in first season, while in the second season the values were 1.48, 1.47, 1.62, 1.33 and 0.66 kg grain/m^3 water and were 2.85, 2.92, 2.88,2.47 and 1.10 kg straw/m^3 water for the water balance approach-based scheduling method (WB), soil water tension-based scheduling method (SWT), canopy temperature-based scheduling method (CT), low application efficiency (LAE) and rain-fed with no manual irrigation (RF) respectively. Results indicated that, the best irrigation scheduling method that achieved the highest CWP was the CT method. The values of CWP agreed with the values obtained by Montazar and Kosari (2007).

CONCLUSION

From the obtained results it could be concluded that:

1. The use of infrared thermometers (IR) to measure canopy temperatures for irrigation scheduling has been successfully applied in arid environments
2. With proper irrigation scheduling, crop yields will not be introduced to water stress conditions, and the losses of water and energy used in pumping will be minimized. Also, losses of nutrients from leaching as a result of excess water applications will be reduced during the growing seasons.
3. Under the experimental conditions, the canopy temperature-based scheduling method proved to be the best irrigation scheduling method that produced the highest water productivity values compared with the other methods.
4. Scheduling with tensiometers is an easy method to be used for an immediate results. The application of canopy–air temperature difference was appropriate for crop water stress determination as it is non-destructive, noncontact, and reliable, provides considerably precise estimation and represents actual crop water demand and reflects the interactions among plants, soil and atmosphere .

5. All irrigation scheduling methods had no significant effect on barley grain and straw yields and yield components indicating that the application of the selected methods resulted in no water stress on barley crop in the two seasons.
6. Seasonal rainfall is far less than the water requirement (WR) of barley calculated by the Penman-Monteith equation.

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التأثير النسبي لجدولة الري المثلي لمحصول الشعير تحت ظروف الساحل الشمالي الغربي.

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هذا البحث يعرض نتائج دراسة تأثير طرق جدولة الري على محصول الشعير ومكونات المحصول (طول السنبلة، عدد الحبوب للسنبله من حبات، وزن حبات / ارتفاع، وزن 1000 حبة)، وكمية مياه الري المضافة، إنتاجية المياه. أجريت التجارب الحقلية في منطقة بحري الميثاق (ارتفاع: 7 م فوق سطح البحر، خط العرض: 29 ° 0'0 "شمالا، والطول: 31 ° 7'0" شرقا)، برج العرب، محافظة الإسكندرية، مصر خلال موسمي الشتاء المتتاليين 2016/2015 و 2017/2016. تم اختبار ثلاث طرق جدولة للري (جدولة الي علي اساس درجة حرارة المجموع الخضري (CT) استنادا إلى مؤشر الإجهاد المائي للمحاصيل، و الموازنه المائيه(WB) ، و الشد االرطوبي(SWT))، وذلك مقارنة بممارستين للمزارعين هما اضافة المياه للري بمعدل اكبر من الاحتياجات المائيه للمحصول اي كفاءة استخدام منخفضة (LAE) و ممارسه اخري هي الزراعه المطرية اعتمادا علي الامطار الموسمية فقط لتغطية الاحتياجات المائيه للمحصول في هذه الدراسة تم اعطاء ريتين عند الزراعة والاخري بعد 10-12 يوم من الزراعه ثم عدم الري الي نهاية الموسم (RF). تم استخدام التصميم الاحصائي القطع كاملةالعشوائية (RCBD) مع أربعة مكررات لإجراء التجربة الحقليه. أشارت النتائج إلى أن متوسط قيم كميات مياه الري المضافة كانت 1515.78 و 1537.37 و 1403.91 و 1788.37 و 625.21 م 3 / الفدان (WB) و (SWT) و(CT) و (LAE) و (RF) ، على التوالي. وتفاوتت نتائج نتائج جدول الري بشكل عكسى مع طرق جدولة الري حيث ازدادت نسبة إيس من 56.96 إلى 94.65٪ فى الموسم الأول ومن 63.67 إلى 95.61٪ فى الموسم الثانى للعلاج لي والعلاج بالترددات الراديوية، على التوالي متوسط الحبوب تم تسجيل قيم المحصول 2.25 و 2.25 و 2.27 و 2.25 و 0.4 طن / فدان ومتوسط قيم قيم قش القش 4.34 و 4.26 و 4.2 و 4.1 و 0.75 طن / فدان للمعاملات(WB) و (SWT) و(CT) و (LAE) و (RF) على التوالي. أظهرت النتائج أن قيم انتاجية المياه كانت 1.48 و 1.46 و 1.62 و 1.25 و 0.63 كجم من الحبوب / م 3 و 2.86 و 2.77 و 2.99 و 2.29 و 1.16 كجم من القش / م 3 للمعاملات (WB) و (SWT) و(CT) و (LAE) و (RF) ، على التوالي. في ظل الظروف التجريبية، ثبت أن جدولة الي علي اساس درجة حرارة المجموع الخضري استنادا إلى مؤشر الإجهاد المائي للمحاصيل هو أفضل طريقة جدوله التي اعطت أعلى قيم إنتاجية المياه مقارنة مع الطرق الأخرى.

PRODUCTION OF ONION BY DRIP AND FURROW IRRIGATION WITH DIFFERENT WATER QUALITY

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Abstract

Selection of the suitable irrigation and schedule method will be advantageous to manage limited water supplies reuse drainage water and increase crop cost-effectiveness. The overall objective of this study was to evaluate the effect of surface, subsurface drip irrigation (SDI, SubDI) and furrow irrigation (FI), and water quality where the irrigation scheduled by budget technique on onion yield. Two field experiments were carried out during two successive seasons of 2014/2015 and 2015/2016 at Al Qaher Village (altitude: 7m above sea level, latitude: 31°27'25" N, and longitude: 30°41'06" E) –-Nubaria region - El-Beheira Governorate, Egypt. The study was conducted as a split-plot design with three replicates. Three irrigation systems as (surface, subsurface drip irrigation and furrow irrigation, and three types of water quality was used (canal water (FW), drainage water (DW) and canal water and drainage water (FDW)) as subplot. Onion (Red Giza cultivar) was used in the experiments. Results indicated that, the average values of applied irrigation water were 2926, 2985, and 3151 m^3/fed for FW, FWD, and DW with FI treatments, respectively, while the values of the same treatment with both SDI and SubDI were 1761, 1950, and 2136 m^3/fed. The large bulb diameter and the massive size yield were higher for both SDI and SubDI system than the furrow system in both seasons. It was concluded that DW with drip and furrow irrigation systems more than culls yields and decreased onion size. Average water use efficiency values were 7.15, 6.98, and 3.9kg bulb/m^3 for SubDI, DI and CFI respectively while water quality achieved average values of 7.24, 6.33, and 4.47kg bulb/m^3 for FW, FWD, and DW respectively. It was concluded that drip irrigation systems produced more yields and increased onion bulb size. This was due to drip irrigation allowing for more frequent and smaller irrigation depths with higher irrigation efficiency than furrow irrigation systems.

Key words: Bulb yield, irrigation rate, Water use efficiency

INTRODUCTION

Water for irrigation is the most important restraint to agricultural production in several parts of the world. Egypt has limited water resources which enforced farmers to use low–quality of water such as drainage water municipal wastewater, and poor quality groundwater. Therefore, efficient use of saline water by irrigation is becoming progressively important, and unconventional water application method as drip may contribute largely to accomplish the different objectives such as higher productivity and optimum use of water. Onion is an important economic crop in

Egypt, where most farmers interested in the cultivation and production of bulb in new especially in new land. Egypt production is about 2,208,080 tons and the cultivated area equals 152,700 faddans . Onions are sensitive to salt, relative excluders of both Na and Cl, and sensitive to sulfate. For maximum yield, the electrical conductivity (EC) of soil extracted from the root zone and in the irrigation water should not exceed 1.2 dS m^{-1}. *Shannon and Grieve, 1999.*

Doorenbos and Kassam (1986) have reported that optimum onion yield requires 350 to 550 mm water. The crop coefficient (kc) relating reference evapotranspiration (ETo) to water requirements (ETm) for different development stages after transplanting is, for the initial stage 0.4-0-6 (15 to 20 days), the crop development stage 0.7-0.8 (25 to 35 days), the mid- season stage 0-95-1.1 (25 to 45 days), the late-season stage 0.85-0,9 (35 to 45 days), and at harvest 0,75-0.85. *Ashry (2013)* studied the effect of irrigation regimes as different available soil moisture depletion (ASMD) and N - fertilization levels as (100,120 and140 Kg.N fed^{-1} soil – injected ammonia gas) on onion bulb yield, yield components and some crop - water relations. The results revealed that seasonal evapotranspiration (ETC)., as a function of N -fertilization levels and irrigation regimes were 35.03 and 33.85 cm in 1^{st} and 2^{nd} seasons, respectively.

Abdul-Ganiyu et al. (2015) study the effect of different water application schedules on growth and yield of onion. T1 (adlib application by farmers), T2 (100% of the daily ETc applied only in the morning at each growth stage), T3 (100% of the daily ETc applied only in the evening at each growth stage) and T4 (50% of the daily ETc applied in the morning and the other 50% applied in the evening at each growth stage) were used for their study. They found that T4 produced the highest mean weight of fresh bulb of 150.2g (25t/ha) with water productivity of 5.45kg/m^3 followed by T3 of 138.8g (23.1t/ha) and water productivity of 5.04kg/m^3 while T2 recorded the least mean weight of fresh bulb of 96.2g (16t/ha).

Juan et al. (2015) found that the total onion yield obtained with the SDI systems was more than 93% higher than the yield obtained with furrow irrigation systems.

The overall objectives of this study were to:

1- Evaluate the effect of irrigation methods (DI, SubDI and furrow irrigation) on onion yield and water productivity.
2- Schedule the irrigation of onion under the experiment circumstances by water budget technique
3- Study the effect of water quality on the production of onion crop.
4- Determine the yield function and the water relation to onion yield.
5- Evaluate the irrigation system used.

MATERIALS AND METHODS

Field Experimental Site:

Two field experiments were carried out during two successive seasons of 2014/2015 and 2015/2016 at Al Qaher Village (altitude: 7m above sea level, latitude: 31°27'25" N, and longitude: 30°41'06" E) –-Nubaria region El-Beheira Governorate, Egypt. Some physical properties (particle size analysis, textural class, bulk density (BD, saturated hydraulic conductivity (ks)) and chemical properties (soil reacting (pH), electric conductivity (EC), and soluble anions and cations of the soil at the experimental site were determined. The measured parameters were determined according to Black *et al*. (1985) and presented in Tables (1 through 3). The parameters were determined according to *Black et al. (1985)*.

Table 1. Physical properties of the soil at the experimental site

Soil depth (cm)	Particle size distribution			Texture class	Bulk density ($Mg\ m^{-3}$)	Hydraulic conductivity ($cm\ h^{-1}$)
	Sand %	Silt %	Clay %			
0-15	60.1	22.6	17.3	Sandy loam	1.41	$7.6x\ 10^{-6}$
15-30	61.4	23.2	15.4	Sandy loam	1.43	$8.5x\ 10^{-6}$
30-45	59.6	24.2	16.2	Sandy loam	1.39	$7.9x\ 10^{-6}$

Climatic weather data was taken from El-Nubaria Agro - weather station. The data was potential evapotranspiration, wind speed, maximum temperature, minimum temperature, relative humidity and soil temperature.

Table 2. Main chemical properties of the soil at the experimental site

Soil	pH	EC	CEC	$CaCO_3$	OM	Soluble cations ($cmol\ m^{-3}$)				Soluble anions ($cmol\ m^{-3}$)			
depth (cm)	1: 2.5	$dS\ m^{-1}$	$cmol\ kg^{-1}$	%	%	Ca	Mg	Na	K	CO_3	HCO_3	Cl	SO_4
0-15	8.1	3.75	15	26.1	0.14	22	13	3.9	0.8	--	11	24	4.7
15-30	8.5	4.66	19	25.4	0.25	11	5.1	28.3	5.4	--	11.1	30.1	7.7

Table 3. Chemical analysis of the fresh water (FW) and agricultural drainage water (DW) samples used for irrigating onion at the field experiment.

Sample	EC $dS\ m^{-1}$	pH	Soluble cations ($mmolc\ L^{-1}$)				Soluble anions ($mmolc\ L^{-1}$)				SAR
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	CO_3^{2-}	HCO_3^{-}	Cl^{-}	$SO4^{2-}$	
FW	1.86	7.78	2	1.5	18.2	0.9	7.8	6	10	4.75	13.76
DW	3.93	7.6	5	8	31.45	1.08	2	6	10	32.66	12.35

Onion cultivar Red Giza was used, onion seeds were sown for nursery rising and transplanted after 70 days on December 11, 2014 and 7 Dec 2015 and bulbs were uprooted on 20 and 29 May in the first and second seasons, respectively. The distance between plots, rows and plants was 1m, 0.30 m and 0.10 m respectively. After onion transplanted, all of the treatment plots were irrigated with the same amount of fresh water to ensure uniform growth. The normal agricultural practices for growing onion were followed as recommended in the region. The irrigation was terminated 10 days before harvest.

Irrigation system

Irrigation systems were:

Conventional furrow treatments (CFI) were irrigated on the basis of soil moisture depletion at 50% of the total soil available water. The experimental plot size was 294 m^2 (4.2 m wide × 70 m long). The treatments were separated by non-irrigated furrows. Water was conveyed through

PVC spiel pipes 80.0 cm length (63.5 mm outer diameter) installed in irrigation channel against the upper end of the furrows, which convey the water according to the required flow rate (one spiel pipe for each furrow). Average water inflow rate were 1.52 l/s. with average head 5 cm. DI and SubDI used GR (4 l/h) lateral per row. The different components and parameters of the drip irrigation systems are summarized in Table (4).

Table (4): Specifications of surface and subsurface drip irrigation networks.

Drip lateral	GR	emitter spacing (m)	0.3
PVC main line diameter (mm)	75	Operating pressure (kPa)	150
PVC submain diameter (mm)	63	Pump discharge (m^3/h)	45
PVC manifold diameter (mm)	50	Pump pressure head (kPa)	380
lateral diameter (mm)	18	Power of elect. motor (kW)	15
Surface emitter flow rate (l/h)	3.5	Sub surface emitter flow rate (l/h)	3.76

1- Conventional furrow irrigation (CFI) System:

Total irrigation

The total irrigation time or cut-off time (T_{co}) for these treatments was estimated by:

$$T_{co} = T_{adv} + T_{req}$$

Where:

T_{adv} = the advance time (min)

T_{req} = the intake opportunity time (min)

The required time (T_{req})

$$T_{req} = (Z_{req}/K)^{(1/a)}$$

Where:

Z_{req} = irrigation depth required estimated from soil water data (mm)

K&a = soil infiltration parameters, there values were determined from infiltration test using double ring infiltrometer

Furrow irrigation inflow rates (q) were calculated according to Michael, (1978) as:

$$q = 0.65 \times 10^{-3} A \times \sqrt{2gH}$$

Where:

H = water head above the center of spiles (cm),

A = spiels cross-section area (cm^2)

g = acceleration of the gravity (981 cm/sec^2).

Volume of applied irrigation water (V)

The volume of water applied for each plot was calculated as:

$$V = q \times T_{co} \times n$$

Where:

V = applied water cm^3/min.

n = number of furrows per plot.

Evaluation of conventional furrows

To evaluate of conventional furrow irrigation (CFI) the following performance indicators were determined according to Walker and Skogerboe (1987) as:

Uniformity coefficient, Uc:

Uniformity coefficient, UC as a parameter that shows how uniformly is water distributed along the furrow can be defined as follows:

$$Uc = 1 - \frac{\sum|Z - Z^{-}|}{NZ^{-}}$$

Where:

Z water depth measured at each station (mm)

Z^- mean of water depths measured at all locations (mm)

N total number of locations

Distribution uniformity, DU:

The distribution uniformity DU defined as the ratio of the average low quarter depth of water infiltrated Z^-_{LQ} to the mean of water depths Z^- along the furrow can be expressed as:

$$DU = \frac{Z^{-}_{LQ}}{Z^{-}}$$

Application efficiency (*Ea*)

The application efficiency evaluate the design of the system synchronizing with the irrigation scheduling. The application efficiency Ea with no tail water runoff, defined as the ratio of infiltrated water stored in the root zone to the total water applied, can be expressed as:

$$E_a = \frac{Z_{req}}{D} \times 100 \qquad If \quad Z_{lq} \geq Z_{req}$$

$$E_a = \frac{Z_{ui}}{D} \times 100 \qquad If \quad Z_{lq} \leq Z_{req}$$

$$D = \frac{q_{ine} \times 60 \times T_{co}}{L \times S}$$

Where:

D average depth of water applied or gross application depth (mm)

q furrow irrigation flow rate (l/s)

L total furrow length (m)

S distance between furrows (m)

Z_{ui} average infiltrated water depth, with the exception of deep percolation losses, along the furrow length (mm);

Z_{lq} low quarter average depth of infiltrated water (mm).

Infiltration functions:

Water intake is reliable only under field condition by using one of the following methods, which are the artificial rainfall or by double ring infiltrometer. Measurements of infiltration were carried out by means of double ring infiltrometer in the field where the experiment was held. The test was repeated twice, at the beginning of each growing season of onion (2014- 2015) and the next at the beginning of 2015 -2016 season. The soils infiltration measurements were measured for the two growing seasons.

Drip Irrigation System Evaluation:

The emission uniformity EU`, and the absolute uniformity, EU`a, as proposed by Walker, (1980), were applied for field evaluation of the drip surface and subsurface systems as:

$$EU` = \frac{qave_{1/4}}{qave} * 100$$

$$EU`a = \frac{1}{2} * \left[\frac{qave_{1/4}}{qave} + \frac{qave}{qave_{1/8}} \right] * 100$$

Where:

$qave_{1/4}$ the average of the lower 1/4 of the emitter discharge rates.

$qave$ the average of all emitter discharge rates.

$qave_{1/8}$ the average of largest 1/8 of the emitter discharge rates.

Scheduling of irrigation water

The scheduling of irrigation by water budget is based on the water balance in soil within a specific limit of soil moisture content depending on soil and plant characteristics in addition to weather climatic data to estimate the crop consumptive use. The water budget technique in determining when to irrigate involves calculating the current water moisture content of the soil, then comparing it to predetermined minimum water content and irrigating to maintain soil water above the minimum level (critical). The critical water content was determined by:

$$\theta_c = \theta_{FC} - (\theta_{FC} - \theta_{WP}) x Dr$$

where:

Θ_c = soil critical moisture content (%),

Θ_{FC} = soil moisture content at field capacity (%),

Θ_{WP} = soil moisture content at the wilting point (%), and

Dr = depletion ratio taken as 0.33 for drip irrigation and 0.5 for furrow irrigation

The current water content of the soil is computed as:

$$\theta_i = \theta_{i-1} - 100 \left(\frac{ET_{drip}}{Rd \ (1 - LR)} \right) i$$

Where:

Θ_i, Θ_{i-1} = volumetric soil water content (%) at the end of day i and day i –1, respectively,

ET_{drip} = daily crop evapotranspiration mm/day,

Rd =effective root depth, and

LR =Leaching requirements.

Leaching requirements of the onion under drip and furrow irrigation were estimated according to

$$LR_{drip} = \frac{EC_w}{2 \max EC_e}$$

$$LR_{furrow} \frac{EC_w}{5\,EC_e - EC_W}$$

Doorenbos and Pruitt, 1977 by the following equations:

Where:

LR_{drip}, = leaching requirements for drip

LR_{furrow} = leaching requirements for furrow irrigation

$MaxEC_e$ = maximum electrical conductivity of the saturation extract soil water

EC_w = electrical conductivity of the irrigation water,

Once the time to irrigate has been determined, the usual practice is to fill the root zone to field capacity. Amount of water required to do this is given by:

$$IAW = \frac{Rd(\theta_{FC} - \theta_c)}{\eta}$$

Where:

IAW = depth of irrigation water (mm),

Θ_c = volumetric water content (%) directly prior to irrigation, and

η = irrigation system efficiency

The estimation of onion effective root depth (Rd) was based on local observations of neighborhood fields used the same variety of onion and cultivated at almost the same conditions. The average depth of roots at the end of the initial stage was found maximum from 30 to 40 cm at full coverage till the end of the growing season. According to Duke *et al*., (1985) the root depth was assumed to increase linearly as a function time from specified minimum root depth at " root development date" to a maximum root depth at the "effective cover date". Based on this assumption, the effective root depth along the crowing season estimated based on this function,

$$Rd(i) = Rd_{\max}\left[0.5 + 0.5\sin\left(3.03\frac{Dap}{Dtm} - 1.47\right)\right]$$

Where:

Rd(i) = root depth at the day No. i (m)
Rd_{max} = maximum root depth (m)
Dap = days after planting
Dtm = days from planting to maximum effective depth.

The daily crop water requirements of onion by the drip system or by furrow system were estimated by:

$$ET_{drip} = ET_o * Kc * kr$$

$$ET_{furrow} = ET_o * Kc$$

Where:

ET_{drip} = water requirements under the drip system (mm/day),
ET_{furrow} = water requirements under the furrow system (mm/day),
ET_o = daily potential evapotranspiration (mm/day),
Kc = the daily crop coefficient, and
Kr = reduction coefficient due to applying drip system (taken as 0.85).

The crop coefficient Kc values of onion along the growing stages were taken from Allen *et al.*, 1998. At the initial stage the onion crop coefficient is 0.7, at development stage is 1.05 and .75 at harvest. The total crop age was 230 days divided as 70 days at nursery, 30 days at establishment period, 30 days at vegetative period, 80 days at yield formation and 20 days at the ripening period. The calculation procedure of estimating the onion daily crop coefficient started by adjusting the selected Kc of the development-season and Kc of the end-season (at harvest) according to the local climatic conditions, where the values of Kc cited is based on 45% minimum relative humidity and 2 m/s for wind speed. The prevailing minimum relative humidity and wind speed during the development stage was 36.12% and 2.54 m/s respectively. According to this the crop coefficient at the development stage became 1.084. The minimum relative humidity and wind speed at harvest stage was 21.05% and 2.48 m/s respectively. Therfore, the crop coefficient at the harvest stage became 0.82. The following formula was applied for this adjustment (Allen *et al.*, 1998):

$$Kc_{adj} = Kc_{cited} + \left[0.04(U-2) - 0.004(RH_{\min} - 45)\right]\left[\frac{h}{3}\right]^{0.3}$$

Where:

Kc_{-adj} = adjusted value of onion coefficient .
Kc_{-cited} = original value of onion coefficient (Allen,1989)
U = mean value of daily wind speed at 2m height (m/s)
RH_{min} = mean value of minimum relative humidity (%)
h = mean plant height taken as 0.6 m for onion.

Estimating the onion daily single crop coefficient considering that during the initial and mid-season stages *Kc* are constants and during the development and late-season stages *Kc* vary linearly between the *Kc* at the end of the previous stage and the *Kc* at the beginning of the next stage. The formula applied for this numerical calculation is:

$$Kc(i) = Kc_{prev.} + \left[\frac{i - \sum L_{prv.}}{L_{stage}}\right]\left(K_{c\,next} - K_{c\,prev}\right)$$

Where:

$Kc\ (i)$ = crop coefficient of the day No. i

Kc_{prev} = Kc value of the previous stage

L_{stage} = length of the stage under consideration (days)

$\Sigma(L_{prev})$ = sum of the lengths of the previous stages (days)

K_{cnext} = Kc value of the next stage

Crop water productivity (WP)

WP (kg/m^3) was used to describe the relationship between seed yield (*Y*) (kg/fed.) and the amounts of irrigation applied water (*IAW*) (m^3/fed). It was determined according to the following equation:

$$WP = \frac{Y}{IAW}$$

Experimental design and tested treatments:

A split plot design with three replicates was used to conduct the field experiment. The main plots represented three irrigation systems treatments, and the sub-plots were assigned for three irrigation water quality.

<u>The irrigation systems (main plots)</u>:

CFI: Conventional furrow irrigation treatments,

DI: Surface drip irrigation.

SDI: Subsurface drip irrigation.

Irrigation water quality treatments (sub-plots):

FW: fresh water (Canal Water salinity of 1.68 – 2 dsm^{-1}),

DW: drainage water (salinity of 3.2 – 4.7 dsm^{-1}), and

FDW: fresh and drainage water alternatively.

Data Analysis:

The data were analyzed using Costat 6.311 win statistical program **CoHort Software (2005).** Average values from the three replicates of each treatment were interpreted using the analysis of variance (ANOVA). The Duncan's Multiple Range Test (SNK) was used for comparisons among different sources of variance.

RESULTS AND DISCUSION

Infiltration function

The results of cumulative Z and infiltration rate I as a function of time are presented in Fig. (1) and Fig. (2) for the successive seasons.

Furrow irrigation efficiency evaluation:

The results of the previous tests were used to determine the infiltrated water along the furrows during the infiltration opportunity time which is essential to evaluate the furrow irrigation system. Average of nine irrigations to determine the opportunity time is presented in Fig. (3). The results of furrow evaluation parameters are given in Table. (5)

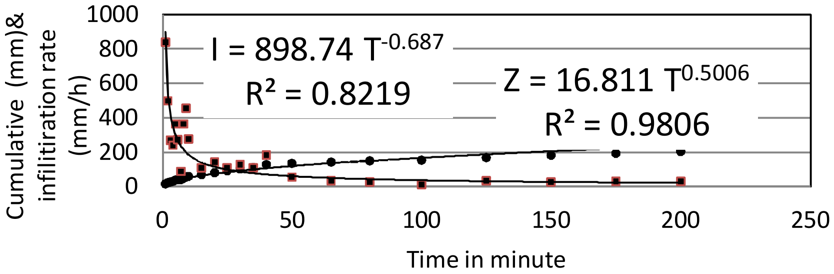

Fig. (1) Cumulative infiltration (Z) and Infiltration rate (I), functions of the experimental site soil at the growing season of 2014 –2015.

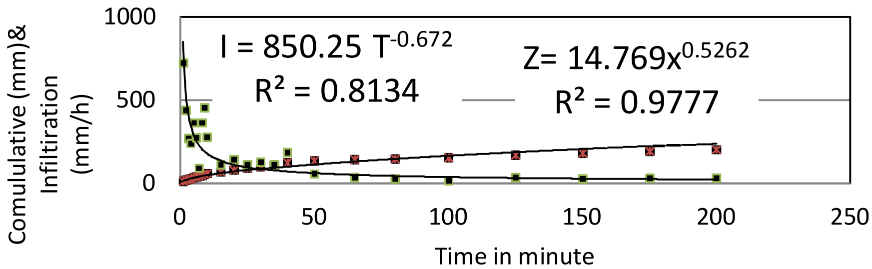

Fig. (2) Cumulative infiltration (Z) and Infiltration rate (I), functions of the experimental site soil at the growing season of 2015 –2016.

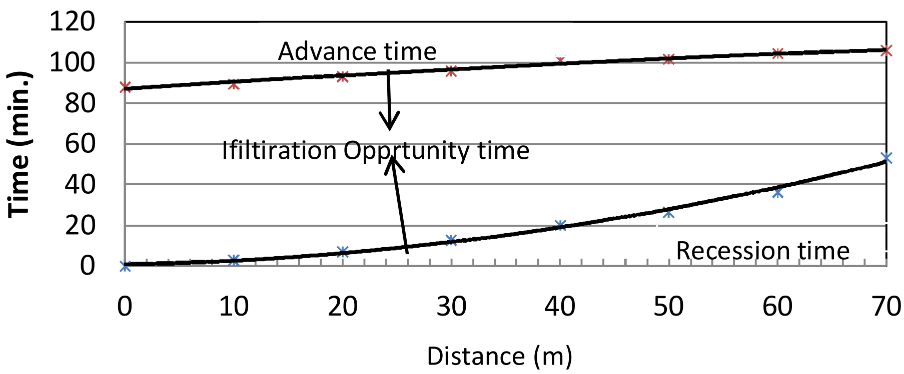

Fig. (3) Average of opportunity time along nine irrigations on the furrows

Table (5): Results of furrow evaluation efficiency parameters.

Experiment No.	Uniformity coefficient %	Distribution uniformity %	Application efficiency %
1	0.95	0.92	59.00
2	0.95	0.92	57.00
3	0.96	0.93	53.40
4	0.96	0.94	53.30
5	0.96	0.94	52.80
6	0.97	0.95	51.20
7	0.97	0.94	49.60
8	0.96	0.94	49.70
9	0.96	0.94	47.50
AVERAGE	0.96	0.93	52.61

Field determination of the emitter function and system evaluation:

For practical senses of designing and evaluation the drip system, it is essential to know the value of emitter flow function constants (the exponent of pressure and the proportionality factor), this is beside the manufacturer coefficient flow variation. Field experiment was conducted as recommended by Boman, 1989 to determine the previous parameters. The result of this test is presented in Fig. (4), where the emitter flow exponent is 0.3182 and the proportionality factor is 1.92. The discharge uniformity is average as the calcification by Solomon 1979 where the value of manufacturer coefficient of flow variation is 0.0545 and the standard deviation is 0.209. Among 40 readings distributed among the drip system the emission uniformity is 0.921 and the application efficiency 0.83.

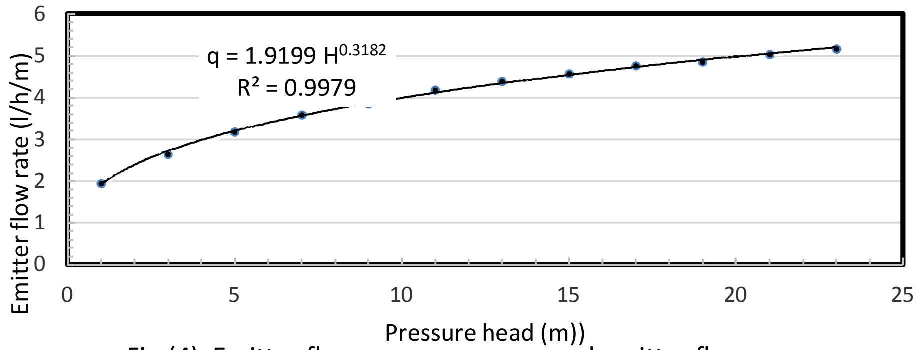

Fig.(4): Emitter flow versus pressure and emitter flow

Irrigation scheduling for onion by water budget technique

The water applied to onion was added according the result of the daily water balance simulation applied by the water budget technique method. The daily soil moisture content is determined according to the consummative use by the onion, rainfall, leaching requirement, and development of the root of the plant. Then, daily check of the moisture to avoid to be less than the critical moisture or the predetermined soil moisture depletion which is 50% of the soil total available water in case of the furrow irrigation and 33% in case of the drip system (surface or sub surface). That means the irrigation should be when the soil moisture is too close to 16.5% in case of the furrow irrigation, and 18.7% in case of the drip irrigation. In these cases the irrigation date is proposed and the depth of irrigation applied water is determined to return soil moisture to the field capacity. The irrigation during the nursery period of the onion was added according to the irrigation scheduling by water balance for furrow irrigation system. The result of irrigation dates from the beginning of the cultivation and the depth of the irrigation applied water is presented in Table (6).

Results in Table(6) indicated that the total applied water to onion during the nursery period is almost the same at the two seasons as 191.65 mm and 192.65mm respectively. The daily depletion of the soil moisture content along the two successive growing seasons are presented in Figs (5 and 6). In figures the field capacity limit is indicated as 22% and the wilting point limit which is 11% and the allowable minimum depletion during the nursery period as 16.5% when the onion irrigated by furrow irrigation.

Table (6): Irrigation dates and irrigation water depths along the nursery period of onion.

Nursery of growing season 2014 -2015		Nursery of growing season 2015-2016	
Irrigation date	Irrigation depth (mm)	Irrigation date	Irrigation depth (mm)
1	4.40	4	3.71
2	4.40	7	3.43
3	4.40	9	3.43
4	4.40	11	3.17
6	3.43	13	3.04
8	3.43	15	3.30
10	3.17	19	7.56
12	3.47	23	9.93
14	3.70	28	14.84
18	8.25	35	21.07
22	10.64	45	26.34
27	15.64	53	30.78
32	13.33	61	30.14
41	27.22	69	31.90
50	27.72		
57	26.34		
65	27.60		
	Total 191.65 mm		Total 192.65 mm

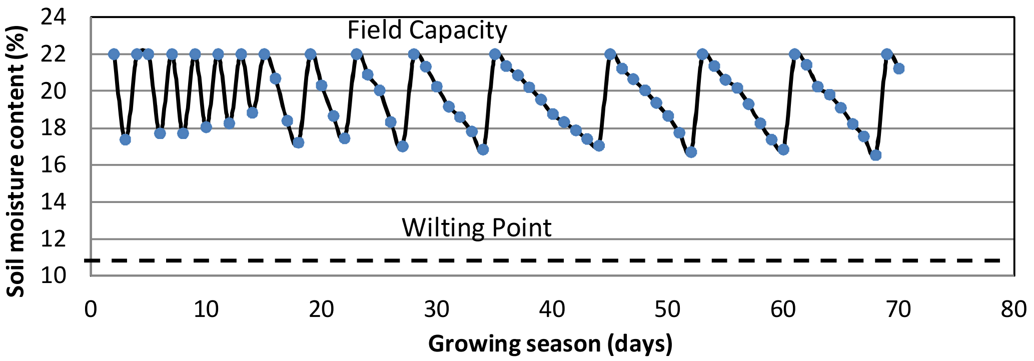

Fig. (5): Daily soil moistur depletion along the nursery period of 2014-2015...

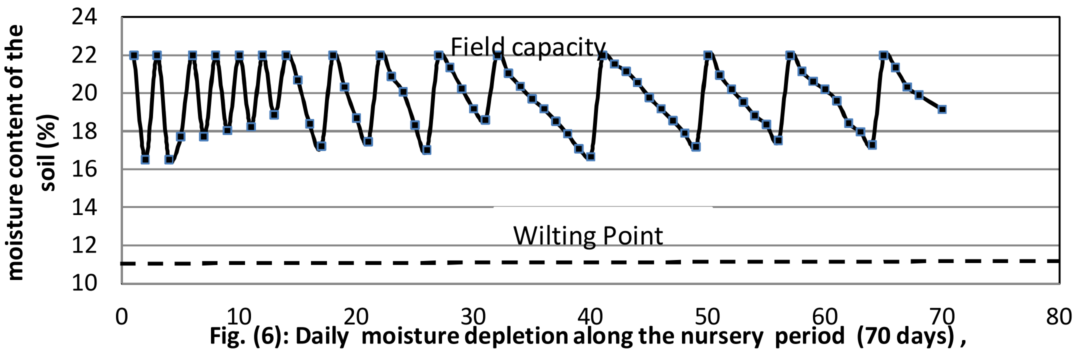

Fig. (6): Daily moisture depletion along the nursery period (70 days) , Season 2014-2015

The irrigation scheduling results based on the drip system:

The results of applying drip irrigation as irrigation dates and total applied water in case of using the fresh water, alternate mixed water and drainage water are presented in Table (7) and Table (8). During the first season the total fresh water applied to the drip system was382.44 mm among 32 irrigations. The total mixed irrigation water applied was 400 mm among 37 irrigations. The drainage water applied was 417 mm among 38 irrigation. It is clear that the irrigation water increased due to the decrease of water quality, due to the increase of leaching requirements. The same trend is found at the second growing season under the same previous condition of irrigation system and water quality. At 2015 -2016 onion growing season under drip system. Total applied fresh water was 365.14 mm meanwhile 400 mm in case of using mixed water and 416.5 mm in case of using drainage water. These quantities of water distributed among 31, 40, and 41 irrigations for the same previous order.

The depletion of the soil moisture under the application of drip irrigation used fresh water, mixed water and drainage water at the growing season of 2014 -2015 and growing season of 2015 -2016 are presented in Figs. (7a, 7b &7c) and Figs. (8a, 8b &8c), respectively. In figures the limits of field capacity and wilting point indicated the limits of moisture depletion between 22% and 18.7%.

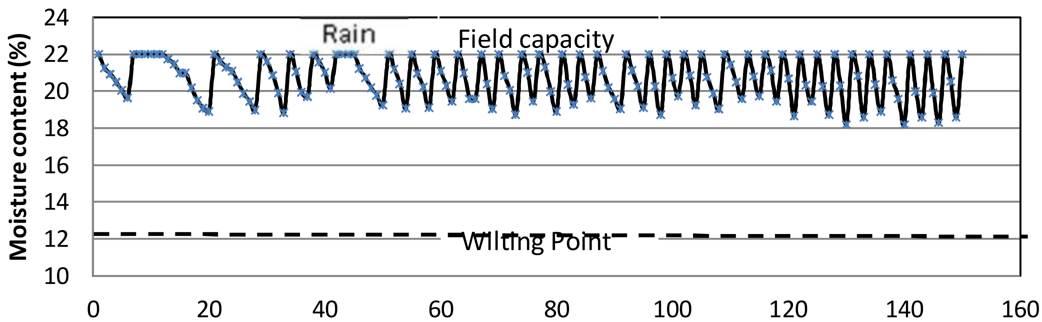

Fig. (7a) :Daily soil moisture depletion along the grown season of onion irrigated by fresh water by drip system for the season of 2014 -2015 (days)

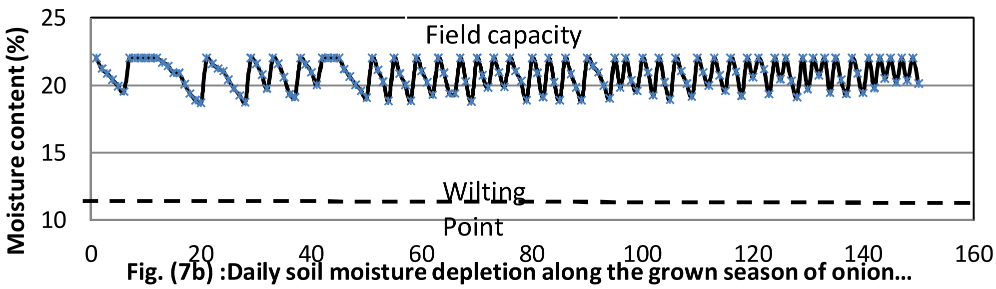

Fig. (7b) :Daily soil moisture depletion along the grown season of onion...

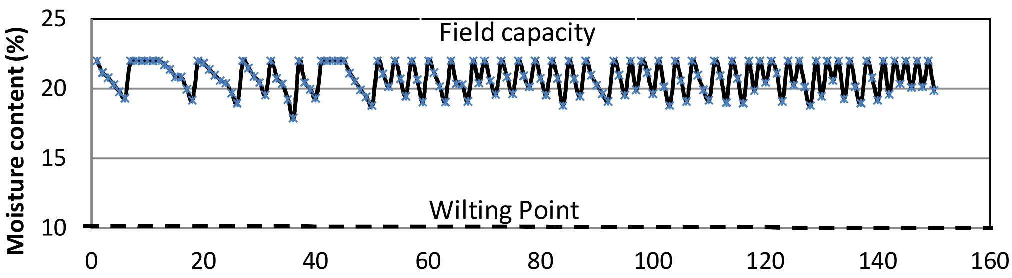

Fig. (7c) Daily soil moisture depletion along the grown season of onion irrigated by drainge water by drip system for the season of 2014 -2015 (days)

Table (7): Irrigation dates of onion by drip system using different water qualities at 2014 -2015 growing season.

Drip irrigation at the growing season of 2014 -20 15					
Fresh water		Mixed (Alternate)		Drainage water	
Day after Transplanting	Irrigation water depth mm	Day after Transplanting	Irrigation water depth mm	Day after Transplanting	Irrigation water depth mm
1	13.59	1	13.59	1	13.59
21	12.75	21	13.58	19	11.60
29	12.47	29	13.39	27	12.51
34	12.96	33	9.33	32	10.11
38	9.44	38	11.94	37	17.04
51	11.28	42	8.18	41	11.03
55	12.04	51	12.17	51	13.27
59	11.87	55	13.07	54	7.79
63	10.52	59	12.98	57	10.50
67	10.02	63	11.23	60	12.16
70	12.15	67	10.87	64	12.08
74	13.40	70	13.24	68	11.97
77	10.45	73	8.89	73	10.00
81	12.71	76	8.72	76	9.77
84	11.17	80	12.92	79	7.73
87	9.85	83	11.91	82	10.10
92	12.18	86	12.95	85	13.23
96	11.84	90	12.78	88	10.58
99	13.40	95	12.23	93	11.91
102	9.22	97	8.91	96	10.19
105	11.38	100	10.03	98	8.62
109	12.17	103	11.40	101	9.84
113	9.90	106	12.67	104	13.22
116	9.22	110	11.71	107	11.97
119	10.58	113	8.38	111	11.57
122	13.76	116	10.01	114	12.33
125	10.53	119	11.62	117	12.60
128	13.47	121	5.81	119	8.82
131	15.66	124	10.95	121	6.38
134	14.03	126	6.47	124	11.92
137	12.78	129	11.83	126	7.16
141	15.66	131	9.42	129	13.28
32 irrigation	Total 382 mm	133	5.30	131	10.54
		135	10.67	133	5.84
		138	11.02	135	11.26
		141	10.68	138	12.56
		143	9.02	141	11.60
		37 irrigation	Total 400 mm	143	9.92
				38 irrigation	Total 416.6 mm

Table (8): Irrigation dates of onion by drip system using different water qualities at 2015 -2016 growing season.

Drip irrigation at the growing season of 2015 -20 16					
Fresh water		Mixed (Alternate)		Drainage water	
Day after Transplanting	Irrigation water depth	Day after Transplanting	Irrigation water depth	Day after Transplanting	Irrigation water depth
1	13.59	1	13.59	1	13.59
16	13.49	14	9.71	14	10.67
29	15.11	17	2.24	17	2.45
40	4.17	27	12.56	26	12.99
47	14.86	30	5.02	30	8.80
54	16.42	38	8.72	38	9.52
58	8.47	45	10.17	45	11.10
63	14.53	50	11.16	50	12.27
68	15.46	54	8.68	54	9.31
73	17.10	58	9.12	58	0.10
79	17.22	62	11.29	62	12.35
83	13.97	65	12.74	64	10.02
86	9.74	69	10.62	67	11.45
89	10.32	72	6.26	71	12.67
92	9.33	75	8.98	73	9.08
95	10.09	79	10.64	76	9.39
99	9.74	82	11.49	79	7.19
103	13.23	85	9.98	82	12.57
106	11.71	88	12.50	85	10.83
109	11.46	91	11.84	87	7.36
111	6.24	95	17.07	90	12.59
114	8.74	99	10.75	93	11.14
117	11.93	102	8.78	95	8.65
120	9.84	104	5.76	99	12.00
123	9.60	107	9.41	102	9.69
126	10.35	109	6.91	104	6.50
129	12.05	112	16.21	107	10.30
132	13.16	115	12.06	110	15.32
135	10.70	118	12.98	113	13.50
137	9.84	121	10.96	116	11.85
140	12.67	123	6.51	118	6.27
31 irrigations	Total 371.41 mm	126	11.31	121	12.17
		129	13.51	123	7.07
		131	8.79	126	12.48
		133	10.86	128	9.10
		135	6.13	130	7.05
		137	11.03	132	6.18
		139	5.41	135	12.66
		142	11.09	137	12.55
		144	6.96	139	6.01
		40 irrigations	Total 400 mm	142	12.14
				41 irrigations	Total 416.5 mm

The irrigation scheduling results based on the furrow system:

The effect of water quality on the yield of onion irrigated by furrow irrigation system was studied. The results of applying furrow irrigation and irrigation dates and total applied water in case of using the previous water qualities are presented in Table (9) and Table (10) for the two growing season of onion

The total water applied by the furrow system were 645.5 mm, 711 mm, 756.3 mm for the three water qualities in the first season. For the second growing season under the same previous condition of irrigation system and water quality. Total applied fresh water was 613.9 mm meanwhile 712.3 mm in case of using mixed water and 734.6 mm in case of using drainage water. These quantities of water distributed on 23, 27, and 29 irrigations for the same previous order.

The same as the drip irrigation system, the depletion of the soil moisture content along the onion growing seasons under different water qualities is presented in Fig. (9a, 9b, 9c) for the first growing season and Fig. (10a, 10b, 10c) for the second growing season 2015 -2016. In these figures it is clear that the minimum depletion of the soil moisture content under furrow irrigation is 16.5% or at 50% of the total available soil water where the soil field capacity is 22% and the wilting point is 11%. In some period the moisture content is constant as 22%, that means rain in this period.

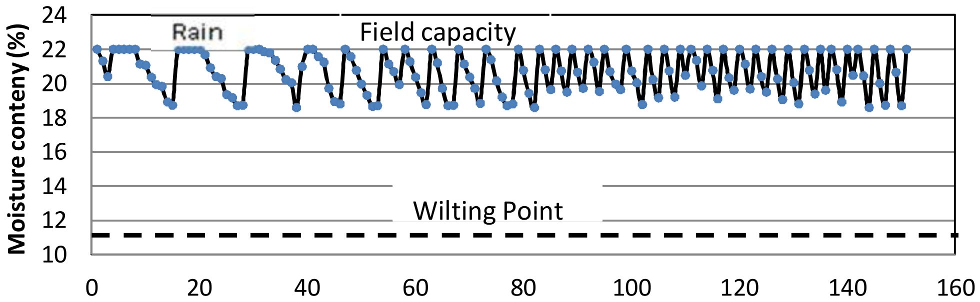

Fig. (8a):Daily moisture depletion along the growing season of onion irrigated by drip system using fresh water for the season of 2015 -2016

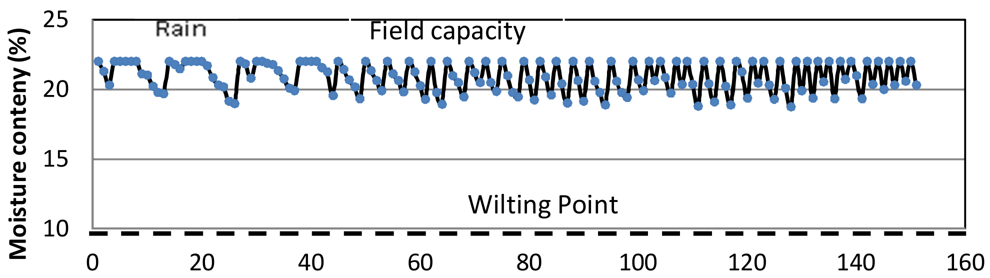

Fig. (8b): Daily moisture depletion along the growing season of onion irrigated by drip system using mixed water for the season of 2015 -2016

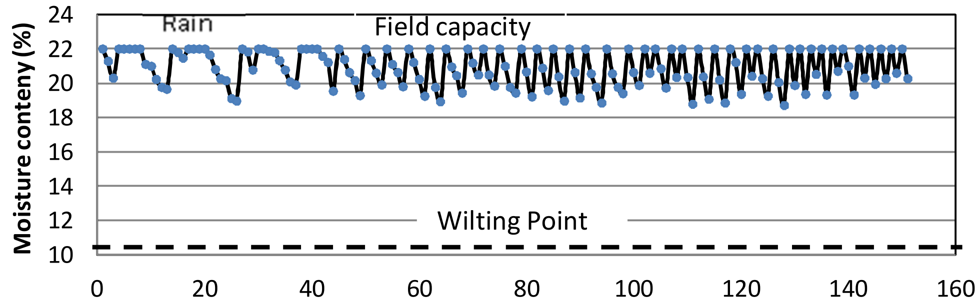

Fig. (8c): Daily moisture depletion along the growing season of onion irrigated by drip system using mixed water for the season of 2015 -2016

Table (9): Irrigation dates of onion irrigated by furrow system using different water qualities at 2014 -2015growing season.

Furrow irrigation at the growing season of 2014 -20 15					
Fresh water		Mixed (Alternate)		Drainage water	
Day after Transplanting	Irrigation water depth mm	Day after Transplanting	Irrigation water depth mm	Day after Transplanting	Irrigation water depth mm
1	32.08	1	31.50	1	31.50
25	30.12	24	31.18	23	29.32
33	27.87	32	27.93	31	26.00
42	5.88	38	26.83	36	26.24
53	28.57	42	13.42	41	20.47
58	28.08	53	31.01	52	27.45
63	26.49	58	30.79	56	26.00
68	23.19	63	28.37	60	25.52
72	26.90	68	25.07	65	28.17
78	37.74	72	29.47	69	21.19
82	23.05	76	23.31	73	27.93
86	26.56	81	29.25	77	27.93
93	29.95	84	19.79	81	24.80
97	26.22	89	31.45	84	21.67
102	30.15	95	23.75	88	27.21
106	26.67	98	26.49	94	26.24
112	26.91	102	21.77	97	24.56
116	25.34	106	29.03	101	28.41
120	28.15	112	29.47	104	21.75
124	29.93	116	27.49	108	25.97
128	30.79	120	30.79	113	25.57
24 irrigations	Total 645.5 mm	123	20.23	117	29.30
		127	28.40	120	26.73
		130	19.77	123	22.15
		27 irrigations	Total 711 mm	127	31.09
				130	21.64
				29 irrigations	756.3 mm

Table (10): Irrigation dates of onion irrigated by furrow system using different water qualities at 2015 -2016 growing season.

Furrow irrigation at the growing season of 2015-20 16					
Fresh water		Mixed (Alternate)		Drainage water	
Day after Transplanting	Irrigation water depth mm	Day after Transplanting	Irrigation water depth mm	Day after Transplanting	Irrigation water depth mm
1	16.04	1	16.04	1	16.04
16	24.12	16	26.64	16	28.99
45	28.53	28	27.77	28	29.32
53	31.51	37	14.37	46	31.54
58	29.69	47	32.01	53	31.68
62	18.77	53	25.55	57	16.55
68	31.78	58	31.77	62	28.37
73	31.36	62	19.94	67	29.79
79	31.25	67	27.74	71	17.97
84	29.57	72	29.63	75	25.77
88	26.76	78	30.71	80	30.03
93	28.50	82	24.00	84	24.12
99	31.15	86	27.49	88	31.68
103	21.24	90	26.56	92	28.14
107	22.20	94	25.86	95	23.64
110	19.84	99	25.05	100	26.95
115	30.23	103	23.77	103	19.86
119	23.48	107	25.00	107	26.25
123	27.52	110	21.74	110	23.64
127	31.00	114	23.92	114	26.25
23 irrigations	Total 643.9 mm	118	31.57	117	22.70
		122	27.93	121	26.01
		126	31.35	124	26.72
		130	31.77	127	29.79
		27 irrigations	Total 712.3 mm	130	26.48
				133	28.85
				29 irrigations	734.6 mm

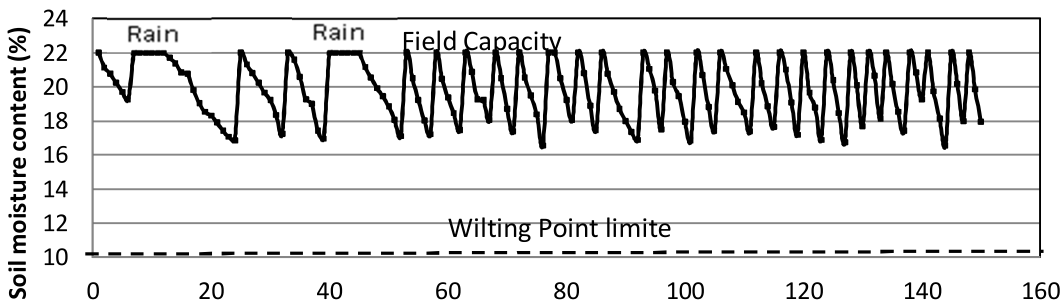

Fig. (9a): Daily soil moisture depletion along the growing season of onion irrigated by fresh water and furrow irrigation system for the season of 2014 -2015

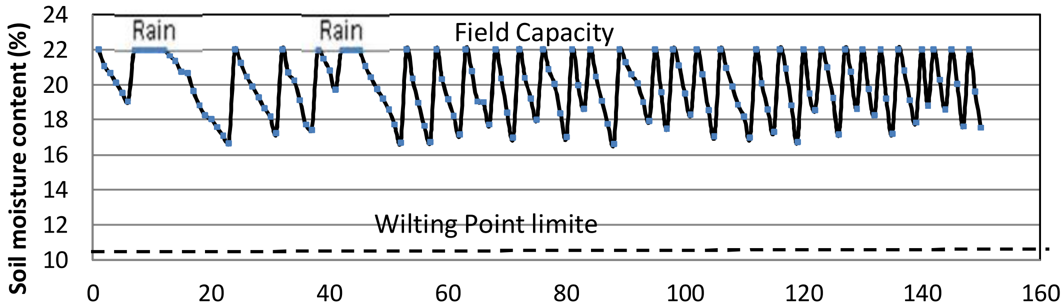

Fig. (9b): Daily soil moisture depletion along the growing season of onion irrigated by mixed water and furrow irrigation system for the season of 2014 -...

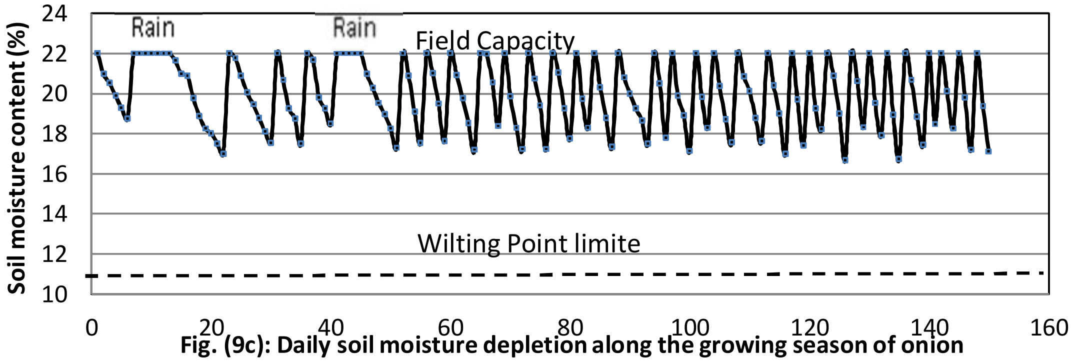

Fig. (9c): Daily soil moisture depletion along the growing season of onion irrigated drainge water and furrow irrigation system for the season of 2014 -2015

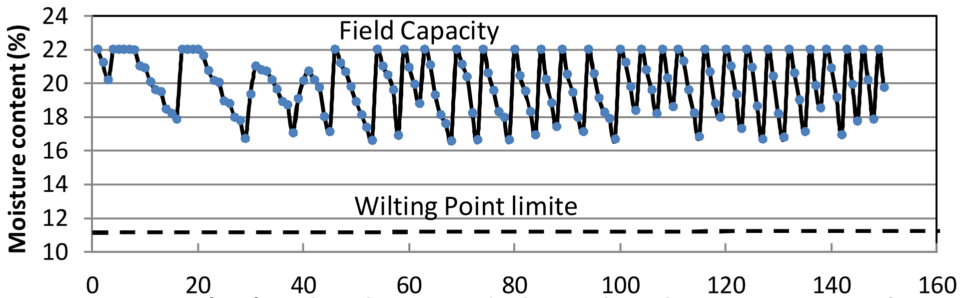

Fig. (10a): Daily soil moisture depletion along the growing season of onion by furrow irrigation using fresh water at the season of 2015 -2016.

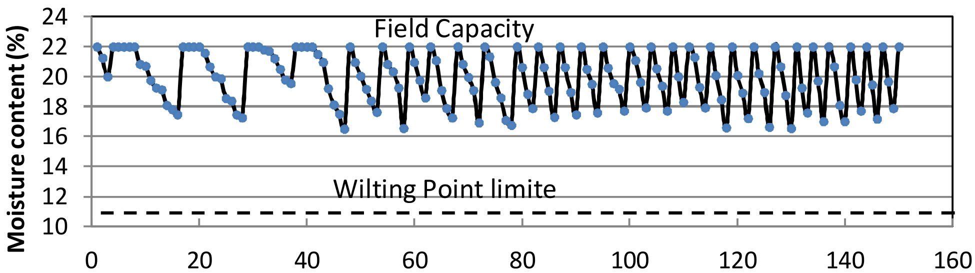

Fig. (10b): Daily soil moisture depletion along the growing season of onion by furrow irrigation using mixed water at the season of 2015 -2016.

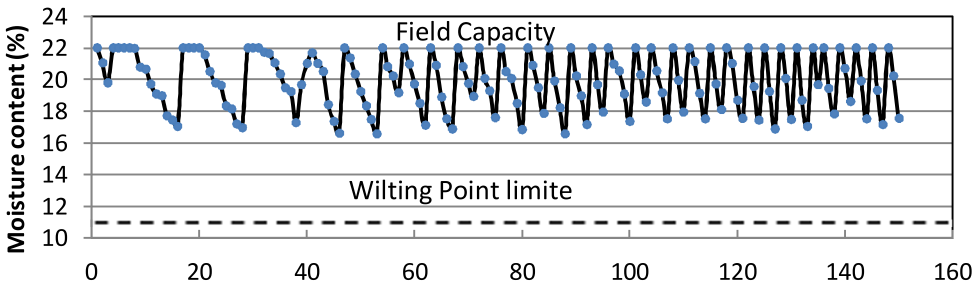

Fig.(10c): Daily soil moisture depletion along the growing season of onion by furrow irrigation using drainage water at the season of 2015 -2016.

Gross irrigation water requirements (*GIWR*) under different irrigation systems:

The average irrigation requirement for production of the onion due to irrigation systems and consumptive use under different water quality in (m^3/fed.) is presented in Table (11).

Table (11): Seasonal applied water and consumptive use (m^3/fed)

Irrigation Type	Water quality	Applied water (m^3/fed)			Water consumption (m^3/fed)		
		1st season	2nd season	Average	1st season	2nd season	Average
Furrow Irrigation	FW	3115.85	2736.55	2926.20	2221.21	1900.58	2060.90
	FDW	3132.36	2838.36	2985.36	2023.18	1798.31	1910.75
	DW	3326.73	2975.99	3151.36	1956.11	1707.76	1831.94
	Average	3191.65	2850.30	3020.98	2066.83	1802.22	1934.53
Drip irrigation	FW	1748.63	1774.25	1761.44	964.95	1024.59	994.77
	FDW	1768.33	2133.64	1950.98	870.83	1237.65	1054.24
	DW	1890.63	2383.33	2136.98	851.13	1340.72	1095.93
	Average	1802.53	2097.07	1949.80	895.64	1200.99	1048.31

Effect of irrigation system and water quality on yield and plant growth parameters:

The data in Table (12) show that onion yield and its components were significantly affected by water quality and irrigation system in both seasons. The highest averages of bulb yield and yield components e.g. bulb weight and bulb diameter in 2014/2015 and 2015/2016 seasons, respectively, were spotted from using drip irrigation with fresh water. There were significant at LSD 0.05 differences among irrigation systems and quality of irrigation water applications on onion bulb yield as shown in table 8. The result indicated that furrow irrigation system and drainage water resulted in low yield of (11.58 and 11.78 mg/fed) for furrow irrigation and of (10.36 and 10.53 mg/fed) for drainage water as compared to that obtained under subsurface drip irrigation of (13.48 and 13.85 mg/fed) and of (14.35 and 14.68 mg/fed) for fresh water for first and second season respectively. Based on the results, drip irrigation treatments (SDI and SubDI) registered 16.41 % and 17.57% increase in yield as compared to surface furrow irrigation (FI) for first and second season respectively. While applied drainage water (Dw) causes decreasing yield with percent of 27.8 % and 28.3% in yield as compared to fresh water (Fw), using of drainage and fresh water together improved the onion yield and reduced the percentage of decreasing if we used drainage water only. Therefore, the study indicated that, if less quality water was supplied through drip irrigation (SDI and SubDI), reduced the effect of using of this water and spotted higher yield of onion was obtained as compared to furrow irrigation. However, decreasing the applied water drainage or low quality water by any percentage led to higher yield of crop. The low yield by furrow irrigation might be due to less availability of nutrients for crop growth due to leaching by runoff and deep percolation and with high weed infestation between the crops.

Table (12). Effect of tested treatments on yield components of onion crop in the two seasons

Irrigation System	Water quality	Season									
		2014/2015					2015/2016				
		Bulb Diameter	Bulb Weight (gm)	Bulb Yield (mg /fad)	Culls (mg /fad)	Marketable Yield (mg /fad)	Bulb Diameter	Bulb Weight (gm)	Bulb Yield (mg /fad)	Culls (mg /fad)	Marketable Yield (mg /fad)
	FW	5.83a	97.83a	14.35a	1.55a	13.00a	5.91a	99.81a	14.68a	1.47a	13.27a
	FDW	5.47b	94.17a	13.49b	1.51ab	11.98b	5.51b	94.68b	13.93b	1.42a	1.51b
	DW	4.75c	80.00b	10.36c	1.35b	8.80c	4.86c	81.66c	10.53c	1.42a	9.07c
LSD 0.05		0.333	7.448	0.698	0.171	0.747	0.064	1.800	0.425	0.089	0.507
SubDI		5.38a	92.25a	13.48a	1.67a	12.25a	5.48a	92.31b	13.52a	1.25a	12.27a
SDI		5.38a	91.50a	13.14a	1.52b	11.92ab	5.45a	96.58a	13.85a	1.48b	12.38a
CFI		5.30a	88.25b	11.58a	1.22c	9.91b	5.35a	87.26c	11.78c	1.59c	10.20b
LSD 0.05		0.270	1.928	1.758	0.177	1.727	0.131	1.077	0.397	0.095	0.488
SubDI	FW	6.00	99.00	14.73	1.05	13.68	6.10	103.20	15.00	1.21	13.79
	FDW	5.45	95.25	13.97	1.38	12.59	5.33	94.63	14.38	1.36	13.02
	DW	4.68	82.50	11.75	1.24	10.51	5.00	79.12	11.17	1.18	9.99
SDI	FW	5.83	98.50	15.03	1.36	13.67	5.92	100.91	15.73	1.36	14.37
	FDW	5.43	96.25	13.98	1.57	12.41	5.69	98.85	14.95	1.44	13.50
	DW	4.65	79.75	10.43	1.64	8.78	4.75	89.97	10.87	1.60	9.28
CFI	FW	5.98	96.00	13.29	1.63	11.66	5.70	95.33	13.33	1.68	11.64
	FDW	5.53	91.00	12.54	1.59	10.59	5.52	90.58	12.46	1.46	11.00
	DW	4.93	77.75	8.90	1.79	7.11	4.85	75.88	9.56	1.62	7.94
LSD 0.05		***	***	***	**	***	***	***	***	**	***

Crop water productivity (WP)

The effect of different irrigation water quality and different irrigation systems on water productivity (WP) of onion crop is presented in Table (13). Results indicated that WP values were significantly affected by both irrigation water quality and different irrigation systems treatments. Results revealed that, decreasing the amounts of applied water, increased the WP values. While, using the drip irrigation system and fresh water increased the WP values, also applied drainage water with fresh water improve the WP with applied drainage water only. The effect of irrigation system ×water quality on WP at LSD 0.05 was significant for both season.

Table (13): Crop water productivity (WP) as affected by the different treatments

Irrigation System	Water quality	Crop water productivity (WP) (kg Bulb/m^3)	
		2014/2015	2015/2016
	FW	7.094a	7.40a
	FDW	6.601b	6.05b
	DW	4.800c	4.15c
LSD 0.05		0.3425	0.1541
SubDI		7.51a	6.63b
SDI		7.34a	6.81a
CFI		3.65b	4.16b
LSD 0.05		2.954	0.159
SubDI	FW	8.41	8.45
	FDW	7.90	6.74
	DW	6.21	4.69
SDI	FW	8.59	8.86
	FDW	7.90	7.00
	DW	5.51	4.56
CFI	FW	4.26	4.87
	FDW	4.00	4.39
	DW	2.68	3.21
LSD 0.05		**	**

CONCLUSION

- Water budget technique was applied to schedule irrigation during two successive seasons of 2014 – 2015 and 2015 -2016. The irrigation systems used were drip surface, drip subsurface and furrow. The irrigation water quality was fresh water, mixed (one irrigation with fresh and the next with drainage) and fully drainage water.
- The results of statistical analysis indicated that onion yield and its components were significantly affected by water quality and irrigation system in both seasons.
- The result also indicated that furrow irrigation system and drainage water resulted in low yield of (11.58 and 11.78 mg/fed) for furrow irrigation and of (10.36 and 10.53 mg/fed) for drainage water as compared to that obtained under subsurface drip irrigation of (13.48 and 13.85 mg/fed) and of (14.35 and 14.68 mg/fed) for fresh water for first and second season respectively.
- Based on the results, drip irrigation treatments (SDI and SubDI) recorded 16.41 % and 17.57% increase in yield as compared to surface furrow irrigation (FI) for first and second season respectively. While applied drainage water (Dw) causes decreasing in yield by 27.8 % and 28.3% compared to fresh water (Fw) yield. Using of drainage and fresh water improved the onion yield compared to yield resulted from applying drainage water only.

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انتاج البصل بنظامى الري بالتنقيط والخطوط مع نوعيات مختلفة من مياه الرى

خليل علام1 ، عزه حسن[1] ، محمد ياسر عدلي1

1 باحث أول، معهد بحوث الهندسة الزراعية

الهدف من الدراسة هو انتاج محصول البصل بواسطة نظامي التنقيط السطحي وتحت السطحي ونظام الرى بالخطوط. وقد تم جدولة الرى بواسطة طريقة الموازنة المائية مع استخدام ثلاثة معاملات لنوعية مياه الرى . ماء سطحى عذب (مياه ترعة) ، مياه صرف زراعى و رى خليط وهو عبارة عن رية بالماء العذب تليها ريه بمياه الصرف الزراعى. ولذلك أجريت تجربة حقلية لموسميين زراعيين متتابعين هما 2014 -2015 و 2015 -2016 و صممت على أساس أن القطاعات الرئيسية هى نظام الرى و القطاعات تحت الرئيسية هى نوعيات مياه الرى .ومع بداية التجربة في كل موسم تم تقدير دالة التسرب وذلك باجراء تجربة حقلية باستخدام الاسطوانة المزدوجة وبذلك امكن تقدير زمن التسرب عل طول الخطوط وتقدير كفاءة اضافة المياه للرى بالخطوط تحت ظروف اجراء التجربة وكانت 52% . وقد تم اجراء تجربة حقلية اخرى لتقدير خواص المنقط المستخدم وذلك لتقدير كفاءة نظام التنقيط المستخدم. واظهرت النتائج ان كفاءة نظام الرى بالتنقيط المستخدم 82% وان نوعية النقاط المستخدم متوسطة. و قد تم شتل محصول البصل لمدة 70 يوم مع ريه بمياه عذبه بواسطة نظام الرى بالخطوط وتمت جدولة الرى بتطبيق طريقة الموازنه المائية مع استخدام بيانات التربة والمحصول والبيانات المناخية المحلية من محطة الارصاد الجوية الزراعية بالنوبارية. واظهرت نتائج فترة الشتل استهلاك مقدار 191.65 مم من المياه في الموسم الاول و 192.65 مم في الموسم التالى وتراوحت عدد الريات مابين 17 فى الموسم الاول واربعة عشر فى الموسم التالى. وبعد الشتل تم تطبيق ثلاثة معاملات للرى بواسطة الرى بالتنقيط السطحى والتحت سطحى بجانب الرى بالخطوط مع تطبيق ثلاثة معاملات لنوعية مياه الرى المستخدمة. واظهرت النتائج ان كميات مياه الرى المضافة بواسطة الرى بالتنقيط مقدارها 382.مم و 400 مم و 417 مم عند الرى بمياه عذبة ومياه خليط ومياه صرف زراعى على الترتيب وذلك فى الموسم الاول. وعند تطبيق نظام الرى بالخطوط لنفس الموسم الزراعى تم اضافة 495مم و 710مم و 756 مم لنفس ترتيب نوعية المياه السابقة. وفى الموسم الزراعى التالى تم اضافة استخدام مياه رى بمقدار 371 مم و 400مم و 416 مم عند الرى بنظام التنقيط عند الرى بمياه عذبة ومياه خليط ومياه صرف زراعى صبحت هذه الكميات 643 مم و 712مم و 734 مم عند الرى بنظام الخطوط لنفس ترتيب نوعية المياه السابقة. هذه الكميات من المياه المضافة لمراحل بعد الشتل يضاف اليها حوالى 33مم/فدان استهلاك المحصول فى مرحلة الشتل والتى تغطى استهلاك قيراط. كما اظهرت نتائج التحليل الاحصائى تأثر انتاجية البصل طبقا لنظام الرى المتبع ونوعية مياه الرى المستخدمة. مع تطبيق نظام الري بالتنقيط زادت الانتاجية بنسبة 16.41% فى الموسم الاول و 17.57% فى الموسم الثانى مقارنة بانتاجية الرى بالخطوط. استخدام مياه الصرف الزراعى ادى الى عجز فى انتاجية البصل بنسبة 27.8% فى الموسم الاول و 28.7% فى الموسم الثانى مقارنة باستخدام الماء العذب.

COMPARATIVE STUDY OF THE PRODUCTION OF SUGAR CROPS UNDER LIMITED WATER

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Abstract

Sugar beet and sugarcane are the major sugar strategic crops. This study includes a comparative study between the both crops and their water consumption on the present cropping pattern under the condition of the current limited water supply. An average quantities of water applied and actual consumptive use for sugar beet were 2100-3200 m^3ofwater per feddan (4200m^2) during the whole season when it is compared to sugarcane crop that consumes 8218-11000 m^3 of water. Results showed that production of sugar from sugar beet is more efficient than production of sugar from sugarcane regarding the limited available land and water resources despite the decline in farm price and net revenue of the sugar beet crop compared to the sugarcane crop. The sugar beet has high values of sugar yield and crop water use efficiency (6.79 and 10.3 kg root / m^3), while sugarcane has the lowest values for the both of them (4.41and 5.9 kg stalkcane /m3), respectively. The results indicated that from view point economic water consumption, the sugar beet recorded the highest values of net return of each water applied and consumptive use units (0.12 and 0.16L.E /m3, respectively). However, it could be concluded that it is necessary to increase of the supply of sugar needs by increase the production of its basic sources which are the sugar beets and sugarcane and this can be done by enhancing the irrigation water management of sugarcane and increasing the area of sugar beets, as well as increasing their productivity. Expansion of the area of sugar beet, especially in the new lands, with preserving the sugarcane area at 326.9 thousand feddans. In addition, the productivity of feddan needs to be developed in both sugar cane and sugar beet, this can be achieved through farmers' adoption of modern technologies and modernization of manufacturing processes used in the production of sugar. On other hand, irrigation water saving can be used to increase the area of cereal crops to meet the shortage of food production.

INTRODCTION

The agriculture sector is considered to be one of the most important sectors consuming water, consuming 82% of the total consumption of 75 billion cubic meters . Irrigation water is the vital element in the agriculture and the basis for agricultural expansion. Therefore, the problem of limited water resources and the low efficiency of irrigation. due to limited water so water use efficiency in irrigation is still low, limiting the possibility of reclamation of more land. Egypt is classified as a water-poverty country, which means that it is unable to provide food and employment opportunities Yasmen(2015). The limited water resources weigh negatively on the cultivation of sugarcane that needs nearly 13 - 15 thousand cubic meters of water per feddan, compared to 2.5 – 3.0 thousand cubic meters for sugar beet. Accordingly, the government has recently paid attention to cultivating the sugar beet especially in the recently-reclaimed areas, taking into consideration that this plant with high salinity and saves a great quantity of water (Amr*et al*., 2010).Egypt is required to increase the cultivated area of sugar beet crop, especially since water consumption is low as it ranges from (2500-3000) m/ feddan. In addition to cash return, the period of sugar beet existence in the soil and the ease of agricultural operations compared to sugar cane crop (Haitham*et al*., 2014).Agriculture plays an important role in the economic development of Egypt, which is the basis of the national economy and the main source of income for more than half the population in Egypt. In addition, agriculture is responsible for meeting consumers' needs of food. It also provides industry raw materials for various industries. The continuation of these roles requires economic development derived from two main sources horizontal and vertical expansion resources. At present and in the future, water resources are the most scarce among other economic production resources. Thus, it is not only a major decision but also a strategy that defines horizontal expansion by adding new territories. The optimal use of water is the cornerstone of the agricultural development sector because the water resources currently available in Egypt are not sufficient for horizontal agricultural expansion in the future given the current types of water use(Raouf, 1996). Sugar is produced in Egypt from sugarcane (61.2%) and, sugar beet (38.8%) of the total local production which was about 1.757 million tons in the year 2007 covering about 67.6% of the domestic consumption. In Egypt sugarcane is considered the first source for sugar production, molasses and sugar cane juice the popular beverage beside other uses, while sugar beet is the second source for sugar production. Its residues are processed and used in cultivation, animal feeding beside other several secondary industries.Sugarcane cultivation consumes plenty of irrigation water, about 12400m3/feddan. That is why the expansion in sugar industry in Egypt depends now on the expansion in the cultivation of sugar beet which becomes about 249 thousand feddans i.e. about 3/4 the area of sugarcane.Laila *et al*. (2009) The Sugar is one of the strategic commodities for most countries on the levels of production, consumption, export or import. In Egypt, it considers a key commodity and gain a high importance by economic-political decision makers due to it takes part in bridge the gap between production and consumption also to reduce the imports. According to statistics, Egypt produces about 1.757 million tons of sugar every year. However, the consumption reaches 2.600 million tons, which indicates a gap of 843 thousand tons and a self sufficiency of almost 68% that can be achieved through boosting the local production of sugar through increasing the cultivated areas of sugar beet . Globally, sugar beet coming in the second rank after sugar cane as sugar production sources and especially in Egypt. The sugar beet represents 25% of Egyptian sugar and 40% of sugar in the world. The sugar beet growing had entered to Egypt since (1981-1982). It is also an important crop as it contribute in generating integrated industrial-agricultural communities, especially in the new and reclamed areas. Due to the crop growing, sugar industry and producing a high-value fodder from sugar industrialization wastes in these areas. In Egypt, the cultivated area reached to 248.308 thousand acres by 2008 -2008 season, the total production was about 5.458 million tons, the production average was 21.98 tons per acre(Amr and Mohamed, 2010)..

MATERIALS AND METHODS

The main objective of this study were evaluate the water consumption and economic efficiency between sugarcane and sugar beet.The study has used the published and unpublished data of the Ministry of Agriculture and Land Reclamation and the Central Administration of Agricultural Economics and the American agricultural agencythrough 2014/2015 season. Also, it has used the records of the Department of Statistics, the bulletins of agricultural economy.

Evapotranspiration calculation

Evapotranspiration is a measure of crop water use and will be calculated, for both, current and future conditions using the Food and Agricultural Organization (FAO) Penman- Monteith (PM) procedure presented by Smith and Pereira (1996). In this method, ETo is expressed as follows:

$$ET_o = \frac{0.408\Delta\,(R_n - G)\; + \;\gamma \frac{900}{T + 273} u_2 (e_s - e_a)}{\Delta + \gamma(1 + 0.34\, u_2)} \qquad 1$$

Where ETo is the daily reference evapotranspiration (mm day-1), Rn is the net radiation at the crop surface (MJ m-2 day-1), G is the soil heat flux density (MJ m-2 day-1), T is the mean daily air temperature at 2 m height (°C), U2 is the wind speed at 2 m height (m s-1), es is the saturation vapor pressure (kPa), ea is the actual vapor pressure (kPa), Δ is the slope of vapor pressure curve (kPa °C-1) and γ is the psychometric constant (kPa °C-1).In application having 24-h calculation time steps, G is presumed to be 0 and es is computed as

$$e_s = \frac{e^0(T_{\max}) + e^0(T_{\min})}{2} \qquad 2$$

Where e0 is the saturation vapor function and Tmax and Tminare the daily maximum and minimum air temperature. The FAO Penman-Monteith equation predicts the evapotranspiration from a hypothetical grass reference surface that is 0.12 m in height having a surface resistance of 70 s m-1 and albedo of 0.23. The equation provides a standard to which evapotranspiration in different periods of the year or in other regions can be computed and to which the evapotranspiration from other crops can be related. Standardized equations for computing all parameters in Eq. (1) are given by Allen *et al* (1998).

Water requirement for sugarcane and suger beet.

The crop evapotranspiration, ETc, is calculated by multiplying the reference crop evapotranspiration, ETo, by a crop coefficient, Kc according to (Ellen *et al*., 1998):

$$IR = (ETo * Kc) * LR * 4.2 \quad \ldots\ 3$$

Where: -

IR = irrigation requirement for sugarcane m3 / Feddan/ day

Kc = Crop coefficient [dimensionless].

ETo = Reference crop evapotranspiration [mm/day].

LR = Leaching requirement LR (%) (assumed 20% of the total applied water).

4.2 = to convert water requirements from millimeter per day to cubic meter per feddan per day (Feddan = 4200 m2)

Field water use efficiency (F.W.U.E.)

The field water use efficiency is the weight of crop produced per the unit volume of irrigation applied expressed as cubic meters of water ***(Michcal, 1978).***It as calculated by the following equation :

$$F.W.U.E. = \boldsymbol{Yield(kg/fed.)/water}\textbf{applied}(\boldsymbol{m}3/\boldsymbol{fed.})\ kg/m^3 4$$

Crop water use efficiency (C.W.U.E)

The crop water use efficiency is the weight of marketable crop produced per the unit volume of water consumed by plants or the evapotranspiration quantity. The crop water use efficiency was computed for each crop by dividing the yield (kg) over units of evapotranspiration expressed as cubic meters of water *(*Abdel Reheem***.2010)*** It is calculated by thefollowing formula :

$$\boldsymbol{C.W.U.E. = Yield(kg/fed.)/waterconsumptive\ use(m\,3/fed.)} \quad = \quad \boldsymbol{kg}/m^3 \ \ldots\ldots\ldots\ 5$$

Economic indicators

The research was based on descriptive and quantitative methods to show the relationship between different variables. With the use of some of the technical efficiency standards in terms of production costs, total revenue, net income of the Fed., profitability of the spent pound and the investor of sugar beet and sugarcane crops. The study was based on the published and unpublished data from the Ministry of Agriculture, Central Agency for Public Mobilization and Statistics of international references and research related to the subject of research .an Economicefficiency encompasses individual or social goals and values (Jean ***et al***.2010).It is calculated by the formula :

$$\textbf{Economic efficiency} = \textbf{Net return}(\text{LE/fed.})/\textbf{total cost}(\text{LE/fed.}) \ \ldots\ldots\ldots\ldots\ldots\ 6$$

RESULTS AND DISCUSSION

Water requirement for sugar beet:

Values of potential evapotranspiration and crop coefficient (Kc) for sugar beet were presented in Figs (1 and2) The results illustrated that maximum crop water requirement values for sugar beet of 2.90 and 2.68mm/day were in February and March, respectively for Kafr Al Sheikh governorate (Longitude:30.95E , Latitude: 31.12N) , 2.81 and 2.65 mm/day were in February and March, respectively for Beheiragovernorate(Longitude: 30.46E , Latitude: 31.03N), 2.98 and 2.72 mm/day were in February and March, respectively for Fayoumgovernorate (Longitude: 30.51 E, Latitude:29.18 N) and3.02 and 2.79 mm/day were in February and March, respectively for El-Minyagovernorate (Longitude:30.44 ,ELatitude:28.05 N)Also, data presented revealed that the highest total applied water values for all studied governorates of 2291m3/fed with an avareg 2100 m3/fed.

Water requirement for sugarcane:

Values of potential evapotranspiration and crop coefficient (Kc) for sugarcanewere presented in Fig (3). The results illustrated that maximum crop water requirement values of 8.05 and 7.84 mm/day were in Jul and Aug, respectively for El-Minya governorate (Longitude:30.44 ,ELatitude:28.05 N)and 9.63 and 9.52 mm/day were in Jul and Aug, respectively for Sohag governorate(Longitude:31.42 E, Latitude:26.34 N. Also, data presented in Tables 5 and 6 revealed that the highest total applied water values of 8871 m^3/feddan with an avareg for all studied governorates8218 m^3/feddan.

Field water use efficiency(F.W.U.E.):

Field water use efficiencyconsider an indicator parameter for the capability of the growing plants to converting the used water into crop yield. Table (1) and Figs. (4 and 5) show the average values for sugarcane stokes and beetroots were 4.41 and 6.79 kg/m^3 water used, respectively. Regarding Field water use efficiencyof sugar yieldabstracted from sugarcane and sugar beet, the corresponding values are 0.62 and 0.75 kg sugar/m^3 of water, respectively.

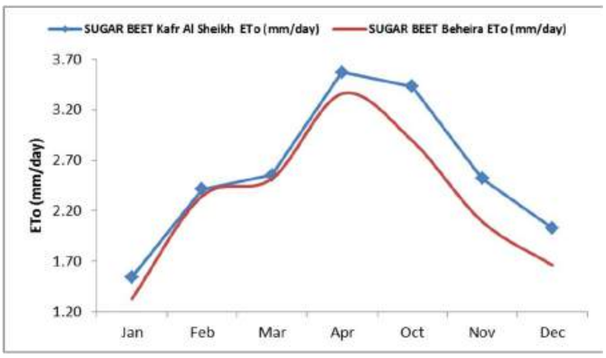


Fig (1)Water requirement for sugar beet for Kafr Al Sheikh and Beheira governorate

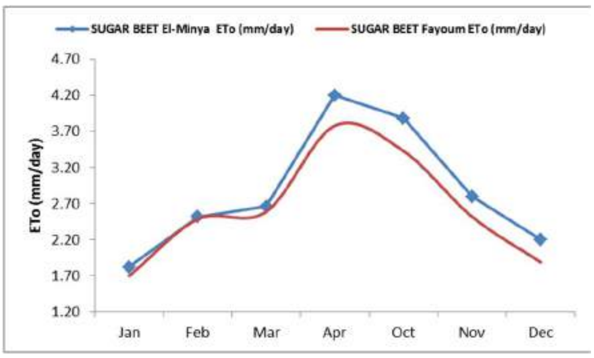


Fig (2)Water requirement for sugar beet for El Minya andFayoum governorate

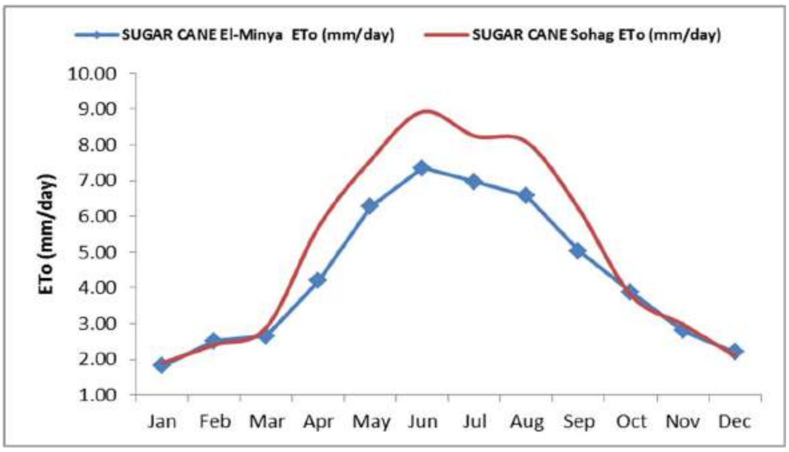


Fig (3)Water requirement for sugar cane for El Minya -and Sohag governorate

Crop water use efficiency (C.W.U.E) :

Thecrop water use efficiency parameter for determine the relation between actual applied water and crop production. It is cleat that increasing applied irrigation waterdecreasing crop water use efficiency as shown inTable (1) and Figs. (4 and 5). Data indicated that average values for sugarcane stokes and beetroots were 5.90and 10.35kg/m^3 water used, respectively. Regarding sugar yield, the corresponding values are 0.8 and 1.4 kgsugar/m^3 of water, respectively.

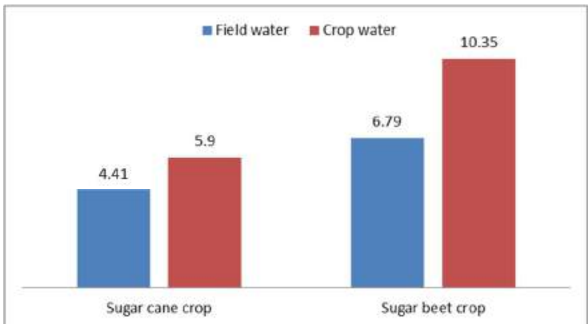


Fig. (4) Field water use efficiency and Crop water use efficiency (kg/m3)

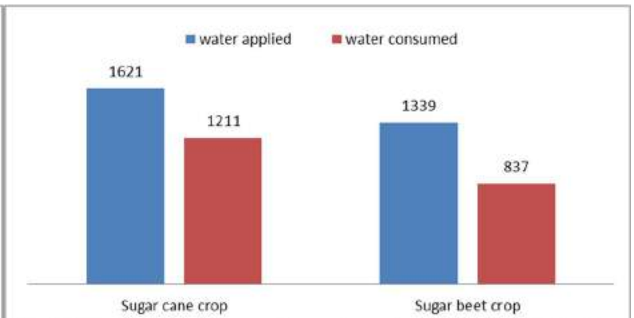


Fig. (5) Water applied and consumptive use to produce one ton sugar (m3/ton)

Domestic Production from Sugarcane and sugar beet:

Sugar production in Egypt depends mainly on sugarcane and sugar beet crops which provides about 43% from Sugarcane and 57%from sugar beet in 2014/2015 season. The area planted with sugarcane for the same year was about 328 thousand feddans. Sugarcane cultivation in Egypt is concentrated in the Middle and Upper Egypt governorates in El-Minya, Sohag, Quena and Aswan governorates which represent about 97.1% of the total area of sugarcane, with average productivity of about 48.45 ton/ feddan. While, the sugar beet area was about 480 thousand feddan. Sugarbeet cultivation in Egypt is concentrated in some governorates of Lower (Delta) and Middle Egypt. Kafr Al Sheikh, Dakahlia, Sharkia ,Beheira,Beni Suef,Fayoum , Port Said,El-Minya and Ismailia governorates which represent about 92% of the total area of sugarbeet, with a average productivity of about 21.45 ton/ feddan. Sugar beet gives about 0.398 ton/feddan sugar per month while sugar cane gives 0.333 ton/feddan sugar in month, taking into consideration the productivity of both types and the period of stay in the land. It is difficult to make expansion in the area cultivated with sugarcane due to the limited water resources where it needs 11000m^3 of irrigation water/ feddan while sugar beet needs 3200m^3/ feddan. The consumed water for sugarcane is about 6848 m^3, while the sugar beet is consumed about 2000 m^3 per feddan. Data in Table 1 revealed that sugar production from sugarcane was about 4.0 ton /feddan and 2.5 ton/feddan of sugar beet, this constitutes about 11 % and 13.7% of the supplied sugarcane andsuger beet, respectively as a mean in 2014/2015 season. This means that production of sugar from sugar beet exceeds that from sugarcane by about 2.7% taking into consideration that the sugarcane have a production season 12 months and sugar beet as a winter crop with a production season of about 7 months. The self-sufficiency rate of sugar produced by crop processing is about 75% according to 2014/2015 season data. It is clear that the sugar beet consumes 30% of the water consumed by sugar beet.It is clear that from the same table the sugar cane produces 4 tons of raw sugarcane, and sugar beet produces 2.5 tons of raw sugar.

Economic indicators

In terms of economic indicators as shwon in Table 2 and Figs (6and 7) data indicated that the total cost of feddan of sugarcane amounted to about 8736 L.E. / feddan and the sugar beet was about 5316 L.E. / feddan. While the net returnfor one sugarcane Feddan is about 10656 L.E. / feddan, and 2898L.E. / feddan for sugar beet.Regarding the economical eficiency of cultivating sugarcane and sugar beet crops was expressed by two factors; 1- ratio of net return to the production costs per feddan; 2-ratio of net return to the irrigation cost per feddan. The ratio of net return to the production costs per feddan were 1.22 and 0.55 L.E. for sugarcane and sugar beet, respectively. Whereas, theratio of net return to the irrigation cost per feddan were 8.1 and 7.55L.E. for sugarcane and sugar beet, respectively.

Table 1. Comparison betweenSugar cane and Sugar beet cropsproduction

Parameters	Sugar cane crop	Sugar beet crop
Crop remain duration, month	12	7
*Cultivate area in Egypt, fed.	326900	480113
Sugars percentage (%)	0.14	0.11
#Water applied (m^3/fed.)	11000	3200
**Water consumptive use (m^3/fed.)	8218	2100
**Field water use efficiency (kg/ m^3)	4.41	6.79
**Crop water use efficiency (kg/m^3)	5.9	10.3
**cost of applied water utilization (L.E/m3)	0.12	0.12
**Field water use efficiency express as (kg sugar /m3)	0.62	0.75
**crop water use efficiency express as (kg sugar /m3)	0.8	1.4
**Field water use efficiency express as (ton sugar /m3)	1621	1338
**crop water use efficiency express as(ton sugar /m3)	1211	837
*Average of yield (ton/fed.)	48.48	21.73

*The Ministry of Agriculture and Land Reclamation, Sugar Crops Council, the Annual Report of Sugar Crops

** Calculated data #Nile Research Institute, National Water Research Centre (NWRC)

Table 2 Economic indicatorsof Sugar cane and Sugar beet crops production of sugar crops

parameters	Sugar cane crop	Sugar beet crop
*Total costs (LE/fed.)	8736	5316
*Total income L.E/fed.)	19392.40	8212.43
*Net return (L.E/fed.)	10656	2898
**Average costs of ton (L.E/ton)	189.70	243.90
*Price of unit (L.E/ton of yield)	400	378
*Average of yield (ton/fed.)	48.48	21.73
**Economic efficiency	1.55	0.55
**Cost of irrigation	1320	384
**Net return /total cost Ratio	1.22	0.55
**Net return /cost irrigation Ratio	8.1	7.55

*The Ministry of Agriculture and Land Reclamation, Sugar Crops Council, the Annual Report of Sugar Crops ** Calculateddata

It is clear that from the above the sugar beet crop is more efficient than the sugarcane crop in terms of its productivity of sugar per water unit. Moreover, regarding the period of land occupationsugarbeet s shorter than of sugarcane because it is staying seven moths while sugarcane staying for twelve months.

Moreover, the production cost of one feddan of sugar beet is lower than sugarcane. Finally sugar yield and net return of sugar beet is better than sugarcane.This is agree with the adoption of the agricultural development strategies (2004-2017 & 2030) and the mechanism of production and price policies to expand the area planted with sugar beet and increase its contribution to the total domestic sugar production. The productive policies were aimed to determining the area cultivated with sugar cane and the expansion of sugar beet cultivation in the new land.

CONCLUSION

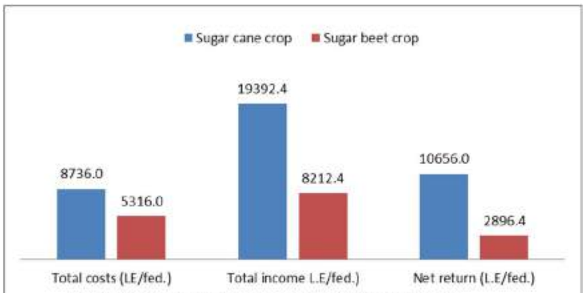
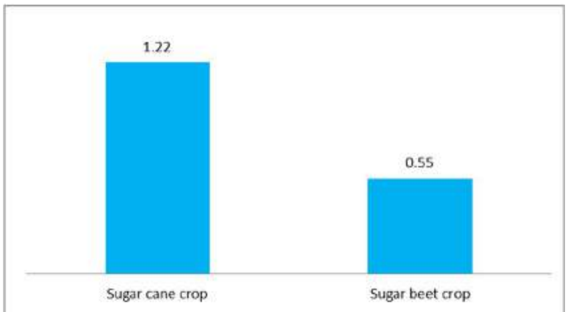


Fig.(6) Total costs , Total income and Net return (L.E/fed.)



Fg.(7) Economic efficiency of Sugar cane and Sugar beet

The results showed that sugar beet production was more efficient than sugar cane production in light of the limited water resources available despite the low farm price and net yield of sugar beet compared to sugarcane yield. The study revealed that the possibility of increasing the quantities of sugar produced at the local level through vertical expansion in increasing the productivity of beet sugar per feddan. The average yield per feddan is 21.73 tons / fed compared to crop production capacity with an average 35 ton/fed. Success in all types of land requires a small amount of water and salinity compared to sugarcane that needs fertile land and large amounts of water. This results in efficient sugar production of sugar beet better than cane sugar under limited available water resources.

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دراسة مقارنة لإنتاج محاصيل السكر فى ظل محدودية المياه

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تعتير المحاصيل السكرية من أهم المحاصيل الاستراتيجية (بنجر السكر وقصب السكر) .وتتضمن هذه الدراسة مقارنة بين المحصولين واستهلاكهما للمياه على نمط الزراعة الحالي وخاصة المحاصيل التي تستهلك الكثير من المياه مثل قصب السكر تحت ظروف إمدادات المياه المحدودة الحالية. كان متوسط الكميات المستخدمة من المياه والاستهلاك الفعلي لمحصول بنجر السكر **3200-2100** متر مكعب من المياه لكل فدان خلال الموسم كله عند مقارنتها بمحصول قصب السكر الذي يستهلك **11000-8218** متر مكعب من المياه. وأظهرت النتائج أن إنتاج السكر من بنجر السكر أكثر كفاءة من إنتاج السكر من قصب السكر في ضوء محدودية الأراضي والموارد المائية المتاحة على الرغم من انخفاض سعر المزرعة وصافي إيرادات محصول البنجر السكري مقارنة بمحصول قصب السكر. أما بنجر السكر فهو يعطى قيم عالية من كفاءة استخدام المياه الحقلية والمحصولية (**6.79** و **10.3** كيلوغرام من الجذور / م ^{3})، بينما لقصب السكر أدنى قيم (**4.41** و **5.9**كجم قصب قصب / م ^{3}) على التوالي. وتشير النتائج أيضا إلى أن بنجر السكر سجل أعلى قيم العائد الصافي لكل وحدة من وحدات المياه المستخدمة والاستهلاكية (**0.12**و **0.18** جنيه / م ^{3}) على التوالي، في حين أن قصب السكر له أدنى قيمه، (**0.12**و **0.16** جنيه / م ^{3}) على التوالي. وفي نهاية الدراسة يمكن الاستنتاج أنه من الضروري زيادة المعروض من السكر يحتاج إلى زيادة إنتاج مصادره الأساسية وهي بنجر السكر وقصب السكر وهذا يمكن القيام به من خلال الحفاظ على مساحة قصب السكر وزيادة مساحة بنجر السكر، فضلا عن زيادة إنتاجيتها. توسعة مساحة بنجر السكر وخاصة في الأراضي الجديدة مع الحفاظ على مساحة قصب السكر ب **326.9** ألف فدان. وبالاضافة إلى ذلك، يجب تطوير إنتاجية الفدان في كل من قصب السكر وبنجر السكر، ويمكن تحقيق ذلك من خلال اعتماد المزارعين للتكنولوجيات الحديثة وتحديث عمليات التصنيع المستخدمة في إنتاج السكر. ومن ناحية أخرى، يمكن استخدام توفير مياه الري لزيادة مساحات محاصيل الحبوب لمواجهة النقص في إنتاج الغذاء.

EFFECT OF PARTIAL ROOTZONE DRYING ON TOMATO PLANT UNDER EGYPTIAN CONDITIONS

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Abstract

The present study was carried out in the experimental farm of the faculty of Agriculture, Menoufia University, during Summer season 2015 and winter season2016.The main goal of this research was to investigate the effect of the Partial rootzone drying irrigation on soil moisture, tomato yield and water use efficiency , and to compare it with the conventional irrigation under three amount of applied water of 100%,75% and 50% of ETC and two ways (covering and non-covering system). Results showed that Partial rootzone drying irrigation and the covering system increased the soil moisture content at soil profile and the percentage of marketable yield and improved the irrigation water use efficiency (WUE) compared to the CI methods especially, when applying them under deficit water.

Key words: Conventional irrigation - Water use efficiency- covering and non- covering ways

INTRODUCTION

Water scarcity and land degradation constitute an important threat for human society in the near East and North Africa (MEAN) region. Irrigation water has become less available in many regions due to global climate change and an increased competition for water by industry, domestic purposes, and the environment. It is known that improving irrigation efficiencies would lead to water savings. To confront this challenge, there is an urgent need to develop water-saving irrigation techniques in order to maximize crop water use efficiency.

Partial rootzone drying irrigation (PRD) is a further development of Deficit irrigation; Deficit irrigation involves irrigating only part of the root zone leaving the other part to dry to a predetermined level before the next irrigation. Accumulated previous studies have shown that partial rootzone drying irrigation allows considerable crop water savings, maintains yield and improves water use efficiency at field scale compared to conventional irrigation using alternate furrow or drip irrigation on tomato. **Yactayo, *et al.* (2013)** found that Partial root-zone drying (PRD) is an irrigation technique which has shown increased water use efficiency (WUE) without yield reductions in potato and other crops.Tomato is the second most valuable vegetable crop next to potato **(FAO,2011)**. The main cropping countries being China, the United States, India, Turkey, Egypt, Italy, Iran, Spain, Brazil and Mexico.

The main of objectives of this study were:

1-Evaluating Partial rootzone drying system compared to Conventional drip irrigation on tomato plant under Egyptian conditions.

2 -Studying the effect of using covering system and deficit water under two irrigation regimes.

3 -Determining moisture content and distribution, tomato yield and water use efficiency.

MATERIALS AND METHODS

Experimental site

The present study was carried out in the experimental farm of the faculty of Agriculture, Menoufia University, Shibin EL-Kom during (Summer season 2015 and winter season 2016). The experimental site has 30 54` N and 31 00` E . Tomato, Lycopersion esculentum Mill. Seeds variaty of Savera (F1 HYBRID TOMAYO) were planted on ridges (0.7*15m) and the distance between plants inter-row was 0.5m.The distance between individual drippers was 0.5 m and emitter flow rate was 4 L/h.

Random samples from three soil layers, (at depths 0-30, 30-60, and 60-90 cm) were collected from the experimental site and analysed to determine the soil physical properties and the soil chemical analysis which according to **Black (1965).**

Mechanical and chemical analysis of the soil samples showed that the soil texture is clay with field capacity of 31.5%, soil welting point of 15.65% and soil bulk density of 1.30 gm/cm^3. The total soluble salts were measured as electrical conductivity (EC) and it was about 0.38 ds.m^{-1} as an average for the soil depth up to 90 cm and the value of PH was 7.73.

The chemical analysis of the irrigation water illustrated that the electrical conductivity value was about 0.37ds.m^{-1} and the SAR value was about 1.06 . Soil moisture content was calculated by using the following equation **(Casillas,G. 1978)**:

$$\mathbf{Pw} = \left(\frac{W_w - W_d}{W_d}\right) \times 100 = \left(\left(\frac{W_w}{W_d}\right) - 1\right) \times 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \mathbf{(1)}$$

Where:

P_W = The soil moisture content (w_d) %.

W_w = The wet weight of soil (gm).

W_d = The dry weight of soil (gm).

Studied treatments

Field experiments were concerned with three factors as shown in Fig 1. Which can be described as follows:

1-Irrigation regime: contains two regimes (Conventional irrigation (CI), partial rootzone drying irrigation (PRD)).

2- Amount of water: contains three amount 100%-75%-50% of (ETc).

3-Type of covering system: in this factor two types were studied (Covering ,Non-covering).

Irrigation system:

Surface Drip Irrigation System was used to irrigate the tomato plants grown in open field. The system consisted of the following units as shown in Fig 1:

- 50 mm diameter of Polly Vienil Cloride (PVC) pipe main line, with 30 m long to convey water from water source.
- Two (PVC) manifold lines of 32 mm diameter.
- Lateral line was 30m along which has Ø 13.6 mm inner diameter and Ø 16 mm outer diameter was used.
- Emitter discharge was 4 l/h, distance between emitter was 0.5m and the distance between plants 0.5m

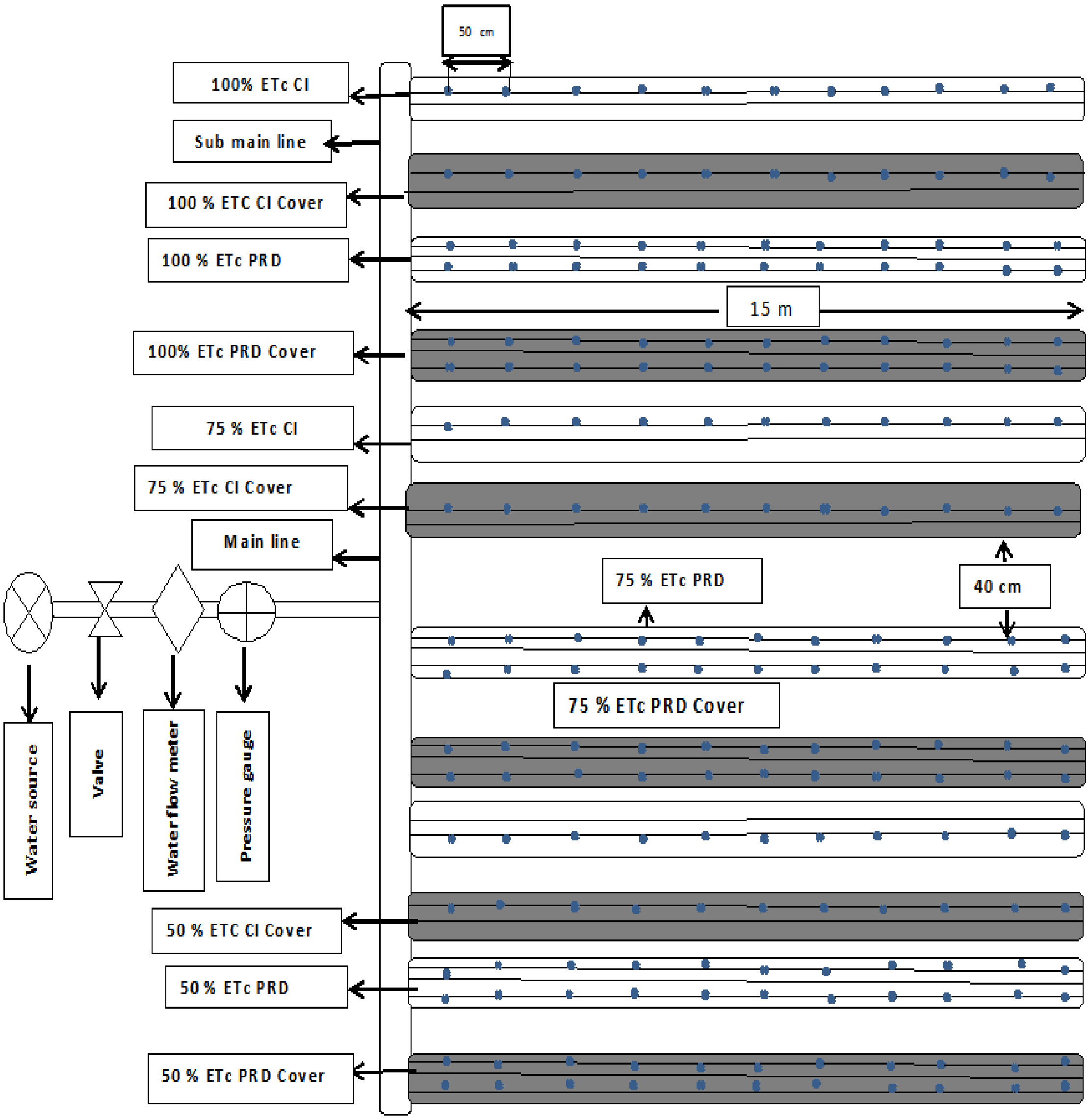


Fig.(1):Experimental layout conducted in randomized design with three replicates.

Hydraulic evaluation of emitters:

Hydraulic characteristics were carried out for long path emitter used with flow rate of 4l/h.Emitter flow rate vs. pressure curve was determined and expressed by the power curve equation as presented by **Keller and Karmeli (1974)**, as follow:-

$$q = KP^{X} \quad ....(2)$$

Where:

q= Emitter discharge, (l/h).

K= Constant of proportionality that characterizes each emitter.

P= Average of Pressure,(bar)

X= Emitter discharge exponent that is characterizes by the flow regime.

A lab experiment was conducted before field experiment to determine the manufacturing coefficient of variation (C_V). Flow rate of 30 new emitters (as samples) were measured at reference uniform pressure (nominal operating pressure), and C_V value was computed by using the following equation **Solomon (1987):**

$$CV = \frac{S}{q^{-}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where:

S= the standard deviation of flow rate values, (l/h), at reference pressure.

q^{-} = average flow rate of the emission points sampled, (l/h)

Emission uniformity (EU) of lateral line was determined in the field by using EU test, which determined by measuring, under normal conditions, the pressure at the inlet and at the far end of each lateral. Emission uniformity (EU) was calculated using the following equation by **Keller and Karmeli (1975)**:

$$EU = \frac{q_n}{q_a} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Where,

EU= emission uniformity, %

q_m= the average of lowest 1/4 of emitter flow rate , in (l/h)

q_{av}= tha average of all emitter flow rate, in (l/h)

Irrigation time:

It is calculated according to the evapotranspiration (ETo) for the experimental area and design parameters for drip system. The irrigation time was calculated according to the evapotranspiration (ETo) in AENRI Weather station. To determine the irrigation time, the following equations was used:

$$ET_c = K_c \times ET_o \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Where:

ET_c = Evapotranspiration for the crop, (mm/day)

K_c = Crop coefficient

ET_o = Evapotranspiration from pan for the investigated area, (mm/day)

$$\textbf{APP. Irri. Rate} = Q / S_m . S_L \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (6)$$

Where:

APP. Irri. Rate = Applied irrigation rate, (mm/h)

Q = discharage from the emitter (l/h)

S_m = distance between emitters (m)

S_L = distance between laterals (m)

$$\textbf{Irri. Duration} = ET_c / \textbf{App . Irri. Rate} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

Tomato yield

Tomato fruits were harvested manually, and total crop yield per hectar (Mg/ha) was recorded.

Water use efficiency

Water use efficiency (WUE) in this work was calculated was calculated using the following equation **:**

$$WUE = \frac{Y}{I} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$

where:

WUE: Irrigation water use efficiency , Kg m^{-3}

Y:Total yield , Kg/fed

I: Irrigation seasonal water applied , m^3 /fed

RESULTS AND DISCUSSION

Hydraulic characteristics of emitter:

The effect of pressure on the long path emitter was studied. The influence of pressure on the emitter discharge can be presented in two ways either directly as the average of emitter discharge as shown in Fig 2 or as variable percentage of discharge at the same actual operating pressures of 1bar.

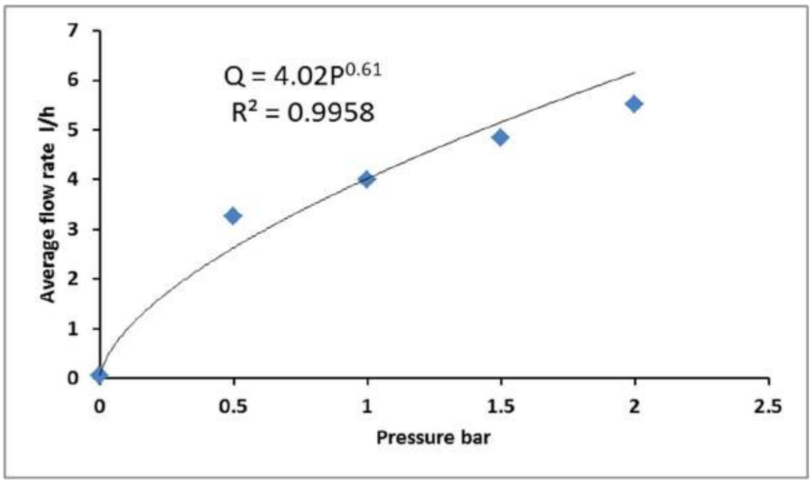


Fig 2: Pressure-discharge curve of the long path emitter of 4 l/h flow rate.

Results show that the relationship between the pressure and the discharge of the long path emitter of 4 L/h flow rate can be expressed as the following equation:

$$q = 4.02p^{0.61} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots...(3.1)$$

where:

q= average emitter discharge, l/h

P= Average of pressure, bar

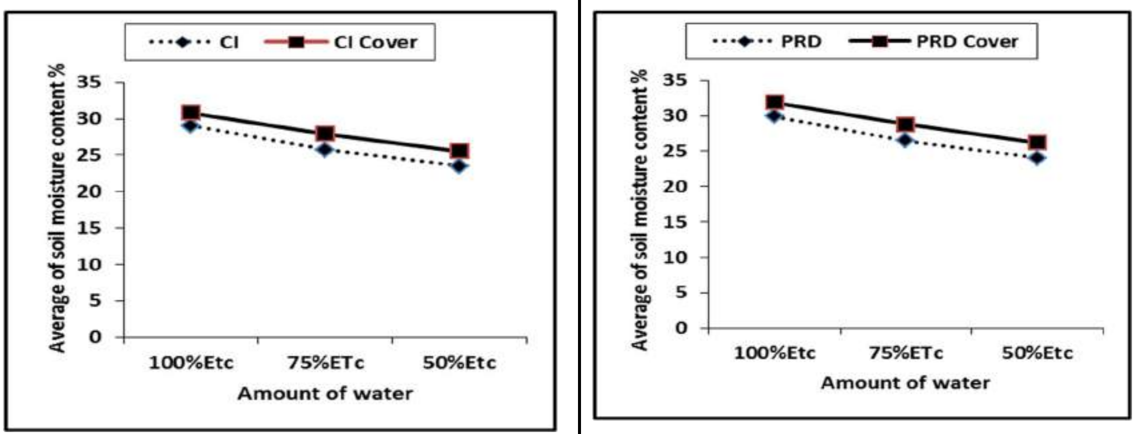
The data show that the exponent of the operating pressure was approximately equal to 0.61 which means that in this case, the flow was turbulent and is less sensitive to pressure variation.

Emission uniformity (EU) and coefficient of manufacturing variation (C_V).

The Emission uniformity (EU) and coefficient of manufacturing variation (C_V) for the tested long-path emitter are calculated. Results show that the value of emission uniformity for the studied emitter was recorded about 99.45% at the operating pressure of 1bar and the average emitter discharge of 4l/h. This value seemed to achieve the higher emission uniformity. Coefficient of manufacturing variation (C_V) varied according to the operating pressure. The data showed that the value of manufacturing coefficient (C_V) was 0.5%. The lower value of manufacturing coefficient of variation seemed the higher uniform distribution of irrigation water along lateral line. Emitter seemed to be achieving uniform distribution of water at 1bar of operating pressure at which the drip irrigation system will be operated in the field.

Average of soil moisture content.

Fig 3: revealed that Average of soil moisture content using two irrigation regime with different amount of water at winter season. At cover and non-cover system the results showed that 100%ETc recorded the higher value, followed 75%ETc and finally 50%ETc. The PRD regime was higher than CI treatment under three amount of water.At cover system the results of reported that, the PRD treatment was higher than CI treatment by 3.44%, 2.95% and 2.36% at 100%ETc,75%ETc and 50%ETc respectively. Meanwhile at non-cover system, the PRD treatment was higher than CI treatment by 3.03%, 2.56% and 2.16% at 100%ETc,75%ETc and 50%ETc respectively.At CI treatment the results showed that, cover system recorded the higher value compared to non-cover system by 5.80%,7.66% and 8.05% at 100%ETc, 75%ETc and 50%ETc respectively.Meanwhile the results of PRD treatment reported that, the cover system was higher than non-cover system by 6.20%, 8.20and 8.24% at 100%ETc, 75%ETc and 50ETc respectively.These are in agreement with those obtained by **Hutton and loveys. (2011)**.



a- at CI regime

b- at PRD regime

Fig (3) Average of soil moisture content using two irrigation regime with different amount of water at winter season 2016.

Yield of tomato

Table (1). yield of tomato using two irrigation regimes with different amount of water at summer season 2015, winter season 2016.

Ton with yield Ton/fad	Cover						Non-cover					
	100%ETc		75%ETc		50%ETc		100%ETc		75%ETc		50%ETc	
	CI	PRD	CI	PRD	CI	PRD	CI	PRD	CI	PRD	CI	PRD
Season 2015	12.63	13.42	13.44	14.73	10.98	12.64	14.10	14.80	11.92	13.53	8.69	10.60
Season 2016	17.95	28.85	15.53	25.91	13.98	21.06	16.47	18.55	12.48	15.80	10.30	14.24

The results showed that increasing amounts of water from 50% ETc to 100% ETc gradually increased yield of tomato. It was found that PRD treatment produced a higher yield compared to CI treatment. Data presented that the yield of tomato using two irrigation regimes with different amount of water at summer season 2015, at covering treatment of 75% ETc produced a higher yield, followed 100% ETc and 50% ETc. The PRD treatment was higher than CI treatment by 8.81% at 75% ETc. Meanwhile at non-covering treatments, 100% ETc produced the highest value. Moreover the PRD treatment was higher than CI treatment by 4.71%, 11.86% and 17.92% at 100% ETc, 75% ETc and 50% ETc respectively. At CI treatments, the covering treatment was higher than the non-covering treatment by 11.25% and 20.84% at 75% ETc and 50% ETc respectively. But at 100% ETc, the covering treatment was lower than the non-covering treatment by 11.70%. At PRD treatments, the covering treatment produced the higher value compared to the non-covering treatment by 8.18% and 16.18% at 75% ETc and 50% ETc respectively. But at 100% ETc, the covering treatment produced the lower value compared to the non-covering treatment by 9.36%. The results of winter season 2016 showed that at covering treatments reported that, 100% ETc produced a higher yield, followed 75% ETc and 50% ETc. The PRD treatment was higher than CI treatment by 37.76, 40.06 and 41.11% at 100% ETc, 75%ETc and 50% ETc respectively. Meanwhile at non-covering treatments, the PRD treatment was higher than CI treatment by 11.21%, 21.05% and 27.66% at 100% ETc, 75% ETc and 50% ETc respectively. At CI treatments, the covering treatment was higher than the non-covering treatment by 8.26%,19.66% and 26.31% at 100% ETc, 75% ETc and 50% ETc respectively. At PRD treatments, the covering treatment produced the higher value compared to the non-covering treatment by 35.69% , 39% and 39.98at 100% ETc, 75% ETc and 50% ETc respectively.PRD gave the highest value compared CI , because the individual fruit weight was increased. This reason might be the same as for the results from **Krida, *et al.* (2004)** . They said that the PRD treatments had 7-10% additional yield over the deficit irrigation receiving the same amount of water. The PRD treatments gave 10-27% higher marketable tomato yield (>60 gm/ per plant), compared with the DI treatment.

Water use efficiency

Water use efficiency, WUE was considered a remarkable differentiation parameter that was affected by the variation of the studied factors. Water use efficiency depends on the yield and the water applied.

Table (2). represents that the calculated water use efficiency WUE (Kg/m^3) as affected by the treatments under study.

WUE Kg/m^3	Cover						Non-cover					
	100%ETc		75%ETc		50%ETc		100%ETc		75%ETc		50%ETc	
	CI	PRD	CI	PRD	CI	PRD	CI	PRD	CI	PRD	CI	PRD
At Season 2015	5.04	5.67	7.28	8.31	9.29	10.70	5.34	5.97	6.72	7.63	7.36	8.97
At Season 2016	8.89	14.29	10.26	17.12	13.86	20.87	8.16	9.19	8.24	10.44	10.21	14.12

The data in Table 2 showed that, WUE of the covering treatments were higher than WUE the non-covering treatments. The PRD treatment was higher than CI treatment under three amount of water. At season 2015, the data in Table (2) inidicated that, the WUE of PRD treatment was higher than CI treatment by 11.11%, 12.39% and 13.17% of 100% ETc, 75% ETc and 50% ETc respectively at covering treatments. WUE of the covering treatments at CI treatments, the 50% ETc was higher than 100% ETc and 75% ETc by 45.74% and 21.63% respectively. At PRD treatments, 50% ETc was recorded the higher value compared to 100% ETc and 75% of ETc by 47.00% and 22.33% respectively. Meanwhile at non-covering treatments, it was found that the WUE of PRD treatment was higher than the WUE of CI treatment by 10.55%, 11.92% and 17.94% at 100% ETc, 75% ETc and 50% ETc respectively. 50% ETc was higher than 100% ETc and 75% ETc by 27.44% and 8,69% respectively at CI treatments. At PRD treatments, 50% ETc recorded the higher value of WUE compared to 100% ETc and 75% of ETc by 33.44% and 14.93 %. On winter season 2016, the results showed that, the WUE of PRD treatment was higher than CI treatment by 37.78%, 40.07% and 33.58% at 100% ETc, 75% ETc and 50% ETc at covering treatments. The value of WUE at CI treatments, 50% ETc was higher than 100% ETc and 75% ETc by 35.85 % and 25.97% respectively. At PRD treatments, 50% ETc recorded the higher value of the WUE compared to 100% ETc and 75% ETc by 31.52% and 17.96% respectively. At non-covering treatments, the value of WUE at PRD treatment was higher than CI treatment by 11.20%, 21.07% and 27.69% at 100% ETc, 75% ETc and 50% ETc respectively. The value of WUE of CI treatments, 50% ETc was higher than 100% ETc and 75% ETc by 20.07% and 19.29% respectively. The value of WUE at PRD treatments 50% of ETc was higher than 100% ETc and 75% ETc by 34.91% and 26.06% respectively.

Hence, comparing between the two irrigation regimes, the PRD treatment achieved the optimum value of WUE under the same amount of water and covering condition. For all treatment, WUE increased with decreasing amount of water for all treatment. These are agreement with these obtained by **Wang, *et al* (2012).** They found that, Water use efficiency (WUE) was the highest in PRD, followed by Deficit irrigation and the lowest in drip irrigation iir; while N-fertilization rate had no effect on WUE.

CONCOLUSON

Yield of Tomato was increased with increasing soil moisture content. On summer season at PRD treatment, the highest value was recorded as 35.24Mg/ha at 100% of ETc with non-covering condition. On winter At PRD treatment, the highest value was recorded as 68.66Mg/ha at 100% of ETc with covering condition. On summer season at PRD treatment, The highest value of water use efficiency was recorded as 10.70kg/m^3 at 50% of ETc with covering condition. On winter season at PRD treatment, The highest value of water use efficiency was 20.87kg/m^3 at 50% of ETc with covering condition.

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تاثير الرى الجزئى على محصول الطماطم تحت الظروف المصرية

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أجريت التجربه خلال موسمين (صيفى2015 – شتوى2016) لنبات الطماطم فى مزرعة كليه الزراعة بشبين الكوم لتربه طينيه وذلك لدراسه تأثير الرى الجزئى على نبات الطماطم تحت الظروف المصريه. تم زراعة النباتات على مصاطب وكانت ابعاد المصطبة (7 ، 15*) م والمسافة بين المصاطب 40سم والمسافة بين النقاطات 50 سم وتصرف النقاط 4 لتر/ساعة. **وكانت معاملات التجربة:**

1- نظام الرى بالتنقيط (التقليدى – الجزئى)
2- مستويات الماء (50-75-100) من البخر نتح.
3- نظام التغطيه (التغطية- عدم التغطية).

وأوضحت النتائج التالى:

1- حقق الرى الجزئى توزيع أمثل للمحتوى الرطوبى فى منطقه الجذور مقارنة بنظام الرى التقليدى . ارتفاع المحتوى الرطوبى تحت نظام التغطيه مقارنة بنظام عدم التغطية.
2- ارتفاع العائد المحصولى فى نظام الرى الجزئى مقارنة بنظام الرى التقليدى خصوصا عند مستويات نقص الماء. ارتفاع محصول الطماطم تحت التغطية مقارنة بعدم التغطية لأن التغطية تساعد على ارتفاع الرطوبة.
3- الحصول على أقصى استفادة للماء عند مستوى ماء 50% من البخر نتح وذلك تحت مستويات الماء، اما نظام الرى الجزئى أعطى أقصى استفادة للماء مقارنة بالرى التقليدى.

EXPERT SYSTEM FOR EMITTER CLOGGING MANAGEMENT

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Abstract

To prevent poor distribution efficiency and to extend the durability of the irrigation system, protection efficiency is a must; especially for the high cost modern irrigation systems. Preventive maintenance keeps the emitters from plugging. Emitters can be plugged by suspended solids, magnesium and calcium precipitation, manganese-iron oxides and sulfides, algae, bacteria, and plant roots. In this study, an expert system for management of emitter clogging problems in micro-irrigation system was developed. The standard development procedure was followed. CLIPS; an open source expert system development environment, was used. CLIPS; is a very flexible tool for organizing declarative knowledge into databases of facts and procedural knowledge into rules. The expert system was verified and validated through a series of tests during development and after the completion. Different group of data; that represent different clogging problem symptoms were used as inputs. The output recommendations of the expert system were compared with the recommendation of the domain expert and proved its correctness. The target users of this expert system are the extension agent in cooperative company, farmers and farm owners. It also could be used as training tool for student. One of the advantage of the expert system is the ease of add new information when available and the performance of the system keep getting better.

INTRODUCTION

A well designed, managed and maintained micro irrigation system can enhance efficiency of utilization of irrigation water, fertilizers and agricultural chemicals. The major cause of failure in micro-irrigation system is emitter plugging which can severely degrade irrigation system performance and application uniformity (Benham and Ross, 2002). So, enciso, 2015, stated that the longevity of subsurface drip irrigation (SDI) can be increased through properly designed and maintained systems; these systems could be economically justified for a great diversity of row crop. The drip-line represents the greatest cost of the system and its longevity can greatly impact the system's annual amortized cost.

Micro irrigation system can deliver water and nutrients in precise amount and at controlled frequency directly to the plants root zone. Haman, 2014, stated that, the plugging of emitters is one of the most serious problems associated with micro-irrigation use. Emitter plugging can severely hamper water application uniformity.

A properly designed and maintained micro-irrigation system should last more than 20 years. A maintenance program includes cleaning the filters, flushing the lines, adding chlorine, and injecting acids. If maintenance programs are followed, the need for major repairs, such as replacing damaged parts often can be avoided, and the life of the system extended.

Bucks *et al*., 1979, showed that, plugging hazards for micro-irrigation system fall into three general categories: physical (sediment), biological organic (bacteria and algae), and chemical (scale). Benham and Ross, 2002, stated that: plugging is caused by a combination of these factors depending on the source of irrigation water.

Gilbert and Ford, 1986, stated that emitter clogging is directly related to the quality of the irrigation water; suspended load, chemical composition, and microbial activity. These factors dictate the type of water treatment necessary for prevention of clogging. Clogging of drip emitters can be also affected by the type of emitter. Enciso, 2015, showed that on-line compensating emitters have better anti-clogging properties than in-line emitters. It has also been observed that turbulent flow emitters have better anti-clogging properties than laminar flow emitters. Successful maintenance programs can help prevent emitter clogging and increase longevity of the system. The longevity of the SDI is the key factor in the profitability of these systems when used for lower-value commodity crops (typically the fiber and grain crop).

Water sources can be grouped into two categories: surface and ground water. Waters from a creek, river, pond, or reservoir, or waters that have been stored in a pond should categorize as a surface water source even if the water was originally from a well. The irrigation water used in micro irrigation systems should be carefully evaluated to assess any potential clogging problems.

Each of these water sources is likely to present specific plugging hazards. The quality of irrigation water is judged not only by the total concentration of ions, but also by the individual ions present. The most common cations in irrigation water are calcium, magnesium, sodium, and potassium, and the most common anions are bicarbonate, sulfate, and chloride (Hoffman *et al*., 1983). Water hardness and total dissolved salts are the major water quality concerns. The chemical composition and pH of the water source and the water's interaction with chemicals added during chemigation can have a very significant influence on the level of emitter clogging.

Asgari *et al*., 2012, studied the effect of emitter clogging on water application uniformity. The results showed that clogging due to water chemical component has more effect than hydraulic uniformity in reduction of water application uniformity in drip irrigation system.

Micro irrigation system maintenance aims at preserving design emission uniformity (EU) and efficiency. There are two kinds of maintenance; preventive and after-the-fact, the former saves money and the later cost money. Hassan, 2007, developed a knowledgebase for preventive maintenance of modern irrigation systems, which covers the three principal stages; before the beginning of irrigation season; during the season or routine program; and after the irrigation season. If the rate of water flow progressively declines during the season, the tubes or tape may be slowly plugging resulting in severe damage to the crop (Haman, 2014). Clogging of drip emitters is a common problem with significant production and cost consequences. It can be avoided by testing irrigation water. The analysis of biological, chemical and particles content of the water plays a major role in choosing appropriate prevention measures.

The goal of this work is to develop an expert system for emitter clogging management problem. The expert system will assess the potential emitter clogging problem based on irrigation water analysis data. It also will diagnose emitter clogging problem based on symptoms and suggest the required treatment.

Expert System Development

Identification

Clogged drip emitters result in a reduction or total elimination of water discharge from the emitter. Partially clogged drip emitters are particularly problematic, since they reduce water application but can easily go unnoticed until they stop discharging entirely. Partial clogging of drip emitters is difficult to detect by eye, but you can detect it if you measure timed water discharge rates from a sampling of emitters. CLIPS (C Language Integrated Production System) version 6.30 March 17th 2015 is used in the development of **E**mitter **C**logging **M**anagement **E**xpert **S**ystem (ECMES). CLIPS; is an expert system development tool originally developed by Software Technology Branch (STB) NASA/Lyndon B. Johnson Space Center. The ECMES will cover the assessment of potential clogging of the irrigation system, diagnose the kind of emitter clogging and propose the required treatment. The main source of information was literature including bulletins, reports, manuals, etc.

Conceptualization and Formalization

Information from publications that cover the management of emitter clogging problems was gathered. This information includes; 1) the decision variables of irrigation water analysis that affect the clogging problems, 2) the method of collecting water samples from the irrigation water source, 3) the methods of flushing the irrigation network, 4) chlorination procedure, 5) acidification procedure, 6) symptoms of different emitter clogging problems, and 7) proposed treatments for different clogging problem.

1) Irrigation Water Analysis

The first step for maintaining the irrigation system is to take samples of irrigation water source. Such samples will assist the system designer to assess the leaching requirement. The quality of irrigation water will determine, in part, the filtration, maintenance, and water treatment measures that are required to prevent emitter plugging and maintain good system performance. Temperature, soluble organic matter, and pH are factors that influence bacterial growth and slime development (Gilbert and Ford, 1986). The principal physical, chemical and biological contributors to clogging of trickle systems are summarized in Figure 1. Criteria for evaluating the plugging potential of micro irrigation water sources is shown in Table (1) (Adapted from Bucks *et al*., 1979, Enciso, 2015, Gilbert and Ford, 1986, and Haman, 2014).

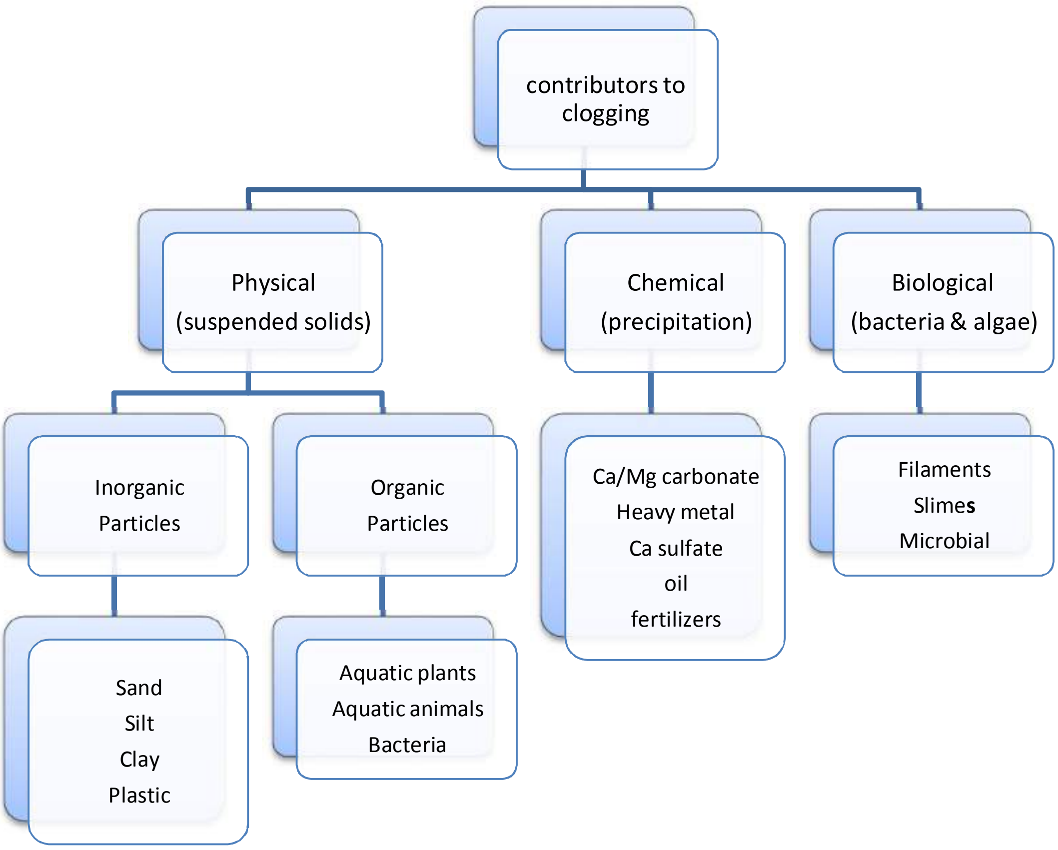

Fig. 1- Principal physical, chemical and biological contributors to clogging of trickle systems

Table 1 Effect of water quality on emitter clogging potential

Factor	Plugging hazard based on concentration		
	Slight	Moderate	High
Physical			
Total Suspended solids mg/l	< 50	50-100	>100
Chemical			
pH	<7.0	7.0-7.5	>7.5
Total Dissolved solids mg/l	<500	500-2000	>2000
Iron (Fe) mg/l	<0.1	0.1-1.5	>1.5
Manganese (Mn) mg/l	<0.1	0.1-1.5	>1.5
Hydrogen sulfide (H_2S) mg/l	<0.2	0.2-2.0	>2.0
Hardness as ($CaCO_3$)	<150	150-300	>300
Biological			
Bacteria (units/ml)	<10,000	10,000-50,000	>50,000

2) Method of collecting water sample

Hassan, 1998; Lamm and Porter, 2017, recommended that; when collecting a sample from a well, first allow the pump to run for at least 15 minutes. A liter sample volume is usually ample for chemical constituent analyses. Make sure the sample bottle is clean and rinsed. Flush the bottle with the water to be sampled a few times prior to gathering the sample. Collect the sample as close to the well as possible but do not collect samples too close to a chemical injection point since there may be insufficient mixing. Thoroughly flush all pipes and components prior to sampling.

Surface water is more difficult to sample, and its test results can change significantly over the season. Try to take as representative a sample as possible. If suspended solids, organic matter, or both, are of concern, a liter-sized sample may not be adequate. Contact the laboratory doing the analysis for more guidance.

Deliver the sample to the lab as soon as you can. Storing the sample in a cooler or a refrigerator until it can be delivered is a good idea; keeping it in a hot pickup truck for days before taking it to the lab should be avoided since volatile and biological contaminants in a sample can change with time and high temperature may speed the process.

If the water is to be analyzed for iron, the sample must be acidified to a pH of 4 or below; otherwise, the soluble (ferrous) iron in solution will precipitate as insoluble (ferric) iron before it reaches the lab and the water analysis will show little iron in solution. Thus, two samples must be collected: one acidified sample for iron and one plain sample for the remaining constituents in solution (University of California and W-2128, 2015). The laboratory can provide a sample bottle with the correct amount of acid in it for gathering the iron sample. Do not rinse the bottle prior to collecting the sample.

3) Flushing Method of the Irrigation Network

Very fine particles pass through the filters and can clog the emitters. As long as the water velocity is high and the water is turbulent, these particles remain suspended. If the water velocity slows or the water become less turbulent, these particles may settle out. This commonly occurs at the distant ends of the lateral lines. If they are not flushed, the emitters will plug and the line eventually will be filled with sediment from the downstream end to the upstream end. Systems must be designed so that main-lines, sub-mains, manifolds and laterals can all be flushed. Mainlines, sub-mains and manifolds are flushed with a valve installed at the very end of each. Lateral lines can be flushed manually or automatically. It is important to flush the lines at least every 2 weeks during the growing season, or as needed based upon local conditions. Details of flushing procedure as described by Hassan, 1998, are shown in the output report example of running the expert system (fig. 2).

4) Chlorination Procedure

Chlorination is an effective and economical solution to the problem of orifice and emitter clogging caused by microbial growth (Hassan, 1998). The required equipment for injection of acid and chlorine; personnel; at pump discharge line; and injection equipment are summarized in the output report (Fig. 2). There are two patterns of chlorination (Hassan, 1998); continuous and periodic. If the goal is to control microbial growth in lateral, emitters, or other parts of the system, then periodic injection of chlorine is satisfactory. If the goal is to treat water that has high level of algae or bacteria, or to precipitate dissolved iron, then super chlorination treatment are used with much higher doses of chlorine injected with the system to dissolve organic material restricting emitter flow. At low concentration (1 to 5 mg/l), chlorine kills bacteria and oxidizes iron. At high concentration (100 to 1000 mg/l), it oxidizes organic matter and effectively removes it from the system. Calcium hypochlorite Ca $(OCl)_2$, Sodium hypochlorite Na OCl or Chlorine gas may be used.

Fig. 2. Sample output report

Clogging Management Report
****
Procedure of collecting water sample
****
When collecting sample from a well, first allow the pump to run for at least 15 min
A liter sample volume is usually ample for chemical constituent analysis
Make sure the sample bottle is clean and rinsed
Flush the bottle with water to be sampled a few times prior to gathering the sample
Thoroughly flush all pipes and components prior to sampling
Collect the sample as close to the well as possible
Deliver the sample to the lab as soon as you can
Store the sample in a cooler or a refrigerator until it can be delivered
If water is to be analyzed for iron, another sample must be acidified to a pH <=4
Surface water is more difficult to sample, and its test results change over the season

---

Input Water Analysis Data

What is the amount of suspended solids in irrigation water in mg/l?
100
potential emitter clogging problem due to suspended solids is moderate
What is the pH of irrigation water?
7.8
Potential emitter clogging problem due to water pH is high
What is the Total Dissolved Solids in irrigation water in mg/l?
500
potential emitter clogging problem due to total dissolved solids is moderate
What is manganese content in irrigation water in ppm?
0.5
potential emitter clogging problem due to manganese content in water is moderate
What is the iron content in irrigation water in ppm?
2.1
Potential emitter clogging problem due to iron content in water is high
What is the hydrogen sulfide content in irrigation water in ppm?
0.2
potential emitter clogging problem due to hydrogen sulfide content in water is moderate
What is the bacterial population in irrigation water number/ml?
8000
potential emitter clogging problem due to bacterial population in water is low
What is the source of irrigation water? surface/well
surface
What is the quality of irrigation water? clear/turbid
turbid
Check symptoms of carbonate precipitation

Are there white deposits in the emitter orifice? t/f

t
Are there white precipitate shows with sediments flushed out from lateral? t/f
t
Are there white film or plating on the inner surfaces of the system? t/f
t
Check Symptoms of Iron Oxide Precipitation

Are there reddish stains and rust particles in the water? t/f
f
Are there reddish deposits in the orifices and stain on the emitter? t/f
f
Are there brown filamentous sludge shows with flushed sediments? t/f
f
Are there brown filamentous sludge shows on screen filters? t/f
f
Check Symptoms of Manganese oxide precipitation

Are there dark reddish stains and rust particles in the water? t/f
f
Are there reddish deposit in the orifices and black stain on the emitter? t/f
f
Are there dark brown filamentous sludge shows with flushed sediments? t/f
f
Are there dark brown filamentous sludge shows on screen filters? t/f
f
Check Symptoms of Iron Sulfide Precipitation

Are there black sand-like materials in the sediments flushed out of the lateral lines? t/f
t
Check Symptoms of Bacterial Precipitation of Sulfer

Are there white cotton-like slimes in the sediments flushed out of the lateral lines? t/f
t
Check Symptoms of Bacterial Precipitation of Iron

Is there red filamentous sludge in the sediments flushed out of the lateral lines? t/f
f
Are there reddish deposits in the orifices and stain on the emitter? t/f
f
Are there brown filamentous sludge shows on screen filters? t/f
f
Check Symptoms of Algae and Bacterial Growth

Are there slimy masses flushed out of the lateral lines? t/f
t
Treatment of Root Intrusion in Buried Drip Lines
****
Frequent irrigation tend to minimize or prevent root intrusion
Avoid deficit irrigation

Apply chlorine or phosphoric acid to the water
Use a drip tape impregnated with herbicide to prevent intrusion

---

Check Symptoms of Precipitates from Fertilizer Injection

Do you use phosphate fertilizers? t/f
t
Do you use calcium based fertilizers? t/f
f
Do you use anhydrous and aqueous ammonia? t/f
t
Treatment of Soil Ingestion in Buried Drip Lines
****
Install vacuum relief valve at the upper end of the laterals and downstream of all shut-off valves
Periodic flushing of laterals is required to remove any deposited material
Flow rates at the end of the lateral for flushing are 1 gpm and 2 gpm for 5/8 inch and 7/8 inch diameter tape/tubing respectively
Tape length may need to be relatively short on steep slope

Potential clogging of irrigation system due to turbid water is high
Settling basin and filtration is required
Frequent chlorination is required
Frequent system flushing is required

Treatment Options of Carbonate Precipitation
****
1. Continuous injection of acid in irrigation water
2. Use acidifying fertilizers to maintain 5<pH<7
3. Slug injection of acid for 30-60 min regularly with irrigation to maintain pH<4 for cleaning the system
4. Acid injection should be done before total blockage of the emitters occurs
5. If both of Ca concentration and pH are high, a sand media filter should be used to remove the precipitate that may form

---

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5. If both of Ca concentration and pH are high, a sand media filter should be used to remove the precipitate that may form

---

No Iron Oxide Precipitation Problem
No Manganese Oxide Precipitation Problem
Treatment of Iron Sulfide Precipitation
****
Inject acid continuously to lower the pH of the water to between 5 and 7

Treatment of Bacterial Precipitation of Sulfur
****
Inject chlorine continuously at rate of 1ppm free available chlorine per 4 to 8 ppm of hydrogen sulfide
For disinfecting the system, inject chlorine intermittently at 10 ppm for 30 to 60 min regularly with irrigation

---

No Bacterial Precipitation of Iron Problem
Treatment of Algae and Bacterial Growth
****
Inject chlorine at a rate of 1ppm continuously
Inject chlorine at a rate of 20 ppm for 20 min at the end of each irrigation cycle

---

Treatment of Precipitates From Fertilizer Injection
****
Potential clogging depends on the solubility of fertilizer elements, irrigation water quality, pH and temperature
Highly soluble fertilizer formulations will lead to fewer clogging problems
Nitrogen fertilizer and chlorine should be applied at different time

---

Treatment of Precipitates From Fertilizer Injection
****
Potential clogging depends on the solubility of fertilizer elements, irrigation water quality, pH and temperature
Highly soluble fertilizer formulations will lead to fewer clogging problems
Nitrogen fertilizer and chlorine should be applied at different time

---

Settling Basin Specification
****
It should have a series of baffles
The entering water should take 15 min to reach the pump
Filtration unit should be placed after to get ride off most sand and silt particles

---

Required Equipments for Chlorination and Acidification
****
Use safety equipment for chlorine or acid injection
Wear protective garments, gloves, masks, and gaggles
Ensure of accessible source of clean water
To prevent chemicals from flowing back into the well, check valve required between well and injection point
Vacuum or air relief valve between check valve and well, to allow air to flow in pipeline and prevent vacuum in pump discharge line
Low pressure drain (10 gpm) between check valve and well, to dispose of small amounts of chemicals that may leak through check valve

Low-pressure cutoff sensor on the discharge side of the pump, to avoid reversed flow in the line if discharge pressure falls below a set limit
Chlorine compounds should be stored separately in fiberglass or epoxy-coated plastic tanks
Acid and chlorine should never be stored together
Always add chlorine source (dry or liquid) to the water, not vice versa

---

Pattern of Chlorination
****

1. Periodic treatment, to control microbial growth in laterals, emitters and other parts of the system
2. Continuous treatment, to treat the water of high levels of algae or bacteria or to precipitate dissolved iron
3. Super chlorination treatment, to dissolve organic material restricting emitter flow
4. Use calcium hypochlorite, $Ca(OCl)_2$, if irrigation water contain low concentration of calcium <20 ppm or when field soils are dominantly sodic
5. Use Sodium hypochlorite, NaOCl, in case of water contains high concentration of calcium > 20 ppm. It is not recommended for sodic soils
6. Use Chlorine gas, is preferable where the addition of sodium or calcium is to be avoided, generally, it is the least expensive method
7. Do not inject chlorine when fertilizers, herbicides, and insecticides are being injected, since the chlorine may destroy the effectiveness of these compounds
8. Waters of high pH may require a dual injection system for injecting acid and chlorine at the same time to maintain water pH < 7
9.Chlorine injection upstream from the filter prevent iron and manganese precipitates from entering the system and controls microbial growth in the filter

---

Irrigation System Flushing Procedure
****

1. While system running adjust flow velocity to be .3 m/s
2. Start with mainlines and proceed to the submain, manifolds and laterals
3. Prepare a glass jar to collect sample of flushed water and examine carefully
4. Take notes of the nature of the impurities in the water
5. Open the end of the line while the system running and allow water to flow 3-4 min until it runs clear
6. Close the end valve

Flush underground lines 4-5 times during the irrigation season
Laterals should be flushed weekly
Laterals should be flushed following fertilizer or chemical injection
Laterals should be flushed after any periodic chlorine injection
Laterals should be flushed after any repair in the system

CLIPS>

5) Acidification Procedure

Acid are injected into irrigation water to prevent or treat plugging caused by precipitation of calcium carbonate (lime), magnesium and some other salts. Water with a pH of 7.5 or higher and a bicarbonate level of more than 100 ppm is likely to have problems with lime precipitation, depending on the hardness of the water. Maintaining a low pH (6.5 or less) can generally prevent chemical precipitation and subsequent plugging of emitters; alternately periodic shock acid injection (temporarily lowering the pH below (4) can prevent build-up of precipitates (Hassan, 1998).

6) Symptoms of Emitters Plugging Problems

Sources of physical plugging hazards include sand and other suspended solids that are too large to pass through emitter openings. Screen filters are used to remove suspended solids and sands from the irrigation water. Media filters are excellent for removing bacterial slimes and algae. Disc filters; a hybrid of screen and media filters; are sometimes used to remove biological materials from irrigation water. A summary of symptoms of physical, chemical and biological clogging problems and the proposed treatment is summarized in Table (2).

7) Proposed Treatments for Clogging Problems

Chlorine is commonly injected into a micro-irrigation system to eliminate any unfiltered biological material. Hassan, 1998, recommended that; if biological load of the irrigation water is severe, a low concentration (1 to 2 mg/l) of chlorine should be injected continuously. If the biological load is slight to moderate, a periodic chlorine shock treatment may be used in concentration of 10 to 30 mg/l. Sodium hypochlorite (Na OCl) or liquid bleach is a safe and easily obtained chlorine source. Chlorination is relatively ineffective for bacterial control if pH of water is above 7.5, so adding acid may be necessary to lower pH and increase the biocide action of chlorine.

The major chemical plugging hazard for micro-irrigation systems are precipitation of calcium carbonate ($CaCO_3$), also called lime or scale, and the formation of iron precipitates. Continuous acid injection is often used to lower the water pH (< 7.0) and decrease the possibility of $CaCO_3$ precipitation. Sulfuric, hydrochloric, and phosphoric acid can be used for this purpose.

Every system should contain a flow meter and pressure gauges-one gauge before the filters and another after the filters. Daily monitoring of these gauges will indicate whether the system is working properly. A low pressure reading on a pressure gauge can mean that a part is leaking or a pipe is broken. A difference in pressure between the filters may mean that the system is not being back-flushed properly and that the filters need to be cleaned. Gradual increasing pressure with reduced flow can indicate an emitter clogging problem.

Implementation

The basic knowledge about the irrigation system was stored in the knowledge base as facts. The relations between facts were stored in the rules. The ECMES consists of about fifty rules. The rules cover water sampling procedure, assessment of clogging potential, settling basin specifications, flushing procedure, chlorination procedure, diagnose and treatment of different clogging problems such as; carbonate precipitation, iron oxide precipitation, manganese oxide precipitation, iron sulfide precipitation, bacterial precipitation of sulfur, bacterial precipitation of iron, algae and bacterial growth, root intrusion, precipitation potential from fertilizer injection, and soil ingestion in buried pipe lines. Fig. (3) shows an example of rule for assessing clogging potential due to suspended solids based on irrigation water analysis data. Fig. (4) shows another example of rule of how to diagnose carbonate precipitation problem and the proposed treatments.

Fig. 3. Rule for assessing clogging potential due to suspended solids

```
(defrule clogging-potential1
=>
(printout t "Input Water Analysis Data" crlf
            "________________________" crlf
            "What is the amount of suspended solids in irrigation water in mg/l?" crlf)
(bind ?suspended-solids (read))
(if (< ?suspended-solids 50)
   then
  (printout t "potential emitter clogging problem due to suspended solids is low" crlf)
   else
   (if
   (and (>= ?suspended-solids 50) (<= ?suspended-solids 100))
   Then
  (printout t "Potential emitter clogging problem due to suspended solids is moderate" crlf)
   else
   (printout t "Potential emitter clogging problem due to suspended solids is high" crlf))))
```

Fig. 4. Rules for diagnose and treatments of carbonate precipitation problem

```
(defrule Carbonate-Precipitation
         "check symptoms of carbonate precipitation"
=>
(printout t "Check symptoms of carbonate precipitation" crlf
         "Are there white deposits in the emitter orifice? t/f" crlf)
(assert (white deposits in emitter orifice (read)))
(printout t "Are there white precipitates shows with sediments flushed out from lateral? t/f"
crlf)
(assert (white precipitation with flushed water (read)))
(printout t "Is there white film or plating on the inner surfaces of the system? t/f" crlf)
(assert( white film on inner surface (read))))

(defrule Treatment-Options-of-Carbonate-Precipitation
         "treatment option of carbonate precipitation"
(or (white deposits in emitter orifice t)
   (white precipitation with flushed water t)
   (white film on inner surface t))
=>
(printout t "Treatment Options of Carbonate Precipitation" crlf
  "********************************************" crlf
  "1. Continuous injection of acid in irrigation water" crlf
  "2. Use acidifying fertilizers to maintain 5<pH<7 "crlf
  "3. Slug injection of acid for 30-60 min regularly with irrigation to maintain pH<4 for
cleaning the system" crlf
  "4. Acid injection should be done before total blockage of the emitters occurs" crlf
  "5. If both of Ca concentration and pH are high, a sand media filter should be used to
remove the precipitate that may form" crlf))
```

Table2 Symptoms and treatments of emitter clogging problems

Symptoms	Problem diagnose	Treatments
white deposits in the emitter orifice white precipitation with flushed water white film on inner surface	Carbonate precipitation	Continuous injection of acid in irrigation water Use acidifying fertilizers to maintain 5<pH<7 Slug injection of acid for 30-60 min regularly with irrigation to maintain pH<4 for cleaning the system Acid injection should be done before total blockage of the emitters occurs
Reddish stain and rust particles in the water Reddish deposit in the orifices and stain on the emitter Brown filamentous sludge shows with flushed sediments Brown filamentous sludge shows on screen filters	Iron Oxide precipitation	***Aeration and settling*** Chlorination should be used to control microbial growth in the basin Allow the water entering the basin to run over a series of baffles to be thoroughly aerated Spray the water through the air to oxidize the ferrous oxide to ferric oxide The ferric oxide will precipitate and settle to the bottom Sufficient time should be allowed for iron settling The water can then be drawn off for use ***pH control*** Acid may be injected to maintain the iron in solution Acid may be used periodically to clear the system partially clogged with iron The pH is lowered to <= 4.0 for 30-60 min to dissolve iron and flushes it from the system
Dark reddish stain and rust particles in the water Reddish deposit in the orifices and black stain on the emitter Dark brown filamentous sludge shows with flushed sediments Dark brown filamentous sludge shows on screen filters	Manganese Oxide precipitation	***Aeration and Settling*** Chlorination should be used to control microbial growth in the basin Allow the water entering the basin to run over a series of baffles to be thoroughly aerated Spray the water through the air to oxidize the manganese The manganese oxide take longer time to precipitate and settle to the bottom Sufficient time should be allowed for manganese settling The water can then be drawn off for use
Black sand-like material in the sediments flushed out of the lateral lines	Iron Sulfide precipitatio n	Inject acid continuously to lower the pH of the water to between 5 and 7

White cotton-like slime in the sediments flushed out of the lateral lines	Bacterial precipitation of sulfur	Inject chlorine continuously at rate of 1ppm free available chlorine per 4 to 8 ppm of hydrogen sulfide For disinfecting the system, inject chlorine intermittently at 10 ppm for 30 to 60 min regularly with irrigation
Red filamentous sludge in the sediments flushed out of the lateral Reddish deposit in the orifices and stain on the emitter Brown filamentous sludge shows on screen filters	Bacterial precipitation of iron	Inject chlorine at a rate of 1 ppm free chlorine continuously Inject chlorine at the rate of 10 to 20 ppm for 30 to 60 min with irrigation
Slimy masses flushed out of the lateral lines	Algae and bacterial growth	Inject chlorine at a rate of 1ppm continuously Inject chlorine at a rate of 20 ppm for 20 min at the end of each irrigation cycle
	Root Intrusion	Frequent irrigation tend to minimize or prevent root intrusion Avoid deficit irrigation Apply chlorine or phosphoric acid to the water Use a drip tape impregnated with herbicide to prevent intrusion
Phosphate fertilizers Calcium based fertilizers Anhydrous and aqueous ammonia	Precipitates from fertilizer	Potential clogging depends on the solubility of fertilizer elements, irrigation water quality, pH and temperature Highly soluble fertilizer formulations will lead to fewer clogging problems
	Soil Ingestion	Install vacuum relief valve at the upper end of the laterals and downstream of all shut-off valves Periodic flushing of laterals is required to remove any deposited material Flow rates at the end of the lateral for flushing are 1 gpm and 2 gpm for 5/8 inch and 7/8 inch diameter tape/tubing respectively Tape length may need to be relatively short on steep slope

Testing

A sequence of verification and validation of ECMES is used to prove its correctness and functionality. The expert system was tested during the development and after the completion by comparing the output recommendation for different sets of input conditions with the recommendation of the domain expert for the same sets of input data.

RESULTS AND DISCUSSION

The emitter clogging management expert system (ECMES) was developed by the standard procedure. CLIPS; is used to develop the expert system. The expert system starts by asking the user to input the data about the source of irrigation water and its analysis parameters such as; the amount of suspended solids in mg/l, pH, total dissolved solids in mg/l, manganese content in mg/l, iron content in mg/l, hydrogen sulfide content in mg/l, and the bacterial population in number/ml. According to these inputs, the expert system assesses the potential of emitter clogging problem of the irrigation water.

The expert system also provides the user with the general guidelines for collecting irrigation water samples that is going to be sent for analysis. Then, it asks the user about the different symptoms of precipitation of carbonate, iron oxides, manganese oxides, iron sulfide, sulfur, iron, algae and bacterial growth, precipitation from fertilizers injection, and root intrusion in buried pipelines. The user answers are just t/f. To show the utility of the ECMES a sample run and the associated output report will be as follows:

The output report will contain; procedure of collecting water sample, potential emitter clogging problem according to water quality (slight- moderate – high), treatment of; root intrusion in buried pipe lines, soil ingestion in buried pipe lines, carbonate precipitation, iron oxide precipitation, manganese oxide precipitation, iron sulfide precipitation, bacterial precipitation of sulfur, bacterial precipitation of iron, algae and bacterial growth, precipitates from fertilizer injection, settling basin specifications, required equipment for chlorination and acidification, pattern of chlorination, and irrigation system flushing procedure. Figure (3) shows the output report for above

CONCLUSION

The **E**mitter **C**logging **M**anagement **E**xpert **S**ystem, ECMES, was developed by the standard method. It was tested for verification and validation during and after the completion and proved its correctness. The expert system could be used as a training tool and it could be used by extension specialist or farmer or farm owner to manage their emitter clogging problems. Expert systems is open ended programs, maintenance of the programs include adding deleting or adjusting information when available.

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نظام خبير لإدارة مشاكل انسداد المنقطات

عزة حسن

معهد بحوث الهندسه الزراعيه – مركز البحوث الزراعية – دقى - جيزه

الصيانة الوقائية لنظم الرى مرتفعة التكاليف، كالرى بالرش والتنقيط، ضرورية جدا لمنع مشاكل الإنتظامية الضعيفة وكذلك للحصول على أطول عمر لنظام الرى. أول خطوة لصيانة نظام الرى هى تحليل عينات من مصدر الماء المستخدم فى الرى، حيث ان هذه البيانات تساعد المصمم على تحديد الاحتياجات الغسيلية للنظام والتى تؤثر بدورها على اختيار المنقط ومقاس خط التنقيط وفترة التشغيل. وهناك ثلاثة أنواع من عوامل الإنسداد للمنقطات والتى يجب ان تؤخذ فى الإعتبار عند تصميم برنامج للصيانة وهى: عوامل طبيعية مثل الرمل والسيلت؛ عوامل كيميائية مثل بيكربونات الكالسيوم والكبريتات والمنجنيز؛ وعوامل حيوية مثل البكتيريا والطحالب.

وللتغلب على مشاكل الانسداد الطبيعية يمكن استخدام انواع مختلفة من الفلاتر حسب كم المواد العالقة فى مياه الرى وكميتها كما ان الفلاتر تساعد فى التخلص من بعض العوامل الحيوية. بينما يستخدم الكلور للتخلص من البكتريا والطحالب. ولمنع الترسبات الكيميائية لبعض المركبات قد يسخدم الحقن باحد الاحماض مثل الهيدروكلوريك او الكبريتيك او الفوسفوريك.

فى هذا البحث تم جمع المعلومات والتوصيات الخاصة بالصيانة الوقائية لنظم الرى بالتنقيط من مصادر مختلفة وتم وضع المعلومات الاساسية كمجموعة من الحقائق (facts) والعلاقات بينها على صوره قواعد (rules). وتم بناء النظام الخبير باستخدام CLIPS وهو عبارة عن بيئة لبناء النظم الخبيرة تم انشائة بواسطة هيئة الفضاء الامريكية NASA وهو مصدر مفتوح للاستخدام المجانى اصدار 6.3 مارس 2015.

تم اختبار النظام اثناء انشائه وبعد الانتهاء منة باعطائة مجموعات مختلفة من البيانات والتى يمكن عن طريقها تحديد المشكلة ومصدرها ومراجعة التوصيات الناتجة بواسطة النظام الخبير واثبت فاعلية جيدة. لذا نوصى باستخدام النظام الخبير بواسطة مهندسى الارشاد الزراعى كما انة يمكن ان يستخدم كوسيلة للتدريب للطلبة على ادارة بعض مشاكل الانسداد لنظم الرى بالتنقيط بتحديد مظاهر المشكلة وادخالها للنظام لاقتراح الحل المناسب لها. ومن مميزات النظام الخبير انه يمكن اضافة اى معلومات جديده حال توافرها ويستمر اداء النظام فى التحسن.

OLIVE PRODUCTION EXPERT SYSTEM

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Abstract

Olive is one of the economic fruit crops that have multiple purposes. Maximum concentration of olives in the world is in the Mediterranean Region. In Egypt, Siwa, Fayoum, Arish, Rafh, Ismalia, Alamin, Giza, Menya and newly reclaimed lands are the main olives productive areas. So many researches have been done about olive production. The results of these researches should be delivered to farmers and farm owners to improve their lives socially and economically. In this work, the results of previous studies, projects, bulletins, and human expertise about olive production were collected to build an expert system. This system covers the establishment of new orchard and the management of the existing ones. The system can give recommendation about site selection, cultivar selection, land preparation, fertilization, irrigation, and harvesting. The traditional method of developing the expert system was followed. The expert system was validated during and after completion and proved to be a good tool for enhancing olive production.

INTRODUCTION

Olive (L. Olea europea) is long lived permanent tree crop with high adoptability and resistance to the most adverse conditions (drought, salinity, and varying soil types). Egypt is the world leader in growing olives in arid and semi arid conditions on the desert land with poor sandy soil and less than 80 mm rainfall/year. The cultivated area of olives increased by 25 fold from 2,185 hectares in 1975 to 54,000 hectares in 2005 (Harrison and El-Kholy *et al*, 2010). Almost 55% (29,700 hectares) of the current area cultivated with olives are within new reclaimed desert locations. Most of the old historical regions in which olives have been traditionally considered as the backbone of the domestic economy (Siwa, Fayoum, and Wadi El-Arish) have seen considerable olive expansion from roughly 1,700 hectares to 23,750 hectares. In 2005 the total olive production was 530,460 MT, of which 85% was used for table olives and only 15% for oil production. The average production (MT/ha) has increased from 6.2 in 1975 to 12.6 in 2005 (Average production is 3.8 ton/fed, total production is 2,817,000 ton/year). Olive oil production for the last seven years was 5800 tones which represent about 0.2% of international production (International Olive Oil Council November 2013).

Olive is an evergreen tree with endless history. This tree was regarded as a holy plant to symbolize peace and abundance. Tree height varies from 5 to 20 m. Root system is strong; distributed almost all over top soil but with roots having capabilities to hint rocky soil. Horizontal growth of roots is almost three times the canopy width. Some trees have been lived for 1000 years. Therefore; a minor mistake at time of orchard establishment creates a big problem later and make a considerable loss of investment. Many research works have been done for olives (Mohamed and Saad Eldin 2002; Mourad 1998; Fouad *et al*, 1986; and Ali *et al*, 1999). The results of these works did not reach the actual olive growers to improve their production and management practices and to raise their income while saving the environment. Harrison *et al*.,2010, concluded that we need better knowledge and information on a range of production issues to improve the quality and quantity of the olive crop, along with the need to meet the ever growing complexity of agro-food industries related to the demand of safe and healthy food.

A well established grove must produce a large quantity of fruits annually to reach its economic bearing stage as early as possible after planting. Proper planting and careful attention in site selection, land preparation, orchard design, cultivar selection, spacing, planting, and initial training of trees are critical (Bartolucci and Dhakal, 1999). The proper pruning of the tree to regularize fruiting habit and plant protection measures are equally important.

Expert system as one of the promising AI technology can serve in this situation by gathering the different expertise and knowledge in one information system which is able to give the required recommendations to the farmer through either the internet or the cooperatives and to keep them aware of the most up to date practices. Therefore, the main objectives of this research are to collect the results of previous studies and researches that have been done about olive and develop an expert system for olive production and to make this program available to extension specialists and to the investment people. This expert system will help in pointing out the points that need more studies, and the conflict between studies to finally get a good extension tool for developing the olive production. This expert system will give recommendations about the establishment of a new orchard and management of the existing ones. The expected end users are farmers, farm owners and extension specialists. They can make better decisions about olive production and develop policies that enhance economic and social life, and preserve the environment. LEVEL5 OBJECT tool kit is used to develop the system. Previous weather data for the areas that cultivate olives in Egypt were used.

SYSTEM DEVELOPMENT

Identification

In 2010, FAO developed GAP (Good Agriculture Practices) guide lines to elaborate on the internal factors related to the production systems in order to improve the productivity and the quality of olive oil and olive production in an economically viable, environmentally sustainable and socially acceptable way.

One of the basic steps to improve olive production and to enhance the livelihood of the farmers and farm owners is to develop a complete extension program for olive production and to make this program available to them and to the investment people. One way to achieve this goal is to make use of information technology to deliver information in direct and simple way. Expert system is one of an open ended activity than with conventional programs. Because expert systems are not based on algorithms, their performance depends on knowledge. As new knowledge is acquired and old knowledge modified, the performance of the system improves and keep getting better. **O**live **P**roduction **E**xpert **S**ystem **OPES** will give information about the establishment of a new olive orchard and management of the existing ones. LEVEL5 OBJECT tool kit is used to develop the system.

Conceptualization

At this stage, information about establishment of a new grove and management practices of the existing ones is gathered and verified to avoid conflict. Then, this information was checked by domain experts. Fig. (1) shows the management steps for olive production that **OPES** will cover.

Management of Olive Grove

New olive grove | *Old Olive Grove*

Site selection
Land preparation
Grove design
Cultivar selection

Fertilization
Irrigation
Harvesting

Fig. 1. Olive Production Expert System (OPES) modules.

Formalization

During this stage all the information characterizing the management practices of olive grove were represented in a way suitable for expert system development. The basic olive management includes; site selection, land preparation, grove design, cultivar selection, fertilization, irrigation, and harvesting. The first four practices are for new olive grove while the rest are for old and new ones.

1. Site selection

It is impossible and impractical to recommend a specific cultivation system without carrying out a preliminary study of the characteristics of soil and local climate. GAP guidelines (FAO, 2010) recommended that the cultivation system selected should basically comply with: a) optimum use of rain water being the principal constraint in olive production; b) maximum benefits and commercial returns from land use; c) conserve soil and prevent erosion; d) facilitate many other cultural operations, particularly harvesting; and e) reduce vegetation competition on water and nutrients with olive crop.

The production capacity of a plant and profit from an orchard are greatly affected by the site. Fig. (2) shows the important elements to be considered while selecting a site for orchard establishment.

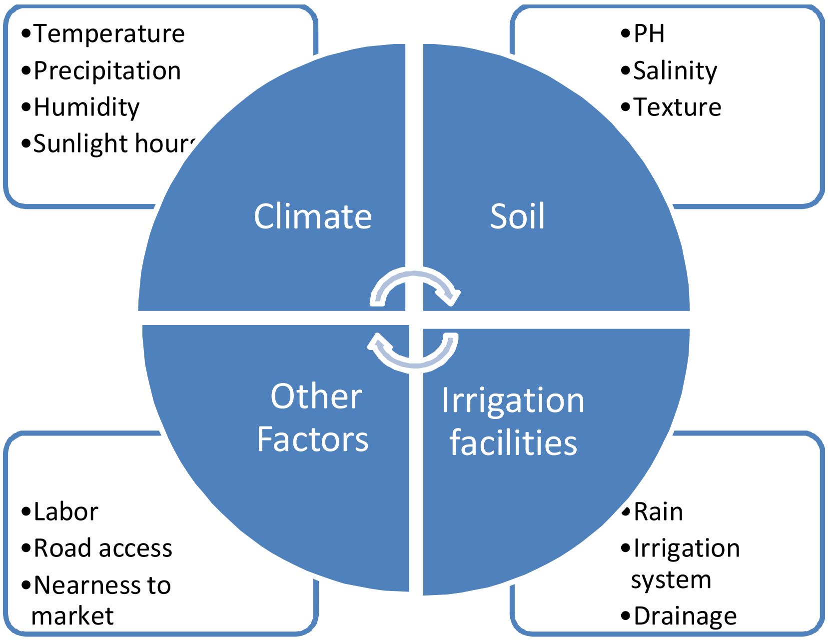

Fig. 2. **Factors that affect site selection for olive grove establishment.**

The best olive production and fruit quality occur in areas having mild winter and long, warm, and dry summer. If the annual rainfall is below 400 mm, which is the condition in Egypt, irrigation must be given to have good production. Olive likes sunny and warm environments. It is a long-day plant and benefits from the strong sunlight. The olive is a plant that likes nitrogen and is addicted to calcium. The olive is sensitive to boron also. Boron deficiency in soils can cause a serious problem in halting the growth of growing points. Olive trees are sensitive to poor drainage and water logging. The root growth is poor under stagnated conditions thus reducing nutrient uptake. There is a chance of root decay in poorly drained soils. Although olives are drought tolerant adequate water must be available throughout the season for the growth and maximum production. Irrigation water with high nitrogen promotes excessive vegetative growth that impedes fruit production. Excess of sodium salt in water accumulation in the soil creates water penetration problem. Hence, analysis of irrigation water is also an important tool for selecting olive plantation sites.

Olive could be irrigated with saline water up to 4000ppm without effect on crop quality and quantity. Selected area and cultivars should be free from disease-causing organisms. Table 1 summarize the optimal values for climate parameters, soil data and irrigating water that suit olive grove establishment.

Table 2 Optimal values for pedo-climatic conditions for orchard establishment (GAP manual, 2010)

Parameter (Class)	Attribute	Optimal value
Climate	Max. temperature	38
	Min. temperature	> -8ºC
	Annual precipitation	< 1000 mm/year
	Relative humidity	40 – 65 %
	Sunlight hours	2400 - 2700 hours/year
Soil	Electrical conductivity (EC)	<= 4.5 mmhos/cm
	PH	5.5 ≤ PH ≤ 8.5
	Permeability	80 – 150 mm/hr
	Sand particles	45 – 65 %
	Silt particles	10 – 35 %
	Clay particles	10 – 35 %
	Nitrogen	1 – 1.5 %
	Phosphorus	0.60 – 0.75 %
	Potassium	0.4 %
	Chloride	10-25 moles/l
	Sodium (exchange rate)	< 15%
	Organic matter	2 – 3 %
	Water soluble salt	4 – 5 g/Kg. soil
Irrigation water	soluble salt	< 4000 ppm

2. Land preparation

The land for establishing a new grove should be cleared by removing bushes and stumps. Then, it is important to create a favorable environment for the absorption system of the tree by improving the soil layers physically and chemically. The improvement of soil up to deep layers is possible only before plantation in fruit crops.

The olive groves are tilled two or three times in winter; the first is immediately after harvesting in December, the second in February/ March, and the third in April/ May. The summer tillage operation is carried out in June or July. The tillage operation should be shallow (5 -15 cm deep).

The pit size for new plantation of olive should be 75cm x 75cm x 75cm. Fill the pits with top soil mixed with 40g Furadane or other insecticide and fertilizers and recommended in Table 2. Digging and filling of pits should be completed one month before planting. After leveling and plowing, drainage is vitally important in order to get rid of excess moisture in soil. Drainage system can be developed by using stones, or bricks, or perforated plastic tubes underneath the plantation area. A deep drainage channel, as per the slope gradient, can also be helpful.

Table 3 Recommended fertilizers during land preparation (Mohamed and Saad ElDin, 2002)

Fertilizer application before planting	Recommended amounts/pit
Manure	50 kg
Super phosphate	1 kg
Potassium sulfate	0.25 kg
Ammonium sulfate	50 g
Nile fertile or agriculture lime	0.5 kg

3. Grove design

Design of olive grove must provide maximum sun exposure over the trees in all ages and allow efficient operation of orchard equipment. The square, the rectangular, and the hexagonal or triangular systems are some popular designs of layout of olive. The transfer of pollen grains from is exclusively operated in olive by wind. Most of olive cultivars need cross-pollination. Pendolino, an Italian cultivar, is considered an effective and universal pollinizer. The pollinizer percentage and layout scheme in an olive orchard is shown in Fig. (3) as recommended by Bartolucci and Dhakal 1999.

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O main variety, X pollinizer

Fig. 3. Pollinizer percentage and layout scheme in an olive orchard

4. Cultivar selection

The cultivar chosen should be well adapted to the local condition and according to the purposes of oil extraction or table olives. There are cultivars or cultivar group suitable for each particular geographic area. Factors determining selection of cultivars include suitability for processing, size of fruit, climatic limitations and disease resistance. The best time to plant is in any time during the year in irrigated areas except summer months (July and August). A single variety is never used in large orchards. GAP (2010) recommended the use of at least 3 cultivars with a progressive ripening season. Also, there is an increase in productivity due to cross pollination. The spacing of trees is particularly important for plant protection and for levels of insect pests and diseases in ecological groves. For dry farming conditions (<200-300 mm rainfall) GAP, 2010, proposed planting distances 100 tree/ha. Windbreaks consist of densely planted fence-like row(s) of perennial trees, five meters apart from all sides, with a root system and foliage that can resist strong winds, reduce their velocity and protect downwind agricultural lands grown with trees, crops or vegetables. The most widely grown olive varieties adaptable for growing conditions in Egypt are shown in Table 3.

Table 4 Most widely grown olive varieties adaptable for growing conditions in Egypt (Mohamed and Saad Eldin 2002)

Name	origin	purpose	size	weight	oil %	ripening	area
Picual1	Spain	dual	medium	3-7	15-22	Oct.-Jan.	Arish, Alamyn, Rafh, Ismaelia
Manzanillo	Spain	dual	medium	4-6	16-20		Arish, Alamyn, Rafh, Ismaelia
Watieken	Egypt	dual	medium	4-6	18-20	Sept.-Nov.	Siwa
Ageizi Shami	Egypt	table	large	7-10		Sept.-Oct.	Fayoum,Giza, Sohag
Hamed	Egypt	table	medium	5-8	16-19	Sept.-Nov.	Siwa, Arish, Sohag
Taffahi	Egypt	table	large	8-16	5-7	Aug.-Sept.	Fayoum, Giza, Benisuief, Sohag
Ageizi Akks	Egypt	table	medium	6-8		Oct.-Dec.	Fayoum
Ageizi Balady	Egypt	table					
Kalamata	Greece	table	medium	3-9	15-20	Sept.-Oct.	Reclaimed, Arish, Alamyn, Rafah,Sohag
Dolci	French	table	medium	3-6	15-18	Oct.-Nov.	
Mission	American	table	medium	3-6	15-20	Sept-Nov	
Frantio	Italy	oil	small	2-3	18-23	Sept.-Nov.	
Koroneike	Greece	oil	small	1-1.5	16-24	Nov.-Dec.	Sohag
Coratina	Italy	oil	small	3-4	18-22	Nov.-Jan.	Sohag
Sebhawi	Egypt	oil					
Cemlalli	Tunisia	oil	small	1	15-20	Oct.-Nov.	Siwa
Arbiquena	Spain	oil	small	1-2	17-20	Nov.-Dec.	
Marraki2	Egypt	oil	medium	3-6	>25	Nov.-Dec.	Marrakia, Siwa

5. Planting

Bartolucci and Dhakal, 1999, recommended taking out the soil-ball from the plastic tubes and pruning off any broken or long roots that do not easily fit into the hole, then; place the earth ball with the plant into the hole. A correct planting depth should vary from 10 to 20 cm in heavy soil and 25 to 40 cm in light soil. The grafted part of the plant should be above the ground level. Fill the hole with top soil and press the soil firmly with feet little by little to remove air pockets and save roots from drying out. Irrigate the soil around plant immediately after planting. A two-meter tall staking, which can last for two years is erected into the pit along the planting center towards the wind direction before plantation. The main stem of the plant is tied with the stake.

6. Fertilization

Fertilizing the plants depends on many factors such as soil, climate, tree age, growth, variety, nature of the plants, etc. These factors are to be critically observed before deciding the amount of fertilizer dose to the plants. Bartolucci and Dhakal 1999 recommended fertilizer dose based on soil analysis, systematic experimentation, and analysis of the plant tissues. The recommendation based on "foliar diagnosis" is the most acceptable and reasonable. Table 4 shows the critical level of essential elements in olive leaves that is imperative to add fertilizers according to Mohamed and Sad Eldin, 2002 recommendations.

Table 5 Critical levels of essential nutrients in olive leaves

Element	Deficient
Nitrogen (%)	1.8
Phosphorus (%)	0.15
Potassium (%)	0.8
Calcium (%)	0.66
Magnesium (%)	0.15
Manganese (ppm)	36
Zinc (ppm)	24
Copper (ppm)	9
Boron (ppm)	20
Iron (ppm)	134

Sixteen elements are considered essential for plant growth and development. Two, carbon and oxygen, come from the air; the others are provided by the soil. In order of magnitude required by the plant they are carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, sulfur, calcium, magnesium, iron, manganese, copper, boron, zinc, molybdenum, and chloride. Table 5 shows the fertilization program according to tree age as recommended by Mohamed and Saad Eldin, 2002.

Table 6 Recommended annual fertilization according to tree age

Tree Age (Years)	Fertilizer type and amount in kg/tree/year			
	N (20.6%)	P (15.5%)	K (48%)	Mg
1	0.5	-	-	-
2	1.0	0.5	0.25	-
3	1.5	0.75	0.5	-
4	2.0	1.0	0.75	0.2
5	3.0	1.25	1.0	0.3
6	4.0	1.5	1.25	0.4
> 6	5.0	1.75	1.5	0.5

Most Egyptian olive growers/farmers feed their trees through two different methods (soil application and fertigation) which complement one another (Gregorion and El-Kholy, 2010). In soil application; most growers/farmers incorporate well composted organic matter into the soil around their trees within the first ten years of planting. This practice should be done every year or every second year. It is very beneficial as it helps to improve soil fertility and physical structure. Normally the application is done during winter time when the trees are relatively dormant by applying one of the following two methods as recommended by FAO, 2010.

1st Method: Trenches are dug all around the trees’ periphery within the wetted areas inwards from the canopy drip line and a mix of compost and a portion of the annual mineral nutrient ration is mixed with the excavated soil and backfilled. The width and depth of the round trench would not be less than 250 mm wide and 300 mm deep. The nutrient mix commonly contains phosphorous, potassium, sulfur, magnesium and gypsum. Boron can be also added in small quantities if the leaf analyses show deficiencies or if there is a problem in pollination. This method results in preventing the roots from confinement and encourages them to move outwards and downwards.

2nd Method: The same mix, but with smaller quantities, is incorporated into small holes dug around the tree. The number of the these holes can vary between two to four and the size of each hole is roughly 300 – 500 mm wide and 300 mm deep. Alternate the position of these holes from one year to the other.

Drip irrigation makes fertilization through injection (fertigation) a very viable tool in increasing productivity and improving the fruit quality as it allows precise timing of fertilizer application relevant to the specific physiological stages on demand. It also reduces the potential risk of polluting groundwater due to fertilizers leaching from heavy applications and excess irrigation. One of the very important advantages of fertigation in olive growing is that it provides an excellent management tool for the application of nitrogen. Under fertigation, nitrogen is applied regularly all year round, except during winter and the final stages of ripening, in small doses to prevent excessive vegetative growth caused by single large applications.

In Egypt the most common fertilizers for fertigation are ammonium sulphate, ammonium nitrate and calcium nitrate for N, Potassium sulphate for K and phosphoric acid for P. Since phosphorus is immobile in the soil, a great proportion of the P ration is incorporated during the winter time with compost and the remaining portion can be added through fertigation. The average uptake of nitrogen, phosphorus and potassium ratio is about 2: 1: 2.5.

The studies on foliar - diagnosis indicate that optimal main nutrient content in olive leaf vary, i.e. 2 - 2.5% nitrogen, 0.3 - 0.5 % phosphorus and 1 to 1.5% potassium.

Table 7 Application seasons and quantities of major nutrients (Bartolucci and Dhakal, 1999

Season/month of Application	Non bearing olive tree (2-4 years after plantation)			Bearing olive (after 4 years of plantation)		
	N	P2O5	K2O	N	P2O5	K2O
Critical stage for nitrogen December	0.1-0.3 kg	0.05-0.1 kg.	0.1 - 0.2 kg	0.3-0.5 kg	0.1- .25 kg	0.2-0.4 kg
Differentiation of buds and shoots (March) Spring Time	0.05 - 0.1 kg.			0.1 -0.2 kg. N (after bloom)		
Fruit setting (May-June)						
Autumn Time Heading of stone in fruits (August)	0.05-0.1 kg N			0.1 -0.2 kg N		

The time of fertilizer application may differ according to the availability of irrigation water or moisture content in the soil,

Nitrogen: Gregoriou and El-Kholy, 2010, stated that nitrogen is the element to which the olive tree responds most swiftly and with the greatest benefits in that it speeds up and generally increases productivity. It accelerates the vegetative growth and development of the plant, increases the quantity of chlorophyll and thus increases the plant's capacity to assimilate photosynthetic materials. The tree reacts quickly to the addition of nitrogenous fertilizers and its production increases but it should not be forgotten that the plant becomes more susceptible to cold and fungal diseases with excess application of nitrogen

Phosphorus: It favors flowering and setting of fruits. It accelerates maturation. It acts as antidote to an excess of nitrogen. It should be applied in autumn, when soil is in the best condition and damage less to the root system.

Potassium: "Olive trees require potassium in the greatest quantities after calcium. Potassium moves to fruit at ripening time and thus it contains a great quantity of potassium. Its consumption increases with rainfall. Potassium makes the plant more resistant to Peacock Spot *(Cycloconium oleaginum)* and other fungal diseases. It makes the plant more resistant to drought and cold. In potassium deficiency, trees have underdeveloped fruits.

Trace element: Deficiency of boron can be easily corrected by applying 200 to 400 g of borax per tree to the soil or on the leaves as foliar sprays. This treatment should be sufficient for many years.

Organic matter: Organic materials improve soil conditions, cohere the loose soils, improve texture of heavy soils, control soil pH, increase ion exchange capacity in the soil, retain soil humidity, activate the micro-organisms, assimilate the nutritive elements present in the soil, etc. Mohamed and Saad Eldin, 2002, recommended the application of organic materials in autumn and buried as deeply as possible. The application of manure 5 to 10 tons per hectare in the dry climate should be made in every one to two years and in humid climate in every three or four years; green manuring with legume crops is an excellent practice.

7. Olive irrigation management

Water management in orchards is critical for tree uniformity and sustained high yields of superior quality. Olives are considered drought tolerant but olives do not produce well without proper irrigation. Critical stages for olives are: 1) two to three weeks before flowering (March-April) 2) Immediately after flowering and fruit setting (May-June)3) At pit hardening (July-August), and 4) When the fruit reaches its full size and fruit turns color (September). Tables (8, 9) show the irrigation requirements in liter per tree per day according to tree ages and the frequency of irrigation as recommended by Mohamed and Saad Eldin, 2002.

Table 8 Water consumptive use (l/tree/day)

Tree age (year)	Irrigation amount (l/tree/day)		
	November, December, January, February	March, October	April- September
1	10	20	30
2	20	30	40
3	25	40	50
4	30	50	60
5	35	60	70
6	40	70	80
> 6	50	80	100

Table 9 Irrigation Frequency

November, December, January, February	2 times/week
March, April, September, October	3 times/week
May, June, July, August	6 times/week

Important points to be considered are 1) irrigate at critical stages of plants, 2) irrigate when plants show wilting symptoms in the morning time, and 3) use auger to find out the depth and area moistened with water. Calculate the time required to moisten whole root zones or soil area in each plot by using auger, keep records and irrigate accordingly next time.

Sandy soils have little capacity to retain water for use, approximately 4-5 % of their volume, while heavy soils can provide up to 15 and 17%. Sandy soils become saturated with low quantities of water (400 to 500 m3 /ha per irrigation) and thus require frequent irrigation, whereas heavy soils require more water (1000 to 1200 m3 / ha per irrigation) and hold moisture for longer period of time. Irrigation in heavy soils should be given for long time until water reaches quite deep to the root zones. Water permeability in heavy soils is slow and in sandy soils it is rapid.

Permeability is the velocity of penetration of water, while the capacity is represented by the depth dampened by given quantity of water. A close attention should be given to the depth of penetration of water while irrigating the grove and a good irrigation system for proper distribution of water over the surface should be adopted. Invisible irrigation under the soil surface is more important that the visible soil surface.

8. Harvesting

Olive harvesting is one of the most important practices done for olive production throughout the growing season. Maturation is a long, slow process that extends over several months. The optimum harvesting time and method should meet the following objectives(as recommended by FAO, 2010); fruit must have the highest amount of oil production of best quality, table olives must be at the right stage of ripeness for processing as black or green olives, olive trees must receive as little damage as possible and harvesting must be cost-effective. Ripening in olives is characterized by increased fruit size and a change of skin color which turns from green to yellow then to a reddish-violet and finally to a deep violet. Olive harvesting should be done when the fruit color changes from dark green to pale green and of about 50% reddish-violet coloration (maturity indices should be done), because fruits at this stage attain the highest content of best quality oil and anti-oxidants. The method used to harvest olives depends on cultural technique, tree size and shape, and orchard topography. Hand harvesting (picking) and mechanical harvesting are common. El Attar *et al*. 2004 concluded that the shaker harvester must be designed to apply various frequencies with the ability of changing shaking amplitude.

9. Implementation:

The classes and its attributes were developed. All information was transformed into rules, demons, when changed, and when needed methods. Figure 4 shows an example of class 'Soil' and its attributes. All olive cultivars suitable for cultivation in Egypt were stored as instances of class Olive cultivar. Each instance is a record in the database. Figs (4, 5) show examples of instances of class 'Olive cultivar' and 'Governorate'.

```
CLASS Soil
 WITH Salinity COMPOUND
  Neutral
 WITH PH NUMERIC
 WITH Permeability NUMERIC
 WITH Texture COMPOUND
 WITH Sand particles percent NUMERIC
  REINIT 0
  SEARCH ORDER CONTEXT WHEN NEEDED RULES QUERY DEFAULT
 WITH Silt particles percent NUMERIC
 WITH Clay particles percent NUMERIC
 WITH Soil texture report STRING
 WITH PH report STRING
 WITH Nitrogen percent NUMERIC
 WITH Phosphorous percent NUMERIC
 WITH Potassium percent NUMERIC
 WITH Organic matter percent NUMERIC
 WITH Water soluble salt in g per kg NUMERIC
 WITH chemical properties report STRING
```

Fig. 4 Class soil and its attributes

```
INSTANCE Olive Cultivar 5 ISA Olive Cultivar
 WITH Name: = "Hamed"
 WITH Oil percent: = "16-19"
 WITH Ripening time: = "Sept. - Nov".
 WITH Recommended cultivation area: = "Fayoum, Siwa"
 WITH Purpose: = "table"
 WITH Size: = "medium"
 WITH weight: = "5-8"
```

Fig. 5 Instance of class olive cultivar and its attributes

INSTANCE Governorate 10 ISA Governorate
WITH Name: = "Giza"
WITH Latitude: = 30.02
WITH Longitude: = 31.13
WITH Elevation: = 22.5
WITH Mean Temperature: = 22.8
WITH Relative Humidity: = 53
WITH Wind Speed: = 8.13
WITH Potential Sunshine Hours: = 9.5

Instance of class Governorate and its attributes Testing:

The expert system is tested during and after the completion to ensure that it gives recommendations as those of human expert. To achieve this goal a different scenarios has been tested by human expert and the scenarios used as input to the expert system. The recommendations were compared and they agree with each other. Therefore; OPES is recommended to be used by extension specialist and farm owner to improve the management practices which will reflect on the improvement of farmers socially and economically. It also could be used as training tool. Moreover, it recommended to extend the OPES to cover the training and pruning, propagation practices and disease and pest management.

RESULTS AND DISCUSSION

The olive production expert system OPES is developed by the use of LEVEL5 Object tool kit. The expert system covers management practices for establishing a new orchard and for the existing ones. These practices include; site selection, land preparation, grove design, cultivar selection, fertilization, irrigation and harvesting. For site selection, information about the Egyptian governorates; name, latitude, longitude, elevation mean temperature, relative humidity, wind speed, and potential sunshine hours; were stored as instances of class 'governorate' in the database. Also olive cultivars suitable for Egyptian condition were stored as instances of class 'olive cultivar'. The attributes of cultivar; name, oil percent, ripening time, recommended cultivation area, purpose, fruit size and fruit weight represent the fields in the database. The expert system starts by title display (Fig. 5) which have a push button labeled Info when clicked a message appear that give information about the benefits of olive (Fig. 6). Then, when the continue button clicked, the main input display appears (Fig. 7) it has a group of button labeled by a name of one of the management module that OPES will cover. The user select the button and the associated display appear. If the user click site selection button, the display in figure 10 appear. After the user input the required data the conclusion display appears (Figs 8 and 9); that gives the final recommendation practices as proposed by the expert system.

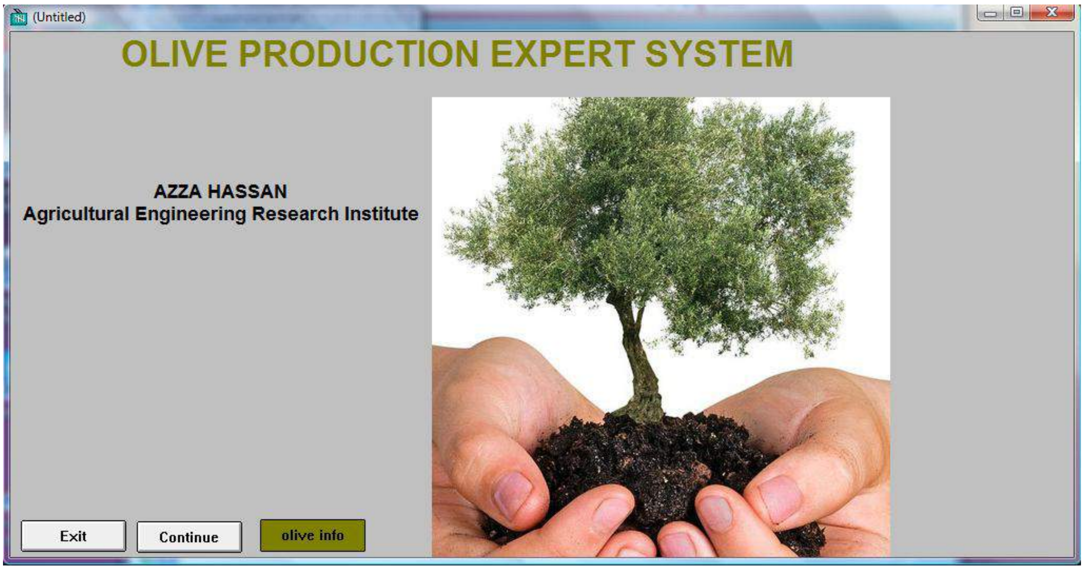

Fig. 5. Title display

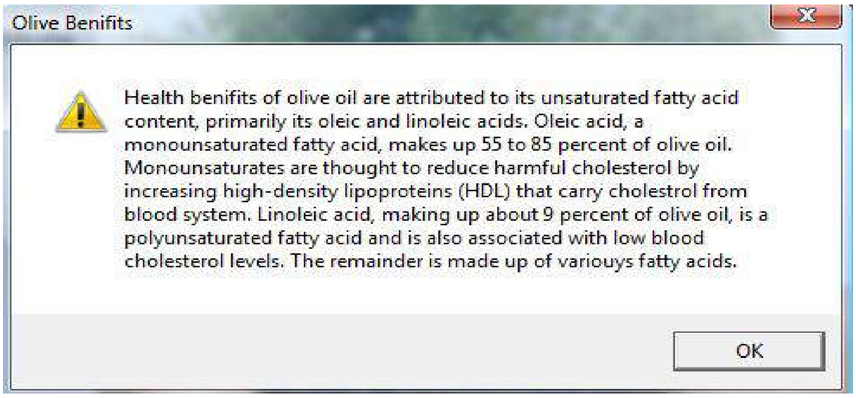

Fig. 6. Olive benefits window

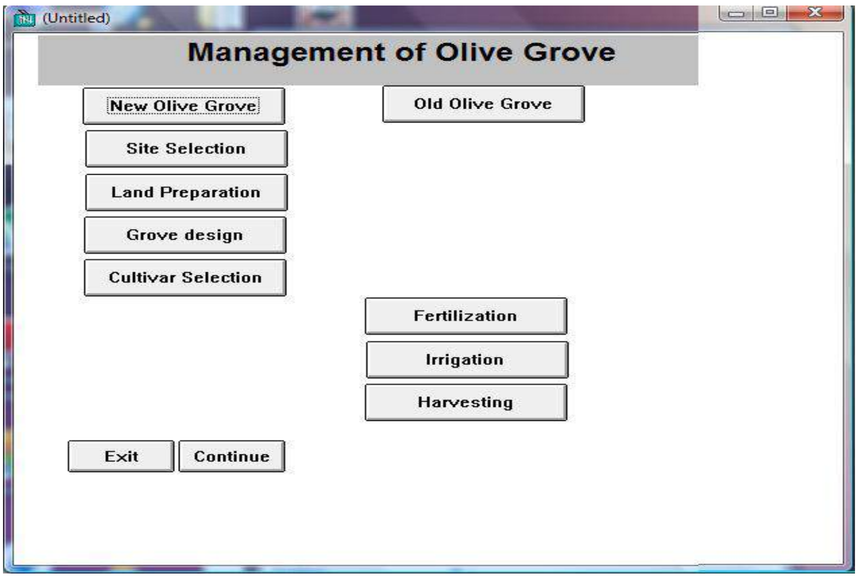

Fig. 7. Main input display

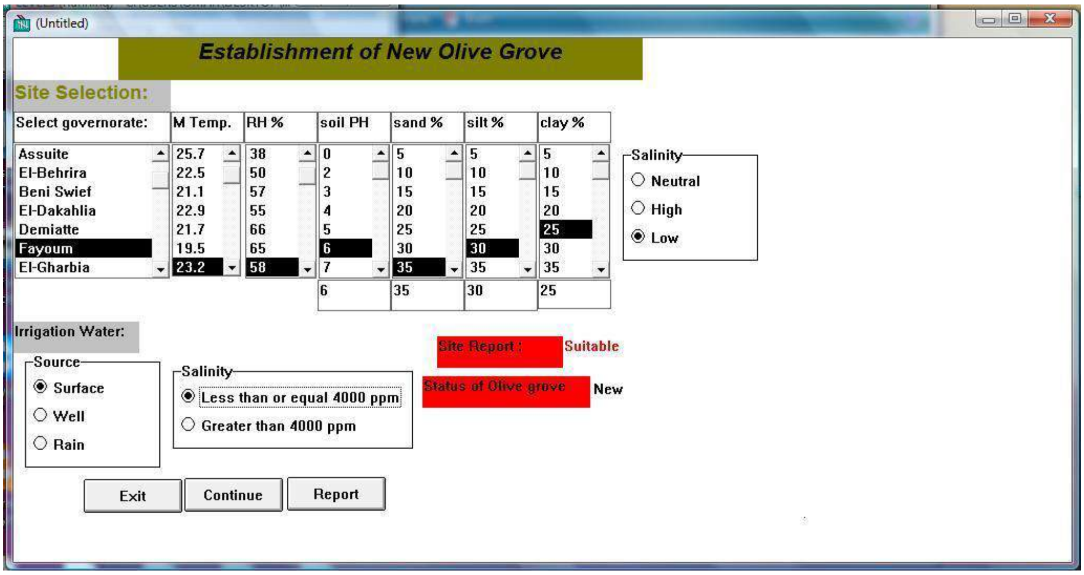

Fig. 8. Site selection display

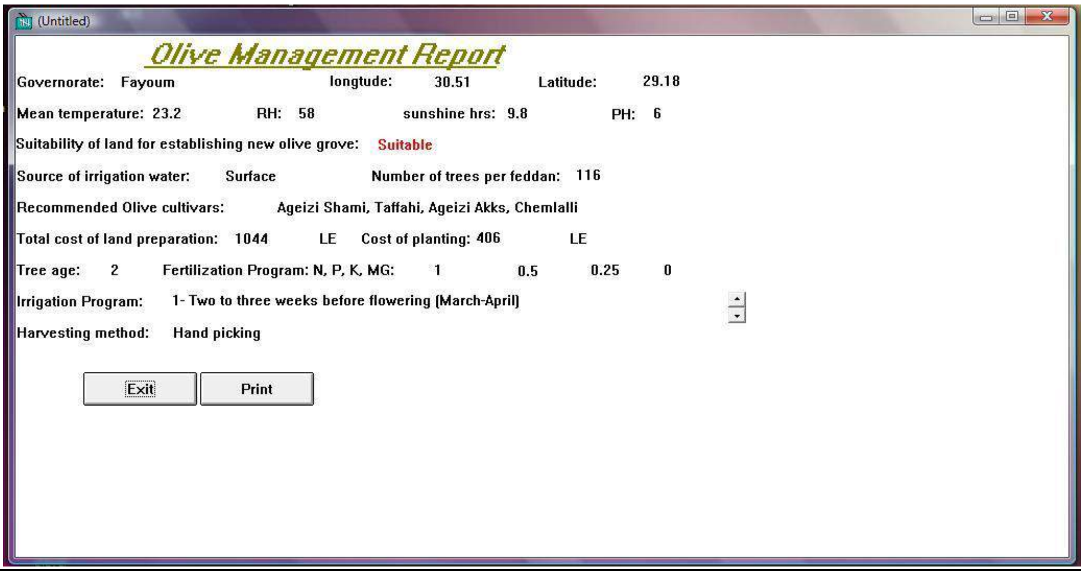

Fig. 9. Olive management output report

CONCLUSION

Farmers and farm owners should be better informed so that they make better decisions and develop policies based on evidence leading to economic and social enhancement of rural livelihood of the poor. Agricultural information professionals would be able to ensure their work has more impact and to work together more effectively. The olive production expert system developed in this work is a step to gather information about olive production in a way that would be useful for farmers and farm owner to improve their productivity. It covers some of the management practices related to olive production. OPES can give recommendation about site selection for a new orchard, land preparation, cultivar selection according to site conditions, land preparation before planting, grove design, fertilization recommendations, irrigation and harvesting. The expert system was verified and validated during development and after completion. The intended user for the expert system are farmer, farm owner and extension specialist in cooperatives to be able to have better management decisions based on information. It is recommended to extend the work to cover training and pruning, propagation, disease and pest control.

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نظام خبير لإنتاج الزيتون

عزة حسن

معهد بحوث الهندسه الزراعيه – مركز البحوث الزراعية – دقى - جيزه

تنتشر زراعة الزيتون فى العديد من دول العالم وخاصة المطلة على حوض البحر الأبيض المتوسط. فشجرة الزيتون إقتصادية تتميز بإنتاجها الوفير ولكن يلزم الإهتمام بالمقومات الأساسية التى تهيئ للأشجار الظروف المثلى للنمو والاكثار. ولشجرة الزيتون استخدامات عديدة منها الاستهلاك الغذائى للثمار واستخلاص الزيت للاغراض الغذائية والصناعية والطبية. وبالرغم ان مصر تنتج اعلى انتاجية/هكتار على المستوى العالمى فان اجمالى الناتج من الزيتون لا يكفى القدرة التصنيعية الموجودة لدينا بالفعل. ومع وجود العديد من الأبحاث الخاصة بانتاج الزيتون فى مصر إلا انه لم تتم الإستفادة منها بشكل جيد بما ينعكس على زيادة انتاج الزيتون من حيث الكم والنوع كمحصول استراتيجى يساعد على زيادة الدخل القومى بزيادة الصادرات من الزيت والثمار المصنعة وبالتالى تحسين مستوى معيشة الفرد والمجتمع.

لذا كان الهدف من البحث هو بناء نظام خبير لانتاج الزيتون يجمع العديد من الخبرات ونتائج البحوث السابقة والنشرات العلمية بصورة يمكن االاستفادة منها، كما انه يبرز النقاط التى تحتاج إلى المزيد من البحث. ويشمل النظام الخبير افضل التوصيات الخاصة بإنشاء البستان وإختيار الأصناف حسب ظروف المزرعة وإعداد الأرض بالإضافة الى إدارة البستان من حيث التسميد قبل وبعد وأثناء الزراعة وكذلك مواعيد الزراعة وجدولة الرى والحصاد.

وتم بناء قاعدة بيانات لاصناف الزيتون الموجودة فى مصر وخصائصها من حيث الشكل والحجم والوزن ونسبة الزيت والغرض منها، والأماكن التى تجود زراعتها بها، كما تم عمل قاعدة بيانات لمحافظات مصر ونوعية الأراضى بها وخصائصها وتم ربط تلك القواعد بالنظام الخبير.

وقد اتبعت الطريقة التقليدية فى بناء النظام الخبير من تعريف المشكلة وتحديد وسيلة البرمجة والمعلومات اللازمة لحل المشكلة وتحديد العناصر الرئيسية وخواصها وتحويل العلاقات بينها الى مجموعة من القواعد لتكوين النظام الخبير. وتم اختبار النظام أثناء البناء وبعد الإنتهاء منة للتأكد من سلامة توصياتة. واظهرت اختبارات النظام الخبير انها تتفق بشكل جيد مع توصيات الخبير الفعلى(Domain expert).

EMISSION OF GREENHOUSE GASES FROM APPLIED NITROGEN RATES FOR TOMATO UNDER DIFFERENT NET COLORS

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Abstract

This study investigated the effects of different net color (white, yellow, red, blue and black) for covering greenhouses and nitrogen levels (82, 164 and 245 kg N/feddan) on the growth and production of tomato plants in terms of air temperature, relative humidity, plant growth early and total yield. The trial was carried out during two growing summer seasons of 2013 and 2014 at El-Bossily farm, Central Laboratory for Agricultural climate, Agricultural Research Center, El-Behira Governorate- Egypt.

Using black and blue net led to decrease maximum temperatures and increased relative humidity compared with white net cover. The use of white or yellow net resulted in a significant increase of the number of leaves, total leaf area, fresh and dry weight of tomato plants compared to other treatments.

Regarding the nitrogen treatments, increase nitrogen level from 120 to 360 ppm led to increase tomato plant growth and productivity during the two tested seasons. Using of net color and nitrogen rates was significant on the nitrogen (N) phosphor (P) Potassium (K) content of tomato plant. The highest NPK in tomato fourth leaf were obtained by white and yellow net combined with 360 ppm of nitrogen during the both seasons. This paper suggests using white or yellow net cover combined with 360 ppm of nitrogen for tomato production during the summer season.

Moreover, the greenhouse gas emissions (N_2O and CO_2) from fertilization increased but the emission rates (kg CO_2/kg yield) were decreased by increasing N rate due to the highest tomato production. The highest yield with low emission was obtained by 120 ppm (82 kg N/ Feddan).

Keywords: Early and total yield, screenhouse, microclimate and vegetative growth.

INTRODUCTION

The colored net introduces additional benefits, on top of the various protective functions of nettings especially during the summer season. The role of screen net is scattering the transmitted light (Zakher ***et al*., 2014**). The colored net cover includes absorbing spectral bands shorter, or longer than the visible range. The spectral manipulation is aimed at specifically promoting physiological responses, while light scattering improves light penetration into the inner canopy **(Rajapakse and Shahak, 2007).** Application of proper management practices to enhance vigorous early growth is very important to achieve higher plant yield under the net house (**Caliskan *et al*., 2004**). Improved management includes enhance soil properties, optimum plant seeds, proper fertilize application rate and timely harvesting. The optimizing of plant density is one of the most important subjects of tomato production management, because it affects to seed cost, plant development, yield and quality of the crop (**Abdrabbo *et al*., 2010**). Although cover of greenhouse by net (screenhouse) have been used for many years, but it is still requires increased understanding of the domintated climate for each region and proper net house color for each region (**Abdrabbo *et al*., 2013**).

The high temperatures during summer season determine the vegetative growth of the plants and damage their floral induction (**Zakher and Abdrabbo, 2014**). The interactions between the temperature and the light under screenhouse are the key factors to plant growth. In order to relief the negative impacts of high temperatures during the plant growth period, many growers use greenhouse covered with dark color net where the microclimate offers conditions closer to the ideal microclimate (**Abdrabbo *et al*., 2015**). **Saleh (2005)** mentioned that the new plant leaves placed in the upper part of the plant can be cause to light inhibition, whereas those placed in the lower portion of the plant did not reach the ideal light intensity of photosynthetically active photons. According to this fact, a higher amount of diffused light in the environment could be thought, even if the total amount of photosynthetically active photons were kept in order to benefit the cultivation either by light inhibition or by increasing the amount of light intensity received by the lower-positioned leaves (**Iglesias and Alegre, 2006**). As a consequence, a higher technology in the microclimate is required. Among the problems that affect this cultivation, the low temperatures during the summer and the excess of temperature and solar radiation in summer (**Saleh, 2005**). Large inputs of mineral fertilizer especially nitrogen (N) are routinely used to maintain the high yield of crops. Nitrogen not recovered by crops which can cause environmental pollution. The detrimental impacts of nitrate loss from the soil have toxicological implications for animals and humans and also on the environment leading to the eutrophication of freshwater (**Camarguo and Alonso, 2005**).Inappropriate nutrient application and management might lead to nutrient imbalances and low plant growth. There is no apparent difference in growth of plant seedlings in early growth stage from higher fertilizers application compared to the other lower rates. However, later in the season, higher rate of nitrogen fertilizer application usually increased the amount of vegetative growth and total yield, then sufficient application of nitrogen fertilizers during the growing season improve the fruit yield (**Abdrabbo *et al*., 2005).**The objectives of this study are investigating the growth and productivity of tomato plant by using different net cover colors and nitrogen rates.

MATERIALS AND METHODS

The experiment was carried out in the two successive summer seasons of 2013 and 2014 under net house at El- Bossily Protected Cultivation Experimental Farm, Central Laboratory for Agricultural Climate, Agricultural Research Center, at El-Behaira Governorate, Egypt. The treatments comprised five greenhouse net covers (white, yellow, red, blue and black) and three nitrogen levels 120 (82 kg N/Feddan), 240 (164kg N/feddan) and 360 ppm (245 kg N/feddan). The dimensions of each greenhouse were 9 m width x 60 m length x 3.5 m height. Five raised beds in each greenhouse (60m width and one meter width). Two rows of tomato seedlings (***Solanum** Lycopersicon L.* Mill. GS **F1 hybrid**) were cultivated in March, 17, 2013 and March, 24, 2014 for first and second seasons, respectively. The distance within each two tomato plants was 0.50 m.The experiment was designed in a split plot arrangement with three replicates. Greenhouse net color treatment was in the main plots, nitrogen rate was allocated in the sub plot.

Tomato plants were irrigated using drippers of 4 l/hr discharge. The chemical fertilizers were injected within irrigation water system by using small fertilizer tanks for each nitrogen level. Samples of five plants of each experimental plot were taken to determine growth parameters at the end of season as follows (number of leaves per plant, total leaf area, fresh and dry weight, early and total yield per plant. For mineral analysis, dried the youngest mature leaves were digested in the sulphuric acid and hydrogen peroxide digestion according to the method described by **Allen (1974)**. Total nitrogen was determined by Kjeldahl method according to the procedure described by **FAO (1980).** Phosphorus content was determined using spectrophotometer according to **Watanabe and Olsen (1965)**. Potassium content was determined photo-metrically using Flame photometer as described by **Chapman and Pratt** (1961). The permanent wilting point (PWP) and water field capacity (FC) of the each trial were determined according to **Israelsen & Hansen (1962).** The soil chemical and physical properties results were tabulated in Tables (1). Maximum and minimum temperature and humidity were measured under different net color treatments every day. Average relative humidity (RH %) have been measured daily by Digital thermo hygrograph. Maximum and minimum temperature was measure used thermometer (model, 5458 Fetcher, NC 28732) . Statistical analysis was determined by using SAS program. The differences among means for all traits were tested for significance at 5 % level according to the procedure described by **Snedicor and Cochran (1981).** All other agriculture practices of tomato cultivation were in accordance with standard recommendations for commercial growers by the Ministry of Agriculture, Egypt.

Estimation of Greenhouse Gas Emission from applied Nitrogen Fertilization

The aerobic microbial oxidation activity of ammonia to nitrate is called nitrification, while denitrification is the reduction of nitrate to nitrogen gaseous (N_2). Both reactions produce the intermediate gaseous nitrous oxide (N_2O) through microbial activities in the soil and eventually this gas is released to the atmosphere. The
emission of N_2O from field was estimated according to **Millar *et al.* (2010)**; the following equation was adopted:

N2O emission = [1.47 + (0.01x F)] x N2OMW x N2OGWP

Where:

F Mass of N applied from synthetic fertilizer, kg N ha−1

N2OMW Ratio of molecular weight of N2O to 2N, kg N2O (kg N)−1

N2OGWP Global Warming Potential for N2O, kg CO2-e (kg N2O)−1

The GWP value of 298 for N_2O used in the protocol (N2OGWP) is the 100-year value used in the most recent IPCC fourth assessment report (**Forster *et al.*, 2007**). The CO_2-e equivalent emission for each gas (CO_2, N_2O and CH_4) were summed together to give total CO_2-e.

Table (1): Physical and chemical properties of experimental soil at El-Bossily farm

Parameters		Units	Values
Physical properties			
	FC	(%)	16.4
	WP	(%)	8.2
	BD	(g cm^{-3})	1.32
	OM	(%)	0.30
Particle size fraction			
	Sand	(%)	71.0
	Silt	(%)	26.6
	Clay	(%)	2.4
	Texture		Sandy
Chemical properties			
	pH (H_2O)	-	7.75
	EC	(ds m^{-1})	1.25
Major cations			
	Ca^{++}	(meq l^{-1})	2.74
	Mg^{++}	(meq l^{-1})	2.11
	Na^{+}	(meq l^{-1})	6.64
	K^{+}	(meq l^{-1})	0.9
Major anions			
	CO_3^{--}	(meq l^{-1})	0.0
	HCO_3^{-}	(meq l^{-1})	1.73
	Cl^{-}	(meq l^{-1})	4.50
	SO_4^{--}	(meq l^{-1})	6.10

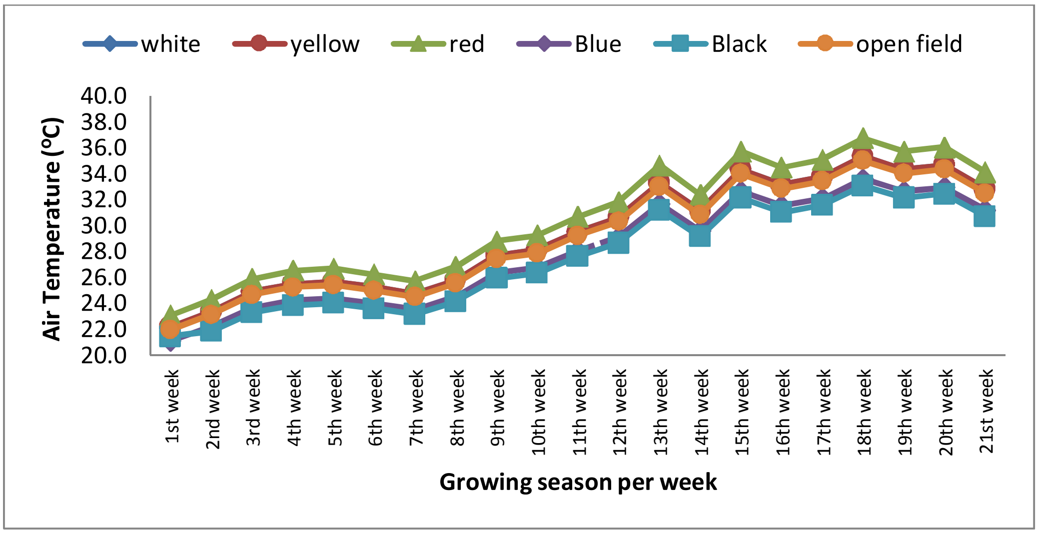
FC: Field Capacity; WP: Wilting Point; BD: Bulk Density; OM: Organic Matter; EC: Electrical Conductivity; Ca: Calcium; Mg: Magnesium; Na: Sodium; K: Potassium; CO_3: Carbonate; HCO_3: Bicarbonate; Cl: Chloride; SO_4: Sulfate.

RESULTS AND DISCUSSION

Climatic data

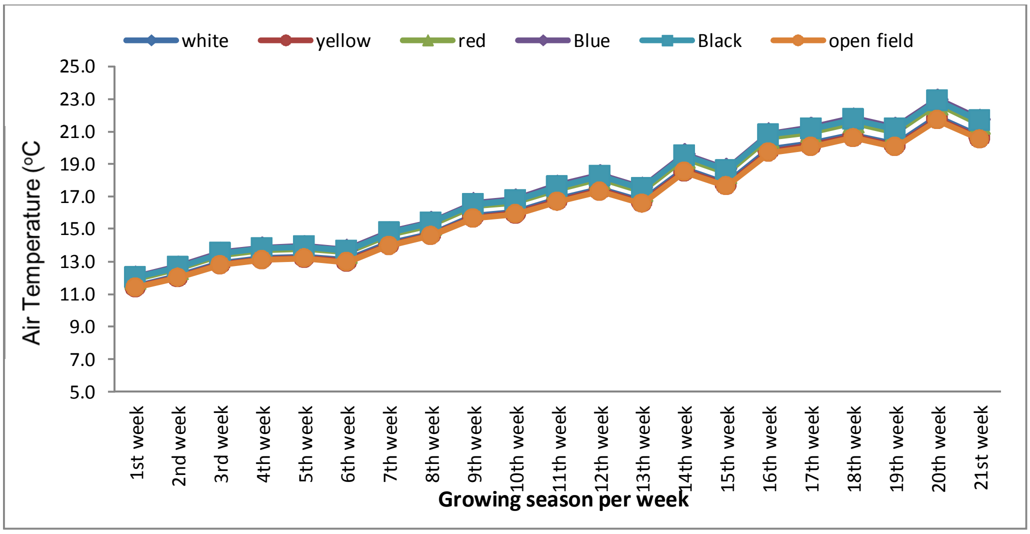
Average weekly air temperatures under different net colors as well 2013 and 2014 summer seasons showed that the use of nets affected the air temperature under tested greenhouses (Fig. 1). The higher temperature was recorded by the red net cover treatment followed by white net, while the lowest maximum temperature was recorded in black net greenhouse. Maximum temperatures tended to be lower under the blue and black net by 1- 2°C in comparison with red net cover, due to under red color more interception of solar radiation which is greater than the gain of temperature caused by the use of color nets due to their role in the interception of air circulation.

Fig. (1): The average maximum air temperature (°C) under different color net and open field during the two studied seasons (2013 and 2014).



Bigger differences were recorded on the growing seasons .The air temperature were decreased during the growing season during April, May, June and July in comparison with end of March (cultivation date was second half of March in the two seasons). Similar results were reported by **Zakher and Abdrabbo., (2014),Abdrabbo *et al*., (2010), Elad *et al.,* 2007,** who mentioned that the influence of cover net (screenhouse) upon maximum temperatures under different net cover, they found black or blue net were decreased the air temperature under greenhouse in comparison with other net cover. The low temperature had the same trend (Fig.2).

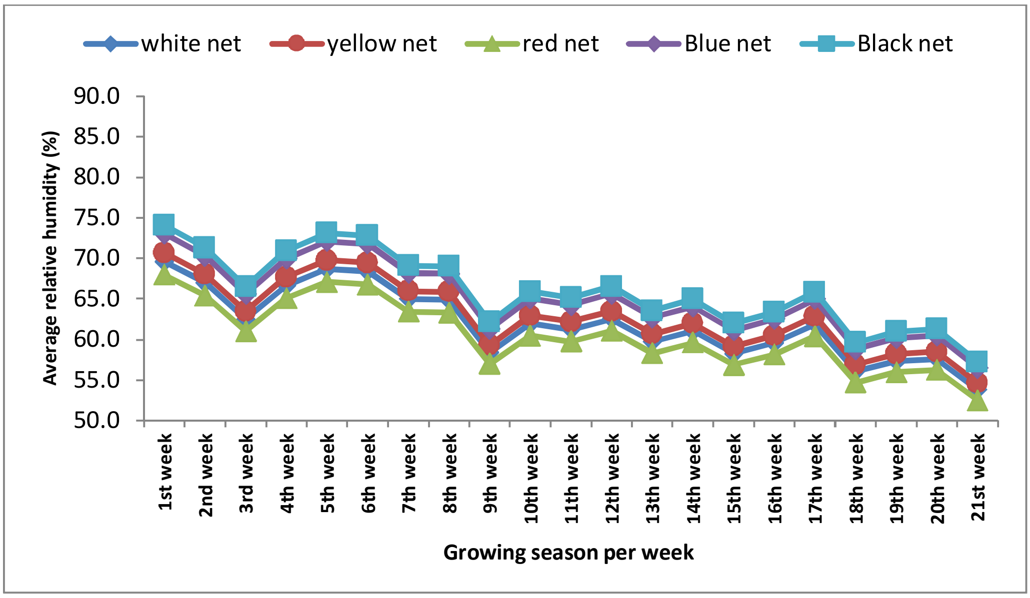
Fig. (2): The average minimum air temperature (°C) under different color net and open field during the two studied seasons (2013 and 2014).



Average relative humidity was increased by the use of black net color by 2-4% compared to red net color during the two seasons (Fig. 3). These results were accepted with **Elad *et al*.,**

(2007) who indicated 2-6% increase in relative humidity associated with the use of nets. The same authors also reported a decrease in evaporation associated with the use of nets and a significant reduction in wind speed. **Campen and Bot (2003)** explained the ventilation phenomenon. The pressure difference over the openings of net was one of the driving forces for good ventilation, which could be due to the air temperature difference over the openings.

Fig. (3): The average relative humidity (%) under different color net and open field during the two studied seasons (2013 and 2014).



Vegetative characteristics

The obtained results in Table (2) revealed that the net colors significantly affected tomato vegetative characteristics (i.e. number of leaves, total leaves area and fresh and dry weight per plant) in the two growing seasons. The white net treatments were produced the highest vegetative characteristics for *tomato* plants during the two studied seasons. The yellow net came in the second order followed by red net, while black produced the lowest vegetative characteristics. Increasing vegetative characteristics under white greenhouse cover net could be due to the suitable climatic conditions for tomato plants under the white net cover during summer season. The greenhouse cover net (regardless of color) led to diffuse light and then increase radiation use efficiency and even be a factor affecting plant growth (**Abu lSoud *et al.*, 2014, Farag *et al.*, 2014, Abdrabbo *et al.*, 2013 and Farag *et al.*, 2010).** Shade netting scatter solar radiation rays, especially ultraviolet because netting is usually made by using ultraviolet-resistant materials **(Wong, 1994). Nissim-Levi *et al.*, (2008)** added that cover net that increases light scattering but does not affect the light intensity has been shown to increase vegetative growth due to increase the physiological photosynthesis process.

Table 2: Vegetative characteristics of tomato plants under different net colors and nitrogen levels during 2013 and 2014 seasons.

Season	1st season				2nd season			
Treatment	N1	N2	N3	Mean A	N1	N2	N3	Mean A
Total leaf area (cm^{-2})								
NC-W	5367f	5801c	6578a	5915A	5206f	5627c	6381a	5738A
NC-Y	5098h	5621d	6280b	5666B	4945h	5453d	6091b	5496B
NC-R	4635j	5262g	5502e	5133C	4496j	5105g	5337e	4979C
NC-B	4336k	4784i	5203g	4784D	4205k	4641i	5047g	4640D
NC-K	4344k	4793i	5213g	4774D	4214k	4650i	5057g	4631D
Mean B	4756C	5252B	5755A		4613C	5095B	5582A	
No. of leaves per plant								
NC-W	39.0ab	39.0ab	39.7a	39.2A	41.0ab	41.0ab	41.7 a	41.2A
NC-Y	36.0c	37.0bc	38.3ab	37.1B	38.0c	39.0bc	40.3ab	39.1B
NC-R	31.0d	31.3d	35.0c	32.4C	33.0d	33.3d	37.0c	34.4C
NC-B	27.0f	27.7ef	29.3de	28.0D	28.0f	28.7f	30.7e	29.1D
NC-K	19.7h	24.0g	26.3f	23.3E	20.7h	25.0g	27.3f	24.3E
Mean B	30.5C	31.8B	33.7A		32.1C	33.4B	35.4A	
Fresh Weight (g $plant^{-1}$)								
NC-W	198.3c	194.7d	220.7a	204.6b	188.25c	184.92d	209.70a	194.29a
NC-Y	171.3g	188.3e	211.0b	190.2b	162.52h	179.20e	200.17b	180.63b
NC-R	155.7i	176.7f	184.7e	172.3c	147.74j	167.76g	175.38f	163.63c
NC-B	145.3j	160.7h	174.7f	160.2d	138.21k	152.51i	165.85gh	152.19d
NC-K	145.3j	160.7h	174.7f	160.2d	138.21k	152.51i	165.85gh	152.19d
Mean B	163.2C	176.2B	193.1A		154.99	167.38B	183.39A	
Dry Weight (g $plant^{-1}$)								
NC-W	23.87ef	25.80c	29.27a	26.311A	22.93ef	24.78c	28.10a	25.269A
NC-Y	22.70h	25.00d	27.97b	25.222B	21.78h	24.01d	26.82b	24.202B
NC-R	20.63j	23.40f	24.47d	22.833C	19.79k	22.48fg	23.48de	21.917C
NC-B	19.30k	21.30i	23.10g	21.444D	18.52l	20.44j	22.20gh	20.597D
NC-K	19.23k	21.90i	23.20g	21.233D	18.47l	21.02i	22.30gh	20.386D
Mean B	21.15C	23.48B	25.60A		20.298	22.543B	24.581A	

N1: Nitrogen level (82 kg N/Feddan); N2: Nitrogen level (164 kg N/feddan); N3: Nitrogen level (245 kg N/feddan*); NC: Net cover; W: White; Y: Yellow; R: Red; B: Blue; K: Black. Small letters compare between interaction: Means followed by the same letter are not significantly different at P< 0.05. Capital letters compare between main factors: Means followed by the same letter are not significantly different at P< 0.05. *Feddan = 4200 m2

Colored nets can also increase light scattering and this alone may affect plant growth. On the other hand, black or blue net reduce radiation reaching crops underneath. Obviously, the higher the shade by using dark net color, the more radiation will be blocked. Reductions in radiation resulting from net cover will affect the climatic conditions under net and then reduce the plant growth (Stamps, 2008). The nitrogen rate treatment indicated that, using 360 ppm of nitrogen led to increase vegetative growth of tomato followed by 240 ppm; while using 120 ppm gave the lowest tomato vegetative growth during the two seasons. Regarding the interaction among the net cover color and nitrogen rate revealed that using white cover combined with 360 ppm led to increase vegetative growth; whereas, using black cover combined with 120 ppm of nitrogen gave the lowest vegetative growth of tomato. These results agreed with Abdrabbo *et al.*, (2005) who concluded that increase nitrogen level led to improve plant growth and number of fruits per plant.

These results might be due to adequate availability of N in the nutrient solution which might lead to improve physiological processes, better uptake of nutrients and higher rates of photosynthesis, which might reflected on more plant growth (Nerson *et al*., 1997).

Early and total yield

Table (3) showed that all tested treatments were have significantly effect on the parameters of early and total yields and fruit weight of tomato plants which protected under greenhouse by using white, yellow, red, blue and black. The highest tomato yield was obtained with white and yellow net followed by red net, while the lowest tomato production was obtained under black net. These results might be due to the favorable effect of light intensity and temperature during the period of growth and reproduction process which possessed much vegetative growth as mentioned before that induce more photosynthetic rates. On the contrary, the lowest previous parameters were obtained with those plants grown black net because of the low radiation and then low photosynthesis process. The proper net can reduced crop transpiration and thus water uptake, and improved water use and moisture availability in the soil which might have increased various physiological processes, better plant nutrient uptake, higher rates of photosynthesis, which might reflect on more number of fruits and higher fruit weight (Farag *et al.,* 2014, Farag *et al*., 2010, Abdrabbo *et al.,* 2009 and Ngouajio *et al*., 2007). Furthermore, the reduction of radiation is responsible for down-regulation of photosynthetic capacity of leaves and consequently a lower light saturated photosynthetic rate compared to the control (Farag *et al*., 2013 and Medany *et al.* 2009). The nitrogen rate treatment indicated that, using 360 ppm of nitrogen led to increase early and total yield of tomato followed by 240 ppm; while using 120 ppm gave the lowest early and total yield during the two seasons.

Table 3: Early and total yield of tomato plants under different net colors and nitrogen levels during 2013 and 2014 seasons.

Season	1st season				2nd season			
Treatment	N1	N2	N3	Mean A	N1	N2	N3	Mean A
Early Yield								
NC-W	0.77f	0.89cd	1.10a	0.91A	0.68e	0.78c	0.98a	0.81A
NC-Y	0.73h	0.87d	1.05b	0.88B	0.65f	0.78c	0.93b	0.78B
NC-R	0.63k	0.75g	0.79e	0.72D	0.57i	0.67e	0.70d	0.65D
NC-B	0.62l	0.71i	0.89c	0.74C	0.55j	0.63g	0.79c	0.66C
NC-K	0.52m	0.61l	0.67j	0.60E	0.47k	0.55j	0.54h	0.54E
Mean B	0.65C	0.77B	0.90A		0.58C	0.68B	0.80A	
Total Yield								
NC-W	2.33F	2.67CD	3.34A	2.78A	2.07F	2.38CD	2.97A	2.47A
NC-Y	2.22H	2.66D	3.18B	2.69B	1.97H	2.37D	2.83B	2.39B
NC-R	1.94K	2.30G	2.40E	2.21D	1.73K	2.04G	2.13E	2.00C
NC-B	1.88L	2.17I	2.70C	2.25C	1.68L	1.93I	2.40C	1.97D
NC-K	1.59M	1.87L	2.03J	1.83E	1.41M	1.67L	1.81J	1.63E
Mean B	1.99C	2.34B	2.73A		1.77C	2.08B	2.43A	

N1: Nitrogen level (82 kg N/Feddan); N2: Nitrogen level (164 kg N/feddan); N3: Nitrogen level (245 kg N/feddan*); NC: Net cover; W: White; Y: Yellow; R: Red; B: Blue; K: Black. Small letters compare between interaction: Means followed by the same letter are not significantly different at $P< 0.05$. Capital letters compare between main factors: Means followed by the same letter are not significantly different at $P< 0.05$. *Feddan = 4200 m2

Regarding the interaction among the net cover color and nitrogen rate revealed that using white cover combined with 360 ppm led to increase early and total yield; whereas, using black cover combined with 120 ppm of nitrogen gave the lowest early and total yield of tomato during the both seasons. Decrease tomato yield under low nitrogen level may be because of the stress due to the low nutrient element concentration, in the root zone area, led to reduce number of fruit per plant and total fruit weight (abdrabbo *et al*., 2005). The effects of nutrient supply on yield response are often a reflection of sink limitations imposed by either a deficiency or an excessive supply of nutrients during certain critical periods of plant development (Farag *et al*., 2013 and Marschner, 1995).

Leaf elementals content

The obtained results in Table (4) showed that the net color and nitrogen rate treatments significantly affected the percentages of NPK by tomato leaf during the two growing seasons. The white net color increased the NPK percentages followed by yellow net, while the lowest NPK content obtained by black net cover. These results were in line with those obtained by Abdrabbo *et al*., (2015), Farag *et al*., (2014), Abdrabbo *et al*., 2013, Farag *et al*. (2010) and Folta and Maruhnich (2007) who concluded that the increasing uptake of NPK by white net may be attributed with increase in soil temperature due to application of greenhouse covers which resulted in improve of air and soil environment around roots of plants, which led to increasing plant growth, and hence increasing nutrient absorption. Moreover, Cooper, (1973) concluded that the optimal temperature conditions in root zone allow for adequate uptake.

Table 4: NPK in fourth leaf of tomato plants under different net colors and nitrogen levels during 2013 and 2014 seasons.

Season	1st season				2nd season			
Treatment	N1	N2	N3	Mean A	N1	N2	N3	Mean A
N content (%)								
NC-W	2.047J	2.447F	2.993A	2.497A	1.947J	2.327F	2.840A	2.371A
NC-Y	1.967K	2.350G	2.873B	2.397B	1.873K	2.233G	2.730B	2.279B
NC-R	1.940K	2.317H	2.830C	2.362C	1.843L	2.200H	2.690C	2.244C
NC-B	1.763L	2.107I	2.573D	2.148D	1.673M	2.000I	2.447D	2.040D
NC-K	1.740L	2.050J	2.537E	2.108E	1.650M	1.943J	2.410E	2.001E
Mean B	1.892C	2.253B	2.761A		1.797C	2.141B	2.623A	
P content (%)								
NC-W	0.353H	0.424D	0.548A	0.441A	0.353H	0.424D	0.548A	0.441A
NC-Y	0.351H	0.407E	0.486B	0.425B	0.351H	0.407E	0.486B	0.416C
NC-R	0.348H	0.392F	0.536A	0.416C	0.348H	0.392F	0.536A	0.425B
NC-B	0.316I	0.377G	0.461C	0.385D	0.316I	0.377G	0.461C	0.385D
NC-K	0.312I	0.387F	0.430D	0.376E	0.312I	0.387FG	0.430D	0.376E
Mean B	0.336C	0.397B	0.492A		0.336C	0.397B	0.492A	
K content (%)								
NC-W	0.323G	0.390D	0.503A	0.406A	1.770H	2.127DE	2.743A	2.210A
NC-Y	0.323G	0.360E	0.447B	0.381C	1.760H	2.043EF	2.437B	2.083C
NC-R	0.320G	0.373E	0.493A	0.391B	1.740H	1.963FG	2.687A	2.130B
NC-B	0.293H	0.350F	0.423C	0.356D	1.587I	1.890G	2.310C	1.929D
NC-K	0.287H	0.357F	0.393D	0.346E	1.560I	1.937G	2.153D	1.883E
Mean B	0.309C	0.366B	0.452A		1.683C	1.992B	2.466A	

N1: Nitrogen level (82 kg N/Feddan); N2: Nitrogen level (164 kg N/feddan); N3: Nitrogen level (245 kg N/feddan*); NC: Net cover; W: White; Y: Yellow; R: Red; B: Blue; K: Black. Small letters compare between interaction: Means followed by the same letter are not significantly different at $P< 0.05$. Capital letters compare between main factors: Means followed by the same letter are not significantly different at $P< 0.05$. *Feddan = 4200 m2

Plant nutrient uptake, plant growth, and yield under mulch fit a quadratic relationship with root zone temperature. Regarding the nitrogen rate, there were significant differences among the treatments during the two seasons. The highest NPK percentages was obtained by high nitrogen level in this study (360 ppm) followed by 240 ppm. Regarding the interaction among net color cover and nitrogen rate, the highest NPK percentages was recorded in white net cover combined with 360 ppm of nitrogen followed by yellow cover net combined with 360 ppm nitrogen during the both seasons. These results agreed with Abdrabbo *et al.* (2005) who mentioned that increasing nitrogen supply enhances cucumber plant growth, and consequently, increases the demand for phosphorus and potassium, which creates favorable conditions for photosynthesis and metabolites translocation.On the other hand, Marschner (1995) explain the decrease of plant growth with decrease nutrient content. Interactions between two mineral nutrients are important when the levels of both are near the deficiency range. Increasing the supply of only one mineral (N) nutrient simulates growth, which in turn can induce a deficiency (P) of the other by dilution effect. At N limitation a faster growth rate can only be achieved by increasing the plant's N concentration (more component required for instance for the photosynthetic machinery), whereas the phosphorylated intermediated can turn over more rapidly, with no need for a major increase in their pool size. Thus, an increase in N availability at low N will be used for building extra machinery (Zandstra and Liptay, 1999).

Greenhouse Gas Emission from Nitrogen Fertilization and Impacts on Warming, Pollution and Plant Yield

The results presented in Table 5 and Fig. 4 showed that the nitrous oxide (N_2O) and carbon dioxide (CO_2) emissions from different applied N rates more increased with increasing nitrogen rate from 82 to 245 kg/feddan. Values of N_2O emission varied from 3.91 to 7.12 kg/feddan; those of CO_2 emission were variable between 1166 and 2123 kg/feddan. The highest tomato yield (15819kg/feddan) with minimum emission rate (73.7 CO2 eq g/kg yield) was found with 82 kg N/feddan treatment. Similar results were obtained by other scientists Cui *et al.* (2012). High application of nitrogen fertilizer resulted in higher N_2O emission and then increase air pollution, therefore the vegetable industry potentially contributes a significant proportion of N_2O emission, with emissions likely to be relatively high on either ‘per unit area’ or ‘per unit production’ basis (Dalal *et al*., 2003). Numerous field studies conducted on nitrogen input gradients in many crop agriculture and found that emissions of N_2O positively correlated well with fertilizer N rate (Drury *et al*., 2008).

CONCLUSION

The present investigation revealed that, using net cover especially white and yellow net are useful for encouraging vegetative growth, early and total tomato yield. This study also recommended the highest nitrogen rate (360 ppm) for produce highest fruit yield, but, this recommendation consider completely wrong in terms of sustainability vegetable production and conserve environment.

Table (5). Greenhouse gas emission from applied nitrogen fertilization

Nitrogen fertilization	Tomato Yield	CO_2 emission		N_2O emission
N Kg/feddan	ton/feddan	g CO_2/Kg yield	CO_2 kg/feddan	N_2O kg/feddan
82	15.82	73.7	1166	3.91
163	18.50	88.9	1644	5.52
245	21.65	98.0	2123	7.12

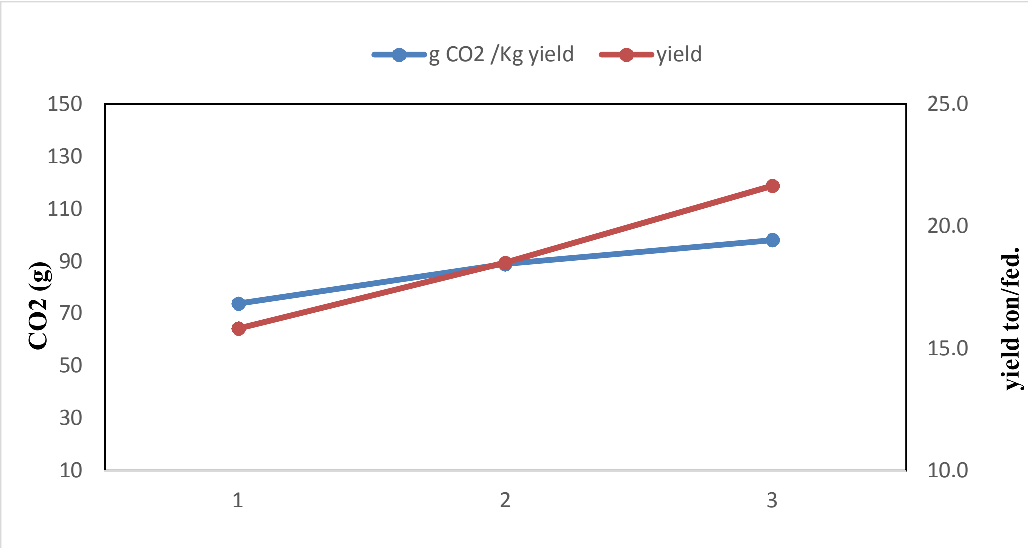


Fig. 4. CO2 emission and total yield under different nitrogen rates (1=82, 2=163 and 3=245 kg/feddan)

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انبعاث الغازات الدفيئة من اضافة معدلات النتروجين للطماطم المنزرعة تحت الوان شبك مختلفة

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1- *المعمل المركزى للمناخ الزراعى- وزارة الزراعة.*
2- *مركز بحوث الرى – وزارة الرى*
3- *معهد بحوث الهندسة الزراعية– مركز البحوث الزراعية .*

اجريت التجربة على نباتات الطماطم المنزرعة تحت الوان الشبك المختلفة (الابيض- الاصفر- الاحمر – الازرق والاسود) مع اضافة معدلات مختلفة من النتروجين (82 – 164- 245 كجم / فدان) . وتم عمل الدراسة خلال موسمى النمو الصيفي 2013 و 2014 فى مزرعة البوصيلى التابعة للمعمل المركزى للمناخ الزراعى- مركز البحوث الزراعية فى محافظة البحيرة جمهورية مصر العربية. وركزت الدراسة على تاثير الوان الشبك المختلفة و اضافة معدلات مختلفة من النتروجين على نمو وانتاج نباتات الطماطم كما تم قياس درجات الحرارة والرطوبة النسبية و نمو النباتات والمحصول تحت هذه الظروف خلال موسمى النمو.

اوضحت النتائج ان استخدام الشبك الاسود والازرق ادى الى انخفاض درجات الحرارة العظمى وزيادة الرطوبة النسبية مقارنة بالشبك الابيض. استخدام الشبك الابيض او الاصفر يعمل على زيادة معنوية في عدد الاوراق والمساحة الاجمالية الاوراق الوزن الطازج والوزن الجاف لنباتات الطماطم مقارنة بالمعاملات الاخرى. كما أدى استخدام معدلات مختلفة من النتروجين من 82 الى 245 كجم / فدان لزيادة نمو النبات والانتاج فى الطماطم خلال موسمى الدراسة

التفاعل بين معاملات الوان الشبك والنتروجين وجد ان اعلى نمو خضرى ومحصول فى معاملة الشبك الابيض او الاصفر مع معاملة النتروجين 245 كجم /فدان فى موسمى الدراسة.

توصى الدراسة باستخدام الشبك الابيض او الاصفر فى انتاج الطماطم خلال فصل الصيف تحت الظروف المصرية.

اما بالنسبة الى انبعاثات الغازات الدفيئة (اكسيد النتروز او ثانى اكسيد الكربون) نتيجة استخدام معدلات مختلفة من النتروجين فقد وجد ان نقص معدل النتروجين يقلل من الانبعاثات فى انتاج الطماطم. واعلى محصول منتج باقل انبعاث من غاز ثانى اكسيد الكربون مع معدل نتروجينى 82 كجم /فدان.

SOME ENGINEERING FACTORS AFFECTING SOLAR DRYING OF DATE

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Abstract

A study was carried out to test and evaluate the effect of three different geometric shapes of green house type solar dryers on drying characteristics of date palm under three different levels of air velocity (0.5, 1, and 1.5 m/sec) compared with natural sun drying method. The studied different shapes were, Quonset shape (SD1), gable-even-span (SD2) and pyramid shape (SD3). High moisture hayani date was dried under two different pre-treatments (peeled date and unpeeled date). The results showed that, the use of solar dryer Quonset shape at 1 m/s of air velocity and peeled date could decrease the drying time by about 31 hours in comparison with the traditional drying method of peeled date which has been taken about 43 hours. The thermal efficiency of different studied dryers was varied and increased with the increase of drying air velocity up to 1 m/s and start to decrease at air velocity of 1.5 m/s. Results of quality evaluation tests revealed a better quality of the dried dates using different shapes of the greenhouse- type solar dryer compared with the natural sun drying method.

INTRODUCTION

Date palm (Phoenix dactylifera L.) is a major fruit crop in most Arab countries. It has been historically connected with sustaining human life and the tradition of the people in the old world as a major agricultural crop. Arab countries possess 70% of the 120 million date palms cultivated in different countries in the world and are responsible for 67% of the global date production (El-Juhany, 2010).

Egypt is one of the main producers of dates with annual production reaching 1,470,000 tons in 2012 as mentioned in UN Food& Agriculture Organization (FAO, 2012). Date production of Egypt alone represents about 21% of the total World production, while Iran, Saudi Arabia and Algeria are among the five leading date-exporting countries (Zaid, 2001). It was found that, in Egypt Hayane variety ranked the second position of production after Meghal variety (M.O.A, 2003).

Dates are highly nutritious and reputed to have many health benefits. They contain more natural sugar than any other fruit and deliver a substantial amount of dietary fiber and potassium. They are unique in supplying phosphorous as well as providing many vitamins and mineral salts (Reilly, 2012). Economically, "Hayani" date is the most important soft cultivar grown in Egypt. It is usually harvested and consumed at Khalal stage when fruits reach full maturity and are crunchy and red color. A considerable percentage of Hayani variety items produced are deteriorate rapidly in quality after harvest due to the high moisture content of soft date which reach above 30% (dry weight). This high level of moisture content lead to fast spoilage due to infestation by microorganisms.

Nowadays, solar energy is an important alternative source of energy. It is relatively preferred to other sources because it is free, abundant, inexhaustible and non-pollutant in nature compared with higher prices and shortage of fossil fuels (Basunia and Abe, 2001).

The drying process is one of the most common applications of solar energy in sunny countries. In most of these areas, the general practice is using natural sun drying. In this method, Field losses are high because the dates are spread on mats in the open air being directly exposed to the sun under heavy attack by various influences, such as rodents, birds, insects and rain. and covering of mats to avoid moisture absorption during night. The use of solar dryers significantly reduces drying time and prevents mass losses; furthermore, product quality can be improved compared with traditional sun drying methods (Lutz and Muhlababauer, 1986). So, the aim of the present work was to study the effect of three different geometric shapes of the green-house type solar dryers operated under three different levels of air velocity on drying characteristics of date palm. The final quality of the dried dates was also determined.

MATERIALS AND METHODS

The experimental work was conducted at the Department of Agricultural Engineering, Faculty of Agriculture, Suez Canal University (latitude of 30.62°, longitude 32.27° and 5m above sea level) during September 2015.

Preparation of samples

The date samples were divided into two sub samples as follows:

1- The first sub sample of peeled date which coded as (T1).
2- The second sub sample of un-peeled date which coded as (T2).

Date samples were stored in plastic bags and kept in a freezer at (-18°C) until used (Matouk *et al*, 2010) . Before any experimental run, the date sample taken out of the freezer and kept inside the laboratory to attain room temperature. The initial moisture content of the freshly harvested date used in this study ranged from (111.5 to 113.2 % d.b.), the total sugar content ranged from (43.52 to 61.47 % d.b.), the antioxidant content ranged from (5.12 to 6.24 μmol TE/g dry basis) and the phenolic compounds ranged from (192 to 203 mg/100g).

The Green- House Type Solar Dryers

Three different geometric shapes of the greenhouse type solar dryers were designed, built and installed on the roof of the Agricultural Engineering Department at Suez Canal University (latitude of 30.62°, longitude 32.27° and 5m above sea level). The gross surface area of each dryer was 2.0 m^2. The three shapes of the dryer were orientated in the East-West direction to maximize the intensity of the solar radiation. As shown in Fig.(1) the first geometrical shape of the greenhouse type solar dryer was Quonset shape with gross dimensions (2.0 m long, 1.0 wide, and 0.9 m high). The second dryer was a gable-even-span with gross dimensions (2.0 m long, 1.0 wide, and 0.9 m high). The third dryer was Pyramidal shape with gross dimensions (1.14 m side lengths and 0.9 m high).

The three different dryers shapes were constructed from iron frame covered by single layer of polyethylene sheet with effective transmittance of 88.48 % . Wire netting makes a drying floor was fixed at 15 cm over the bottom of the greenhouses forming a plenum chamber under the wire netted floor. Each solar dryer was equipped with a centrifugal fan driven by a 0.33 hp electric motor placed at one side of the dryer. It was controlled by vertical gate to provide the desired level of air velocity. An open window with surface area of 0.053 m^2 was positioned at the top position of the opposite side of a suction fan position for air intake through the dryer. After air heating inside the solar collector of each dryer, the hot air is passing through the date beds. The drying air was continuously introduced from the top position of the solar collector and leaves through the bottom position under the drying chamber via the suction fan.

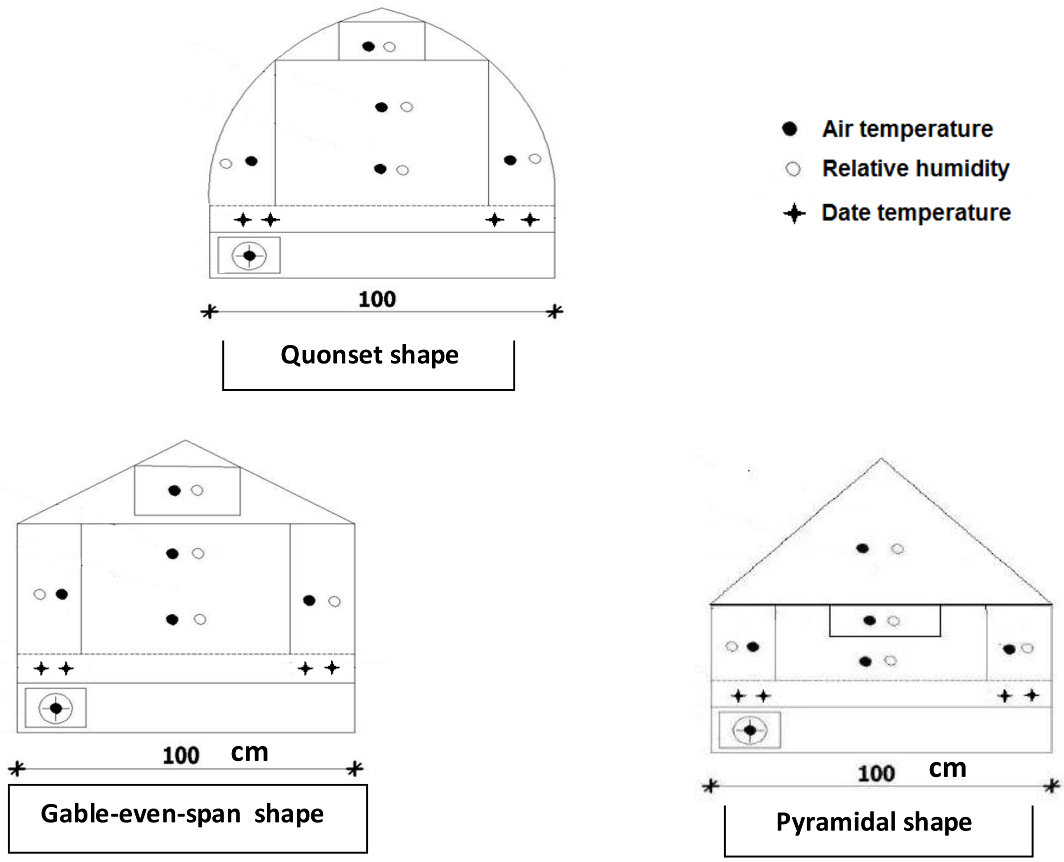


Fig.(1): Schematic diagram of different studied geometric shapes of the green-house type solar dryer.

Experimental Treatments

The experimental treatments of the drying process included three different geometric shapes of the green-house type solar dryer namely the Quonset shape (SD1), the Gable-even-span shape (SD2) and the Pyramidal shape (SD3), three different drying air velocity (0.5, 1, 1.5 m/s) and two different per-treatments of dates (Peeled and un-peeled date).

Test Procedure

The experimental work was run only through the period from 7 am to 5 pm, solar time. Before each experimental run, the dryer was adjusted for the required level of drying air velocity. The dryer bed of each studied geometrical shape was divided into two equal parts to accommodate the samples of dates. After making sure that the dryers working at stable condition, the dryer's beds were loaded with dates samples at capacity of 12 kg (6 kg/m^2) and distributed uniformity over the surface of the perforated wire net of each dryer in a single layer. The initial moisture content of date samples was determined before the drying process and throughout the drying period every 30 min during the early stage of drying process and then it was determined each one hour until the end of the drying process. Air temperature and relative humidity were measured every hour during the drying process at different locations of each dryer shape. The solar radiation was measured and recorded during the drying period. The drying process was kept running until the moisture content almost ceased to approach the final moisture content of the dried samples. At the end of each experimental run, sub samples were collected for chemical analysis. The chemical analysis included antioxidant content, phenolic compounds and total sugar content.

The Traditional Drying Method:

The traditional sun drying method was similar to the method used by farmers to dry date in the field. The freshly harvested dates (peeled and un-peeled date) were spread on a wooden frame of 2 m^2 surface area and subjected to direct sun. During the night time, the wooden frame was covered by a plastic sheet to prevent moisture re-absorption by the date samples.

Experimental Measurements:

Meteorological data

The meteorological data included the solar radiation flux incident on a horizontal surface (pyranometer), dry-bulb, wet-bulb, and dew-point air temperatures (ventilated thermistor), the wind speed and direction (cup anemometer and wind van), and the relative humidity of the air (hygrometer) were obtained from the meteorological station (Vantage Pro 2, Davis, USA) which was located approximately 2.0 m above the solar dryers.

Date moisture content

The moisture content of date samples was determined by drying the samples of dates (10 g, in duplicate) in electric oven at 70 °C until reaching a constant weight as recommended by **(AOAC 1990).**

Air temperature, relative humidity and date temperature

Thermocouples were fixed at different locations of each studied solar dryer to measure the dry and wet bulb temperatures inside the solar dryers as shown in **Fig.(1)**. The thermocouples were connected to a data-logger system (Lab-Jack logger, powered by USB cable, supply 4-5.25 volt, USA) to display, and record the data during the experimental work. All the thermocouple sensors were calibrated with an electronic thermometer (-10 up to 100ºC). The output data were recorded every ten minutes.

Air velocity

The velocity of drying air over the surface of drying floor was measured using vane type anemometer (model YK-80AM).

Overall thermal efficiency of the dryer

The overall efficiency was calculated for different studied dryers using the equation of (Abdelatif, 1989) as follows:

$$\eta_d = (Q_{ev} / Q) \times 100 , \quad \% \quad \text{.........................} (1)$$

$$Q_{ev} = [h_{fg}\, m_w + m\, C_{pg}\, (T_{ai} - T_d)] / 3.6 , \quad \text{Watt} \quad \text{.........................} (2)$$

$$Q = R\ A_d , \quad \text{Watt} \quad \text{..............................} (3)$$

Where :

η = thermal efficiency, %

h_{fg} = The latent heat of vaporization for water in dates, kJ/kg

m_w = The mass of water evaporated from the dates during the drying process, kg

m = The mass of dates in the dryer, kg

C_{pg} = The specific heat of dates, kJ kg^{-1} $°C^{-1}$

T_d = The dates bulk temperature (°C).

T_{ai} = The air temperature inside the dryer, ºC.

R = The solar radiation flux incident inside the solar dryer, W/m^2

A_d = the net surface area of the drying chamber, m^2.

RESULTS AND DISCUSSION

Air Temperature and Relative Humidity

The average measured ambient air temperature at the minimum air velocity of 0.5 m/sec was 31.27 ºC while the air relative humidity was 49.55%. As the air pass through the SD1,SD2 and SD3 solar dryers, the air temperature increased to 54.77, 51.57 and 50.81 ºC while the air relative humidity decreased to 28.84, 32.73 and 33.61% respectively as shown in Fig.(2). While, at the maximum air velocity of 1.5 m/sec, the average ambient air temperature was about 30.52 ºC, while the air relative humidity was 52.11%. As the air pass through the SD1, SD2 and SD3 solar dryers the average air temperature increased to 43.12, 40.76 and 39.79 ºC while the air relative humidity decreased to 33.59, 38.31 and 38.44 % respectively as shown in Fig.(3).

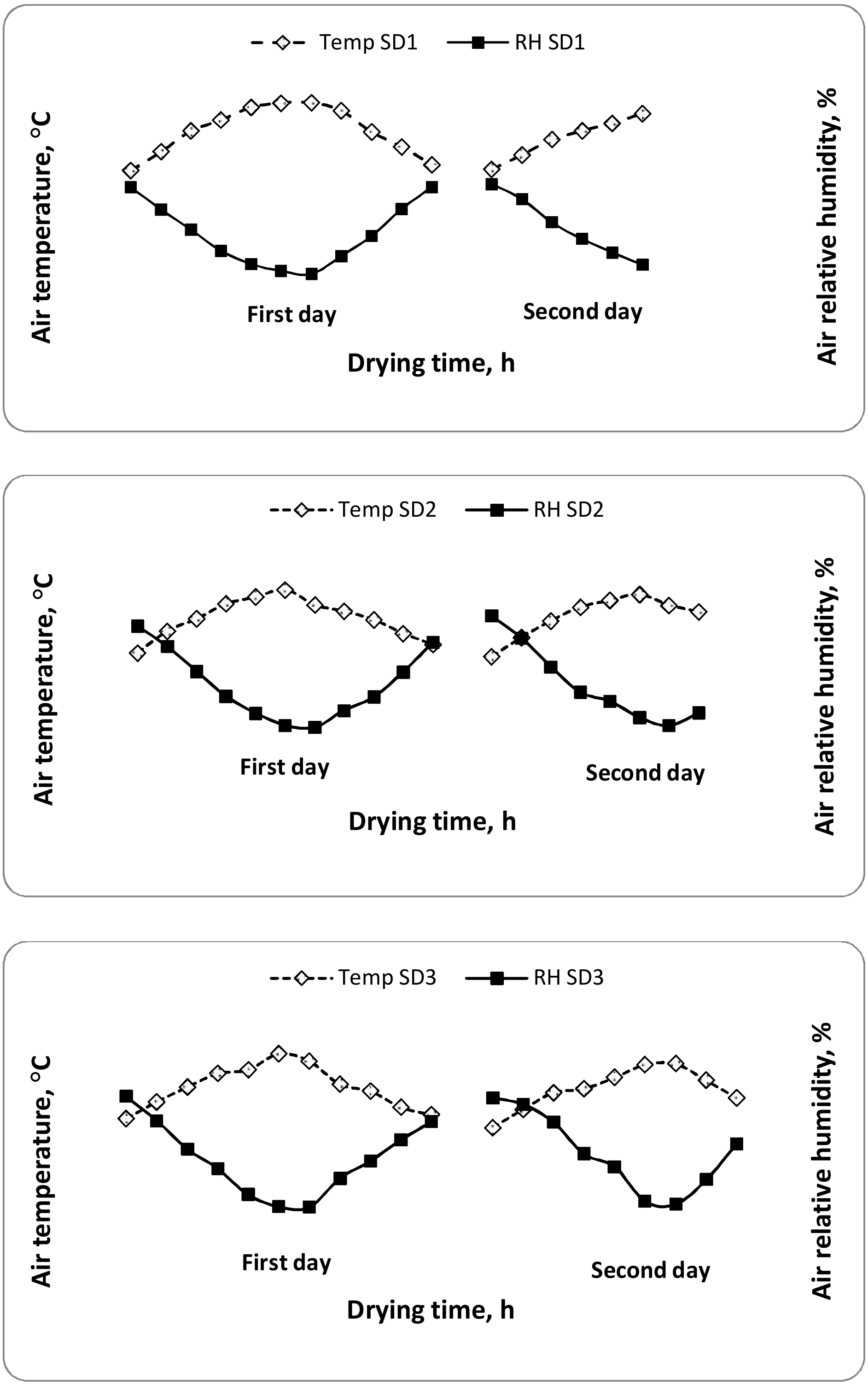


Figure (2): Air temperature and relative humidity as related to drying time inside the three solar dryers at air velocity of 0.5 m/s.

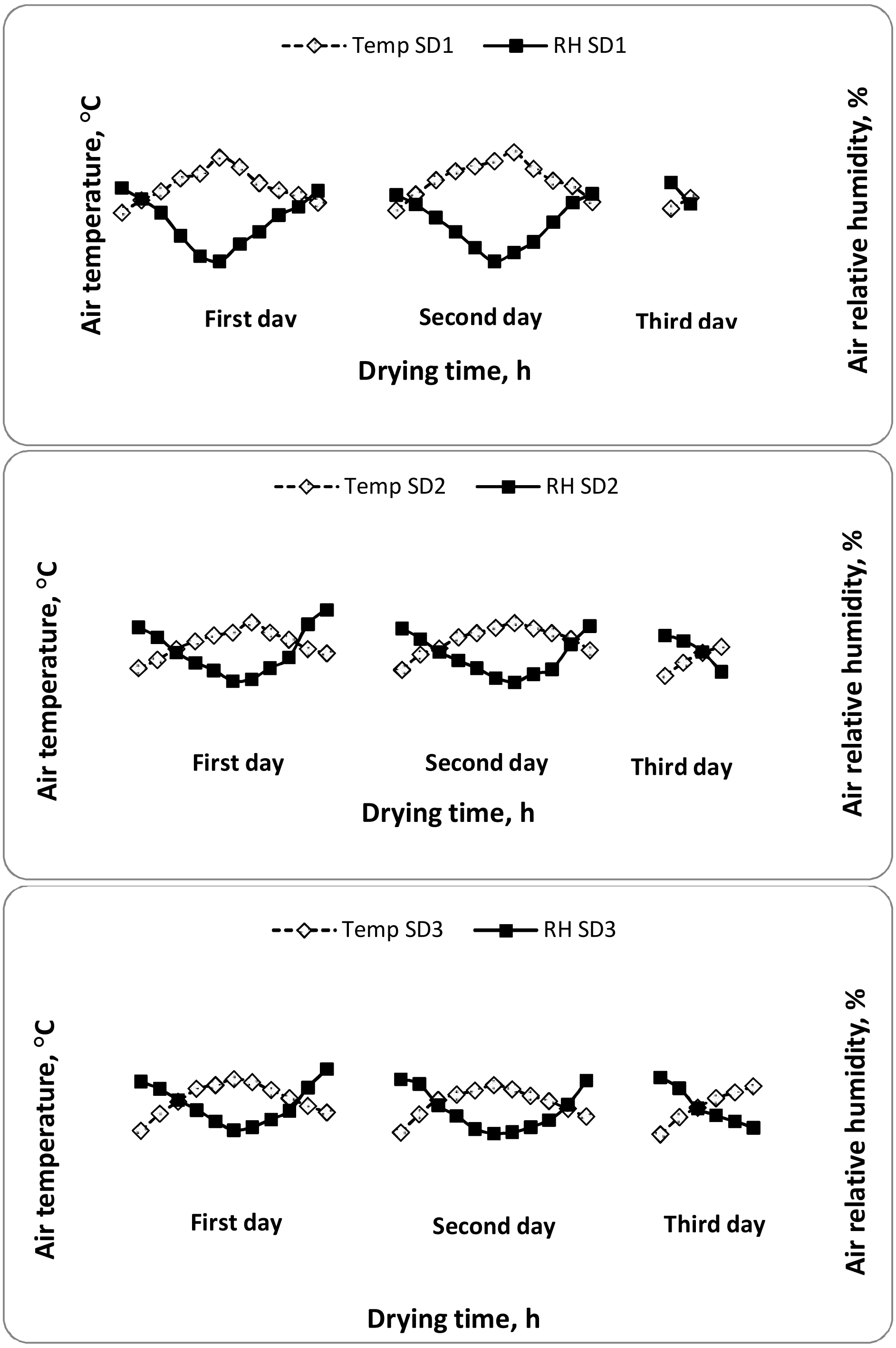


Figure (3): Air temperature and relative humidity as related to drying time inside the three solar dryers at air velocity of 1.5 m/s.

In general, the solar collector of different geometrical shapes of the solar dryer could increase the average ambient air temperature by about 9.57 to 23.36 ºC. While, it was decreased the average relative humidity by about 15.04 to 19.54 % at different levels of drying air velocity.

Date temperature

Date bulk temperature of all date conditions steadily increased with time till approaching the adjusted level of drying air temperature. Then, it was decrease with the drying time based on the drying rate and the corresponding evaporative cooling of date. Following this stage and near the end of drying process a noticeable increase of temperature was observed as the date moisture content decreased and approached the final moisture content. the recorded average date temperature for peeled date at the minimum air velocity of 0.5 m/s for the three studied dryers of SD1, SD2 and SD3 were 48.60, 46.15 and 42.73 °C respectively as shown in **Fig.(4)** While for the unpeeled date were 50.92, 48.58 and 45.91 °C respectively. The corresponded values for the peeled date at air velocity of 1.5 m/s were (39.8, 35.4 and 36.3 °C) and (41.1, 38.1 and 37.4 °C) for the unpeeled date, respectively as shown in **Fig.(5).** Also, the results revealed that, all peeled date showed lower bulk temperature in comparison with the unpeeled due to the higher drying rate of the peeled date and the corresponding evaporative cooling as mentioned above.

Changes in date moisture content during the drying process

Fig.(4) through (8) illustrate the change in date moisture content as related to drying time at the different levels of drying air velocity and two different conditions of date. As shown in the Figures, at the first stage of drying process, the moisture removal rate was high, then it was decreased continuously with drying time. The drying rate and the reduction in moisture content of date were varied with air velocity, drying air temperature inside the greenhouse and date condition.

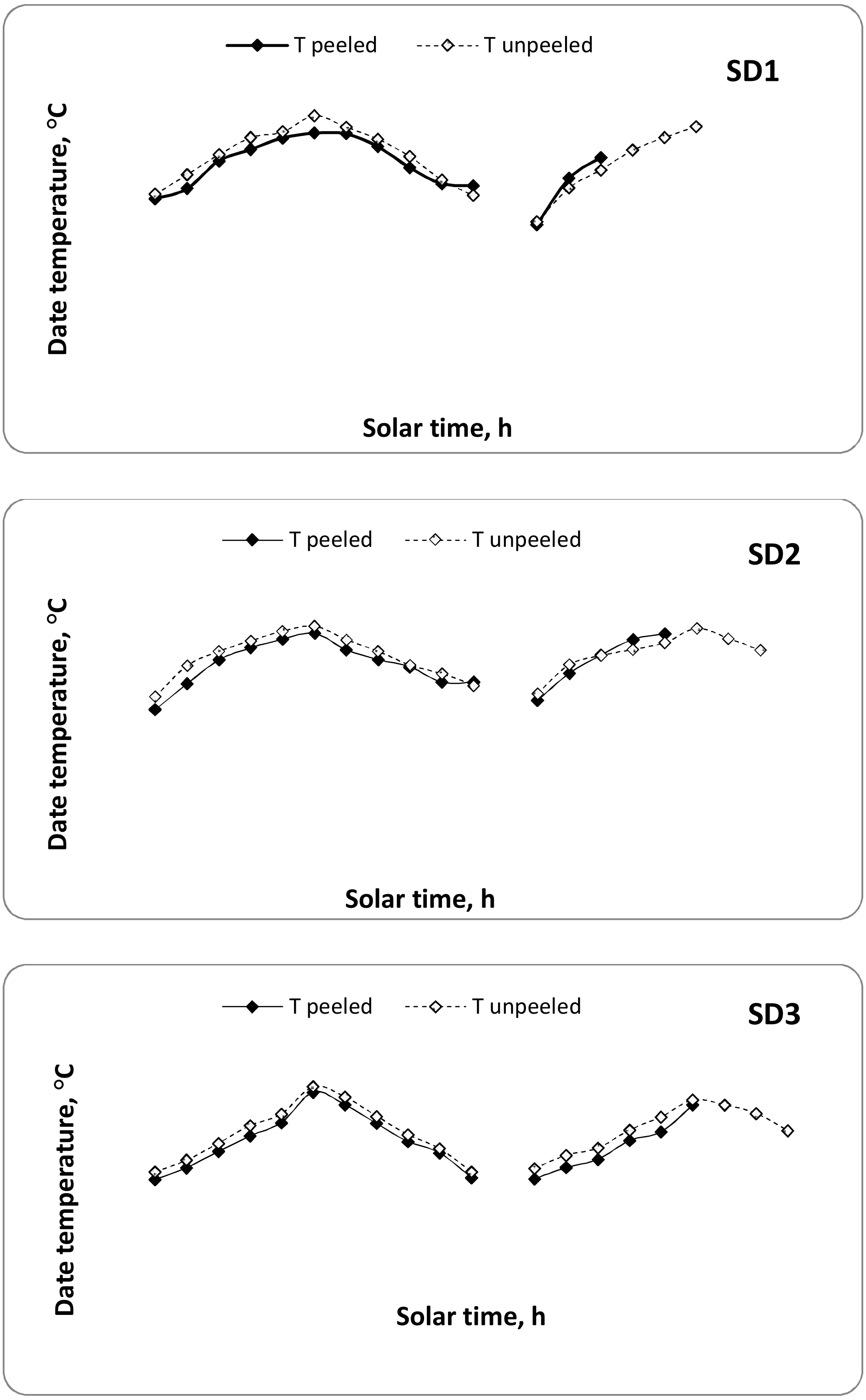


Fig. (4): Date temperature as related to drying time for the three solar dryers at the minimum air velocity of 0.5 m/sec.

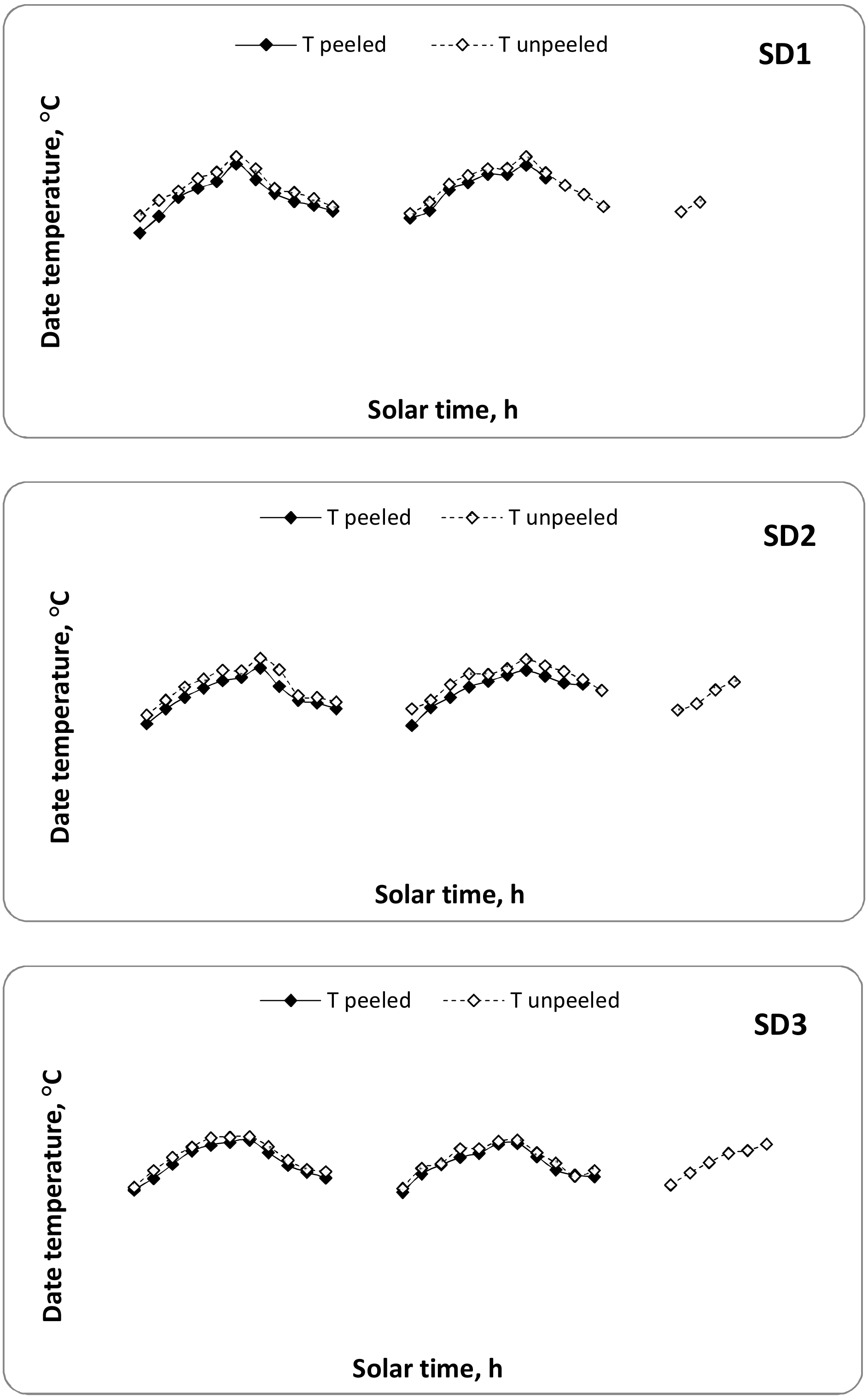


Fig. (5): Date temperature as related to drying time for the three solar dryers at the maximum air velocity of 1.5 m/sec.

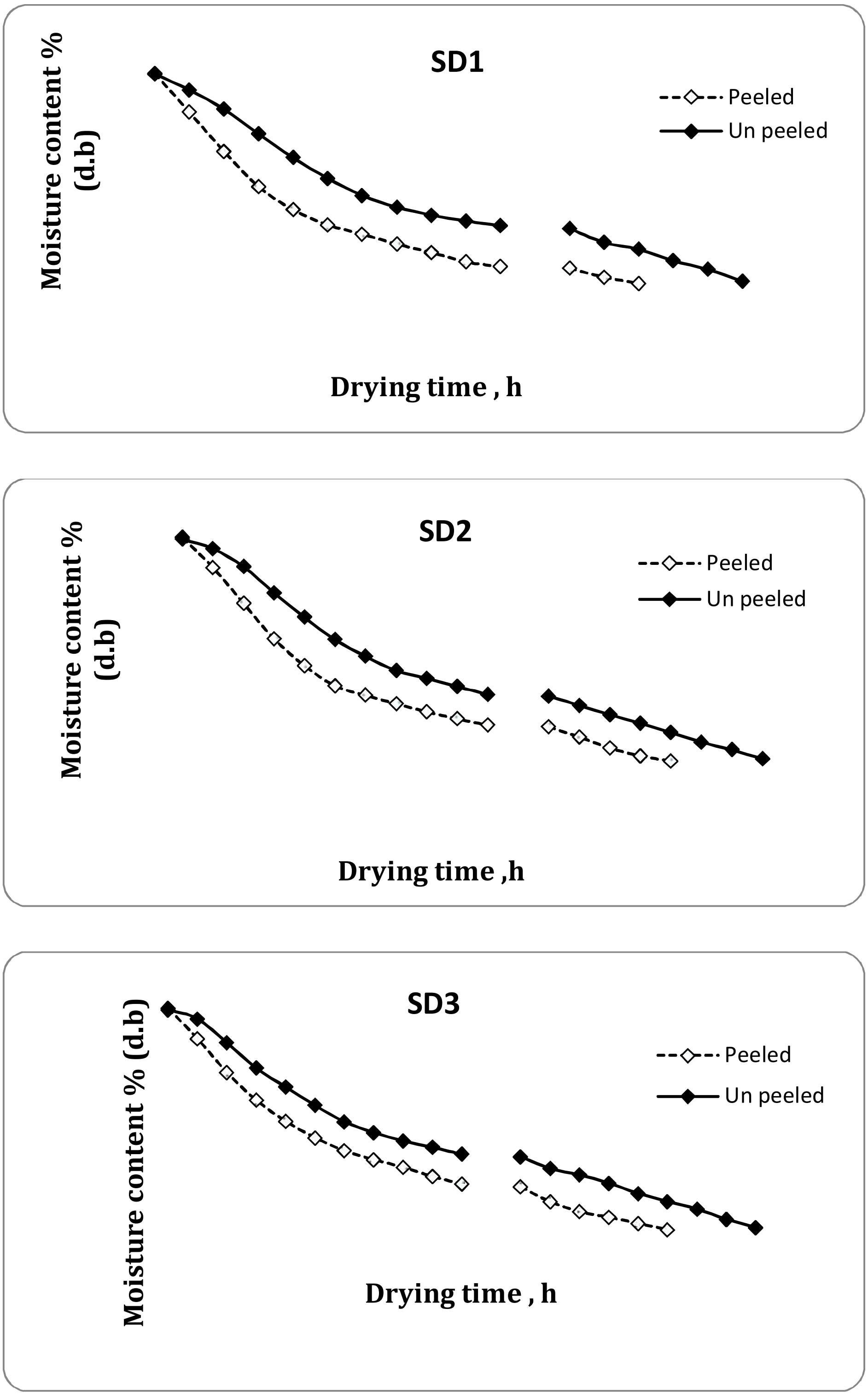
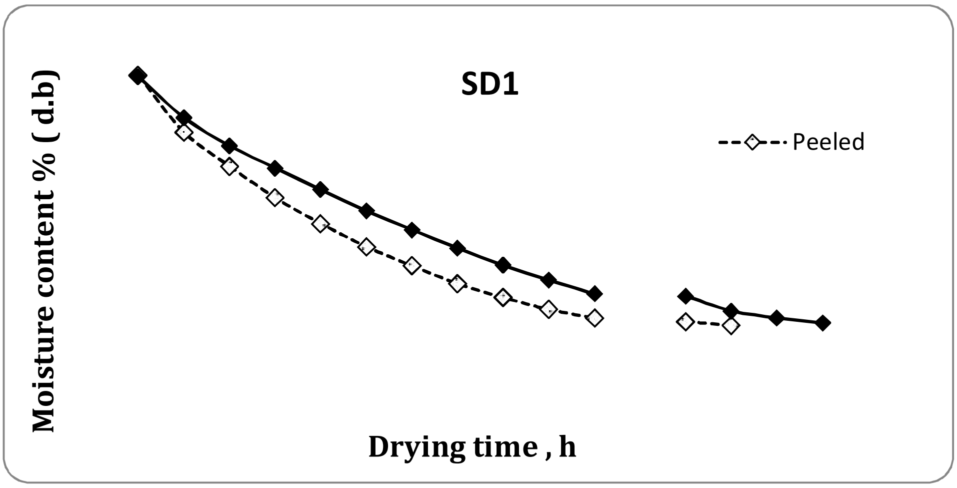
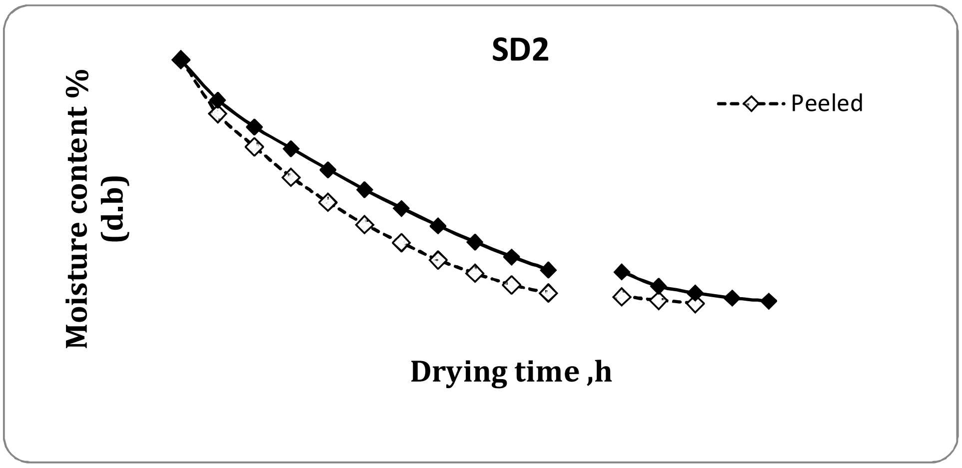


Fig. (6): Change in date moisture content versus drying time for the three studied solar dryers at air velocity of 0.5 m/s.





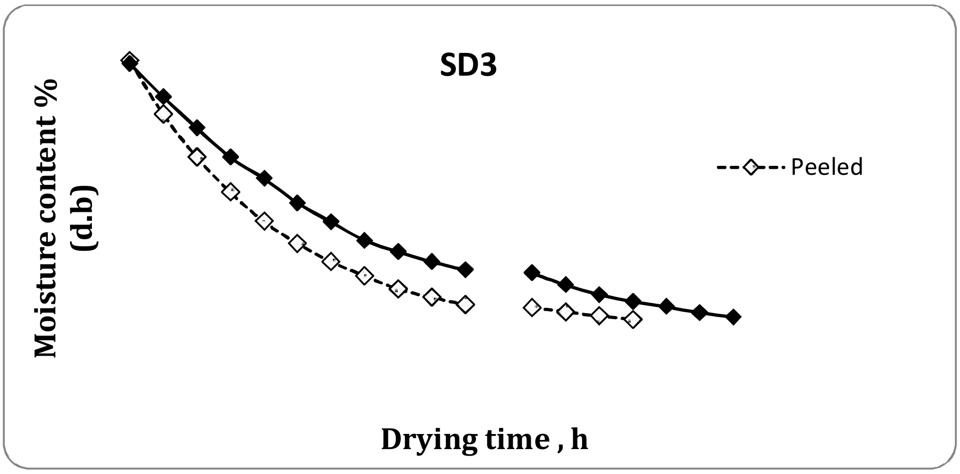


Fig. (7): Change in date moisture content versus drying time for the three studied solar dryers at air velocity of 1 m/s.

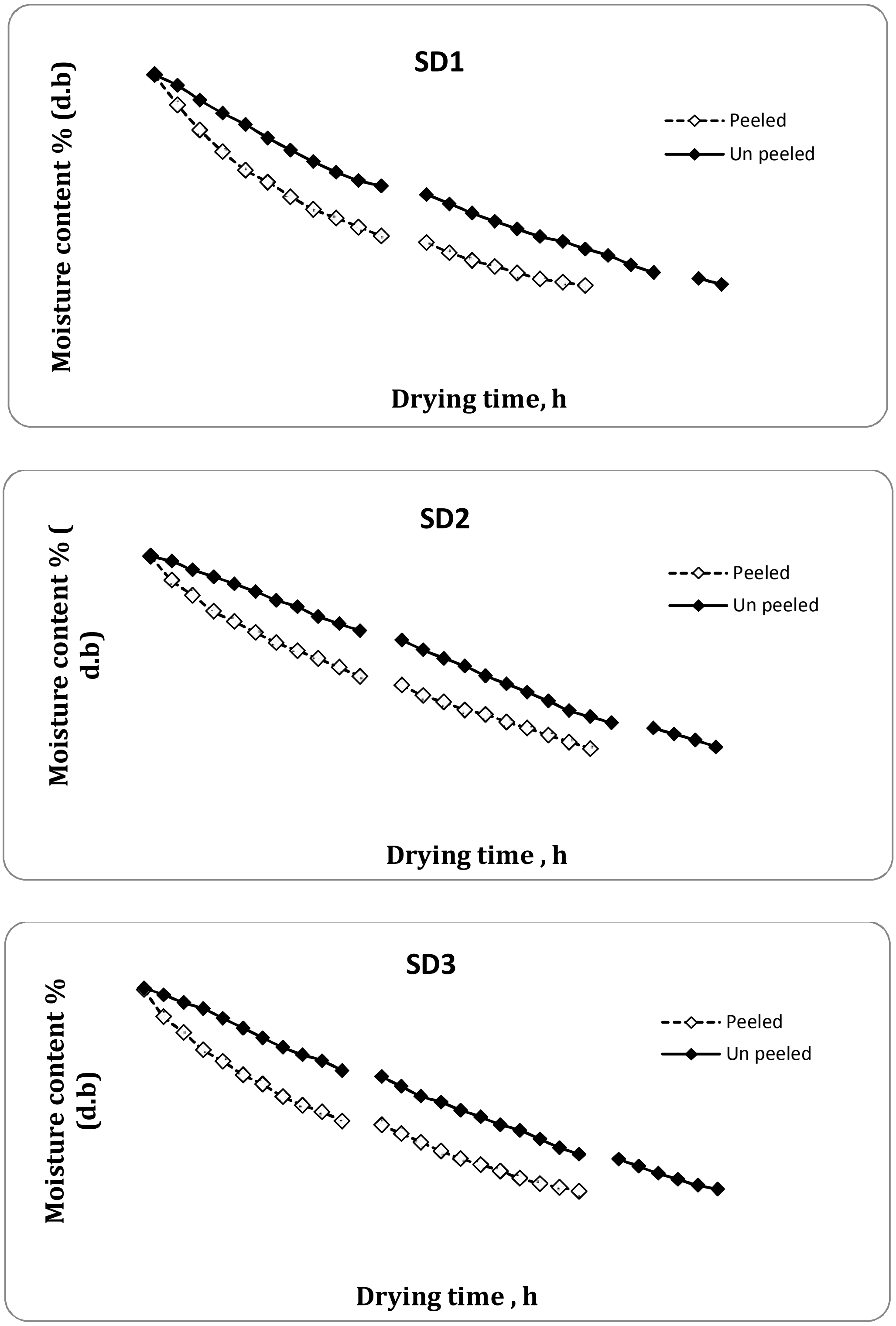


Fig. (8): Change in date moisture content versus drying time for the three studied solar dryers at air velocity of 1.5 m/s.

Drying time of dates

As shown in the Fig. (9) the longest drying time was obtained at air velocity of 1.5 m/s, this may be due to insufficient time for passing the air through the product and the reduction in air temperature as previously mentioned. It was noticed that, the air velocity of 1 m/s is the most proper drying velocity which gave the shortest drying time. For solar dryer (SD1) the drying time was decreased by (7.7 % and 12.5 %), (33.3% and 39.13%) for the peeled and un-peeled date compared with air velocities of 0.5 and 1.5 m/s, respectively. While, the solar dryer (SD3) operated at air velocity of 1 m/s decreased the drying time by (12.5 % and 10.5 %), (33.3% and 37%) for peeled and un peeled date compared with air velocities of 0.5 and 1.5 m/s, respectively. The same trend was also noticed for the solar dryer (SD2).

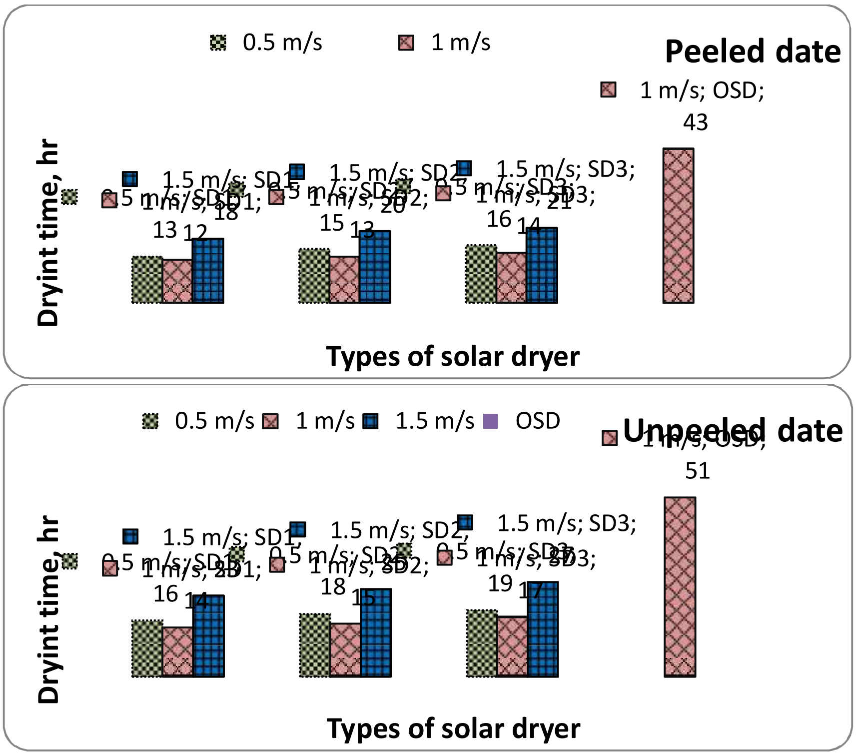


Fig.(9): Drying time of date for the three solar dryers compared with the traditional sun drying method.

It can be concluded that, the fastest drying time to approach the final moisture content of date for the three studied solar dryers was achieved using the geometrical shape (SD1) solar dryer at air velocity of 1 m/s. However, the open sun drying method (OSD) has taken 43 and 51 hours to approach the final moisture contents of 20.4 and 22.2 % (d.b) for peeled and un peeled date, respectively.

Thermal efficiency of the studied dryers

The total amount of water to be evaporated from the date surface requires an adequate amount of heat energy equal to the total heat energy utilizes in drying process. The total heat energy utilized in drying process of date included two amounts of heat; sensible heat used to raise the temperature of date and latent heat used to vaporize the water from the date.

To evaluate the overall performance of the studied dryers, the thermal efficiency was determined for actual drying tests at different air velocities. The obtained results are presented in Table (1). As shown in the Table, the observed differences in thermal efficiency are due to the differences in mass flow rate of drying air, geometric shapes of the studied solar dryer and initial moisture content. The results showed that, At air velocity of 1 m/s the thermal efficiency of the solar dryer (SD1) loaded with peeled date recorded a value of 31.85 % in comparison with 29.67 % and 19.29 % at air velocities of 0.5 and 1 m/s. While it was recorded 26.18 % in comparison with 24.73 % and 18.06 % at air velocities of 0.5 and 1 m/s for the dryer loaded with unpeeled date. Similar trend was observed for the dryers shapes SD2 and SD3 respectively.

Table (1): Thermal efficiency (%) of the three solar dryers at different drying air velocity.

Air velocity, m/s	Date condition					
	Peeled date			Un-peeled date		
	SD1	SD2	SD3	SD1	SD2	SD3
0.5 m/s	29.67	28.11	27.63	24.73	22.96	20.18
1 m/s	31.85	30.54	29.95	26.18	26.01	24.56
1.5 m/s	19.29	18.45	18.14	18.06	17.45	17.04

Quality evaluation tests of date

The total sugar, antioxidant and phenolic compounds for the dried date are listed in Table (2). The total sugar, antioxidant and phenolic compounds for the dried date were affected by geometric shape of the studied solar dryers, air velocity and date conditions (peeled and unpeeled). Results clarified that the highest percentage of the total sugar was recorded for the solar dryer SD1 at air velocity of 1m/s, it was 56.32% for peeled date and 55.78% for unpeeled date. While, the lowest percentage was found to be 52.12 % for peeled date and 51.47 % for unpeeled date for the solar dryer SD3 at air velocity of 1.5m/s. This observation may be attributed to the long time of heating during the drying process of date using the solar dryer SD3 which led to decrease the total soluble sugars of date and giving darker colour due to caramelization of sugars as mentioned by Perera (2005). Similar trend was observed for the antioxidant content and phenolic compounds of dried date.

Table (2): Total sugar %(d.b), antioxidant and phenolic compounds of the dried date.

Drying system	Air velocity, m/s	Total sugar, %		Antioxidant compounds		phenolic compounds, mg GAE/100mg	
		T1	T2	T1	T2	T1	T2
SD1	0.5	55.21	55.69	4.10	3.94	241.2	236.4
	1	56.32	55.78	4.56	4.31	244.3	238.6
	1.5	53.42	53.84	3.87	3.64	237.4	233.3
SD2	0.5	54.14	53.45	3.96	3.74	238.5	236.3
	1	55.95	55.33	4.43	4.28	240.6	237.1
	1.5	52.47	51.16	3.54	3.22	234.8	231.6
SD3	0.5	53.76	53.41	3.88	3.67	236.1	235.2
	1	55.67	55.24	4.43	4.23	240.2	237.4
	1.5	52.12	51.47	3.36	3.20	232.3	231.1
OSD	-	47.38	45.61	2.53	2.28	219.5	197.2

In general, determinations of sugar content did not reveal any significant variations during the drying process. While it was reduced the antioxidant content. This loss may be due to the breakdown of natural antioxidants after drying. but the phenolics compounds increased after drying because dates can be considered as a good source of phenolics, as mentioned by Al-Farsi and Lee (2008).

CONCLUSION

1. The peeled date showed lower levels of final moisture contents compared with the unpeeled date..
2. The recorded drying times for the three studied solar dryers (SD1, 2 and 3) were (16, 18 and 19 h), (14, 15 and 17 h) and (23, 25 and 27 h) at air velocity of 0.5, 1, 1.5 m/s respectively compared with 51h for the traditional sun drying method.
3. The drying rate of date was varied from hour to hour and day to another according to the initial moisture content of the date, drying air temperature, intensity of solar radiation and the date condition. The highest drying rate was achieved at air velocity of 1m/s for all studied shapes solar dryer.
4. The thermal efficiency values of the three solar dryers (SD1, SD2 and SD3) were (29.67, 28.11 and 24.73%), (31.85, 30.54 and 29.95%) and (19.29, 18.45 and 18.11%) for the peeled date at air velocity of (0.5, 1, 1.5 m/s), respectively. While the corresponded values for the unpeeled date were (24.73, 22.96 and 20.18%), (26.18, 26.09 and 24.56 %) and (18.11, 17.45 and 17.04 %) at air velocity of (0.5, 1, 1.5 m/s), respectively.
5. Total sugar percentage, antioxidant and phenolic compounds increased by increasing the air velocity up to 1 m/s and then they were decreased at air velocity of 1.5 m/s. The total sugar percentage ranged from 51.16 to 56.32 % (d.b). While the phenolic compounds ranged from 231.1 to 244.3 mg GAE/100 mg and the antioxidant compounds ranged from 2.30 to 4.56.

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بعض العوامل الهندسية المؤثرة على التجفيف الشمسى للبلح

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أجريت هذه الدراسة لأختبار وتقييم تأثير ثلاث اشكال هندسية مختلفة للبيوت المحمية المستخدمة كمجففات شمسية على تجفيف البلح وتمت الدراسة عند ثلاث مستويات مختلفة لسرعة الهواء (0.5م/ث ، 1 م/ث ، 1.5 م/ث) ومعاملات مبدئية للبلح (بلح منزوع القشرة و غير منزوع القشرة) مقارنة مع الطريقة التقليدية المستخدمة لتجفيف البلح تحت اشعة الشمس. الاشكال الهندسية موضوع الدراسة هى الشكل النصف اسطوانى (SD1) والشكل الجمالونى (SD2) والشكل الهرمى(SD3).
وقد أظهرت النتائج المتحصل عليها مايلي:

1- أدى استخدام المجفف الشمسى ذو الشكل النصف اسطوانى عند سرعة هواء 1 م/ث مع معاملة البلح المنزوع القشرة الى خفض زمن التجفيف بمقدار 31 ساعة بالمقارنة بالطريقة التقليدية لتجفيف البلح المنزوع القشرة والتى وصلت الى حوالى 43 ساعة.

2- أختلفت الكفاءة الحرارية للمجففات الشمسية الثلاثة حيث زادت بزيادة سرعة الهواء حتى سرعة 1 م/ث ثم بدأت بالانخفاض عند سرعة ١,٥ م/ ث.

3- أوضحت نتائج اختبارات تقييم الجودة افضل جودة للبلح المجفف بأستخدام الاشكال الهندسية المختلفة من البيوت المحمية كمجففات شمسية مقارنة بطريقة التجفيف الشمسى الطبيعى .

SOLAR DRYING OF CORN FOR SEED PRODUCTION

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Abstract

The main objective of the present study was to test and evaluate the ability of utilizing greenhouse type solar dryers for drying corn in order to obtain the best quality of dried seeds with the least drying time and highest germination percentage. The solar drying process was compared with the natural sun drying method. Corn variety (Giza 168) was used for the experimental work at initial moisture content of 31.73% (d.b). Two different forms of corn were tested (ear and shelled corn). The tests were conducted at different air velocity (0.5, 1.0 and 1.5 m/s). The experiments were carried out in Rice Mechanization Center at Meet El- Dyba, Kafr El- Sheikh Governorate, Egypt during September 2016. The quality tests included germination percentage for both drying methods using ear and shelled corn. The average air temperature inside the solar dryer at air velocities 0.5, 1.0 and 1.5 m/s reached 43.89, 42.39and 39.9 ˚C, respectively. The corresponding relative humidity were 36.36%, 37.92% and 41.09%. The recorded drying times were 26, 24 and 28 hours to reduce the moisture content from an initial level of 31.73 to final level of 14.07%(d.b.) for ear corn and for shelled corn were 12, 10 and 14 hours to reduce the moisture content from an initial level of 27.23% to 19.97% (d.b.) as ear corn, and 8, 6, 10 hours to reduce the moisture content from 19.97% to final level of 14.12%(d.b.) as shelled corn. While the drying times were 46 and38 hours for ear and shelled corn dried by natural sun drying method, respectively. Germination percentage of dried ear corn for natural sun drying method was 97 % and for solar drying at air velocities 0.5, 1.0 and 1.5 m/s were79, 81, and 89%, respectively. The corresponding values for shelled corn were 93, 97 and 98% in comparison with 95 % for natural sun drying method.

INTRODUCTION

Drying is an excellent way to preserve food. It preserves foods by removing enough moisture from food to prevent decay and spoilage. In Egypt, natural sun drying is one of the most common ways to conserve agricultural products; the food is dehydrated when it is exposed directly to solar radiation. The moisture is carried away by wind as it blows above the product. There are losses may occur during natural sun drying due to various influences, such as rodents, birds, insects, rain, storms and microorganisms. The quality of the dried products may also be lowered significantly.

Solar-drying technology offers an alternative process for crop drying**.** It saves energy, time, occupies less area, improves product quality, makes the process more efficient and protects the environment.

Corn *(Zea Mays L.)* is one of the most important strategic cereal crops in Egypt. In 2015, about 2259730 faddans were planted with white and yellow single and three –way crosse and a total production of about 7057735 tons according to Bulletin of the agricultural statistics (2015).

Maize grains are also the main component of animal and poultry feed production since it represents about 70%of components. In addition, it is used in silage production. It is also used in oil extraction and in some other industrial purpose such as starch and fructose.

For seeds production, the grains must not expose to high temperature. High temperatures would kill the germ so the air temperature for drying maize must not exceed 42-43˚C FAO (1982)

Sturton *et al*., (1981) reported that high drying temperatures can adversely affect the viability and quality of grains and seeds.

Peplinski *et al*., (1989) studied two methods of drying corn, the first was using ambient air at 25˚C and the second method was using air heated to 60 ˚C. The results showed that increasing drying air temperature from 25 to 60 ˚C had no effect on kernel chemical makeup or test weight but lowered germination up to 10 percentages.

Mohamed (2000) mentioned that corn is usually harvested at a relatively high moisture levels to minimize field losses and give a chance to clear the field earlier after ripening and helps serving and preparing the field for the next crops.

Kamal and El-Kholy (2002) developed a greenhouse type solar dryer. The dryer was tested and evaluated for drying high moisture ear and shelled corn and compared with natural sun drying method. The results showed that the developed dryer was able to dry ear corn from an initial level of 29.85% to final level of 14.26% in 84 h as compared to 187h for sun drying method. The corresponding drying times for shelled maize from an initial grain moisture level of 19.87%to 14.13% were 18h and 34h, respectively. The grain germination tests showed an average percentage of over 90% for both solar and natural methods of ear and shelled corn.

Gebreil (2008) developed an improved technology for utilizing solar energy for drying grains in using solar dryers where the air is heated in the solar dryer and then passed through grain bed. The greenhouse type which is facilitated with metal frame covered with plastic film, wire netting for floor, fans and duct for air suction to give a required airflow rated was investigated under Egyptian conditions and it was considered more economic method for artificial drying of agriculture crops.

Abdellatif *et al*. (2010) studied the possibility of utilizing solar energy for heating air inside greenhouse and use it for drying some agricultural crops under Egyptian conditions. They stated that, the solar energy available was considered as the most important parameter affecting thermal performance of the solar greenhouse dryer.

FengWei *et al*., (2010) designed a corn ears solar heating drying system based on two-stage drying process. Experiments showed that the system could dry corn ears in short time. It could save 18 h when compared with traditional drying technology.

Hellevang (2011) stated that corn above 21% moisture should not be dried using natural air and low temperature drying to minimize corn spoilage during drying. Adding heat does not permit drying wetter corn and only slightly increase drying speed. The primary effect of adding heat is to reduce the corn moisture content.

Vijaya *et al*. (2012) stated that the best alternative to overcome the disadvantages of traditional open sun drying and the use of fossil fuels is the development of solar crop dryers. In addition to mitigation of fossil fuels, the quality of the dried crops is also higher and the loss of dried products is considerably reduced.

Aravindh and Sreekumar (2015) reported that, drying is one of the most prevailing methods of food preservation, where the moisture is removed preventing the growth of micro-organisms that causes food damage. This method helps in reducing the weight and volume of the product which reduces the transportation and storage load and also helps in storing the food in ambient temperature. The moisture content of the product to be dried is an important factor for determining the quality of the product and thereby the market value.

The main objective of the present study was to test and evaluate the ability of utilizing greenhouse type solar dryers and comparing with natural sun drying method for drying corn (ear and shelled) in order to obtain the best quality of the dried grain with the least drying time, and highest germination percentage.

MATERIALS AND METHODS

Preparation of Sample

Corn (Giza 168) was used for the experimental work at initial moisture content of 31.73% (d.b). The tested samples were harvested from the experimental farm of Rice Mechanization Center at Meet El-Dyba, Kafr El-Sheikh Governorate during 2016 harvesting season. The capacity of the solar dryer was 60 kg of ear corn and 48 kg of shelled corn.

Solar Drying Method

Three identical dryers were used in this study as shown in Plate (1). The dimensions of the dryers are 200cm long, 100cm wide and 80cm height. The drying chamber dimensions are 200cm long, 100cm wide and 9cm height. The dryer's frame was constructed from galvanized iron pipes of 12.7mm installed on the circumference of four walls forming a batch. The pipes frame was covered by a clear plastic film 100µ thick. Wire netting constitutes a floor at the bottom of the batch was used for crop accommodation. A black plastic wire net covering the surface of the drying chamber was used as a solar absorber in order to increase the collection efficiency of solar radiation and protect the direct exposure of grain to solar radiation. Suction fan of air was fixed at one side of the dryer and driven by electric motor of 0.5 hp where the required air velocity was adjusted using a control valve, and the other side of the dryer has an open window for air inlet with dimensions 0f 35 × 10 cm and a front door with dimensions of 70 × 45 cm is located at the front of side the dryer for loading, unloading and collecting samples of corn as shown in Fig. (1).

Test procedure and measurements

Test Procedure

Experimental Treatments

1- Two different drying methods (Solar drying method using greenhouse type solar dryer and natural sun drying method).
2- Three different air velocities for solar dryers (0.5, 1.0 and 1.5 m/s).
3- Two different conditions of corn (complete drying of ears and two stages drying of corn (ear drying up to 19.97% (d.b.) followed by shelled corn drying up to 14.12% (d.b.)).

Methodology

The greenhouse type solar dryers were operated for 30 minutes before product loading to be in a stable operation condition and then the dryer's beds were loaded with the corn samples at capacity of 15 Kg/batch and uniformly distributed over the wire netted floor. Corn was placed into the dryers in a single layer and covered by a perforated black plastic net to absorb solar radiation, protect corn from direct solar radiation and polluted air.

Under natural sun drying method, the product was placed in wooden frame and was exposed to direct solar radiation.

For ears treatment, moisture content was reduced from an initial moisture content 31.73 % to final level of 14.07% (d.b.) directly, but for shelled corn treatment it has taken two stages to reduce moisture content from an initial level of 27.23% to final level of 14.12 % (d.b.) . The first stage was reduction of moisture content from 27.23% to 19.97% as ear corn and then from 19.97% to 14.12% as shelled corn.

Plate (1): The three identical solar dryers used for the experimental work.

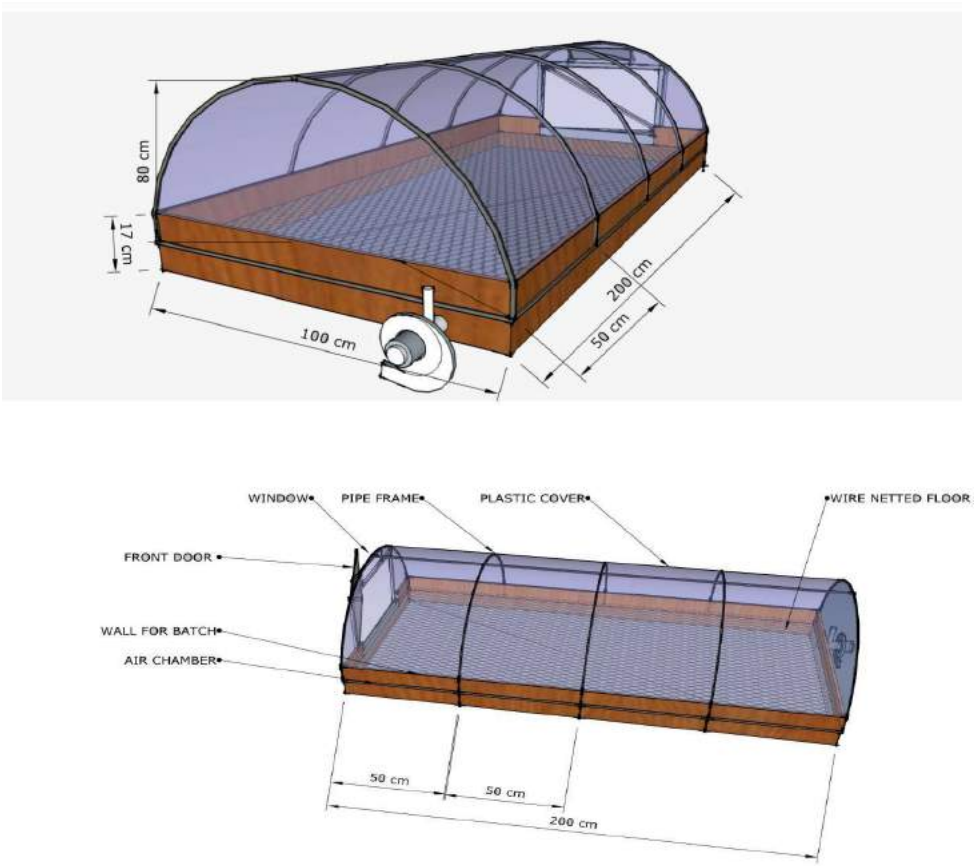

Fig. 1: Schematic of the greenhouse type solar dryer

Measurements

The experiments were carried out and the following measurements were recorded from 8 a.m. to 6 p.m.

1. Solar radiation flux incident in and out the dryer
2. Ambient air temperature and relative humidity
3. Dryer air temperature and relative humidity
4. Ear and shelled corn temperature
5. Moisture content
6. Drying rate
7. Thermal efficiency
8. Quality tests of dried grain

Solar radiation

A pyranometer sensor model H-201, made in Japan was used for measuring the solar radiation. It was connected to a chart recorder model YEW 3057 in order to convert the voltage single to an equivalent reading in kW .h/m^2. Its short wave sensitivity 7.0 (mV/kW.m^2).

Temperature measurements

Corn bulk temperature

Thermocouples of copper-constant (T-type) were used to measure the bulk temperature of grains in different places. It was connected to a chart recorder model YEW 3057 in order to read air temperature in ˚C.

Air temperature and relative humidity meter

Digital temperature and humidity meter, model Chino (HN-K) was used to measure air temperatures and relative humidity inside and outside the tested dryers.

Air velocity

A hot wire anemometer model 37000-00, cole pormer instrument company, Vernon Hill, Illinois 60061-1844, made in USA was used to measure the inlet air velocity over the surface of corn drying bed with an accuracy of 0.01 m/s.

Moisture content

The moisture content of corn grain was measured by the standard oven method. The samples were taken before and during the drying process and the moisture content was measured using an electric oven at 130˚C for 16 hours according to (AOAC, 1990).

The moisture content was calculated as a dry basis according to (Reeb and Milota, 1999):

$$Mc = \frac{Initial\ weight - dry\ weight}{dry\ weight} * 100 \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Weight of corn samples

An electric digital balance was used to measure the mass of wet and dry samples to calculate the moisture content with an accuracy of 0.01g and the maximum mass was 3000g.

Drying rate

$$Drying\ rate\ (Kg/h) = \frac{(M_{t+dt} - M_t)}{dt} \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where:

M_t : moisture content (Kg water/ Kg dry matter) at time t.

M_{t+dt} : moisture content (Kg water/ Kg dry matter) at time t +dt.

According to **ASHRAE(2005),** the drying efficiency (η_d) is the ratio of energy required to evaporate the moisture from the corn to the solar radiation flux incident received over the surface area of the drying bed as follow:

$$\eta_d\,(\%) = \frac{Q_{ev}}{R\,A_d} * 100 \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where:

Q_{ev}: Thermal energy utilized for drying, W.

R : The solar radiation flux incident over the surface of the solar dryers, W/m^2

A_d: the net surface area of the drying chamber, m^2.

The total thermal energy used for drying corn included the following parameters; sensible heat used to raise the temperature of corn ($q_{sensible}$), and the latent heat energy used to vaporize the water from the corn (q_{latent}). It could be calculated as follow:

$$Q_{ev} = qlaten + qsensible \;, Watt \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

$$Q_{ev} = \frac{L_h m_w + m_i c_{pc}(T_{ai} - T_c)}{3.6}, Watt \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

$$m_w = \frac{m_i(M_i - M_f)}{(100 - M_f)}, Kg \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

Where:

L_h : The latent heat of vaporization of water in corn, kJ/kg.

m_w : Mass of water evaporated from the corn during the drying process, kg.

m_i : Mass of corn in the dryer, kg.

C_{pc} : Specific heat of corn, kJ/kg.˚C.(2.13 kJ/kg. ˚C) as mentioned by Meiering *et al*., 1977).

T_{ai} : Air temperature inside the dryer, ˚C

T_C : Bulk temperature of corn, ˚C.

M_i : Initial moisture content of drying load, % w.b.

M_f : Final moisture content of drying load, % w.b .

The thermal efficiency (η_d) could be calculated as follow:

$$\eta d\,(\%) = \frac{Q_{ev}}{RA_d} * 100 \ldots\ldots\ldots\ldots\ldots\ldots (7)$$

Quality tests of dried corn:

Germination test:

The test was done according to ISTA rules (INTERNATIONAL SEED TESTING ASSOCIATION) and also (MD 368/1998- article 3). The main purpose of this test is to determine the percentage of germination for seed samples.

Corn samples were divided into 100 kernel sub-samples in three replicates. Samples of each replicate were surface sterilized using 2% sodium and rinsed three times using distilled water. Germination tests were replicated three times in petri dishes containing moistened filter paper for a week. Corn kernels having both roots and shoots were considered germinated

.

RESULTS AND DISCUSSION

Solar Radiation

For drying ear corn during the period of 2/9-4/9/2016 the average daily solar radiation outside and inside the solar dryer were 529.42 and471.82 W/m^2, 634.25 and 514.46 W/m^2, 853.37 and 688.99 W/m^2 during the first, second and third days of drying period, respectively as shown in Fig. (2). The actual solar radiation inside the solar dryer was lower than that outside the dryer due to the reflectivity, absorptivity and transmissivity of the solar dryer covering material. The highest and the lowest solar radiation values were 1068.571 W/m^2 at the time of 12 noon of 4/9/2016 and 121.429 W/m^2 at 6 p.m. of 2/9/2016 respectively. For shelled corn drying during the period of 7/9-9/9/2016 the average daily solar radiation outside and inside the solar dryer were 726.47 and 528.47 W/m^2, 633.25 and 442.69 W/m^2, 708.12 and 623.12 W/m^2 during the first, second and third days of drying period respectively. The highest and the lowest solar radiation values recorded 1191.481W/m^2 at the time of 12 noon of 7/9/2016 and 131.429W/m^2 at 6 p.m. of 9/9/2016, respectively.

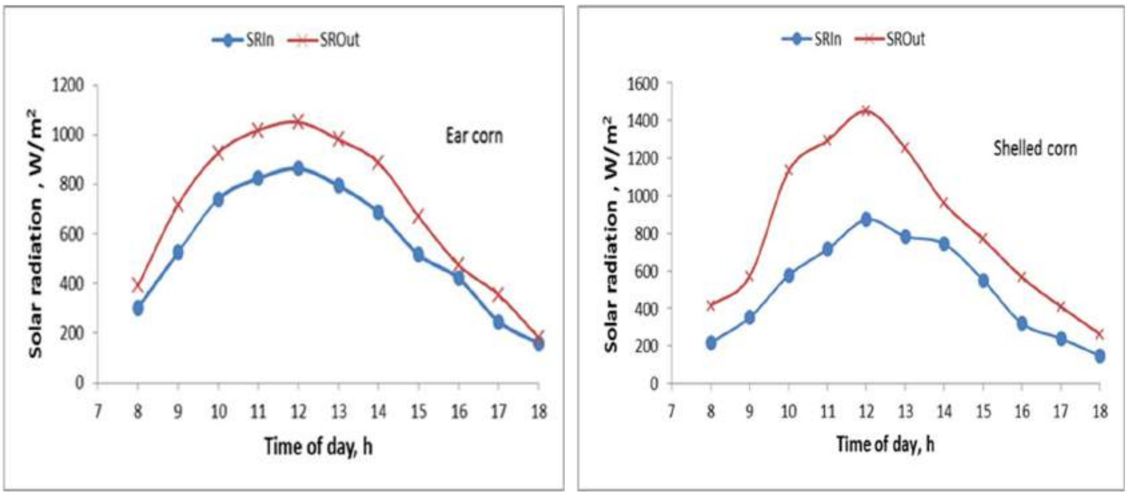

Fig. (2): Average hourly solar radiation flux inside and outside the solar dryers during drying of ear and shelled corn.

Air Temperature and Relative Humidity

Air temperature and relative humidity inside the solar dryer were affected by the air velocity inside the dryer. Increasing the air velocity decreased the air temperature inside the dryers while the relative humidity was increased. When air passes through the dryers at air velocities 0.5, 1.0 and 1.5m/s, the solar dryer increased the air temperature by 11.02, 9.51and 7.11˚C, respectively. The relative humidity also decreased by, 13.09, 12.26 and 10.36 %at air velocities 0.5, 1.0 and 1.5m/s, respectively as shown in Figs.(3and 4).

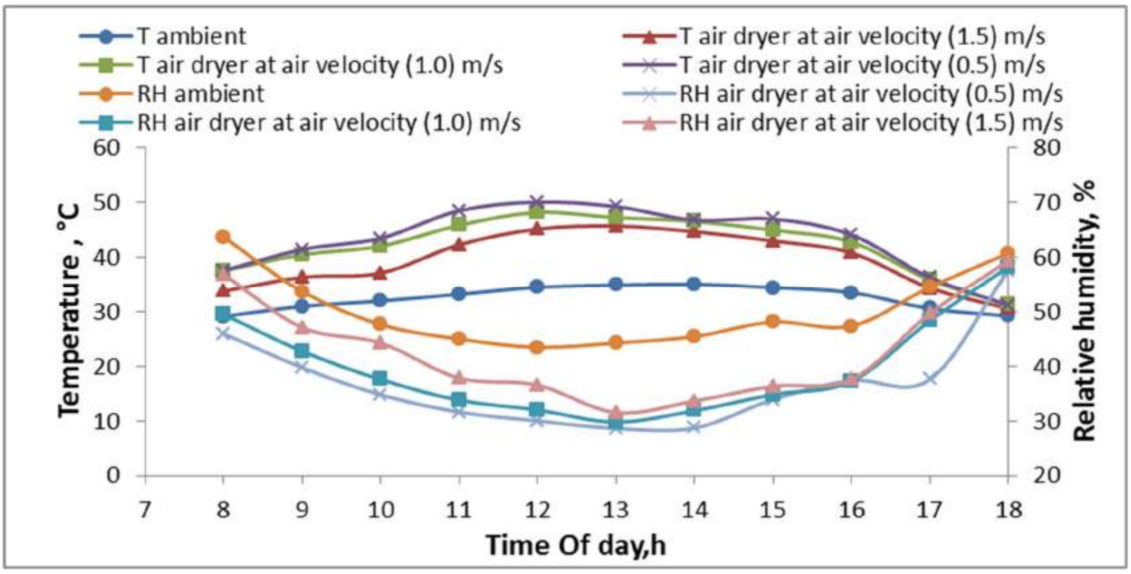

Fig. (3): Average air temperature and average humidity inside and outside the solar dryers during the period of drying ear corn.

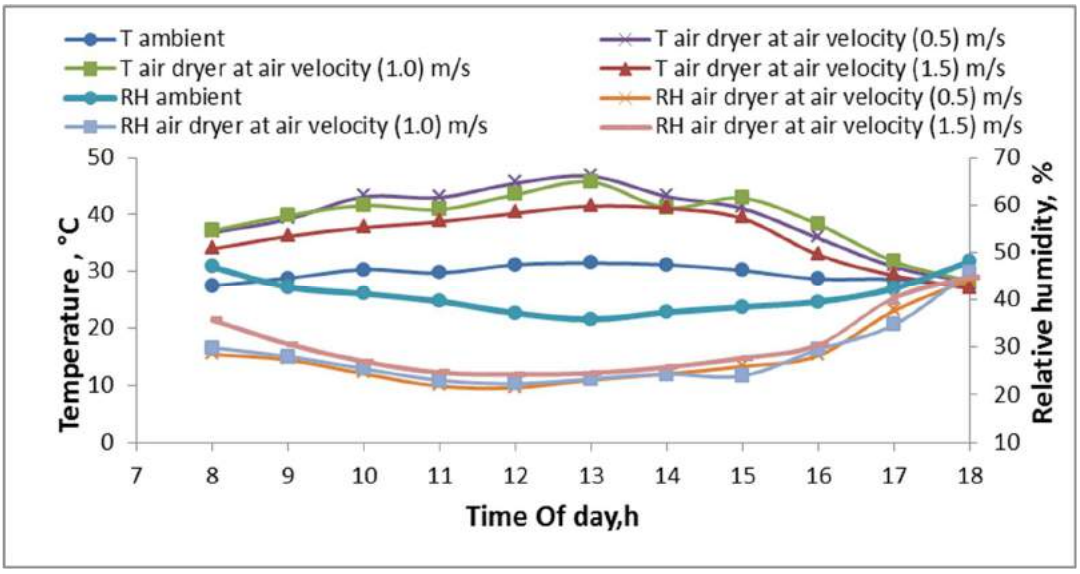

Fig. (4): Average air temperature and relative humidity inside and outside the solar dryers during the period of drying shelled corn.

Grain Bulk Temperature

Bulk temperature of ear and shelled corn was measured at different positions of the drying bed. Figs. (7 and 8) illustrate the average bulk temperature of ear corn. The recorded values were 42.49, 40.56 and 38.63˚C at air velocities 0.5, 1.0 and 1.5 m/s, respectively. The corresponding values for shelled corn were 38.06, 38.32 and 34.39˚C, respectively. The differences in bulk temperatures could be attributed to the variation in ambient air temperature and dryer air temperature. The average daily grain bulk temperatures for ear and shelled corn under natural sun drying method were 31.53 and 28.09˚C respectively.

Grain Moisture Content

The drying rate and the reduction in moisture content of grain were varied with air velocity, air temperature and corn condition. grain moisture content of ear corn decreased from an initial level of 31.73 to final level of 14.07% (d.b.) in 26, 24,28 and 46hours for solar drying at air velocities 0.5, 1.0 , 1.5m/s and natural sun drying respectively, as shown in Fig. (5). For shelled corn, grain moisture content decreased from an initial level of 27.23% to final level of 14.12% (d.b) in 20, 16 ,24 and 38 hours at air velocities 0.5, 1.0, 1.5m/s and natural sun drying respectively as shown in Fig. (6). Increasing the air velocity passing through the drying beds increased the drying rate and decreasing the drying time up to the level of 1.0 m/s and then it was decreased with increasing air velocity to the level of 1.5 m/s as a result of reduction in air temperature as shown in Figs.(7 and 8)

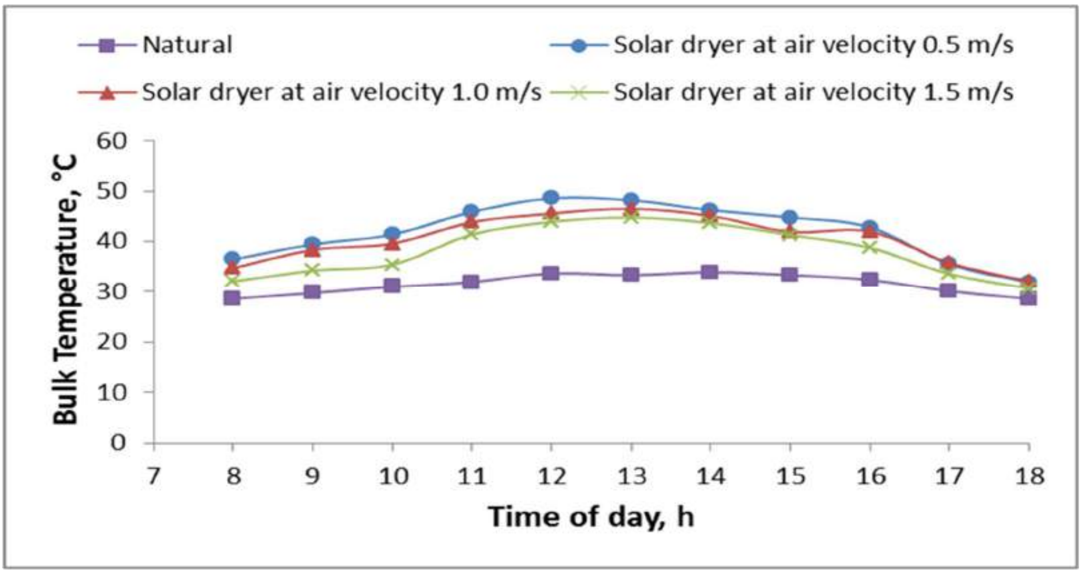

Fig. (5): Average bulk temperature of ear corn.

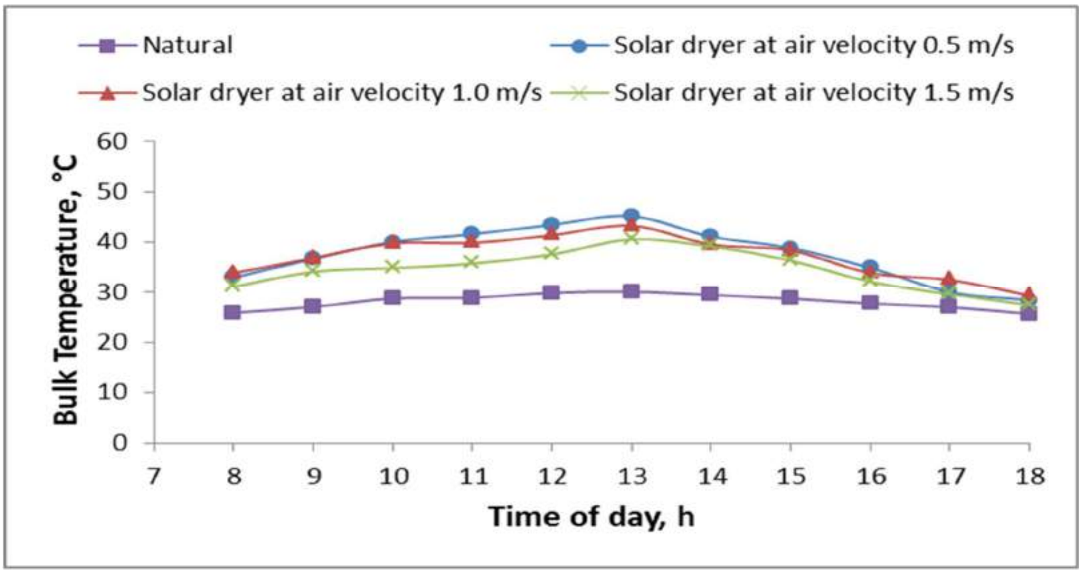

Fig. (6): Average bulk temperature of shelled corn.

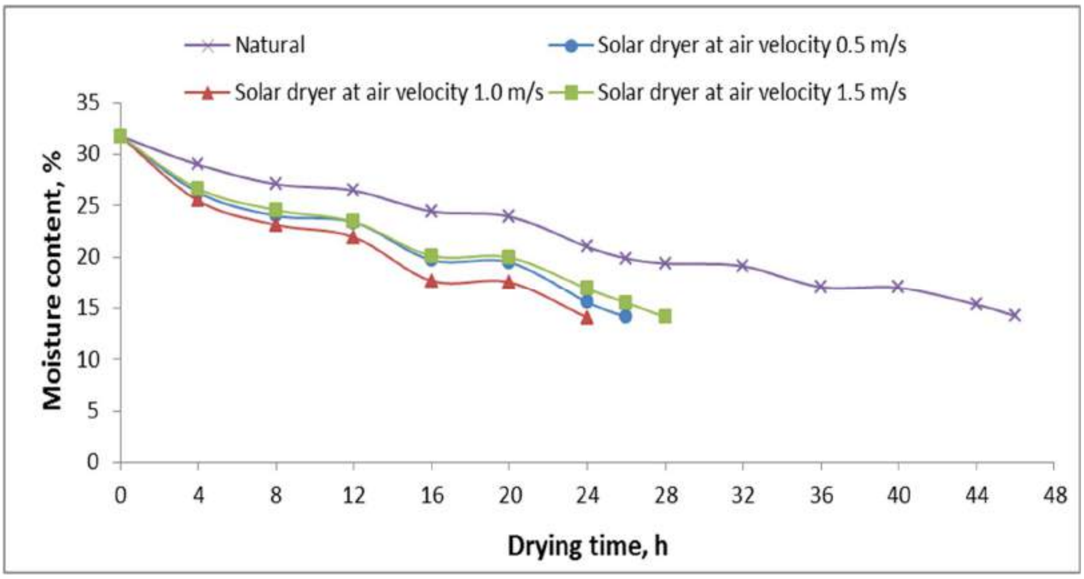

Fig. (7): Reduction in grain moisture content during drying of ear corn.

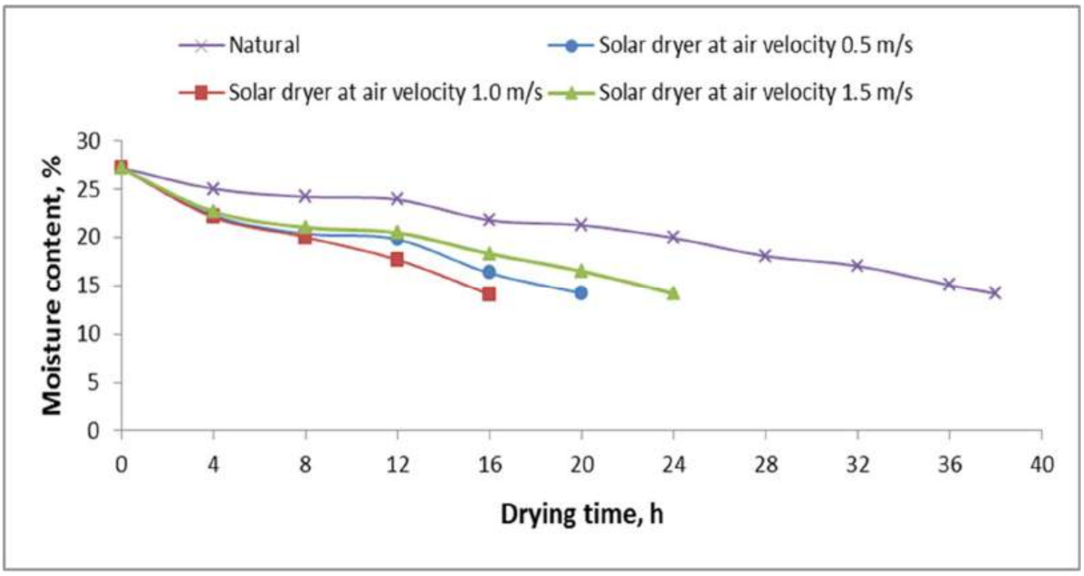

Fig. (8): Reduction in grain moisture content during drying of shelled corn.

Drying Efficiency

The heat energy utilized in the drying process varied from day to day during the experimental period according to the solar energy available and the initial moisture content of grain. As shown in Fig. (9). The average daily thermal efficiency were 18.28, 19.92 and 17.01 % at air velocity 0.5, 1.0 and 1.5 m/s, respectively compared with 8.754% for natural sun drying of ear corn. The corresponding values for shelled corn were 19.57, 21.09 and 18.90%, respectively compared with 9.185 % for natural sun drying method. Due to the difference in mass flow rate of drying air and the initial moisture content of grain, these differences in thermal efficiencies were observed.

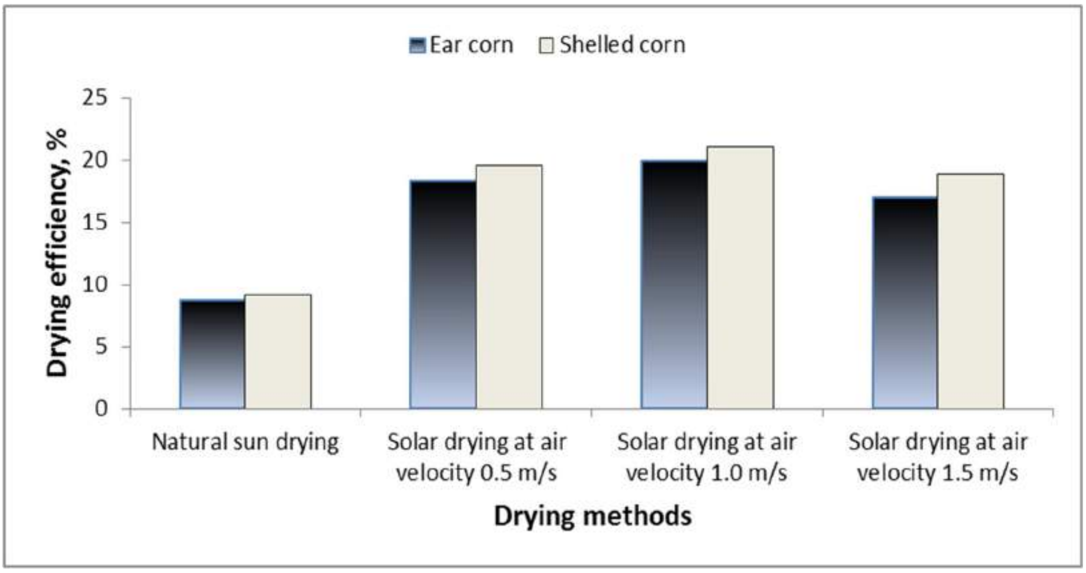

Fig. (9): Drying efficiency of natural sun drying and solar drying methods during the experimental work.

Quality Evaluation Tests of Dried Corn:

The results of grain germination test of dried corn (ear and shelled) using solar drying method at air velocities 0.5, 1.0 and 1.5 m/s in comparison with natural sun drying method are summarized and listed in Table (1).

Table (1): Standard Germination Test.

<table>
<tr><th>Corn condition</th><th colspan="2">Drying methods</th><th>Standard germination test, %</th></tr>
<tr><td rowspan="4">Ear Corn</td><td colspan="2">Natural sun drying</td><td>97</td></tr>
<tr><td rowspan="3">Solar drying</td><td>0.5 m/s</td><td>79</td></tr>
<tr><td>1.0 m/s</td><td>81</td></tr>
<tr><td>1.5 m/s</td><td>89</td></tr>
<tr><td rowspan="4">Shelled Corn</td><td colspan="2">Natural sun drying</td><td>95</td></tr>
<tr><td rowspan="3">Solar drying</td><td>0.5 m/s</td><td>93</td></tr>
<tr><td>1.0 m/s</td><td>97</td></tr>
<tr><td>1.5 m/s</td><td>98</td></tr>
</table>

It is observed that solar drying method for ear corn at air velocities 0.5 and 1.0 m/s obtained lower levels of grain germination percentage. This could be attributed to the longer drying times and the corresponding exposure to high drying air temperature.

CONCLUSION

The Conclusions of This Study included:

1. Solar drying process offers short drying time, high daily drying efficiency and germination percentage, but natural sun drying method offers longer drying time, Low daily drying efficiency and close grain germination.
2. Increasing the air velocity passing through the drying beds increased the drying rate, daily drying efficiency and decreased the drying time by about 45.40 % in comparison with natural sun drying method.
3. In general, both drying conditions of ear and shelled corn showed germination percentage over 85% which means that, the proposed solar drying methods in convenient for seeds production.

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تجفيف الذرة بالطاقة الشمسية لإنتاج التقاوى

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تهدف الدراسة إلي إمكانية استخدام المجففات الشمسية لتجفيف الذرة(كيزان- مفرط) بغرض تقليل زمن التجفيف مع الحفاظ على جودة الحبوب المجففة ومقارنتها بالتجفيف الشمسى الطبيعى لاستخدامها كتقاوى جيدة مما يساهم فى زيادة إنتاجية الفدان وسد الفجوة الغذائية.ولتنفيذ هذه الدراسة تم استخدام صوبة بلاستيكية كمجفف شمسى بأبعاد200*100*80 سم (طول*عرض*إرتفاع)، مثبت فى الجانب الأمامى من الصوبة شباك لدخول الهواء وكذلك باب لتعبئة وتفريغ المحصول،كما يوجد فى الجانب الخلفى مروحة لسحب الهواء من الصوبة. وقد استخدم فى هذه الدراسة محصول الذرة (جيزة 168) تم حصاده من محافظة كفر الشيخ عند محتوى رطوبى إبتدائي 31.73% على اساس جاف خلال موسم حصاد الذرة لعام 2016. تم وضع الذرة في المجفف فى طبقة واحدة أثناء التجفيف بالطاقة الشمسية وتم تغطيته بغطاء بلاستيكى أسود شفاف لامتصاص الإشعاع الشمشى وحماية المنتج من أشعة الشمس المباشرة والهواء الملوث.

اشتملت التجربة علي المعاملات التجريبية التالية:

1. طريقتان للتجفيف (التجفيف بالطاقة الشمسية باستخدام الصوب الزراعية على شكل أنفاق- التجفيف الشمسى الطبيعى).
2. طبيعة المحصول (كيزان كاملة- مرحلتان لتجفيف الذرة (كيزان لمحتوى رطوبى يصل إلي حوالي 19.97% و حبوب لمحتوى رطوبى يصل إلي حوالي 14.12%).
3. سرعات مختلفة لهواء التجفيف داخل المجفف الشمسى (0.5 – 1.0 – 1.5) م/ث.

وكانت أهم النتائج المتحصل عليها كالاتى:

استغرق تجفيف الذرة بالطاقة الشمسية فى حالة الكيزان لخفض المجتوى الرطوبى من محتوى رطوبى إبتدائي 31.73% إلى محتوى رطوبى نهائى 14,07 % على أساس جاف 26 و 24و 28 ساعة بمعدل تجفيف 0.784 و 0.853 و 0.674كجم/ساعة عند سرعات هواء (0.5- 1.0 – 1.5) م/ث علي الترتيب، مقارنة ب 46 ساعة ومعدل تجفيف 0,491 كجم/ساعة للتجفيف الشمسى الطبيعى. أدى تجفيف الذرة على شكل حبوب مفرطة إلى خفض زمن التجفيف حيث ثم خفض المحتوى الرطوبى من 27.23% إلى 19.97 % على أساس جاف فى زمن 12 و 10 و 14 ساعة ككيزان ثم بعد ذلك من 19,97% إلى 14,12% كحبوب فى زمن 8 و 6 و 10 ساعات بمعدل تجفيف 0.699 و0.850 و 0.627 كجم/ساعة فى حالة استخدام المجففات الشمسية على سراعات هواء (1.5-1.0-0.5)م/ث على التوالى مقارنة ب 24 ساعة ككيزان و 14 ساعة كحبوب فى حالة التجفيف الشمسى الطبيعى بمعدل تجفيف 0.427كجم/ساعة.

بشكل عام أظهرت ظروف كل من تجفيف الذرة ككيزان كاملة و كحبوب مفرطة نسبة إنبات أكثر من 85 % مما يعني أن الطريقة المقترحة لتجفيف الذرة بالطاقة الشمسية ملائمة لإنتاج التقاوى.

REMOVAL OF HYDROGEN SULFIDE (H_2S) FROM BIOGAS TO IMPROVE ITS USE EFFICIENCY IN DIFFERENT APPLICATIONS

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Abstract

Hydrogen sulfide (H_2S) represents a risk to the environment and to health, as the SO_2 emissions released from combustion processes cause adverse effects on human health. When SO_2 combined with Carbone hydroxide (CO_2) and water vapor (H_2O), it form Sulfuric acid (H_2SO_4) (very harmful acid) which causes damage in equipment such as boilers and gas pipes. It can also destroy power generation equipment because it causes corrosions in the internal parts of engines. Because of its highly corrosive nature and unpleasant odor, H_2S is typically removed first. The aim of this research work is improve the characteristics of biogas to maximize its use in different applications by removing the H_2S from biogas. The experiments were divided in two phases. In the first phase, several chemical and physical removal methods of H_2S were being tested in laboratory using compressed and directly biogas production to reach the optimal removal method. The chemical methods include; Ferric Chloride (Fe_3Cl 40%), EDTA (Ethylene Diamine Tetra Acetate), Ferric EDTA (Fe(III)EDTA) solution at one and two stages of removal process. While the physical methods included water, Iron filing biogas compression process. The optimal removal method was applied to remove H_2S from biogas production in large scale digesters. The obtained results of laboratory tests showed that the Ferric EDTA (Fe(III)EDTA) at two stages was gave the highest removal efficiency (98.66%) followed by compression process (97.71%) and EDTA (95.82%) while the minimum efficiency was 16.84% and it was occurred with Iron Filing removal method. The results also, showed that the other advantages of using Ferric EDTA (Fe(III)EDTA) are the transformation of H_2S into Sulfur which can be introduced in the fertilizer industry, eliminating the pollution potential of H_2S and it can be easily regenerated by bubbling air into the absorbing Ferric EDTA solution. In the second phase, the Ferric EDTA solution was used to remove H_2S from biogas production in the large scale digester volume of 40 m^3 with average total biogas production of about 21 m^3 per day. The results revealed that, the Ferric EDTA at two stages gave the highest removal efficiency ranged from 98.91% after the first hour to 90.32% after 48 hour. The net H_2S remaining in the biogas was ranged from 22 to 192 ppm at the same times respectively, and then biogas can be used in different applications without any adverse effect either for equipment or the environment.

INTRODUCTION

Hydrogen sulfide is present in biogas produced during the anaerobic digestion of biodegradable substances. It is produced from the degradation of proteins and other sulfur containing compounds present in the organic feed stock to the digester. The concentration of hydrogen sulfide in the biogas depends on the feedstock and varies between 0.1 to 2% (Lastella *et al*. 2002; Boyd 2000). While, Abatzoglou and Boivin, (2009) added that, the range of H_2S varies from 10 ppm to about 10 000 ppm. Generally, biogas produced from manure and protein rich industrial wastes contain higher amounts of hydrogen sulfide (Schieder *et al*. 2003). One of the biggest factors limiting the use of biogas is related to the hydrogen sulfide it contains, which is very corrosive to internal combustion engines (Tchobanoglous *et al*. 2003).

Biogas is an attractive source of energy due to its high methane content. However, direct utilization of biogas as fuel without removal of H_2S leads to the formation of sulphur dioxide (SO_2), which is another toxic pollutant and a major contributor to acid rain in the atmosphere. For use as a fuel, purification to remove carbon dioxide (CO_2) and hydrogen sulfide (H_2S) is required, because H_2S corrodes vital mechanical components within engine generator sets and vehicle engines if it is not removed. (Zhao, *et al.,* 2010).

In order to transfer biogas into biomethane, two major steps are performed: (1) a cleaning process to remove the trace components and (2) an upgrading process to adjust the calorific value. Upgrading is generally performed in order to meet the standards for use as vehicle fuel or for injection in the natural gas grid (Ryckebosch, *et al.,* 2011).

Operational difficulties with the utilization of biogas arise mainly from relatively high hydrogen sulfide concentrations (EMG International, 2007).These difficulties include:

- Corrosion in engines, including the combustion chamber exhaust system, bearings, etc. due to the reaction of H_2S, CO_2 and water with engine materials.
- Elemental hydrogen can form during the combustion process due to decomposition of H_2S at high temperature, causing cracking and blistering of metal parts.
- Oxidation of H_2S to sulfuric acid in combination with water vapor, increasing the risk of corrosion

$$\mathbf{H_2S + 2O_2 \rightarrow H_2SO_4}$$

- The partial oxidation of H_2S to sulfur dioxide in the engine or boiler exhaust can also lead to complaints about odor as regulatin. In addition, combinations of sulfur dioxide and water are particularly corrosive to mild steel.

$$\mathbf{2H_2S + 3O_2 \rightarrow 2H_2O + 2SO_2}$$

H_2S can be removed by a variety of processes such as:

- Iron chloride added to the digester influent.
- Reaction with iron oxide or hydroxide (iron sponge).
- Water. and
- Sodium hydroxide or lime.

Moreover, using of water to remove the hydrogen sulfide from biogas was an important method because it was the simple and cheaper method but it must be used at elevated pressure and high flow rate (Vijay, *et al.,* 2006). Moreover, MNES Report (2001) added that, If water is available in the required quantity, water scrubbing is a better option for removal of CO_2 and H_2S. Moreover, using the Ferric Chloride to remove the H_2S from biogas was an active method specially when it was added to the digester influent (Seeta, *et al.,* 2006 and Ryckebosch, *et al.,* 2011).

The advantages of chemical absorption are complete H_2S removal, high efficiency and reaction rates compared to water, and the ability to operate at low pressure. Because of these advantages, the process is commonly used in industrial applications, including natural gas purification (Kim, *et al.*, 2004; Palmeri, *et al.*, 2008).

AlMamun and S. Torii (2015) used zero-valent iron with 90% purity to remove the H_2S from biogas. Their results indicated that, the H_2S concentration was reach below 50 ppm which acceptable for running the internal combustion engines. They found that, the maximum absorption efficiency was 95% at pH 6 for Fe^o, which are higher than conventional adsorbents. They also, concluded that, the H_2S removal using zero-valent iron reduced high operation cost and risk factor to the process. Therefore, it is still highly recommended not only for preventing metal corrosion but also prevents the environmental pollution.

The H_2S removal efficiency (H_2S RE) was the ratio of the treated H_2S and inlet H_2S concentration in biogas or absorbent solution as shown the simple formula in equation (1). (Rakmak, *et al.*, (2010).

$$H_2S\ RE. = \frac{[H_2S]inlet - [H_2S]outlet}{[H_2S]inlet} \quad \% \qquad (1)$$

Where %$H_2S\ RE.$ is percentage H_2S removal efficiency, H_2S_{inlet} is inlet H_2S concentration in biogas inlet and H_2S_{outlet} is H_2S concentration in biogas outlet.

MATERIALS METHEDOS

This research work is one outputs of the "Development of Biogas Production and Utilization Systems" project which financially supported by the Agricultural Development Program (ADP). It is implementing at the Tractors and Machinery Research and Test Station, Alexandria city-Agricultural Engineering Research Institute.

The treated biogas was produced from two fixed dome digesters volume of 20 m^3 for everyone. The average biogas production from the two digesters was about 21 m^3 per day with average flow rate of 0.875 L/hr. Several chemical and physical removal methods of H_2S from biogas were being done in laboratory using compressed and direct biogas production from digesters to reach the optimal removal method, and then it was used for removing H_2S from direct biogas production in large scale digesters. The chemical methods include; Ferric Chloride ($FeCl_3$ 40%), EDTA (Ethylene Diamine Tetra Acetate), Ferric EDTA (Fe(III)EDTA) solution, while the physical methods were; water, biogas compression and Iron filings.

- **Preparation of Fe(III)EDTA (Fe^{3+}EDTA):**

A Fe (III) EDTA solution was prepared using the following recipe: A 75 kg of EDTA 4 Na powder was dissolved into 200 L of water. A 40 L of 40% $FeCl_3$ solution was diluted to 200 L with water. The EDTA solution was then gentle rinse into the diluted $FeCl_3$ with continuous stirring. The 400 L of Fe (III) EDTA solution was obtained with a concentration of 350 mol/m^3 (**Saelee, *et al.*, 2008 and 2009**).

- **Experiments Setup:**

The different purification and removal methods were conducted in laboratory with the compressed biogas as well as directly from digesters. Two bottles 5 liters volume as showed in Fig. (1) were used in the purification process. The two bottles were filled with different chemicals and the biogas was passed through them to remove the hydrogen sulfide (H_2S) from biogas. The removing process was tested at one stage and two stages Figure (2 a and b) (one stage mean that the biogas was passed through one bottle, while two stages means that biogas was passed through two bottles).

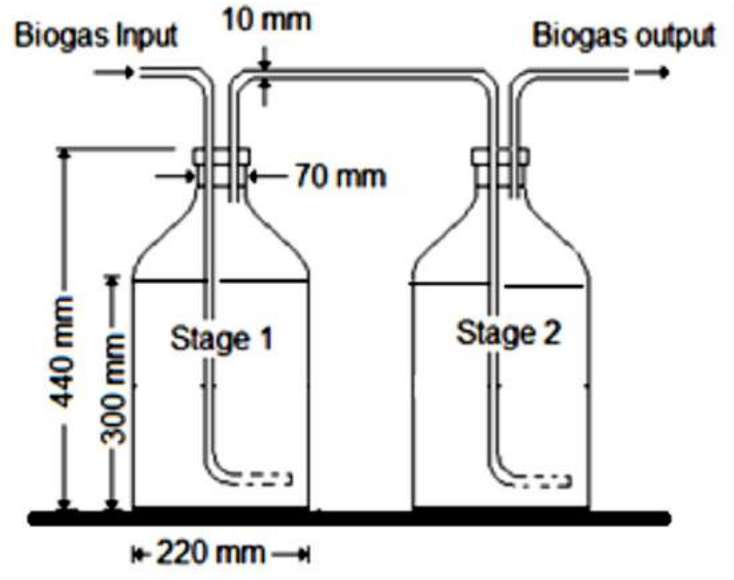

Fig.(1): schematic of H_2S removal system

(a): One stage removal process (b): Two stages removal process

Fig. (2): One and two stages of H_2S removal process

RESULTS AND DISCUSSION

The average values of hydrogen sulfide before and after purification process at different removal methods were listed in Table (1) and illustrated in Fig. (3). The obtained results showed that the Fe(III)EDTA solution gave a higher removal ratio of hydrogen sulfide (H_2S) (98.66%) flowed by Compression, EDTA, Ferric chloride, water and Iron filling methods respectively. However, removal of H_2S with compression process was discovered by accident and indicated that H_2S can be reduced in biogas when it is compressed in cylinders as showed in Fig. (4). In spite of the high removal ratio of H_2S (97.71%) with compression process, the disadvantage of this method is the corrosion of the compressor cylinder parts. So, it strongly recommended to remove the H_2S by another method before compressing biogas or used of it to operate the internal combustion engines. However, the removal efficiency of H_2S from produced biogas using Ferric Chloride was 42.06%, and this mean that it was required additional methods to increase the removal efficiency. The Iron filings was gave the lowest removal efficiency which not exceed 16.84% in the average, so it was not recommended for H_2S removal from biogas. This result was in agreement with Huynh, *et al.,* (2009) who reported that the Iron filings is not suitable method to remove the H_2S from biogas.

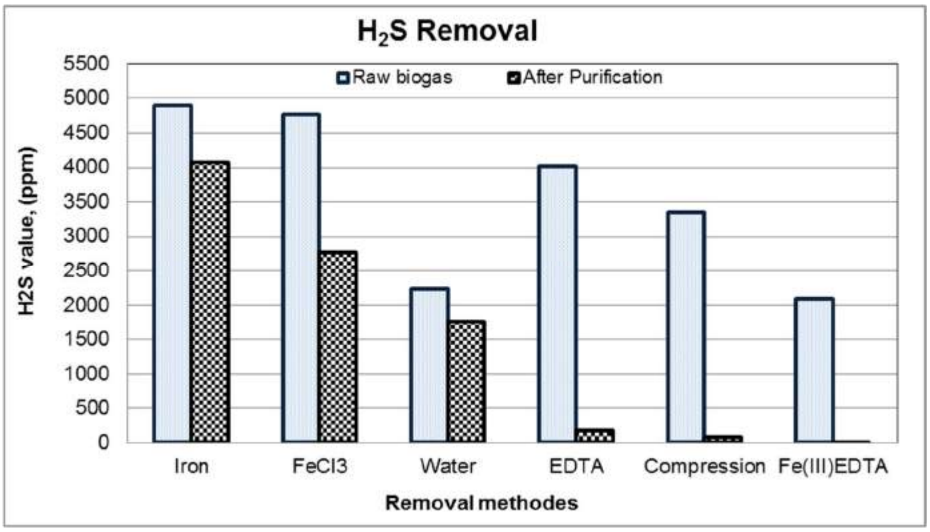

Fig.(3): Removal of H_2S using different chemical and physical methods

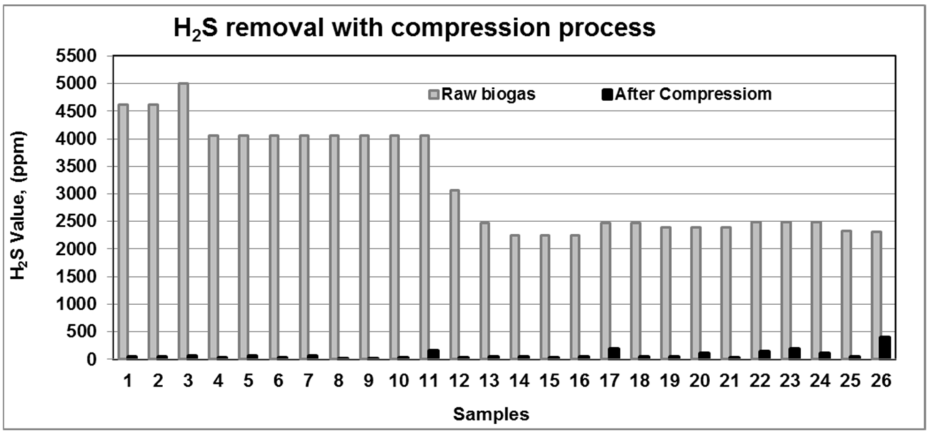

Fig.(4): Removal of H_2S using compression methods

The obtained results cleared that the best method for the H_2S removal was Fe(III)EDTA solution which gave the highest removal efficiency. The remained H_2S in biogas after removal process with Fe(III)EDTA was 28 ppm which was suitable for most applications specially, for internal combustion engines. These results were agreement with Seeta, *et al.*, (2006), since they reported that if the H_2S concentration is maintained below 40 ppm in the biogas after pre-treatment, there would be no need for any further treatment of H_2S for IC engines because the tolerance limits of the IC engines are much higher than 40 ppm.

The results of the previous experiments demonstrated that we can use the Fe(III)EDTA as the main chemical solution to remove the H_2S from biogas before it stored in the storage tanks to prevent any corrosion caused by the H_2S. Several experiments were done to achieve the optimum removal efficiency either with one stage or two stages. The removal procedure with one stage was done by pass the raw biogas through one bottle (5 liters volume) filled with 4 L of Fe(III)EDTA with the concentration of 0.35 mol/L (Saelee, *et al.*, 2009). The biogas compositions were measured before and after the removal process using GA5000 gas analyzer. The removal in two stages was done by pass the raw biogas through two bottles, each one having a gross volume of about 5 liter, every bottle contained 4 liter of the Fe(III)EDTA solution and the same measurements were done. The biogas flow rate was ranged from 310- 350 L/hr with the average of 330 L/hr.

Table (1): Hydrogen sulfate removal methods

Purification Methods	CH_4 (%)			CO_2 (%)			H_2S (ppm)		
	Raw Biogas	Purified Biogas	Increase/ Decrease Ratio	Raw Biogas	Purified Biogas	Increase/ Decrease Ratio	Raw Biogas	Purified Biogas	Removal efficiency (%)
Fe(III)EDTA	56.6	59.4	4.95	43.2	40.4	-6.48	2087	28	98.66
Compress.	55.8	56.1	0.54	44.1	43.8	-0.68	3338	76.5	97.71
EDTA	57.4	58	1.05	42.5	41.9	-1.41	4015	168	95.82
$FeCl_3$ 40%	56.7	57.5	1.41	43.1	42.3	-1.86	4760	2758	42.06
Water	52.1	53.5	2.69	47.6	46.2	-2.94	2226	1749	21.43
Iron filings	59.3	60.1	1.35	40.6	39.8	-1.97	4898	4073	16.84

The average values of biogas composition before and after removal process and removal efficiency were listed in Table (2) and illustrated in Figures (5 and 6). The obtained results showed that the removal efficiency in the first stage was begun at high value of 94.47%, and then declined through the first four hours reached 88.59%, further decline was occurred through the sequent 44 hour reached the minimum value of 11.2%. This decline may be due to decrease the Fe(III)EDTA concentration and increase the H_2S absorption rate (Saelee, *et al.,* 2008).

Table (2): The biogas compositions before and after the removal process and the removal efficiency using Fe(III)EDTA at two stages.

Time	CH_4 (%)			CO_2 (%)			H_2S (ppm)			Removal Efficiency	
	Before removal	After removal		Before removal	After removal		Before removal	After removal		(%)	
hr		Stage 1	Stage 2		Stage 1	Stage 2		Stage 1	Stage 2	Stage 1	Stage 2
1	55.8	56.6	57.8	44	43.2	42	2024	112	22	94.47	98.91
2	55.8	56.6	56.6	44	43.2	43.2	2024	147	28	92.74	98.62
3	55.8	56.4	57.2	44	43.4	42.6	2024	192	40	90.51	98.02
4	55.8	55.8	56.3	44	44	43.5	2024	231	33	88.59	98.37
24	56.3	56.1	56.4	43.5	43.8	43.4	2002	668	50	66.63	97.50
26	56.3	55.8	57.2	43.5	44	42.6	2002	705	53	64.79	97.35
28	56.3	56.5	56.8	43.5	43.3	43	2002	961	65	52.00	96.75
29	56.3	56.6	56.6	43.5	43.2	43.2	2002	1053	70	47.40	96.50
31	57.1	58.1	57.7	42.7	41.7	42.2	1983	1102	88	44.43	95.56
46	57.1	57	57.2	42.7	41.8	42.7	1983	1350	150	31.92	92.44
47	57.1	57.6	58.6	42.7	42.3	41.2	1983	1576	176	20.52	91.12
48	57.1	57.2	56.8	42.7	42.7	43.1	1983	1761	192	11.20	90.32

Meanwhile, the data illustrated in Fig. (5) showed that the H_2S concentration were at the lowest values after the second stage of removal by the Fe(III)EDTA compared with the first stage. The minimum value of H_2S through the second stage was 22 ppm after one hour and a slight increasing in the H_2S concentration reached the maximum value of 192 ppm after forty eight hours. These obtained results indicated that the two stages removal process with Fe(III)EDTA remaining the H_2S concentration at the suitable values for different applications without any problems. Moreover, the removal efficiency at the second stage not less than 90.32% throughout the removal time (48 hr) as compared with 11.2% at the first stage. In addition, the removal efficiency ranged from 98.91% after the first hour to 90.32% at the end of forty eight hours with the average of 94.62%. However, the data illustrated in Fig. (6) showed that the removal efficiency at the two stages remained at the highest values throughout the different experiments. These obtained results mean that it must be use the two stages Fe(III)EDTA solution to maintain the low level of H_2S in biogas production.

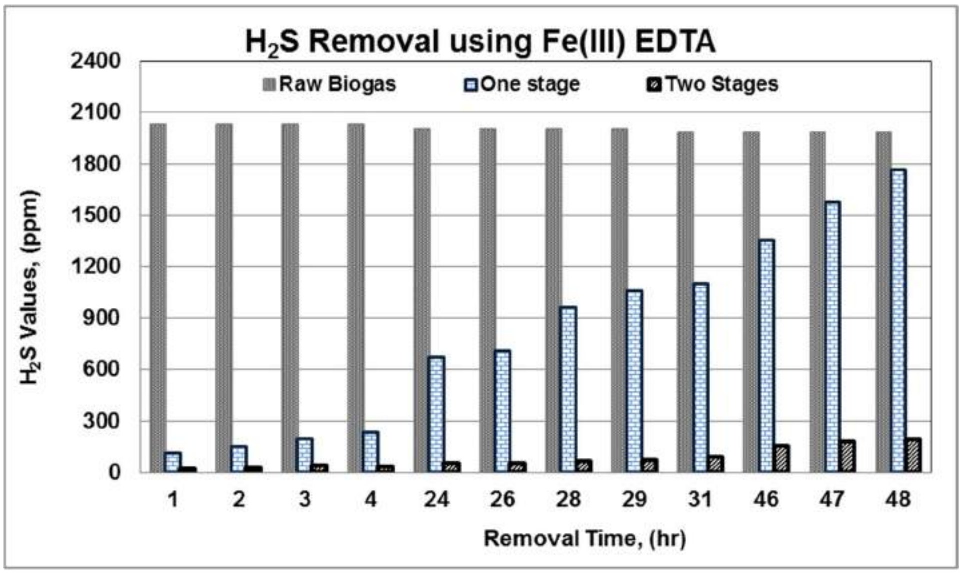

Fig.(5): Removal of H_2S using Fe(III)EDTA

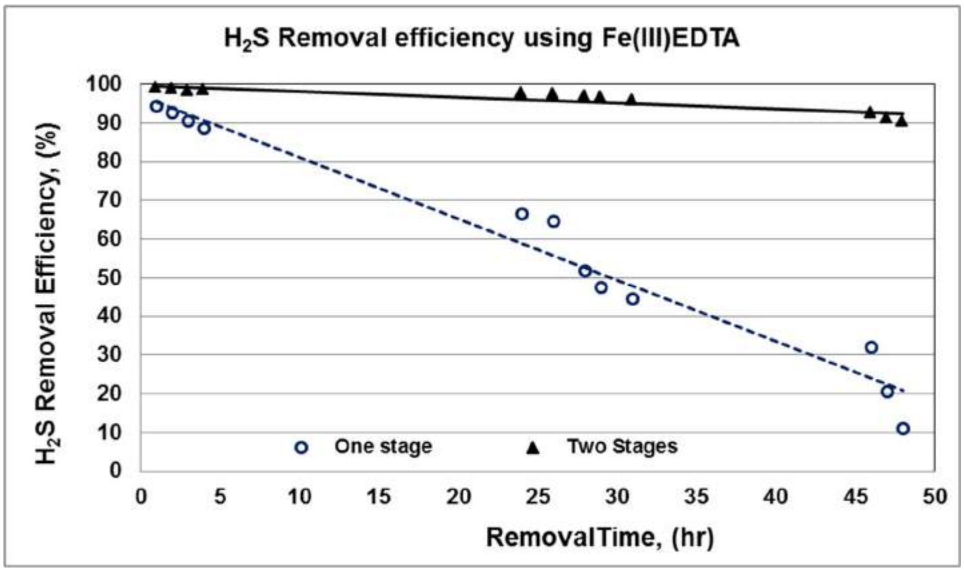

Fig. (6): Removal efficiency of H_2S using Fe(III)EDTA

In addition, the results presented show that the almost selective increased rate of H_2S removal is not the only advantage of this process of chemical absorption. The main advantage is the transformation of H_2S into Sulfur (Fig., 7) which can be introduced in the fertilizer industry as well as eliminating the pollution potential of H_2S (Horikawa1, *et al.*, 2004) and also, the Fe(III)EDTA can be easily regenerated by bubbling air into the absorbing liquid (Saelee, *et al.*, 2009). They also, conclude that chemical oxidation using an iron-chelated solution, catalyzed by Fe(III)EDTA is an economically promising technique to remove H2S from biogas even at high H_2S concentrations. The deposited Sulfur by Fe(III)EDTA was chemically analyzed at Pest Control & Environmental Protection Unit, Faculty of Agriculture – Alexandria University of sulfur, and the results showed the possibility of utilization the output sulfur in the fertilizer industry.

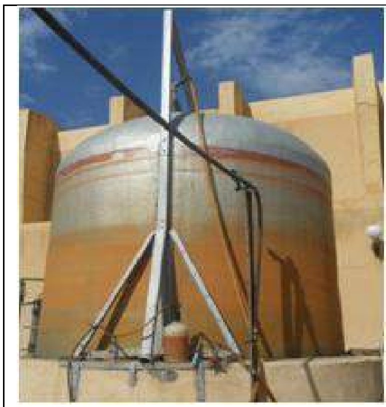		
a- H_2S through removal process	**b- Sulfur in the saturation status of Fe(III)EDTA**	**c- Sulfur sedimentation**

Fig.(7): Transformation of H_2S in biogas production into Sulfur using Fe(III)EDTA

CONCLUSIONS AND RECOMMENDATIONS

The results show that using of Ferric EDTA (Fe(III)EDTA) gave the highest removal efficiency of H_2S as compared with the other removal methods. The high removal efficiency of H_2S ranged from 98.91% after the first hour to 90.38% after 48 hours. The remaining value of H_2S in treated biogas ranged from 22 to 192 ppm and it was safety to use in different applications. The other advantage of Fe(III)EDTA removal method is the transformation of H_2S into Sulfur which can be introduced in the fertilizer industry as well as eliminating the pollution potential of H_2S. In addition, the Fe(III)EDTA can be easily regenerated by bubbling air into the absorbing liquid. It can be also, concluded that chemical oxidation using Fe(III)EDTA is an economically promising technique to remove H_2S from biogas even at high H_2S concentrations.

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إزالة كبريتيد الهيدروجين من الغاز الحيوي لتحسين كفاءة استخدامه في التطبيقات المختلفة

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يمثل كبريتيد الهيدروجين (H_2S) خطرا على البيئة والصحة، حيث إن انبعاثات ثاني أكسيد الكبريت الصادرة عن عمليات الاحتراق تسبب آثارا ضارة على صحة الإنسان. وعندما يتحد ثانى اكسيد الكبريت مع ثانى اكسيد الكربون و وبخار الماء، فإنه يكون حامض الكبريتيك المركز (H_2SO_4) وهو حمض ضار جدا يسبب تأكل في المعدات مثل الغلايات ومواسير الغاز. كما انه يسبب تدمير لمولدات الكهرباء التى تعمل بالغاز الحيوى لأنه يسبب تآكل في الأجزاء الداخلية للمحركات.

لذلك كان الهدف من هذا البحث هو ازالة كبريتيد الهيدروجين من الغاز الحيوى قبل استخدامة فى الاغراض المختلفة خاصة الات الاحتراق الداخلى ومواسير نقل الغاز. وقد تم استخدام عدة طرق لإزالة H_2S من الغاز الحيوى في المعمل سواء المضغوط أوالناتج مباشرة من المخمر وذلك للوصول إلى طريقة الإزالة المثلى .وقد اشتملت هذه الطرق على؛ كلوريد الحديديك 40% ($FeCl_3$ 40 %)، مركب الإدتا (الإيثيلين ديامين تيترا اسيتات)، محلول كلوريد الحديديك مع مركب الإدتا (Ferric EDTA) ، المياه، برادة الحديد ونظام ضغط الغاز الحيوي. حيث تمت عمليات الإزالة على مرحلة واحدة وعلى مرحلتين .

وقد اظهرت نتائج الدراسة المتحصل عليها فى المعمل ان استخدام محلول (Ferric EDTA) على مرحلتين أعطى أعلى كفاءة إزالة لكبريتيد الهيدروجين بلغت 98,66% تليها عملية ضغط الغاز (97,71%) ثم الإدتا (95,82%) بينما اعطت برادة الحديد اقل كفاءة لازالة H_2S من الغاز وبلغت 16,84%. لذلك تم استخدام محلول (Ferric EDTA) فى ازالة كبريتيد الهيدروجين (H_2S) من الغاز الناتج من المخمرات التطبيقية والتى تنتج حوالى 21م3 غاز/يوم (875 لتر/ساعة). حيث اظهرت النتائج المتحصل ان كفاءة الازالة لكبريتيد الهيدروجين تراوحت بين 98.91% بعد الساعة الاولى من التنقية ووصلت الى 90.32% بعد 48 ساعة من التنقية. حيث تراوحت قيمة H_2S فى الغاز بعد عمليات التنقية من 22 جزء فى المليون بعد الساعة الاولى الى 192 جزء فى المليون بعد 48 ساعة من التنقية وهذا يؤدى الى زيادة كفاءة الاستخدام للغاز الحيوى فى كافة التطبيقات دون حدوث اى اضرار سواء للبيئة او المعدات التى تعمل بالغاز الحيوى.

أظهرت النتائج أيضا أن هناك مميزات أخرى لاستخدام محلول (Ferric EDTA) وهي تحويل H_2S إلى كبريت عضوى يمكن إستخدامه في صناعة الأسمدة مما يسهم فى الحد من التلوث الناتج عن H_2S . كما ان محلول (Ferric EDTA) يمكن إعادة توليده بسهولة عن طريق تعرضه للهواء مما يؤدى الى ترسيب الكبريت واعادة استخدام المحلول مرات عديدة فى عمليات التنقية.

DEVELOPMENT OF A SELF-PROPELLED DRUM SEEDER FOR PADDY DIRECT SEEDING

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Abstract

The aim of this work is to develop a self-propelled drum seeder for direct seeding of paddy crop to achieve the uniformity of seed distribution and height products at little cost and energy. This study included modification on the seed hopper shape and size, number of metering holes, distance between metering holes, height of hoppers from soil surface, etc. Longitudinal and transverse scattering, seed rate, hill to hill spacing, average number of seeds/hill, hill missing and over falling, theoretical field capacity, effective field capacity, field efficiency, consumed energy and total costs were measured. From the laboratory calibration test the combination of sprocket ratio (Sr_4) with hopper head 5 cm and (FS_3) 1.95 km/h forward speed under 14 holes of metering openings (MO_2) were selected for field evaluation of drum seeder. The drum seeder was tested on puddle field. Longitudinal and transverse scattering were 8.8 and 8 cm, respectively. Seed rate reached 43.67 kg/fed. The average number of seeds dropped per hill was 11.97. The hill to hill spacing was 17.45 cm. The hill missing reached 7.3%. Theoretical field capacity was 0.74 fed/h and effective field capacity was observed to be 0.45 fed/h. The field efficiency of the seeder was found to be 60.8%, energy requirements of 27.06 kW. h/fed with saving in total costs by 83.07 % as well as saving seeds by 27.2 % when applying the developed self-propelled drum seeder in puddle field.

***Key words**: rice seeder, self-propelled, paddy, puddle, direct sowing*

INTRODUCTION

The rice crop in Egypt and the world is one of the main food crops in importance, and is second only to wheat yield in terms of cultivated area which is about 1.5 million feddans in the Delta of Egypt. The cultivation of rice crops in Egypt continues to face many problems and difficulties in planting methods due to the lack of abundant labor and the increase in the total costs of the production unit. There are two methods for growing the rice crop, the first with the seedling method and the second with the direct seeding. Devnani (2002) reported that labor intensive rice transplanting operation would be replaced by direct sowing to tackle the problem of labor scarcity at the time of planting, to reduce the cultivation cost and achieve proper and timely crop establishment. The sowing techniques had been developed as dry sowing for uplands, rain fed lowlands and wet sowing. However, the rice farmers should understand the various methods and techniques for sowing rice in their areas before adopting the seeders and sowing techniques. Subbaiah *et al*. (2002) conducted an experiment to evaluate the performance of drum seeder in farmers' fields. Crop established with a drum seeder resulted in higher mean grain yield (4.63 t/ha) then with transplanting (4.25 t/ha) and superior over broadcasting (3.34 t/ha). The drum seeder, providing the crop establishment equivalent to traditional transplanting method, also recorded not only the high yield, but also the highest net revenue of $ 304/ha with benefit cost ratio of 1.30. Proper leveling of land before sowing, use of effective herbicide 4 days after sowing of pre-germinated seed and mechanical weeding with rotary push hoe after first top dressing of nitrogen fertilizer (25 DAS0) was a recommended package for drum sowing technology. Siva Kumar *et al.* (2003) conducted a study on the performance of prototype direct-rice seeders with single and double ground wheels with and without furrow openers using dry and soaked seeds. It was found that the use of soaked seeds in the improved seeder with furrow opener resulted in a higher yield of grain and straw. Alam (2005) developed a drum seeder using locally available materials. However, the experiments with different drum seeders show that the filling condition of drum and speed of operation had significant effect on seed rate. The maximum amount of seeds (80.9 kg/ha) were found when the drum was filled of its one fourth capacity. On the other hand, the lowest sowing rate (30.42 kg/ha) was recorded when the drum was filled of its full capacity. These results indicate that the sowing rate was increase with the decrease of filling condition of drum. This is a problem of direct seeder. Abo EL-Naga and Shetawy (2010) studied the effect of some engineering factors of feeding disc for direct seeding of soaked and incubated rice seeds. These factors were divided into three different speeds of feeding disc (0.1, 0.15 and 0.19 m/sec) and different heights of the falling seeds (15, 20 and 25 cm). Sakha 101 variety was used in all tests after soaked for 24 hours and incubated for 48 hours. The best uniformity of seed distribution in lateral and longitudinal direction was achieved with coefficient of variation (C.V) 6.13 and 8.05 %, respectively, at speed of feeding disc of 0.1 m/s and seed falling height of 15 cm. The lowest percentage of visible (3.33) and invisible (0.23) damaged grain were found at speed of feeding disc of 0.1 m/s and seed falling height of 15 cm. The lowest hill area (24.75 cm2) was obtained with speed of feeding disc of 0.1 m/s and seed falling height of 15 cm. Abo EL-Naga (2010) evaluated a field performance of developed direct seeding machine and compared it with the common systems for direct seeding. The results indicated that the germination ratio was 78.4% and plant population was 208.69 plants/m^2. The values of coefficient of variation (C.V) were 9.37 and 13.73 % at lateral and longitudinal direction, respectively. The grain yield reached 3.225 tons/fed when using the developed direct seeding machine with furrow opener at seed rate of 40 kg/fed. The energy consumed and the costs were 0.514 kW.h/fed and 22.12 L.E/fed., respectively. However, the net benefit earn was 86.49 LE and 0.172 ton/fed by using the developed direct seeding with furrow opener at seed rate of 40 kg/fed., comparing with hand direct seeding in hills with furrow opener at seed rate of 60 kg/fed., in addition to 20 kg abundance in rice seeds. Singh *et al.* (2016) tested a manual drawn direct paddy drum seeder on puddle field. The laboratory calibration was carried out with different combinations of drum fill level viz., full, half, quarter, and travel speed viz., 1 km/h, 1.5 km/h and 2 km/h. From the laboratory calibration test the combination of half drum fill level and 1 km/h speed were selected for field evaluation of drum seeder. The theoretical field capacity 0.16 ha/h. While effective field capacity of the drum seeder was observed to be 0.131ha/h. The field efficiency of the seeder was found to be 82.08 percent.

The number of seeds dropped per hill was 5. The hill to hill spacing was 14.5 cm. The hill missing was 5.8 percent. The cost of operation of drum sowing is Rs. 42.67 per hour and Rs. 341.36 per ha. The rice farmers practicing transplanting are facing problem of non-availability of ample water and other inputs. Therefore, this study is necessary to develop the manual drum seeder manufactured by the International Rice Research Institute (IRRI) to be self-propelled and consequently increasing weed control, saving and conservation of irrigation water, covering area, saving seeds quantity while sowing and laborers.

MATERIALS AND METHODS

The laboratory and field experiments were carried out during two successive summer seasons 2015/2016 after wheat crop at a Farm Research in El-Serw Agric. Res. Station Damietta Governorate. Giza 178 variety of rice crop was used at feeding rate of 60 kg/fed. The mechanical analysis of the experimental soil was carried out in El-Serw Plant Nutrition Lab., Soil, Water and environment Res. Institute A.R.C. Giza, Egypt. The mechanical analyses of the experimental soil are summarized in Table 1.

Table (1): The mechanical analysis of the experimental soil

Fine sand %	Coarse sand %	Silt %	Clay %	Soil texture
10.13	05.70	20.30	63.87	Clay

IRRI drum seeder before modification

There were some challenges with the design. Fig. 1 shows a photographic view and a stretch out of the drum and different views of drum before modifications. specification of manually paddy drum seeder are shown in Table 2.

Challenges identified

1. No proper mechanism to control the seed rate according to the variety of the seed.
2. If the hole size is kept at 12 mm for a long grain rice, excessive number of a short grain rice are dropped. If the hole size is kept at 8 mm both long and short grain rice will not drop at all. Hence a mechanism is needed to control the hole size according to the variety.
3. Need baffles inside drums which affect grains and damaged sprouts.
4. Small size of drums which are needed to be re-fill many times to cover one feddan.
5. The weight of the machine is excessive (25 kg without seeds) which needs a strong person.
6. Difficult to turn at end of the plot, need a support of another person.
7. Drums and floater/skid get corroded easily as used in mud. All these challenges were taken in the consideration while constructing the self-propelled drum seeder.

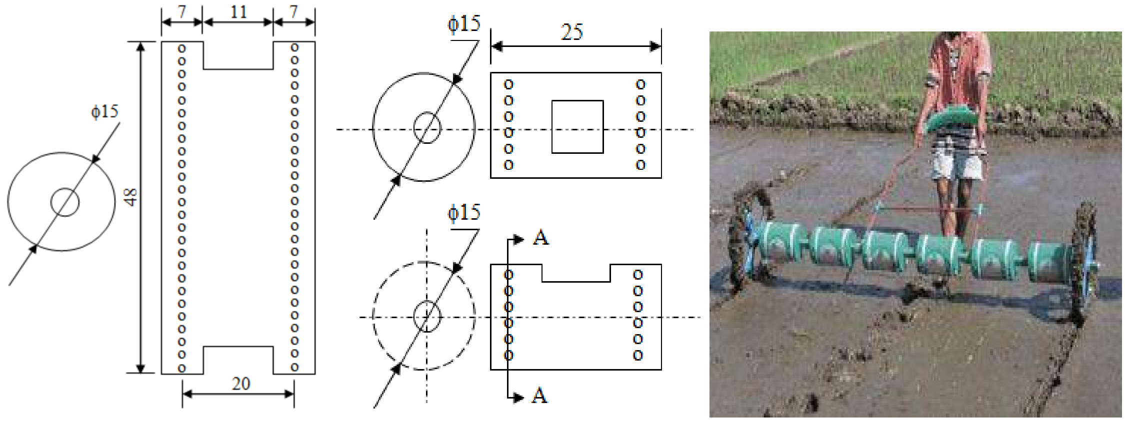


Fig. 1: Shows a photo and a stretch out of the drum **before modification** (Dimensions are in cm)

Table 2: Specification of direct paddy drum seeder before modification

Specifications of drum		
1	Material of construction	Polypropylene copolymer sheet of thickness 2.5mm
2	Number of drums and shape	4 , Cylindrical
3	Drum diameter(outer), cm	20.00
4	Drum diameter(middle), cm	16.25
Specifications of holes of drum		
1	Number of holes on one side of drum	8
2	Average diameter of holes, mm	9
3	Peripheral spacing between two holes, cm	6.0
4	Shape of holes	Circular
5	Number of rows per drum	2
6	Spacing between two rows in a drum, cm	20
Specifications of ground wheel		
1	Material of construction	Plastic
2	Type of wheel	Lugged ground wheels
3	Diameter of wheel, cm	90
4	Spacing between two consecutive lugs, mm	25
5	Average width of wheel, cm	7.5

Modifications have been made to overcome all the apparent problems in the manual drum seeder. Modifications included hopper shape and size, changeable hopper head, changeable metering device, self-propelled, etc. Direct paddy drum seeder has eliminated the need of transplantation and hours of manual work which literally break the back of the farmers in sowing the paddy seeds to the field

Development of self-propelled drum seeder (Constructional details)

The main modifications were on fabricating seed drums (hoppers) in hyperboloid shape (two parts welded against each other) instead of cylindrical shape and changing normal wheels with lugged ones and also the elf-propelled motion apart from other attachments.

1- Chassis: It consists of frame with rear orientation through a 13 hp (≈9.7 kW) diesel engine. The two front wheels provides the motion to the drum seeder through a sprocket and a chain to control the positive motion. A schematic diagram and a photographic view of the self-propelled drum seeder are shown in Fig. 2

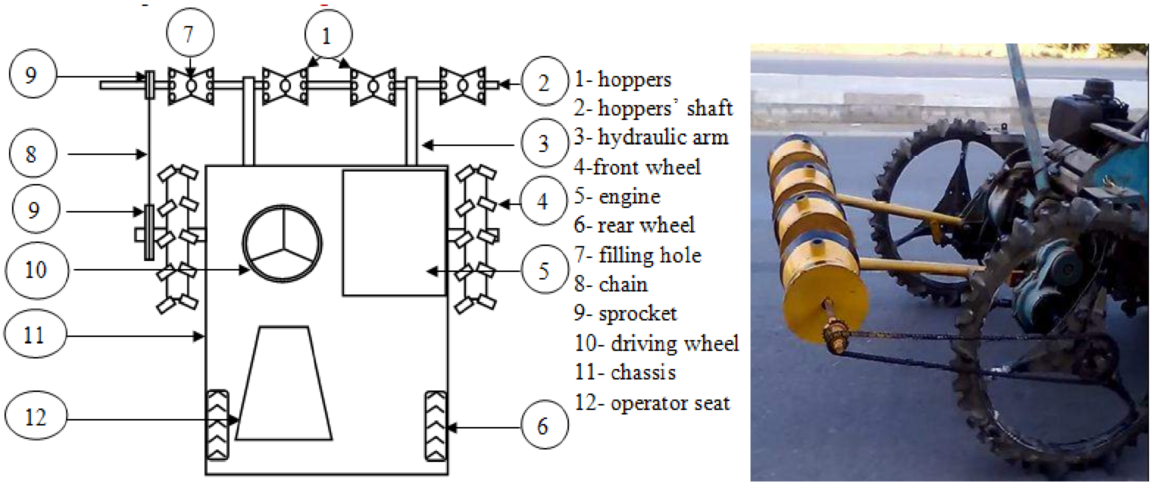


Fig. 2: Schematic diagram and a photographic view of the self-propelled drum seeder

2- Seed drum and metering device: Metering device is the most important part for designing and developing of the applicator. It was made by steel sheet. The seed drum is hyperboloid shaped (Fig. 3, photographic view and a schematic diagram) with 30 and 20 cm for outer and inner diameter, respectively. There is a number of holes, represents metering device, around each drum in two rows with 20 cm between rows on the drum. Sowing metering openings are 1.0 cm hole diameter, at 3.0 cm intervals between holes.

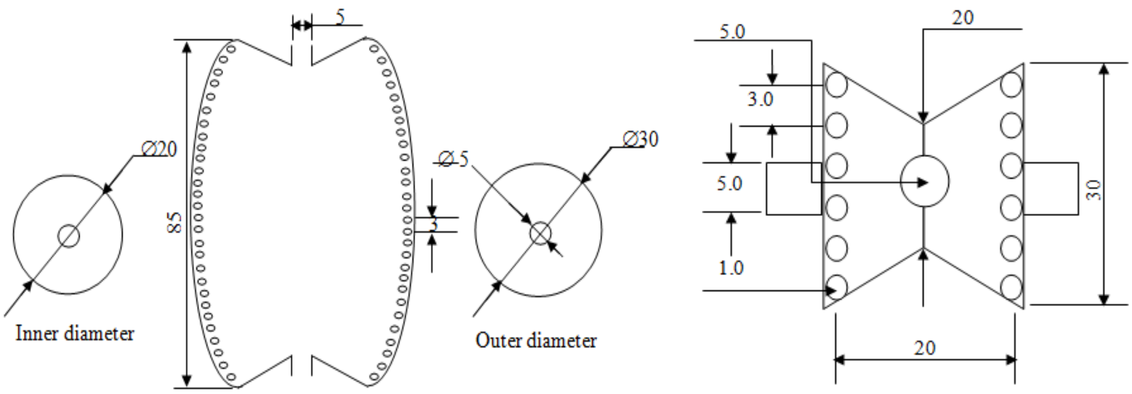


Fig. 3: A schematic diagram and a stretch out of the hopper with metering device after modifications, (dimensions are in cm)

There are four drums (hoppers) cover 8 rows of 20 cm row to row spacing at a time. There is a feeding opening in the middle of each hopper to fill and re-fill the hopper when needed. The hoppers were supported by a round bar on two bearings. When the round bar rotates then the hopper with metering device also rotates.

Note: The numbers of drums could be increased to eight drums or more according to the power engine but four number of drums were chosen to carry out the experiments. Specifications of the drum seeder and metering openings are shown in Table 3

Table 3: Specification of direct paddy drum seeder after modification

Specifications of drum				Specifications of holes of drum	
No	Particulars	Specifications	No	Particulars	Specific.
1	Material of construction	Metal sheet of thickness 1.5mm	1	Spacing between each two holes, cm	3
2	Number of drums	4	2	Number of holes on one side of drum	28
3	Shape of drum	Hyperboloid	3	Average diameter of holes, cm	1.0
4	Drum diam. (outer),	30 cm	4	Shape of holes	Circular
5	Drum diam.(inner),	20 cm	5	Number of rows per drum	2
6	Distance between each two drums, m	20	6	Spacing between two rows in a drum, cm	20

3- Power Transmission System: An engine of 13 hp (≈9.7 kW) was used as power source. The power is transmitted to the lugged ground wheel then through a changeable tooth sprocket and chain to the hoppers' shaft through changeable one-way sprockets with different number of teeth to stop sowing while reverse motion.

4- Hydraulic arms: Two hydraulic arms are attached to the hydraulic system through a hydraulic pump. These two arms controlled up and down motion for the hoppers' shaft during redirection at the end of the field and while transporting between fields.

5- Ground Wheel: Lugged ground wheels is provided. These wheels are made up of iron material lined up with hard rubber to provide clutching characteristics with mud. Wheel diameter is 90 cm. specifications of the ground wheel are shown in Table 4.

Table 4: Specifications of ground wheel

No.	Particulars	Specifications	No.	Particulars	Specifications
1	Material of construction	Iron lined up hard rubber	**4**	Spacing between two consecutive lugs	25 cm
2	Type of wheel	Lugged	**5**	Average width of wheel	7.5 cm
3	Diameter of wheel,	90 cm	**6**	Number of lugs	13

Laboratory Calibration

It is necessary to calibrate the direct paddy drum seeder before using it in the field for actual use to find the desired seed rate with other parameters. The laboratory calibration of the direct paddy drum seeder was carried out at Department of Farm Machinery, El-Serw Agric. Res. Station. The field testing of direct paddy drum seeder was carried out at the Research farm of El-Serw Agric. Res. Station.

The seeder was calibrated for three different speeds 0.47, 1.15 and 1.95 km/h and four metering openings 7, 14, 21 and 28 hole represents 3, 6, 9, 12 cm between each two holes under four different sprocket ratios 0.5, 1.0, 1.52 and 2.53 and three different hopper head 5, 15 and 25 cm from soil level to check the constant seed rate under given distance travelled and to select the forward speed for seeder under field conditions.

Calibration procedure

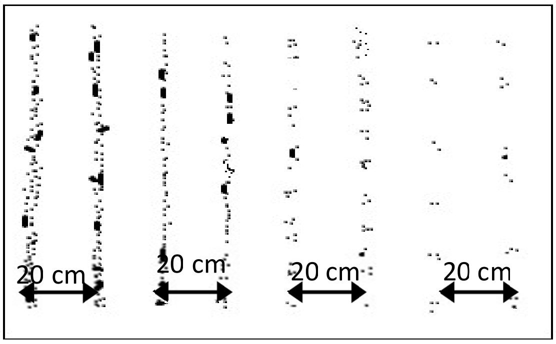
The procedure of testing direct paddy drum seeder for correct seed rate is called calibration of direct paddy drum seeder. To determine the seed rates obtainable at different forward speed the series of metering openings 7, 14, 21, 28 holes of the drum were conducted. All twenty-eight metering openings were covered with a plastic tape and they had been opened gradually to choose the suitable number of 7, 14, 21, and 28 openings, Fig 4. The seeder was jacked to clear the wheel from ground. The step by step procedure was as follows:

1. The nominal width of coverage of paddy drum seeder is determined. The nominal width is equal to the multiplication of the number of openings and the spacing between the openings.
2. The length of strip is found, having the nominal width as determine in (1) above, necessary to make one feddan.
3. The number of revolutions of the ground wheel is determined which has to be made to cover the length of the strip determined in (2) above. It should be done by actually operating the paddy drum seeder in the same field and soil conditions as will be used for field operation test. The number of revolutions is counted in a given distance, for example, 50 meters. A 90 cm diameter wheel will approximately make about 17 revolutions in 50 meters, (about 80 m^2). A number of revolutions of the ground wheel to cover one feddan is selected, for example, 1/50. A drum seeder over a nominal width of 1.6 m.
4. Revolutions per minute of ground wheel of metering device is calculated. The travelling speed for drum seeder was measured 0.47, 1.15 and 1.95 km/hr.
5. The pre germinated paddy seeds is put in the drum. Drive wheel above the ground turn 25 turns and collect seed from outlets of the every drum.
6. The quantity of seeds collected from each drum is weighed and the seed rate kg/fed is calculated. Then the process is repeated three times.
7. The obtained data were tabulated and analyzed statistically through the Minitab 12.1 Computer program.

Preparation of pre-germinated paddy seeds

Giza 178 rice variety was chosen in this trial according to its widespread in Egypt. According to Singh *et al*. 2016, seed preparation for wet sowing was carried out by mixing the salt with water in the proportion of 1:10 (i.e. 100 g salt with 1.0 liter water). Seeds were then soaked in salted water in bucket. After one hour lighter seeds and other impurities floating on the water were removed. Seeds were kept in changeable water, every six hours, for 48 hours. After 48 hours excess water in bucket was drained out.

The soaked seeds were placed in gunny bags and kept for next 24 hours surrounded by paddy straw for increasing the temperature during the incubation. After germination, the seeds were kept in a shade for 2 hours to separate seeds from each other. Length of sprout was expected to be 1.0 to 2.0 mm, and this length is desirable to avoid intervening of root and prevent free flow of seeds through the holes of the drums otherwise seeds should be coated. Also, the germination ratio was calculated and accordingly seed rate was determined.



Metering openings = 28 hole 21 hole 14 hole 7 hole
Distance between holes = 3 cm 6 cm 9 cm 12 cm

Fig. 4: View of paddy pattern by forward speed 1.95 km/h under different metering openings on sand bed and 5 cm hopper head

Seeder application in the field

According to Alam 2005, drums are half filled with grains from the feeder and driven along the field. It is advisable to drive along the lengthwise of the field as it will reduce the number of turnings. The initial field preparation for the seeder is same as for manual broadcasting or transplanting. After the 2nd or 3rd tillage, field should be properly leveled and puddle with the help of tractor. Day before sowing, excess water should be cut off and the field should be properly leveled. It is advisable to put low number of canals as possible and the canals should be put perpendicular to the direction of seeder application.

Field Test

Prior to the start of field test, size and area of plot were measured. Markers were positioned on field boundaries in consideration effective working width to determine the seeder path.

According to the area of field, quantity of the seeds recurred was calculated and pre geminated seeds were prepared. The plot was divided to three parts with uniform distribution of water and ensuring the straight path of the seeder during sowing operation. Pre germinated seeds were field in drums by closing holes to reduce the seed loss during filling of drums. After drum filling was completed, the 14 holes were opened and the seeder was operated in the field. The time required of trial, drum filling and for shifting of seeder during operation was recorded simultaneously.

Field evaluation of the direct paddy drum seeder was conducted under clay soil with pre germinated paddy seeds. Row to row distance was fixed 20 cm. Spacing between hills was measured randomly according to test variables along 10 m at three locations.

Variables and their measurement:

A- Independent variables: Independent variables were those variables which were controlled by the operator. The independent variables which were taken are given below: **1.** Forward speed, FS (km/h): 0.47, 1.15, 1.95

2. Sprocket ratio, (Sr) (tooth/tooth):

38:19 - 38:38 – 25:38 – 15:38 represents (Sr_1 = 0.5), (Sr_2 =1.0), (Sr_3 =1.52) and (Sr_4 =2.53)

3. Drum metering openings (MO) : 7, 14, 21, 28 holes represent 3, 6, 9, 12 cm between each two holes, respectively.

4. Hopper head (Hh): 5, 15 and 25 cm from soil level

B- Dependent variables: The dependent variables were: longitudinal and transverse seed scattering, Seed rate, Actual field capacity, Theoretical field capacity, Field efficiency, number of seeds /hill, hill to hill spacing, and hill missing or over falling.

The observation was statically analyzed and compared with the laboratory test result. The paddy drum seeder was operated in the field to test the following;

1- Seed rate: The seed rate was determined using the following equation:

$$C = \frac{A\ x\ 4200}{3.14\ x\ D\ x\ W\ x\ N}, kg/fed \text{...(1)}$$

Where; C = Seed rate in kg/fed.;

A = Weight of seed collected in N times of wheel revolutions, kg;

D = Diameter of wheel, m; W = Width of seeder, m

2- Uniformity of sowing (Longitudinal and transverse scattering calculation):

In order to simulate field condition, the seeder was run in dry land at determined speed. A frame at section of 2.5 x 2.5 cm square shaped at dimensions of 25 cm, all dimensions were divided by iron wire at equal distance of 1.0 cm and fixed by a nails to obtain a square shape units at dimensions of 1 x 1 cm. The scale was used to calculate the number of rice grains per unit area (1.0 cm^2) from the two directions to measure the uniformity of seed distribution on the field and the distance between seed to seed and row to row and a stopwatch was used to record the time. The space between the hills was measured and recorded. Then the average sowing spacing and standard deviation among hills were calculated. Then evenness of spacing were calculated as follows:

$$Evenness\ of\ spacing = \frac{Average\ seed\ spacing - Standard\ deviation\ of\ seed\ spacing}{Average\ seed\ spacing} \text{...(2)}$$

This procedure was carried out to ensure the uniformity sowing device of the direct paddy drum seeder by sand bed method. The uniformity of seed distribution is checked as; a bed of light sand layer measuring 50 m x1.8 m was broadcasted on the ground for help in sticking of seeds without rolling or bouncing on the bed surface. Direct paddy drum seeder was operated maintaining forward speed of 0.47, 1.15 and 1.95 km/h. The seed metering system was set to place the pre germinated paddy seeds. Seed spacing of 100 -100 seeds of pre germinated paddy were measured on the sand bed to estimate the performance indices and to check the dropping pattern. The test was replicated three times.

The longitudinal scattering of sowing placement was determined statistically by the standard deviation of the distance between seedlings within the row by using the following formula:

$$\xi_{n-1} = \sqrt{\frac{\sum X^2 - (\sum X)^2 / n}{n-1}} \quad \text{...(3)}$$

Where; ξ_{n-1} = Standard deviation, cm;
X = Distance between hills within the row, cm; and
n = Number of observations;

Also; the scattered sowing around the centerline of row measured and used the previous equation (equation 1) to calculate transverse scattering.

3- Hill to hill spacing: Hill to hill spacing was counted and measured by the mentioned above frame. The frame was randomly placed in each sub plot and the data was recorded.

4- Average number of seeds per hill: Average number of seeds per hill was measured in the same way of measuring hill to hill spacing.

5- Hill missing and over falling, %: At first the hopper was filled with 5 kg paddy seeds. The metering device was rotated through turning the wheels by hand. Number of turn was counted and time was recorded by a stop watch. Total falling of paddy seeds was counted and recorded. This experiment was done for 10 times and falling speed of seeds were calculated. Then the missing percentage of paddy seeds was calculated using following equation:

$$Hill\ missing\ or\ over\ falling = \frac{(N\ x\ Y) - NG}{N\ x\ Y}\ x\ 100 \quad \text{...........................(4)}$$

Where, N = Number of turn of wheel/metering device per minute
Y = No. of holes in the metering device
NG = Total number of seeds fallen per minute
If the result is positive then it is missing and if negative, it is over falling.

6- Actual field capacity (AFC); was calculated according to **Suliman *et al.* (2003):**

$$AFC = \frac{1}{A_t / 60}, fed.h^{-1} \quad \text{..(5)}$$

At = Nt + Tt + Pt , h. fed.-1.

Where; At: is the total actual plowing time per fed., min. fed-1.;
Nt: is the time of maintenance and lubrication, min. fed-1;
Tt: is the turning time (Time of run per min. x No. of turns per fed., min. fed^{-1} and, Pt: is the parasitic time, min. fed^{-1}.

7- Theoretical field capacity (T_hFC); was calculated by using the following formula:

$$T_hFC = \frac{OS \times OW}{4.2} fed.h^{-1} \quad \text{..(6)}$$

Where; OS: is the operating speed (km /h);
OW: is the operating width (m)

8- Field efficiency (F.E.); was calculated using the following equation:

$$F.E. = \frac{A.F.C}{T_h.F.C.} x100 \text{...}(7)$$

Where, A.F.C. and T_hFC are actual and theoretical field capacity, respectively.

9- Energy requirement:

To estimate the engine power during topping operation, the decrease in fuel level in fuel tank accurately measuring immediately after each treatment. The following formula was used to estimate the engine power (Hunt, 1995):

$$EP = \left[F.C \left(\frac{1}{3600} \right) x\ \rho E\ x\ LCV\ x\ 427\ x\ \eta THB\ x\ \eta m\ x\ \frac{1}{75}\ x\ \frac{1}{1.36} \right], kW \text{.....}(8)$$

Where; EP = engine power, kW; F.C= Fuel consumption, (l/h).

ρE = Density of fuel, (kg/l), (for Gas oil = 0.85).

$L.C.V$ = Calorific value of fuel, (11.000 k.cal/kg).

η_{THB}= Thermal efficiency of the engine, (35 % for Diesel engine).

427 = Thermo-mechanical equivalent, (kg.m/k.Cal).

ηm = Mechanical efficiency of the engine, (80 % for Diesel engines).

So, the energy can be calculated as following:

$$Energy\ requirements = \frac{power\ (kW)}{field\ capacity\ (fed/h)} \text{........................}(9)$$

10- Costs: When a new technology is introduced to the farmer, they are interested to know whether the machine will be profitable to them or not. Cost analysis is very important for a new technology. Operational cost of the machine is the sum of fixed cost and variable cost of the machine. The total cost of the machine was determined by knowing the cost of the materials used to fabricate the seeder and fabricating cost of the machine. The operational cost (LE/fed) was calculated by assuming some data. The current economic model focuses on the system costs, including both machinery costs (fixed and variable) as well as repair and maintenance costs. The model is derived from theories described by Hunt (1995), and expresses the total yearly fixed and variable costs as a function of machine capacity:

$$C = \left[\psi\ x\ \rho\ x\ \theta + \left(\frac{A\ x\ U}{\theta\ x\ FE} \right) (r\ x\ \rho\ x\ \theta + L + \delta\ x\ \theta) \right] / \Pr \text{..........}(10)$$

Where, C: is the total yearly costs (LE/ton),

Ψ: is a factor expressing depreciation and interest as a fraction of the purchase price, (1/year)

ρ: is the purchase price per unit capacity (LE.h/ton),

θ: is the machine capacity (ton/h), A: is the treated seasonal area (fed/year),

U: is the expected crop yield (ton/fed),

FE: is the field efficiency expressing the ratio between gross and theoretical capacity,

r: is a factor expressing repair and maintenance costs as a fraction of purchase price,

δ: is the fuel costs proportional to the capacity (LE/h), L: number of labors, and

Pr: is process productivity (ton).

The operating cost for topping unit was calculated by the following equation:

$$Costs,\ LE/fed. = \frac{machine\ operating\ \text{cost},\ LE/h}{actual\ \ field\ capacity,\ fed/h} \text{.........}(11)$$

Data analysis: Finally, all obtained data were analyzed for estimating the probability (P-value and R^2) according to a computer program MINITAB 18 and the analyzed data were discussed.

RESULTS AND DISCUSSION

Seed rate (kg/fed.)

The comparative performance of all combination at different forward speed and sprocket ratio is presented in Fig. 5. The maximum seed rate was found to be 61.89 kg/fed with Sr_4 (sowing by drum seeder at the sprocket ratio 2.53) at forward speed 1.95 km/h. The minimum seed rate was 2.13 kg/fed with Sr_1 (sowing by drum seeder at sprocket ratio 0.5) at forward speed 0.47 km/h. The treatment under study at different sprocket ratios and metering openings was found statistically significant at 5% level of significant. The analysis of results in Table 5 indicated that the three main effects of forward speed, sprocket ratio and metering openings were highly significant at ($P< 0.01$) concerning seed rate as the coefficient of determination, R^2= 91.48%. Hopper head (Hh) had no effect on feed rate.

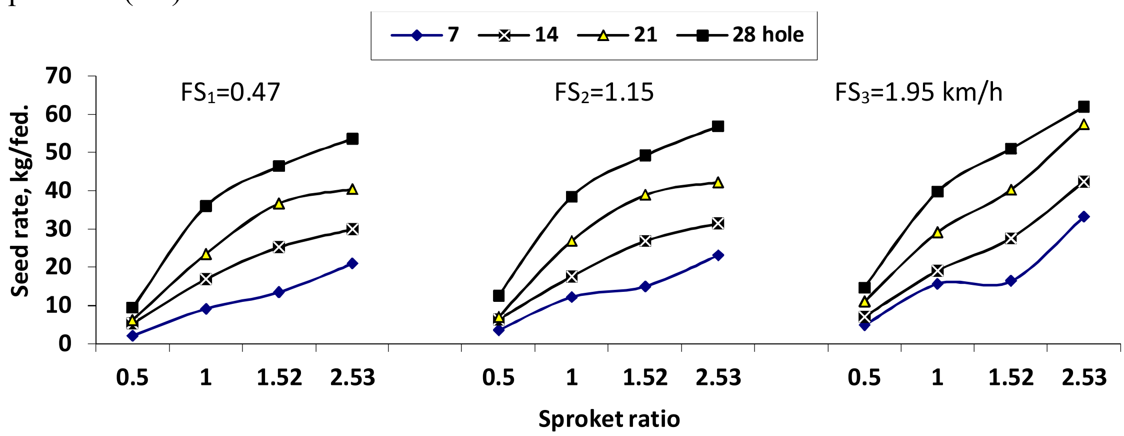


Fig.5: Effect of sprocket ratio and forward speed on seed rate, kg/fed.

Table 5: Analysis of Variance for seed rate, kg/fed., using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
FS	2	297.2	297.2	148.6	6.41	0.004
Sr	3	7377.9	7377.9	2459.3	106.06	0.000
MO	3	4212.1	4212.1	1404.0	60.55	0.000
Error	39	904.4	904.4	23.2		
Total	47	12791.5				

S = 4.81546 R-Sq = 92.93% R-Sq(adj) = 91.48%

Longitudinal and transverse seed scattering:

Fig. 6 illustrates the effect of hopper head and sprocket ratio under different forward speeds on longitudinal and transverse seed scattering. It can be stated that the increase of forward speed from 0.47 to 1.95 km/h increases the longitudinal scattering from 2.5 to 8.8 cm for hopper head 5 cm when using Sr_4. However the transverse scattering increased from 2.9 to 8.0 cm under the same mentioned above conditions, respectively. This may be due to more vibration occurred at high speeds.

On the other hand the same trend for both longitudinal and transverse scattering was obtained for the two various hopper head of 15 and 25 cm. Where the maximum values of longitudinal and transverse scattering were 10.12 and 9.4 cm, respectively at forward speed of 1.95 km/h and Sr_4 when using hopper head 25 cm. Also, the minimum values of longitudinal and transverse scattering seems to be lower at forward speed of 0.47 km/h where they reached 1.2 and 1.8 cm, respectively for hopper head 5 cm and Sr1. This may be attributed to the reduction in impact between seeder wheel and soil and subsequently reduces the machine vibrations. The analysis of results in Tables (6 and 7) indicated that the three main effects of forward speed, sprocket ratio and hopper head were highly significant at ($P< 0.01$) for both longitudinal and transverse seed scattering as the coefficient of determination, R^2= 97.07 and 97.81 % for longitudinal and transverse seed scattering, respectively. Metering openings had no effect on both longitudinal and transverse seed scattering.

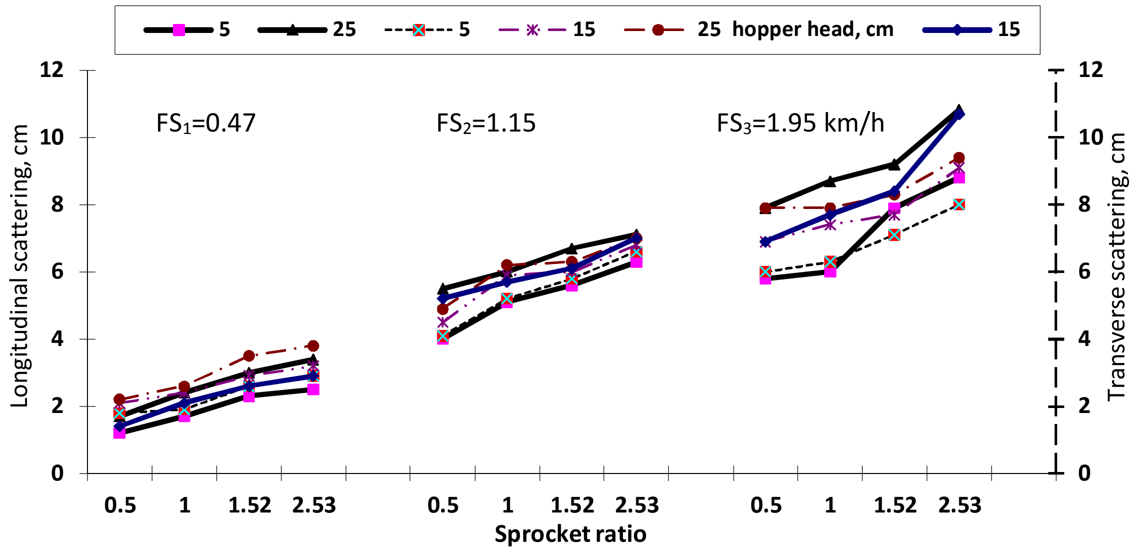


Fig.6: Longitudinal and transverse scattering as affected by hopper head and sprocket ratio at different forward speeds.

Table 6: Analysis of Variance for Longitudinal scattering, cm, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
FS	2	212.811	212.811	106.406	507.32	0.000
Sr	3	22.840	22.840	7.613	36.30	0.000
Hh	2	9.063	9.063	4.532	21.61	0.000
Error	28	5.873	5.873	0.210		
Total	35	250.587				
S = 0.457975 R-Sq = 97.66% R-Sq(adj) = 97.07%						

Table 7: Analysis of Variance for Transverse scattering, cm, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
FS	2	153.502	153.502	76.751	687.57	0.000
Sr	3	16.058	16.058	5.353	47.95	0.000
Hh	2	5.735	5.735	2.868	25.69	0.000
Error	28	3.126	3.126	0.112		
Total	35	178.420				
S = 0.334106 R-Sq = 98.25% R-Sq(adj) = 97.81%						

Hill to hill spacing (cm)

The comparative performance of all combination at different sprocket ratios (Sr) and forward speed (F_S) is presented in Fig.7. The maximum hill to hill spacing was found to be 38 cm with Sr_1 (sowing by sprocket ratio 0.5 and metering holes of 7) at forward speed (FS_3) 1.95 km/h. The minimum hill to hill spacing was 4 cm with Sr_4 (sowing by sprocket ratio 2.53 and metering holes of 28). The analysis of results in Table 8 indicated that the three main effects of forward speed, sprocket ratio and metering openings were highly significant at ($P< 0.01$) concerning hill to hill spacing as the coefficient of determination, R^2= 95.67%. Hopper head had no effect on hill to hill spacing.

Average number of seeds/hill

The comparative performance of all combination at different sprocket ratios and forward speed is presented in Fig. 8 The maximum average number of seeds/hill was found to be 11.65 cm with Sr_4 (sowing by sprocket ratio 2.53 at forward speed of 1.95 km/h) at metering opening 28 holes. The minimum average number of seeds/hill was 2 with Sr_1 (sowing by sprocket ratio 0.5 at forward speed of 0.47 km/h) at metering opening 7 holes. The analysis of results in Table (9) indicated that the three main effects of forward speed, sprocket ratio and metering openings were highly significant at ($P< 0.01$) concerning average number of seeds/hill as the coefficient of determination, R^2= 93.66%. Hopper head (Hh) had no effect.

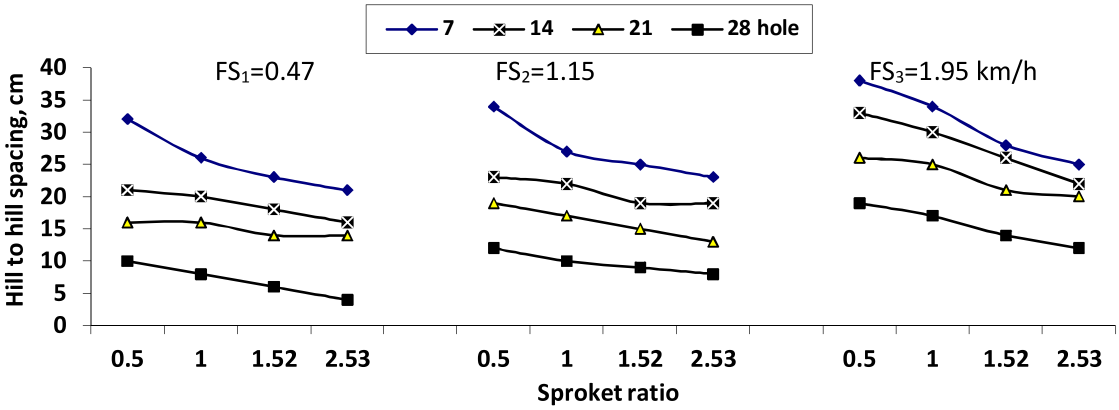


Fig.7: Effect of sprocket ratio and forward speed on hill to hill spacing, cm.

Table 8: Analysis of Variance for Hill to hill spacing, cm, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
FS	2	532.29	532.29	266.15	99.37	0.000
Sr	3	358.42	358.42	119.47	44.61	0.000
MO	3	1910.75	1910.75	636.92	237.80	0.000
Error	39	104.46	104.46	2.68		
Total	47	2905.92				

S = 1.63659 R-Sq = 96.41% R-Sq(adj) = 95.67%

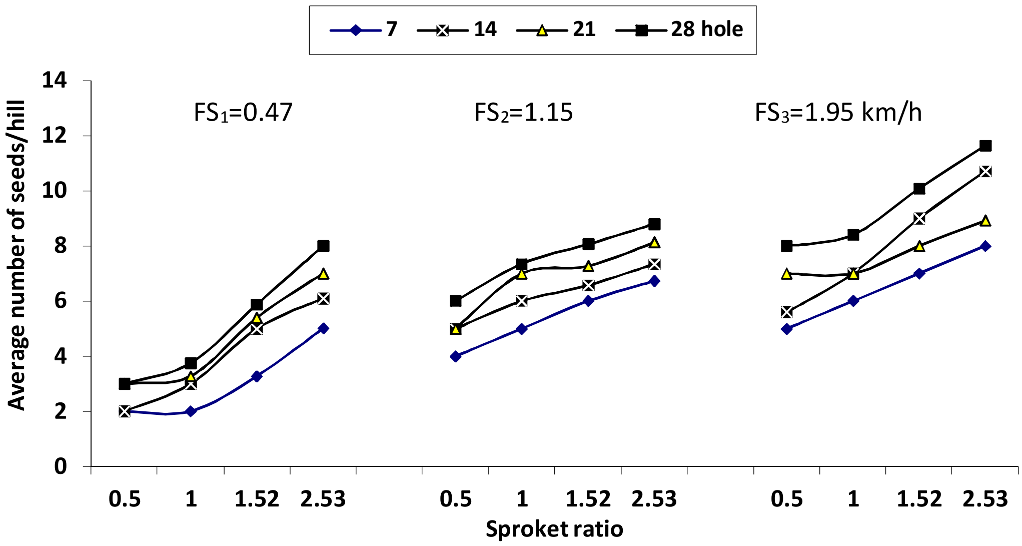


Fig.8: Effect of sprocket ratio and forward speed on average number of seeds/hill

Table 9: Analysis of Variance for Average number of seeds/hill, using Adjusted SS for Tests						
Source	DF	Seq SS	Adj SS	Adj MS	F	P
FS	2	113.225	113.225	56.612	173.57	0.000
Sr	3	80.201	80.201	26.734	81.97	0.000
MO	3	35.517	35.517	11.839	36.30	0.000
Error	39	12.720	12.720	0.326		
Total	47	241.664				
S = 0.571105 R-Sq = 94.74% R-Sq(adj) = 93.66%						

Hill missing and over falling, (%)

The comparative performance of all combination at different sprocket ratio and forward speed is presented in Fig. 9. according to Equation 3, the results obtained were found positive and consequently represented hill missing. The maximum hill missing was found to be 8.32% with Sr_4 (sowing by sprocket ratio 2.53 at forward speed of 1.95 km/h) at metering opening 7 hole. The minimum hill missing was 2.46 % with Sr_1 (sowing by sprocket ratio 0.5 at forward speed of 0.47 km/h) at metering opening 28 hole. The analysis of results in Table 10 indicated that the three main effects of forward speed, sprocket ratio and metering openings were highly significant at ($P< 0.01$) on hill missing under all conditions as the coefficient of determination, R^2= 95 %. Hopper head (Hh) had no effect on hill missing or over falling.

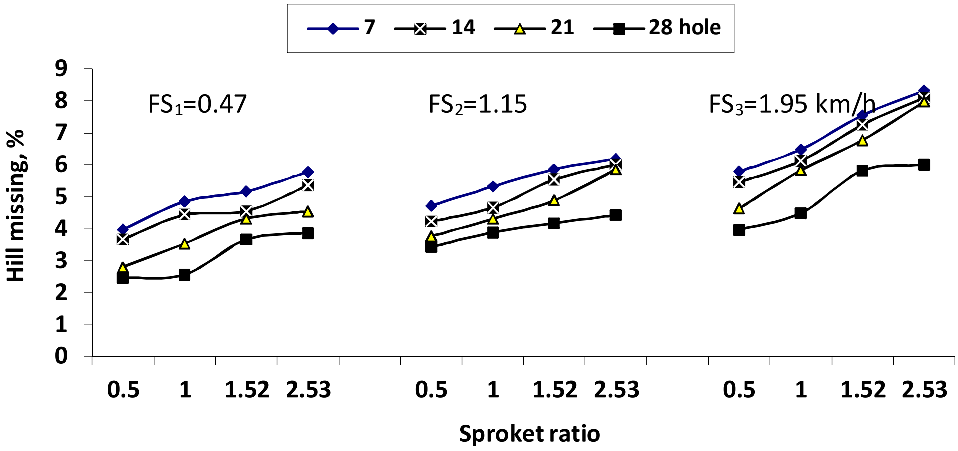


Fig.9: Effect of sprocket ratio and forward speed on hill missing

Table 10: Analysis of Variance for Hill missing, %, using Adjusted SS for Tests						
Source	DF	Seq SS	Adj SS	Adj MS	F	P
FS	2	39.707	39.707	19.854	204.81	0.000
Sr	3	26.441	26.441	8.814	90.92	0.000
MO	3	21.106	21.106	7.035	72.58	0.000
Error	39	3.781	3.781	0.097		
Total	47	91.036				
S = 0.311348 R-Sq = 95.85% R-Sq(adj) = 95.00%						

Field experiment

After laboratory experiments, the drum seeder was applied in the field according to the best results obtained from combination between different variables. From the data analysis that discussed above, it was found that most desirable results were under forward speed of 1.95 km/h, sprocket ratio of 2.53, metering openings of 14 holes and hopper head of 5 cm.

Field capacity and field efficiency:

The effective field capacity was determined as the ratio of area covered and actual time required for the operation of seeder in the field as well as the time lost in the refilling of drums and turning the seeder (productive time + time loss). The theoretical field capacity was calculated from forward speed and the actual working width. The field efficiency was calculated by taking the ratio effective field and theoretical field capacity. The effective field capacity and field efficiency of drum seeder were determined and are presented in Figs. (10 and 11).

The data obtained shows that theoretical field capacity was 0.74 fed/h. The effective field capacity was 0.45 fed/h and field efficiency was observed to be 61 %, Fig. 11 . During field test the effective field capacity was found lower. These results were under forward speed of 1.95 km/h, sprocket ratio, Sr_4, of 2.53 and metering openings of 14 hole. This treatment was carried out under hopper head of 5 cm from soil surface. These results may be according to consumed time for refilling of all the drums and for turning. This ultimately resulted in reducing the field efficiency of the drum seeder. In the field test, the drum seeder was operated with half drum fill and 1.95 km/h forward speed. Hopper head showed no effect on field capacity and consequently field efficiency under all conditions.

Comparing the best results obtained in laboratory tests to the results obtained in field test, it was found that the best results for seed rate were 29.88, 31.45 and 42.32 kg/fed under Sr_4, hopper head 5 cm and metering openings 14 hole under forward speed 0.47, 1.15 and 1.95 km/h. respectively. On the other hand the field results were 30.18, 33.43 and 43.67 kg/fed. Under the same conditions mentioned in the laboratory test. This increase in the seed rate in the field was may be due to jerks to the drum seeder resulting from seeder vibration in the field.

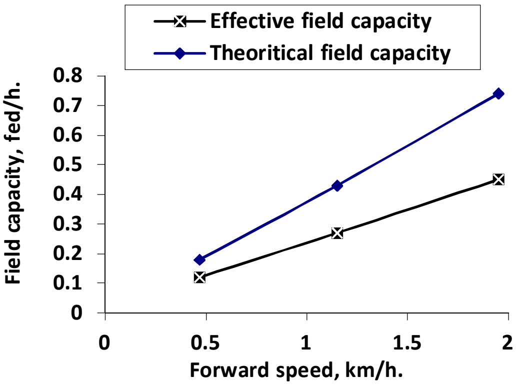


Fig.10: Effect of sprocket ratio and forward speed on effective and theoritical field capacity. Fed/h.

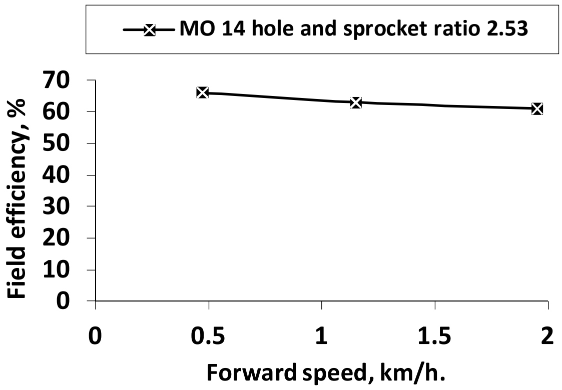


Fig.11: Effect of sprocket ratio and forward speed on field efficiency, %.

The best results for hill to hill spacing were 16, 19 and 22 cm; 14, 17.45 and 19.45 cm in the laboratory test and field test respectively, and under forward speed of 0.47, 1.15 and 1.95 km/h, respectively. These results were under Sr_4, hopper head 5 cm with metering openings 14 hole. In the same way, the best results of the average number of seeds/hill was 6.1, 7.35 and 10.72; 7, 8.8 and 11.97 with laboratory and field tests, respectively. While hill missing results were 5.36, 6 and 8.1 %; 4.2, 5.4 and 7.3 % for laboratory and field test, respectively. These results for seeds/hill and hill missing were under the same conditions of forward speed, Sr_4, hopper head 5 cm with metering openings 14 hole.

The difference between laboratory and field results may be attributed to more vibration and wheel slip in the field. According to the best conditions of forward speed, sprocket ratio, metering openings and hopper head through the laboratory tests for sowing paddy seeds, energy requirements and total costs were determined in the field. For sowing paddy in the puddle field, energy requirements of 27.06 kW. h/fed. was obtained under forward speed of 1.95 km/h., metering openings 14 hole, sprocket ratio of 2.53 and hopper head 5 cm. All other tested parameters showed similar trends in the laboratory tests. These results may be due to using higher forward speed which consequently resulted in increasing fuel consumption.

The seeder operating cost: In manually methods, one feddan needs approximately 8 laborers for applying paddy seeds in hills in puddle field with wages of 50 LE for each labor with total costs of about 400 LE. While the calculation of the operating costs included fixed and variable costs were made for the developed drum seeder. The total fabrication cost of the modification in the developed seeder including prices of materials used and workshop cost was 6300 LE at 2017 price level. The developed self-propelled drum seeder needs an engine 13 hp. The total operating costs for a 13 hp engine and operator were 30.50 LE/h. One feddan needs about 2.22 hours (0.45 fed/h.) according to the actual field capacity under the chosen desirable forward speed of 1.95 km/h. It means that the total cost for sowing one feddan was about 67.71 LE. Comparing the total costs between manually and mechanically method, it is clear that there is a great decrease in total costs by 83.07 % when applying the developed self-propelled drum seeder apart from saving seeds by 27.2 %

SUMMARY AND CONCLUSION

The study was performed in laboratory to check the suitable seed rate under given distance travelled and to select the forward speed and suitable metering device of drum seeder, suitable hopper head and suitable sprocket ratio in field evaluation. This study was undertaken to investigate the effect of different forward speeds, drum metering openings, hopper head and sprocket ratio of direct paddy drum seeder on longitudinal and transverse scattering seeds, seed rate, hill to hill spacing, number of seeds/hill, hill missing and over falling. From the combination of different parameters under study, the following conclusions were drawn from the present study:

1. The combination of sprocket ratio (Sr_4) 2.53 and 1.95 km/h forward speed of direct paddy drum seeder was found to be suitable for operating the seeder in the field.
2. The hill dropping pattern of direct paddy drum seeder was found during the laboratory calibration and also during the field operation.

3. The recommended seed rate for the variety under test was 60 kg/fed for direct sowing. From the laboratory calibration the sprocket ratio Sr_4 and 1.95 km/h operating speed were found to give the average seed rate of 42.32 kg/fed for pre germinated paddy seeds. Actually in the field the seed rate observed was 43.67 kg/fed. The seed rate was found to be increasing during actual field operation this was may be due to jerks to the drum seeder resulting from uneven motion of direct paddy drum seeder in the field.
4. From the field performance test it was found that average number of seeds dropped per hill was 11.97.
5. From the field performance test it was found that the hill to hill spacing was 17.45 cm.
6. From the field performance test it was found that the average hill missing was 7.3%.
7. The effective field capacity of the direct paddy drum seeder was observed to be 0.45 fed/h.
8. The theoretical field capacity of direct paddy drum seeder was observed 0.74 fed/h.
9. The field efficiency of the seeder was found to be 60.8%
10. The energy requirements was 27.06 kW.h/fed.
11. The cost of operation of drum seeder worked out to be 30.50 Le/h and 67.71 LE/fed.

RECOMMENDATIONS

After laboratory and field experiments after data analysis statistically by Minitab 17 computer program, it is recommend to use the direct paddy drum seeder under forward speed of 1.95 km/h, sprocket ratio of 2.53, metering openings of 14 hole with 5 cm hopper head to achieve good results in sowing paddy in puddle fields. Also, it is recommended to use coated grains as a secure manner to preserve sprouts not to be scratched or damaged.

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تطوير بذّارة اسطوانية ذاتية الحركة للزراعة المباشرة لمحصول الأرز

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يعتبر توفير مياه الري والحد من استخدام مبيدات الحشائش من الأهمية بمكان فى الوقت الحالي حيث أنهما من أكبر المشكلات الزراعية والبيئية التى نواجهها حالياً. ويعتبر محصول الأرز من المحاصيل الإستراتيجية في مصر حيث يمثل المحصول الغذائي الرئيسي ، إلا أنه يستهلك كميات ضخمة من ماء الري بالإضافة إلى ضرورة استخدام مبيدات الحشائش لانتشارها بشكل أساسي فى حقول الأرز. وتعتبر عمليات ميكنة زراعة الأرز الشعير من أصعب العمليات الزراعية برغم التطور التكنولوجي، حيث لازالت عميلة الزراعة تتم يدوياً بالنثر أو التسطير وتلاشت طريقة الشتل اليدوي والآلي في الأرز لعدم ضمان توافر مياه الري وقت الزراعة وكذلك صعوبة توفر الأيدي العاملة فى هذا الوقت من الموسم الزراعي لكثرة الأعمال الزراعية في تلك الفترة ، وتسبب ذلك فى انتشار الحشائش بشكل خطير أدي إلى الإسراف فى استخدام المبيدات الكيماوية لمقاومتها مما أثر سلباً على البيئة والصحة العامة. وقد ظهرت بعض المحاولات كما فى المعهد الدولي لبحوث الأرز (IRRI) لتطوير آلات بذر مجرورة بواسطة العمال في الأرض الطينية بعد التلويط ولكن ظهر انخفاض معدل أداؤها لجرها يدوياً مع مشاكل عدم انتظامية النثر وضعف نشاط العامل تدريجياً خلال النهار حيث يتطلب جرها مجهوداً بدنياً كبيراً، كما أن تصميم خزانات البذور (اسطوانات النثر) المستخدمة احتاجت إلى تعديلات لرفع كفاءتها بسبب تراكم البذور فى وسطها وعدم خروجها من فتحات التقليم ، وبالرغم من تزويدها بمقلبات إلا أن ذلك تسبب فى كسر البادرات المستنبتة مما زاد من حجم المشكلة.

من هنا كانت فكرة البحث تصميم وحدة مناسبة لتسطير بذور الأرز المستنبتة (صنف جيزة 178 الأكثر انتشاراً فى مصر) دون إجهاد العامل بالانحناء فترات طويلة لزراعة التسطير مع تقليل العمالة المستخدمة وتوفير الوقت اللازم لعملية الزراعة مع توفير تكاليف الإنتاج.

وتتكون الآلة من عدد أربعة خزانات بذور hyperboloid shape – يمكن زيادتها إلى 8 خزانات أو أكثر حسب قدرة المحرك المستخدم - مثقبة على الجانبين بفتحات قطرها 1 سم ومثبتة على مسافات التسطير الموصي بها 20 سم بين السطور، والخزانات مثبتة على عمود مزود بعجلات مسننة، وتأخذ الخزانات حركتها من عجلة الآلة بواسطة جنزير ناقل وترسين مسننين والآلة مركوبة مزودة بموتور ودبرياج ذاتية الحركة والتحكم في سرعة التقدم مما يوفر في الوقت والجهد أيضا. وقد تم إجراء تجارب معملية لمعايرة البذارة المطورة وتحديد ظروف التشغيل المناسبة بالنسبة لسرعة التقدم 0.47 ، 1.15 ، 1.95 كم/ساعة (ونسبة التكبير في العجلات المسننة) 0.5 ، 1 ، 1.52 ، 2.53 (وعدد ثقوب جهاز التلقيم) 7 ، 14 ، 21 ، 28 ثقب تمثل 3 ، 6 ، 9 ، 12 سم على الترتيب ، بين كل ثقبين على نفس الصف (وارتفاع خزانات البذور عن سطح الأرض) 5 ، 15 ، 25 سم. ثم أجريت التجارب الحقلية فى الأرض بعد التلويط - بعد تحديد علامات على جسور الأرض على مسافات بينية تساوي عرض التشغيل الفعلي للبذارة وذلك لصعوبة تزويد الآلة براسم داخل الحقل في وجود الماء - عند سرعة تقدم 1.95 كم/ساعة ، نسبة تكبير العجلات المسننة 2.53 ، مع عدد ثقوب جهاز التلقيم 14 ثقب تمثل 9 سم بين ثقوب التلقيم وارتفاع خزانات البذور 5 سم عن الأرض وذلك لتحديد السعة الحقلية الفعلية والكفاءة الحقلية وعدد البذور فى كل جورة والمسافات بين الجور وعدد الجور الغائبة والطاقة المطلوبة وكذلك حساب التكاليف الكلية بالجنيه/فدان.

وقد أوضحت النتائج عند ظروف التشغيل المثلى أن معدل تقاوي الأرز المستنبت المستخدمة بلغ 43.67 كجم/فدان وأن متوسط عدد البذور في كل جورة بلغ 11.97 بذور على مسافات بين الجور 17.45 سم وأن نسبة عدد الجور الغائبة بلغ 7.3 % وأن الكفاءة الحقلية بلغت 60.8 % ومتطلبات الطاقة 27.06 كيلووات.ساعة/فدان ومع توفير فى كمية البذور بنسبة 27.2 % وتوفير فى التكاليف الكلية بنسبة 83.07 % حيث كانت التكاليف الكلية 67.71 جنيه مصري/فدان مقارنة بالتكاليف اليدوية 400 جنيه/فدان حسب الأجور الحالية. وتوصى الدراسة بتصنيع وتشغيل البذارة المطورة ذاتية الحركة عند سرعة تقدم 1.95 كم/ساعة، نسبة تكبير العجلات المسننة 2.53 ، مع عدد ثقوب جهاز التلقيم 14 ثقب تمثل 9 سم بين ثقوب التلقيم وارتفاع اسطوانات البذور 5 سم عن الأرض ، مع زيادة عدد خزانات البذور إلى 8 أو أكثر وذلك لزيادة السعة الحقلية وتوفير الطاقة وبالتالي توفير تكاليف الإنتاج. كما توصي الدراسة بأفضلية استخدام بذور مغلفة (coated grains) وذلك لضمان حماية البادرات من الجروح أو التلف.

EVALUATION OF THREE ANALYTICAL APPROACHES FOR ESTIMATION OF COTTON LEAF AREA

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Abstract

Cotton is considered as one of the most important crops in Egypt. Measuring the leaf area of such plant is one of the most accurate indicators to estimate the quantity of pesticides and productivity. Moreover, leaf area is important for estimating plant productivity; analyzing nutrient uptake. It can also be used for analyzing water use and can be helpful in managing weeds and plant pests. Thus the study evaluated the efficiency of three analytical approaches for estimating the leaf area of cotton in comparison with the graphical approach. Two hundred and forty Egyptian cotton (*Gossypium barbadense* L. 'Giza 86') leaves were collected randomly from three different plant heights and four different fields in Egypt. The leaf areas calculated using a graphical approach was compared with the areas calculated using a multiple linear regression approach, an artificial neural network approach, and an approach using a digital camera and ImageJ software. The multiple linear regression and artificial neural network approaches were based on four measured leaf parameters. The digital camera and ImageJ software approach consisted of calculating the area of each leaf by counting the total pixels of the leaf in a digital image. The overall leaf area means were 95.6, 101.1, 98.9, and 93.8 cm^2 for the graphical, multiple linear regression, artificial neural network, and digital camera approach, respectively; for the middle layer, the respective values were 161.1, 157.6, 158.3, and 157.6 cm^2; and for the bottom layer, 191.8, 190.0, 189.3, and 187.5 cm^2. The effectiveness of the approaches was evaluated using the coefficient of determination (R^2) and the mean relative absolute error. Although the R^2 value was high for all approaches, the mean relative error values were different. For the Elnashw field, mean relative error for all heights were 1.98, 0.36, and 1.61% for the multiple linear regression, artificial neural network, and digital camera approach, respectively; for the location near Elkarakool, the respective values were 2.16, -1.73, and -0.68%; for the Elkhadra field, 2.10, -0.81, and -0.84%; and for the Elkarakool field, 2.18, -1.39 and -0.48%. The results indicate that the digital camera and ImageJ software approach is a precise, inexpensive, and simple tool for assessing the leaf area of cotton.

INTRODUCTION

Cotton is an important crop in Egypt. Data on cotton leaf area may be useful for estimating the amount of chemicals to be applied to the crop for disease and pest control (Moustakas and Ntzanis, 1998). The leaf area of a plant culture is also related to its growth (Peksen, 2007). It is important for estimating plant productivity (Demirsoy *et al.*, 2007) and analyzing nutrient uptake (Olivera and Santos, 1995; Williams *et al.*, 2003); it can also be used for analyzing water use and can be helpful in managing weeds and plant pests (Gutierrez and Lavin, 2000; Lockhart *et al.*, 2007).

The development of various indirect methods of acquiring leaf area information is a highly relevant area of work (Marcon *et al.*, 2011). There are several measurement methods that are currently used for estimating crop leaf area (Kumar, 2009). One conventional method uses linear measurements of leaves. Mathematical models based on the measures of variables such as leaf width and length are widely used for various species of plants (Serdar and Demirsoy, 2006); the existing mathematical models can estimate the leaf area at a low cost (Chanda and Singh, 2002). For example, Jayeoba *et al.* (2007) conducted an experiment to develop a mathematical model for predicting leaf area for *Ocimum gratissimum* using linear regression. Dutra *et al.* (2017) developed mathematical models based on leaf length and width to estimate leaf area of citrus genotypes. Monteiro *et al.* (2005) evaluated two different methods of estimating cotton leaf area based on leaf dimensions (length and width) and leaf dry mass. They compared the leaf area estimates from the two methods to leaf area measured in an independent sample. Good accuracy was observed with both methods, but the leaf dry mass method showed a better performance with R^2 ranging from 0.94 to 0.98 and regression slopes between 0.97 and 1.00, when the regression line was forced through the origin.

Artificial neural networks have been increasingly applied to estimating leaf area of crops with high accuracy. Ahmadian-Moghadam (2012) employed an artificial neural network model to predict pepper (*Capsicum annuum* L.) leaf area. After the training process, the values predicted by the neural networks were compared with actual values not used in the training process (10 sets). Results suggested that the artificial neural network model provided an effective means of estimating leaf area. In another study, Dunea and Moise (2008) also developed an artificial neural network model for leaf area prediction with great success.

Traditional methods and the associated equipment for measuring leaf area are being increasingly replaced by computational approaches using digital image analysis techniques. According to Vieira Jr. *et al.* (2006), this technique is a reliable tool for indirect measurements of leaf area. Moreover, Li *et al.* (2008) showed that measuring leaf area based on image processing led to very high accuracy compared with the grid paper method. Marcon *et al.* (2011) presented a method for estimating total leaf area in perennial plants using images and interactive computer software. The use of image analysis to measure leaf area has also been described in other crops, such as betel (Patil and Bodhe, 2011), where the results of the analysis were compared with results acquired using the graphical area measurement technique. It has been proven experimentally that this method for measuring leaf area in sugarcane is highly accurate and results in a very small relative error. Ahmad *et al.* (2015) used digital image techniques and ImageJ software to find a simple and precise method to measure the leaf area of wheat, barley, and oat. The results showed that there was a difference in values recorded by the digital image techniques and the manual method.

This study tested the hypothesis that there are no differences between the cotton leaf areas estimated by the multiple linear regression approach, artificial neural network approach, and the approach using a digital camera and ImageJ software in cotton. The objective of this study is to evaluate the effectiveness of these three approaches in comparison with the conventional graphical approach for estimating the leaf area of cotton plants. This effectiveness was evaluated for three plant heights, and leaf samples from four different fields.

MATERIALS AND METHODS

Collection of cotton plant leaves

Leaves were collected from Egyptian cotton (*Gossypium barbadense* L. ‘Giza 86’) plants that were randomly selected from four different cotton fields located in Elnashw, near Elkarakool, Elkhadra, and Elkarakool; all of these locations are situated in the region of Kafer El-Dawar center of El-Behera Governorate, Egypt (latitude 31°7′52″N, longitude 30°7′48″E; elevation 6 m) during August 2014. The planting date was in April 2014. The neighboring fields were cultivated with rice, maize, and cotton. Each of the four cotton fields used in this study was divided into 20 equal-sized plots. An individual cotton plant was randomly selected from each plot. Each cotton plant was divided into three canopy layers by height, shown in Fig. (1), following the methodology of recent review by Alarcona and Sassenrath (2011): the bottom layer (canopy layer III), from 0 cm (ground level) to 45 cm; the middle layer (canopy layer II), from 45 cm to 105 cm; and the top layer (canopy layer I), more than 105 cm. In total, 240 leaves were collected.

Leaf measurement and graphical area calculation

The following four leaf dimensions were measured: leaf width (the distance between the left and right lobe tips; W), leaf length (the length of the main lobe (Jiang *et al.* , 2000) or the distance between the main lobe tip and the leaf origin; L), right lobe length (the distance between the right lobe tip and the leaf origin; L1), and left lobe length (the distance between the left lobe tip and the leaf origin; L2), as shown in Fig. (2) Each leaf was also traced on graph paper (Fig. 3) and a digital planimeter (Placom, KP-90 N, Koizomi, Japan) was calibrated and used to measure the actual leaf area (the graphical approach).

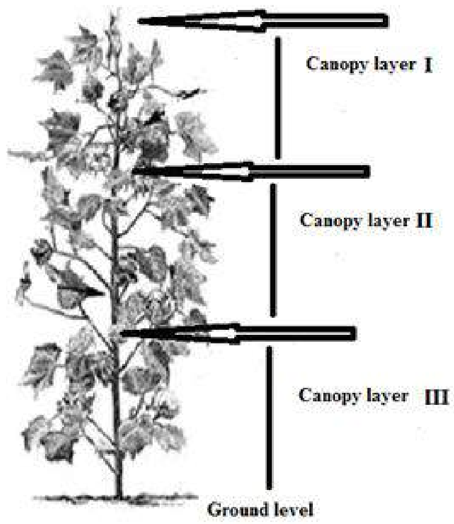


Fig. (1). Diagrammatic representation of canopy layers on a cotton plant.

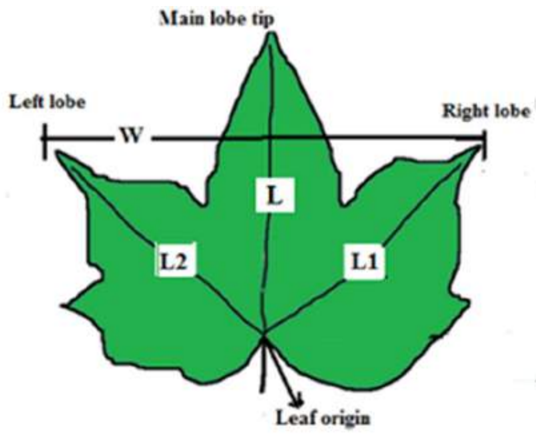


Fig. (2). Diagram of a cotton leaf, showing the measured dimensions: width (W), length (L), right lobe length (L1) and left lobe length (L2).

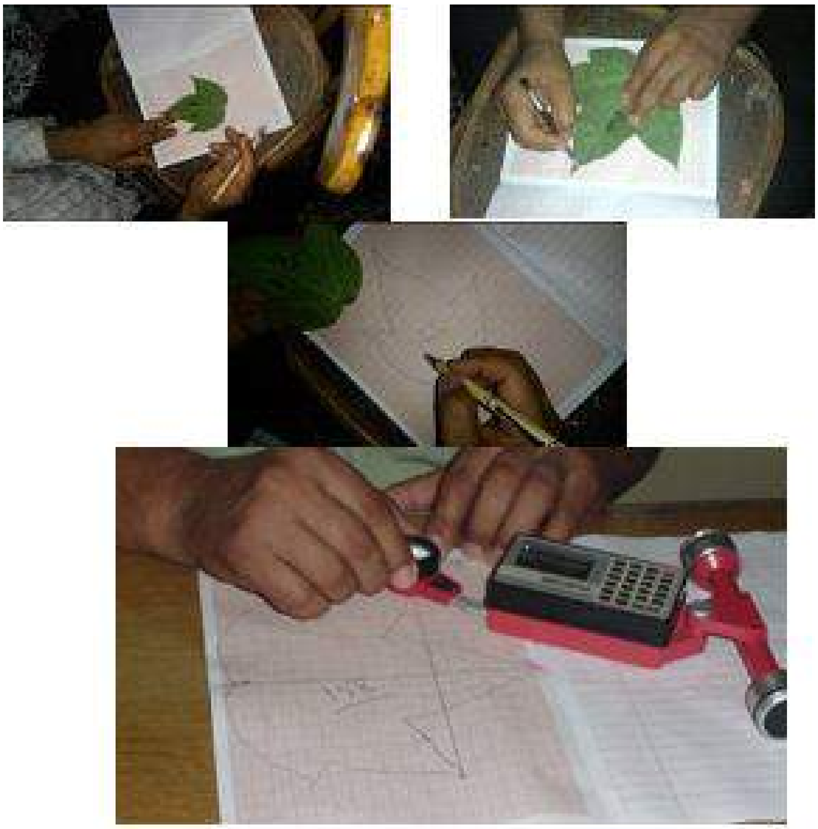


Fig. (3). Leaf tracing on graph paper and measurements using a digital planimeter.

The multiple linear regression approach

A multiple linear regression model was developed based on the measurements of leaf width (W, cm), leaf length (L,cm), right lobe length (L1,cm) and left lobe length (L2,cm). This model was introduced by Aboukarima *et al.* (2015a) as follows, where LA is the leaf area measured in square centimeters:

$$LA=2.451-LW+1.372WL2+1.682LL1-1.345L1L2 \qquad R^2=0.96 \quad \ldots\ldots(1)$$

The artificial neural network approach

An artificial neural network feed-forward model, as described by Aboukarima *et al.* (2015b), was trained using raw data with four input nodes (leaf width, main lobe length, right lobe length, and left lobe length), one hidden layer with six nodes, and one output layer (leaf area) as shown in Fig. (4).

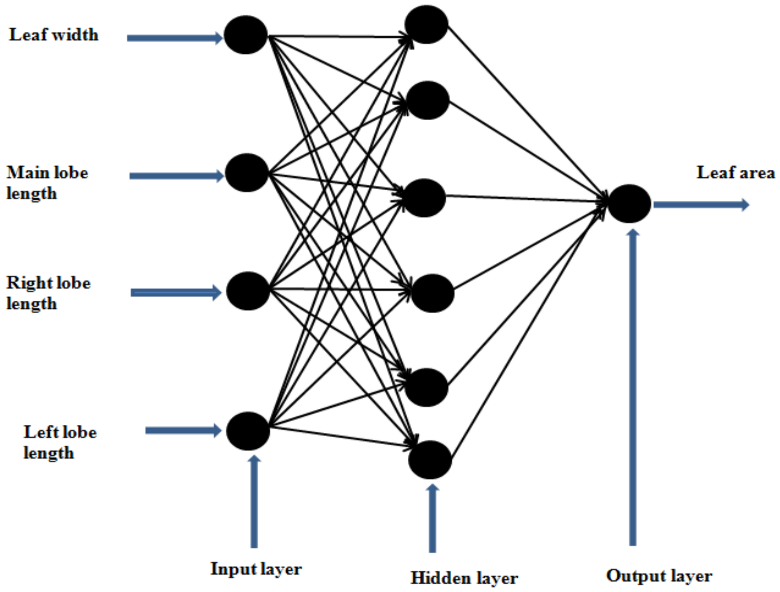


Fig. (4). The architecture of the artificial neural network approach.

The digital camera and ImageJ software approach

As described by Aboukarima *et al.* (2017), a digital image of each leaf was captured using a digital camera (model Canon SX600HS, 18X Optical Zoom with 16 Mega Pixels) with the system described in Fig. (5). ImageJ software (https://imagej.net) was used to calculate the leaf area by counting the pixels in a selected region of the leaf by the software. This software is open platform for scientific image analysis.

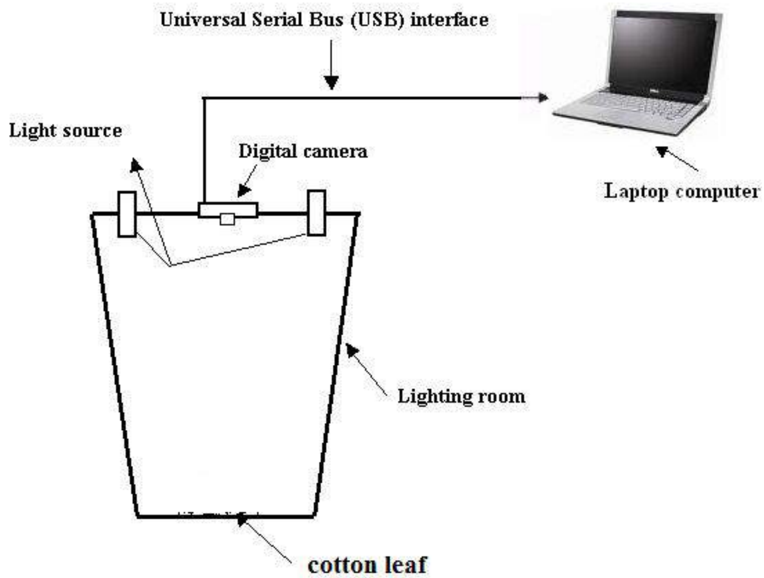


Fig. (5). The system for capture cotton plant leaves images.

Evaluation of the effectiveness of the three analyzing approaches

The mean relative error (*MRA*,%) was utilized to evaluate the effectiveness of the three approaches, determined using the following equation (Makridakis *et al.*, 1998):

$$MRE = \frac{100}{N} \times \sum_{i=1}^{i=N} \left(\frac{LA_{iobs} - LA_{ipre}}{LA_{iobs}} \right) \qquad (2)$$

where LA_{iobs} is the cotton leaf area determined by the graphical approach, LA_{ipre} is the leaf area of the cotton plant estimated by the analytical approach that is being compared, and N is number of observations. To evaluate the correlation between two approaches, the coefficient of determination (R^2) was calculated. The closer the R^2 value is to one, the better the model fits the actual data (in this case, the data generated using the graphical approach). Furthermore, the slope and the intercept of the simple regression model were utilized to evaluate the performance of the three analytical approaches relative to the graphical approach.

RESULTS AND DISCUSSION

Table (1) presents the means and the coefficients of variation (CV) of the cotton leaf areas estimated by the graphical approach and by the three analytical approaches, at different plant heights, at different locations. The overall leaf area means were 95.6, 101.1, 98.9, and 93.8 cm^2 for the graphical, multiple linear regression, artificial neural network, and digital camera approach, respectively; for the middle layer, the respective values were 161.1, 157.6, 158.3, and 157.6 cm^2; and for the bottom layer, 191.8, 190.0, 189.3, and 187.5 cm^2.

Table 2 shows the mean relative errors of the cotton leaf areas estimated by the three analytical approaches when compared with the area calculated using the graphical approach, for various plant heights and locations. The area of the cotton leaf estimated by the digital camera and ImageJ software-based approach was smaller than that measured by the graphical approach. This was true for all plant layers at all locations, as shown in Table (1). This difference was probably a result of some error occurring in the identification of the selected area in the leaf image. The average relative error in the case of the artificial neural network approach was smallest in the Elnashw and Elkhadra locations (values of 0.36% and -0.81%, respectively), which suggests that this approach had high precision in these locations. Meanwhile, the lowest average relative errors were observed near Elkarakool (-0.68%) and in the Elkarakool location (-0.48%), when leaf areas were estimated using the digital camera and ImageJ software-based approach, as shown in Table (2). This suggests that this method was the most precise in these locations.

Based on the coefficients of variation shown in Table (1), the leaf areas estimated by all three analytical approaches were similar to those measured using the graphical approach, which suggests that the precision of all approaches was similar. This finding may attributed to the developed multiple linear regression and the artificial neural network approaches gave high accuracy in prediction cotton leaf area (R^2 was higher than 0.98, Table 3). Meanwhile, Fig. (6) shows the relationship between the average leaf area estimated for each plant height at each location (Elnashw, Elkhadra, near Elkarakool, and Elkarakool) by the multiple linear regression approach, the artificial neural network approach, and the approach using a digital camera and ImageJ software, plotted against the area measured by the graphical approach. It is clear that the leaf area estimated by all approaches follows that estimated by the graphic approach, demonstrating a linear relationship. The straight-line equations in the "slope-intercept" form (Y = mX + b) were determined for all locations using average values of the three plant heights and the results are shown in Table (3). However, X is always area estimated by the graphical approach. All equations yielded an R^2 value higher than 0.9, which means that all approaches produced a robust estimation of leaf area. It should also be noted that all slopes were positive and less than unity.

Table (1). The means and the coefficients of variation (CVs) of the cotton leaf areas estimated by the graphical approach and three analytical approaches for three plant heights layers at four locations.

Field location	Plant height layer	Statics	Graphical approach	Multiple linear regression	Artificial neural network	Digital camera and ImageJ software
Elnashw	Top	Mean (cm^2)	77.2	82.3	78.8	75.8
		CV (%)	30.7	28.2	29.4	30.6
	Middle	Mean (cm^2)	112.8	107.7	108.4	110.6
		CV (%)	28.1	32.8	32.6	28.0
	Bottom	Mean (cm^2)	145.8	141.2	141.5	142.7
		CV (%)	31.4	30.3	31.2	31.2
Elkhadra	Top	Mean (cm^2)	87.8	93.2	91.5	86.2
		CV (%)	22.3	23.0	23.2	22.3
	Middle	Mean (cm^2)	180.8	173.9	175.4	176.9
		CV (%)	25.4	27.2	27.1	25.2
	Bottom	Mean (cm^2)	193.3	193.7	196.0	189.0
		CV (%)	30.1	32.0	30.6	29.9
Near Elkarakool	Top	Mean (cm^2)	84.9	92.3	89.7	83.3
		CV (%)	21.6	23.4	23.9	21.5
	Middle	Mean (cm^2)	165.9	163.0	163.6	162.1
		CV (%)	34.4	36.0	35.3	34.2
	Bottom	Mean (cm^2)	217.2	213.3	212.4	212.1
		CV (%)	14.2	14.3	14.5	14.1
Elkarakool	Top	Mean (cm^2)	132.5	136.7	135.7	129.9
		CV (%)	13.4	15.1	16.4	13.3
	Middle	Mean (cm^2)	184.9	185.7	186.0	180.7
		CV (%)	28.9	28.9	28.1	28.8
	Bottom	Mean (cm^2)	210.7	211.8	207.4	206.0
		CV (%)	19.1	19.4	18.8	19.0
Overall leaf area mean for top layer of the cotton plant (cm^2)			95.6	101.1	98.9	93.8
Overall leaf area mean for middle layer of the cotton plant (cm^2)			161.1	157.6	158.3	157.6
Overall leaf area mean for bottom layer of the cotton plant (cm^2)			191.8	190.0	189.3	187.5

CV= Coefficient of variation

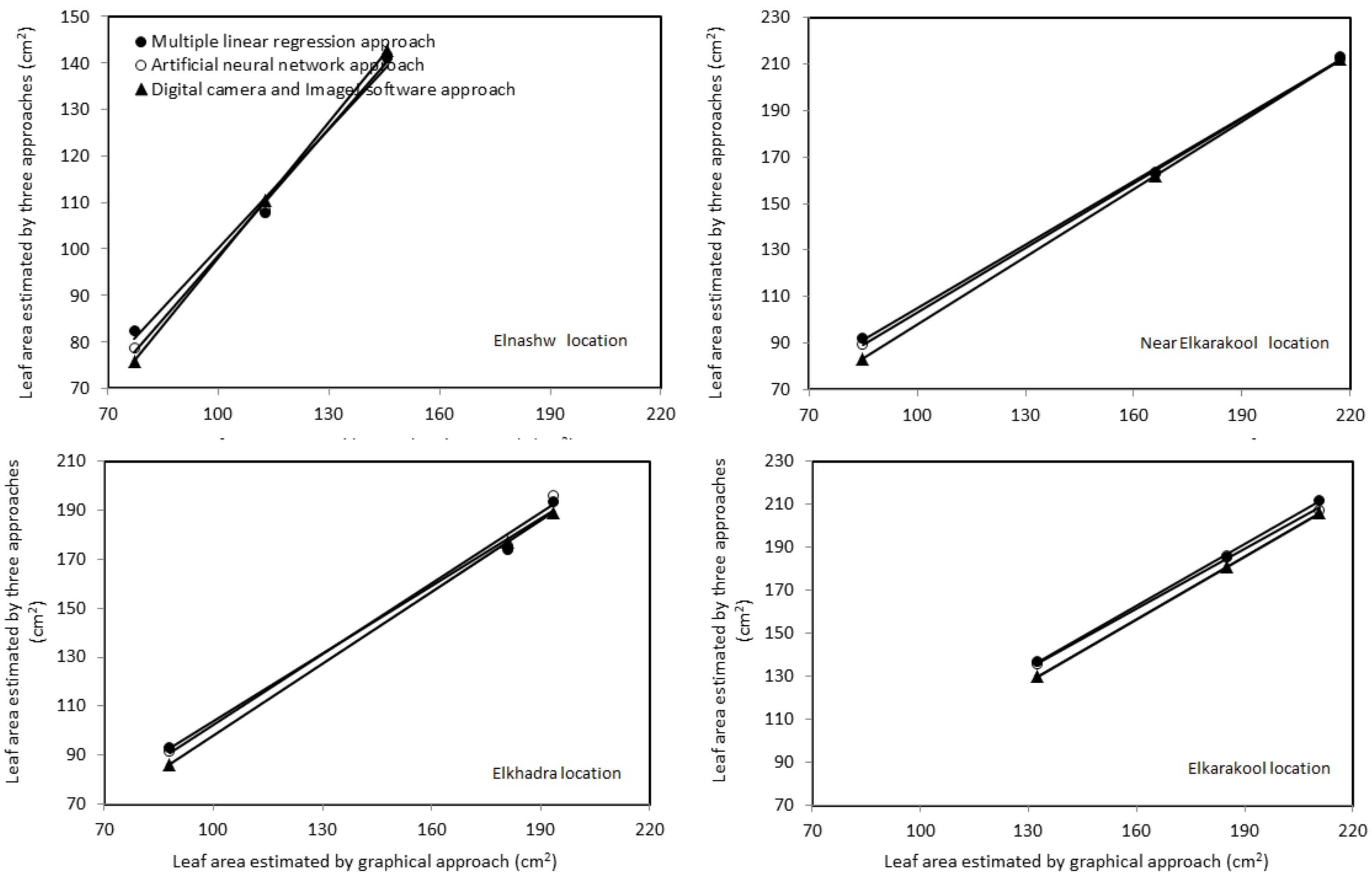
Table (2). Mean relative errors of the cotton leaf areas calculated using three analytical approaches as compared to the graphical approach for both plant height layer and field location.

Field location	Plant height layer	Multiple linear regression approach	Artificial neural network approach	Digital camera and ImageJ approach
Elnashw	Top	-6.56	-2.01	1.86
	Middle	4.49	3.90	1.99
	Bottom	3.15	2.94	2.11
Average		1.98	0.36	1.61
Elkhadra	Top	-6.10	-4.13	1.86
	Middle	3.83	3.02	2.18
	Bottom	-0.18	-1.40	2.27
Average		2.10	-0.81	-0.84
Near Elkarakool	Top	-8.70	-5.61	1.87
	Middle	1.70	1.34	2.26
	Bottom	1.82	2.21	2.34
Average		2.16	-1.73	-0.68
Elkarakool	Top	-3.19	-2.41	2.00
	Middle	-0.46	-0.58	2.28
	Bottom	-0.52	1.57	2.25
Average		2.18	-1.39	-0.48

Table (3). The straight-line equations in the "slope-intercept" form for estimating the cotton leaf area yielded by the three analytical approaches for each of the four locations, calculated from average values of the three plant heights from the three approaches.

Field location	Y (Leaf area , cm^2 estimated by)	Slope (m)	Intercept (b)	R^2
Elnashw	Multiple linear regression approach	0.8572	14.4461	0.9900
	Artificial neural network approach	0.9138	7.2726	0.9971
	Digital camera and ImageJ software approach	0.9762	0.4217	1.0000
Elkhadra	Multiple linear regression approach	0.9208	11.7909	0.9939
	Artificial neural network approach	0.9578	6.7823	0.9938
	Digital camera and ImageJ software approach	0.9744	0.6207	1.0000
Near Elkarakool	Multiple linear regression approach	0.9107	14.1381	0.9991
	Artificial neural network approach	0.9264	10.7193	0.9999
	Digital camera and ImageJ software approach	0.9736	0.6539	1.0000
Elkarakool	Multiple linear regression approach	0.9562	9.7585	0.9996
	Artificial neural network approach	0.9231	13.8561	0.9988
	Digital camera and ImageJ software approach	0.9729	0.9022	1.0000

Fig. (6). The relationship between the average leaf areas at three plant heights at four different locations estimated by the multiple linear regression approach, the artificial neural network approach, and the approach using a digital camera and ImageJ software, plotted against the areas measured using the graphical approach.



CONCLUSION

The estimation of the area of cotton plant leaves using three different analytical approaches resulted in a high coefficient of determination (R^2) in comparison with the graphical approach. The digital camera and ImageJ software approach is a fast, easily applied, and reliable method with low errors and coefficients of variation. Thus, it is considered the most effective method for estimating cotton leaf area for various purposes.

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تقييم ثلاثة طرق تحليل لتقدير مساحة ورقة محصول القطن

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يعتبر نبات القطن أحد أهم المحاصيل الاقتصادية فى مصر، كما أن قياس مساحة أوراق هذا النبات يعتبر من أهم المؤشرات الدقيقة لتقدير كلا من كميات المبيدات وإنتاجية المحصول لذا هدفت هذه الدراسة إلى تقييم كفاءة ثلاثة طرق تحليل لتقدير مساحة ورقة محصول القطن مقارنة بالطريقة الرسومية. تم جمع مائتين وأربعين ورقة من محصول القطن المصري (جيزة 86) عشوائيًا من ثلاثة ارتفاعات لنبات القطن (القمة والوسط وأسفل) ومن أربعة حقول مختلفة تقع في مناطق Elnashw, Elkhadra Elkarakool, Near Elkarakool, في مركز كفر الدوار، محافظة البحيرة، مصر. وطرق التحليل كانت باستخدام الانحدار الخطي المتعدد والشبكات العصبية الاصطناعية وباستخدام كاميرا رقمية و برنامج ImageJ. وقد طورت نماذج الانحدار الخطي المتعدد والشبكات العصبية الاصطناعية على أساس قياسات عرض الورقة، وطول الفص الرئيسي، وطول الفص الأيمن وطول الفص الأيسر. بينما استندت طريقة الكاميرا الرقمية وبرنامج ImageJ على التقاط صورة لكل ورقة بكاميرا رقمية وحساب مساحة الورقة عن طريق عد النقاط الضوئية (البكسل) في منطقة مساحة الورقة. تم تقييم كفاءة الطرق على أساس معامل التحديد (R^2) ومعيار للخطأ هو متوسط الخطأ النسبي. فللطبقة العليا على النبات، كان متوسط مساحة الورقة 95.62، 101.13، 98.90 و 93.79 سم^2 لجميع الحقول، على التوالي للطريقة الرسومية والانحدار الخطي المتعدد والشبكات العصبية الاصطناعية وباستخدام كاميرا رقمية وبرنامج ImageJ. وللطبقة الوسطى على النبات، كان متوسط مساحة الورقة 161.09، 157.60، 158.34 و 157.55 سم^2 لجميع الحقول، على التوالي للطريقة الرسومية والانحدار الخطي المتعدد والشبكات العصبية الاصطناعية وباستخدام كاميرا رقمية وبرنامج ImageJ. وللطبقة السفلية على النبات، كان متوسط مساحة الورقة 191.77، 189.99، 189.35 و 187.45 سم^2 لجميع الحقول، على التوالي للطريقة الرسومية والانحدار الخطي المتعدد والشبكات العصبية الاصطناعية وباستخدام كاميرا رقمية وبرنامج ImageJ . وعلى الرغم من أن قيمة R^2 كانت عالية لجميع طرق التحليل، لكن قيم متوسط الخطأ النسبي كانت متفاوته. فلحقل Elnashw، كان متوسط الخطأ النسبي 1.98 ، 0.36 و 1.61٪ لجميع الأوراق على النبات. ولحقل Near Elkarakool كان متوسط الخطأ النسبي 2.16، 1.73- و 0.68-٪ لجميع الأوراق على النبات. بالإضافة إلى ذلك، فلحقل Elkhadra، كان متوسط الخطأ النسبي 2.10 ،0.81-، 0.84-٪ لجميع الأوراق على النبات. ولحقل Elkarakool، كان متوسط الخطأ النسبي 2.18، 1.39- و 0.48-٪ لجميع الأوراق على النبات. وتقدير مساحة الورقة مستخدمًا الكاميرا الرقمية وبرنامج ImageJ كانت أسهل في عملية القياس، وبالتالي هذه الطريقة يمكن أن تستخدم لتقدير مساحة الورقة لمحاصيل أخرى.

EFFECT OF USING DIFFERENT URBAN SUBSTRATE CULTURE AND PLANT EXTRACTIONS SPRAYING ON GROWTH AND PRODUCTION OF SWEET BASIL

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Abstract

The experiment was conducted on the rooftop of Central Laboratory for Agricultural Climate (CLAC), Agricultural Research Center, Ministry of Agriculture and Land Reclamation, Dokki, Giza, during 2015-2016 seasons respectively. The experiment was aiming to investigate the effect of four nutrient solution concentrations (EC) 1, 1.5, 2 and 2.5, in combination with two volumes of substrate (big volume (8 L) and small volume (6 L)) and three foliar spray by natural plant extracts (without foliar spray (control), Henna and Camphor extract) on the morphological characteristics and productivity of sweet basil herb (*Ocimum basilicum L.*). The experimental treatments were arranged in a split split plot design with 3 replicates for each treatment. Plant height (cm), number of branches, total fresh and dry weight (g/plant), volatile oil percentage, total volatile oil per plant and the main components percentage of the volatile oil were measured. Data obtained that, the concentration of nutrient solution 1.5 EC was the best in influencing the morphological characteristics of the plant and the volatile oil productivity. Also, the best size of the substrate culture was the volume (8L) as was the use of foliar spray with Henna extract effect positive on the results. The interaction between the previous factors gave the best influence. In the same context, the concentration of the main active percentages substances in the volatile oil was increased by increasing the concentration of the nutrient solution with Henna extract, except for the methyl chaficol compound, which was adversely affected with the Henna extract compared with the other foliar spray .

Key words: Soilless Culture Systems, substrate culture systems, Rooftops, Urban Cities, Basil (Ocimum basilicum* L.*), nutrient solution concentration (EC), plant extraction

INTRODUCTION

Just Over half the world's population now lives in urban as opposed to rural environments. As the rate of urbanization increases over time, food production sites should be increasingly located near main consumption centers. Consequently, urban agriculture is gaining relevance all over the world Orsini *et al*. 2013. The possible green cover of most of the empty areas of a city could be a new ecological frontier, and could become a reality in many cities Peck 2003; Kaethler 2006; Grewal and Grewal 2012.Under urban development and its attendant of climate changes and food security needs in Egypt has led to the need of apply urban horticulture (vegetable and medicinal & aromatic plants).

Green roofs provide significant ecological and economic benefits including mitigation of the urban heat island effect and food security. Green roofs application in urban area; it is possible to contribute to the mitigation of environmental problems, enhancement of community functions and development of urban food systems Lim and Kishnani, 2010.

Sweet Basil (*Ocimum basilicum* L.) is included in the Lamiaceae family, which has about 3500 species distributed among 210 genera, most of these herbaceous, less often shrubs, or rarely trees. Herbaceous plants from this family can behave like annual or perennial plants, depending on where and how they are grown Blank *et al*., 2004 , it's cultivated in Egypt for the purpose of producing dry leaves and oil as a summer crop grown in Upper Egypt, especially in Assiut (3000-4000 feddans annually), Beni Suef, Minya and Fayoum. - Mansourieh – Qalioubia Abou Zeid, (1988).

Moreover, Barrage, 1992 and Olympios, 2011. Reported that, soilless culture the most suitable cultivation system for cultivating rooftops where there is no available soil, limited spaces, and adverse production conditions. Soilless culture is defined as any method for growing plants without the use of soil as a rooting medium, in which the nutrients absorbed by the roots are supplied via the irrigation water. The fertilizers containing the nutrients to be supplied to the crop are dissolved in the appropriate concentration in the irrigation water and the resultant solution is referred to as "nutrient solution". Furthermore, soilless cultivation represented a breakthrough and permitting to achieve high yields and a very standardized production.

Substrate culture in solid medium (organic and inorganic substrates) is one of soilless culture methods Savvas *et al*., 2013. Stable and high quality production is the main advantage of soilless substrate culture, which has already been proved by many studies in various crop plants Yashuba and Yazawa, 1995 and Veys, 1997.

The growth of plants in hydroponic systems is affected by the nutrient solution properties, primary factors being EC and pH DeRijck and Schrevens, 1995. The EC of a nutrient solution is used as an estimate of the total dissolved salts Cooper and Charlesworth, 1977 and in general, too high EC may lead to nutrient toxicity while too low EC may induce nutrient deficiency in plants Sonneveld, 1989. The EC of a solution directly affects the quantity of essential nutrients available to the plant for growth. An EC of 1.5 dS/m has been recommended for production of leafy greens such as lettuce Resh, 2012. The concentration of the nutrient solution has a vital and comprehensive influence on the nutrient elements and water absorption by the roots, and on the changing ratio of absorbed ions, plant growth and development, and at last on the plant productivity Mairapetyan and Tadevosyan, 1999; ELBeheiry and Abou-Hadid, 1996.

NeSmith and Duval (1998) mentioned to plants undergo many physiological and morphological changes in response to reduced rooting volume, which can affect transplant quality and performance, where root and shoot growth, biomass accumulation and partitioning, photosynthesis, leaf chlorophyll content, plant water relations, nutrient uptake, respiration, flowering, and yield all are affected by root restriction and container size.

Many types of plant leaves extract such as Aloe, Moringa, Henna, Camphor…….etc used to improve vegetative growth and flowering in some plants Gilmour 1983. Plant hormones can be used to increase yield per unit area because they influence every phase of plant growth and development. Traditionally, there are five groups of growth regulators which are listed: auxins, gibberellins, abscisic acid, ethylene and cytokinins Prosecus, 2006. Plant leaves extractions acts as a plant growth hormone . Moringa , henna , aloe and camphor extractions are one of the richest plant sources of vitamins A, B and C. In addition, some plant extracts have been shown to have high Zeatin content 5 mcg/g and 200 mcg/g of leaves Fuglie., 2000. Fresh *Moringa oleifera* leaves have been shown to have high zeatin content. Moringa leaves gathered from various parts of the world were found to have high zeatin concentrations of between 5 mcg and 200 mcg/g of leaves Makkar and Becker.,1996. In addition, Hamouda and gehan, 2012 indicated that foliar spraying with Aloe vera extract influenced the vegetative growth and oil content of sweet basil. Extracts of Henna (*Lawsonia inarmis* L) produces a red orange dye molecule, “lawsone”, also known as hennotannic acid. This molecule has an affinity for bonding with protein in the planet cells Rout *et al*., 2001. The extract of Camphor (*Eucalyptus citriodora* L) reduced the percentage of radish germination, root and shoot lengths Luo *et al*. 1995. Singh *et al*. 2005. Moreover, some plant extracts possess multifunctional allelopathic effects i.e. have an inhibitory effect on insects, at the same time inhibiting the growth of various acceptor plant species like Radish, Ryegrass, and Barnyard grass, and on pathogens such as rice banded sclerotial blight and phytothora root rot of pepper Lu 1999. According to that, in this study different nutrient solution concentration (EC), different substrate volumes and different natural foliar application and thier interaction effect have been tested growth parameter and production of sweet basil plant as one of the medicinal and aromatic crops cultivated on rooftops in Egypt.

MATERIALS AND METHODS

The experiment has been conducted in the rooftop garden of Central Laboratory for Agricultural Climate (CLAC), Agricultural Research Centre, Ministry of Agriculture and Land Reclamation, Dokki, Giza, during summer seasons of 2015 and 2016 to study the effect of EC of nutrient solution, medium volume and natural foliar application on the yield, oil and oil components of sweet basil.

Plant:

Sweet Basil (*Ocimum basilicum*) is an annual herb which belongs to the family of Lamiaceae Basil seed were obtained from trusted resource (spices king company farm) of. Seeds of Basil for experiment, were sown on1st of March in nursery then transplanting in the studied system on 1st May.

Systems materials

Wood table (100cm length, 100cm width, and 10cm depth) and height of table legs was 60cm from rooftop floor. Each table laid with black polyethylene sheets 0.5 mm in thickness and equipped with drainage tube in one side to collect the leaching to the main tank to offer close substrate culture, system was fertigation from tank filled with nutrient solution, drip irrigation system have been used to deliver the diluted nutrient solution to each plant. The substrate consisted of mixture of peat moss and perlite 1:1 *v/v*.

Substrate physical properties

Substrate mixtures perlite: peat moss (1:1 *v/v*). physical properties i.e. bulk density (B.D), total pore space (T.P.S), water hold capacity % (W.H.C) and air porosity % (A.P) were estimated according to Wilson, 1983 and Raul, 1996. The pH of the potting mixtures were determined using a double distilled water suspension of each potting mixture in the ratio of 1:10 (*w: v*) Inbar *et al*., 1993 that had been agitated mechanically for 2 h and filtered through filter paper no.1. The same solution was measured for electrical conductivity (EC) with a conductance meter that had been standardized with 0.01 and 0.1M KCl were illustrated in Table (1).

Table (1): Physical and Chemical properties of Substrate mixtures perlite: peat moss (1:1 *v/v*)

Substrate	Chemical		Physical			
	E.C mmhos^{-1}	pH	B.D g/cm^3	T.P.S %	W.H.C %	A.P %
Perlite: peat moss (1:1 *v/v*)	0.45	7.6	0.14	65.2	52.8	12.5

Nutrient solution

The composition of the nutrient solution used in the experiment was described by ElBehairy, 1994. The concentrations of macro and micro elements in the nutrient solution are illustrated in Table (2).

Table (2): Element concentrations in the nutrient solution

Elements	Concentration (ppm)
N	200
P	70
K	300
Ca	190
Mg	50
Fe	5.0
Mn	1.0
Cu	0.039
Zn	0.044
B	0.17
Mo	0.1

Plant extractions treatments

The Henna plant (*Lawsonia inarmis*) were collected from vegetables departments section – HRI- Dokki. However and the Camphor plant (*Eucalyptus.citriodora* L) was collected from faculty of agriculture farm- Cairo University- Giza. The dried mature leaves were crushed into powder for effective extraction. In addition, the fresh plant leaves were washed more by water to remove the adhering materials. Then the leaves were dried in an oven at 40^{O} C for 24 hours and finely the dried mature leaves were crushed by a grinding machine into powder for effective extraction. The alcoholic extract was prepared by mixing 25 gm of Henna and Campher powder with 250 mL of 70% ethanol for 12 hours. This mixture was cooled and filtered by filter paper (Wattman No. 185). The solvent was dried and concentrated using Rotary evaporator at 50°C. Water based Henna and Campher extracts were prepared in the same way except that distilled water and were used instead of alcohol Harborne, 1999. The extract weighed 4.98 g (pH 2.86) and was then collected in air tight plastic container and stored in the refrigerator at 4°C ready for use. solutions of powder extracts were prepared by dissolving 2.5 g of the extract in 50 ml distilled water (the dissolved solution was filtered to remove some particles as it does not completely dissolve) Mittal and Aguwa, 1983.

Photochemical screening of Henna and Camphor

Photochemical screening was carried out for Henna and Camphor leaves samples using adopted by Stante *et al*., 2006. Also, photochemical analysis results of Henna and Camphor leaves were reported in Table (3)

Table (3): Phytochemical components of the leaves extracts of Henna plant (*Lawsonia inarmis*) and Camphorplant (*Eucalyptus.citriodora* L)

Henna plant extract		**Camphor plant extract**	
tannin	+	Sterols	+++
glycosides	+	Triterpenes	+++
Resin.	-	Phenol	++
Alkaloids	+	Alkaloids	-
Flavonoids	-	Flavonoids	+++
Naphtaquinone (Hennotannic acid)	+++	Cumarins	-
Saponins	++	Saponins	+++
Carbohydrates	+	Anthraquinone glycoside	-
Sterols	+	cyanogenic glycoside	-
Lipids/Fat	+	Lipids/Fat	-
Mannit	++		
Gallic acid	++		
Crysophanic acid)	+++		
Mucilage	+++		

- = Absent key: + =Trace , ++ = Moderate , +++ = High , ++++ = Very High

Treatments:

The treatments as follows:

Concentration of nutrient solution (EC):

- 1 EC
- 1.5 EC
- 2 EC
- 2.5 EC

Volume of substrata culture:

- **Small Pots System (6L)**

Twelve black polyethylene pots (20 cm diameter x 20 cm length) have been arranged on the previous described wood table. Each pots was filled with 6 liters filled by substrate mixtures perlite: peat moss (1:1 *v/v*). In each pot were planted one seedling.

- **Big pots system (8L)**

Twelve black polyethylene pots (25 cm diameter x 25 cm length) have been arranged on the previous described wood table. Each pot was filled with 8 liters filled by substrate mixtures perlite: peat moss (1:1 *v/v*). In each pot were planted one seedling.

Plant extractions spraying:

- Without spraying **(0)**
- Henna extract spraying **(H)**
- Camphor extract spraying **(C)**

The extraction spraying was applied on sweet basil plants every fifteen days after the transplanting to studied systems (three times between every harvesting cutting)

The experiment was designed using split split plot design (three factors were studied) with three replicates. The main plots, subplots and sub-subplots were assigned to concentration of nutrient solution (EC), substrate culture volume and plant extractions spraying, respectively. The total treatments were 24 treatments.

Data were statistically analyzed using the analysis of variance method one way ANOVA with SAS package software version 6 (SAS Institute, 1990). Tukey test was used to compare the significant differences among means of the treatments at 0.05 level of probability

The measurements

The vegetative growth and herb yield parameter:

After 45 days from the transplanting date growth parameters (branches numbers, plant height) and yield parameters (plant fresh weight and plant dry weight after six days in shad dryer). The data recorded as an average of four harvesting cuts.

The volatile oil yield parameter:

- Volatile oil percentage
- Total volatile oil yield
- The main components percentage of the volatile oil (as average of two seasons)

Basil plants were collected from each treatment during the first and second seasons; air dried herb was taken, then 100 g from each replicate of all treatments were subjected to hydro-distillation (HD) for 3 h using a Clevenger type apparatus according to Italian
Pharmacopoeia 2008 Volatile oil extracted from basil plants were collected during the first and second seasons from each treatment and dried over anhydrous sodium sulphate to identify the chemical constituents. Gas chromatography (GC) analyses were performed using a Shimadzu GC-9A gas chromatograph equipped with a DB5 fused silica column (30 m x 0.25 mm i.d., film thickness 0.25µm). Oven temperature was held at 40°C for 5 min and then programmed until 250°C at a rate of 4°C/min. Injector and detector (FID) temperature were 260°C; helium was used as carrier gas with a linear velocity of 32 cm/s.. Identification compounds also, the components of the oils were identified by comparison of their mass-spectra with those of a computer library or with authentic compounds and confirmed by comparison of their retention indices either with those of authentic compounds. Kovat's indices Adams, 1995 were determined by coinjection of the sample with a solution containing a homologous series of n-hydrocarbons, in a temperature run identical to that described above.

RESULTS

Data in Table (4) illustrate the effect of different concentration of nutrient solution (1, 1.5, 2 and 2.5 EC), volume of substrate culture (6 and 8 L) and different plant extractions spraying (Henna and Camphor extracts) on plant height and branch number. The results were as the follow.

Data showed that, application of 1.5 EC of nutrient solution gave the higher average of plant's length and branches numbers compared with application of 2.5 EC which gave the lowest average in both seasons. While, the higher average of plant's length and branches numbers were also recorded in plants grown in big volume of substrate (8L) flowed by small volume of substrate (6L) with no significant different between them in plant's length and with significant different between them in branches numbers. In addition, highest average of plant's length and branches numbers were recorded by used Henna extract spray flowed by camphor extracts spray without significant different between them in plant's length while with significant different between them in branches numbers compared with the treatment without sparing in both seasons.

Concerning the first order interactions, 1.5 EC with big volume (8L) gave highest values of plant's length and branches numbers flowed by 1.5 EC with small volume (6L) of substrate without significant different between them in plant's length and with significant different between them in branches numbers, however the lowest average of plant's length and branches numbers was with the concentration of 2.5 EC in both volume of substrate in both seasons. Also the highest plant's length and branches numbers were recorded by application of 1.5 EC with henna extract spray but the lowest values of plant's length were obtained by 2.5 EC with or without extracts spray, while the lowest values of branches numbers were recorded by 2.5 EC combined with camphor extract spray in both seasons. As to volumes of substrata culture with plant extractions spraying, plants grown in big volume of substrate with henna extract spray which gave the highest plant's length and branches number on the other hand, the lowest values of branches numbers were estimated by small volume without spraying.

Concerning the second order interaction among concentration of nutrient solution, volume of substrate and plant extractions spraying, the highest plant's length and branches numbers were obtained from the combination among 1.5 EC, big volume of substrate and henna extract however, the lowest value was recorded in 2.5EC, small volume and all foliar spry plant extractions .This was true in both seasons.

Data in Table (5) illustrate the effect of different concentration of nutrient solution (1, 1.5, 2 and 2.5 EC), volume of substrate culture (6 and 8 L) and different foliar spry of plant extractions (Henna and Camphor extract) on fresh weight and dry weight. The results showed that.

Date indicated that, fertigation by nutrient solution concentration 1.5 EC recorded the higher values of fresh and dry weight a compared with those fertigation by 2.5 EC.

Table (4): Effect of concentration of nutrient solution (EC), volume of substrate and plant extraction spraying on plant height, number of branches

Treatment		First season		Second season	
		Plant highest(cm)	N. of branches	Plant highest(cm)	N. of branches
Concentration of nutrient solution (EC)					
1 EC		69.6 B	50.7 B	71.9 B	59.0 B
1.5 EC		73.3 A	53.8 A	75.0 A	64.5 A
2 EC		66.8 C	50.2 B	68.5 C	57.1 B
2.5 EC		53.9 D	33.6 C	55.6 D	40.1 C
Substrate volume					
Big		66.2 A	49.1 A	68.2 A	57.3 A
Small		65.7 A	45.0 B	67.3 A	53.1 B
plant extraction spraying					
O		63.9 B	44.6 C	65.3 B	52.8 B
H		67.2 A	50.5 A	69.1 A	59.1 A
C		66.7 A	46.0 B	68.9 A	53.7 B

Treatment		First season		Second season	
		Plant highest(cm)	N. of branches	Plant highest(cm)	N. of branches
EC * Substrate volume					
1.EC	Big	70.0 b	52.7 b	71.8 b	60.8 b
	Small	69.3 b	48.7 c	72.0 b	57.2 bc
1.5 EC	Big	73.6 a	56.8 a	75.4 a	67.7 a
	Small	73.1 a	50.9 b	74.5 ab	61.2 b
2 EC	Big	67.2 c	52.6 b	69.4 bc	59.4 bc
	Small	66.4 c	47.9 c	67.7 c	54.9 c
2.5EC	Big	54.1 d	34.4 d	56.3 d	41.2 d
	Small	53.8 d	32.7 d	54.9 d	39.0 d
EC * plant extraction spraying					
1 EC	O	65.3 d	43.5 f	67.7 c	51.5 d
	H	71.6 b	55.7 b	73.0 b	66.0 b
	C	72.0 b	52.8 c	75.0 ab	59.6 c
1.5 EC	O	72.0 b	52.3 c	73.4 b	62.1 bc
	H	76.3 a	62.7 a	77.8 a	74.0 a
	C	71.7 b	46.5 e	73.7 b	57.3 c
2 EC	O	64.8 d	46.8 e	66.5 c	54.7 cd
	H	66.5 d	49.8 d	68.7 c	55.4 cd
	C	69.2 c	54.0 bc	70.4 bc	61.3 bc
2.5 EC	O	53.3 e	35.8 g	53.6 d	43.0 e
	H	54.5 e	34.0 g	56.8 d	40.8 ef
	S	54.0 e	30.8 h	56.5 d	36.5 f

Cont. Table (4) :

Treatment			First season		Second season	
			Plant highest(cm)	N. of branches	Plant highest (cm)	N. of branches
			Substrate volume * plant extraction spraying			
	Big	O	63.6 c	46.5 b	64.1 c	55.1 b
		H	67.9 a	54.1 a	69.9 a	62.3 a
		S	67.2 ab	46.8 b	70.7 a	54.4 bc
	Small	O	64.2 c	42.8 c	66.5 bc	50.5 c
		H	66.5 ab	47.0 b	68.3 ab	55.8 b
		S	66.3 b	45.3 b	67.1 b	52.9 bc
			EC * Substrate volume* plant extraction spraying			
1 EC	Big	O	67.0 c	46.3 de	68.6 c	54.6 cd
		H	70.3 bc	58.7 b	69.2 c	68.0 ab
		C	72.7 b	53.0 c	77.6 ab	59.7 bc
	Small	O	63.7 d	40.7 f	66.8 c	48.3 d
		H	72.8 b	52.7 cd	76.9 ab	63.9 bc
		C	71.3 bc	52.7 cd	72.5 bc	59.5 bc
1.5 EC	Big	O	72.3 b	59.0 b	72.3 bc	69.7 ab
		H	77.3 a	63.3 a	79.8 a	73.8 a
		C	71.0 bc	48.0 de	74.1 bc	59.6 bc
	Small	O	71.7 bc	45.7 e	74.5 b	54.5 cd
		H	75.3 ab	62.0 ab	75.8 ab	74.3 a
		C	72.3 b	45.0 e	73.4 bc	55.0 cd
2 EC	Big	O	61.7 d	44.3 ef	60.7 d	52.4 cd
		H	69.3 c	58.7 b	72.7 bc	65.1 b
		C	70.7 bc	54.7 c	74.7 ab	60.6 bc
	Small	O	68.0 c	49.3 d	72.3 bc	57.0 c
		H	63.7 d	41.0 f	64.7 cd	45.8 de
		S	67.7 c	53.3 c	66.2 c	62.0 bc
2.5 EC	Big	O	53.3 e	36.3 gh	54.7 e	43.6 de
		H	54.7 e	35.7 gh	57.8 de	42.4 de
		S	54.3 e	31.3 h	56.5 de	37.7 e
	Small	O	53.3 e	35.3 gh	52.5 e	42.4 de
		H	54.3 e	32.3 h	55.8 de	39.3 e
		C	53.7 e	30.3 h	56.5 de	35.3 e

0: without spraying, **H**: Henna extraction, **C**: Camphor extraction

Table (5): Effect of concentration of nutrient solution (EC), volume of substrate and plant extraction spraying on fresh weight and dry weight of branches

Treatment	First season		Second season	
	Fresh weight(g)	Dry weight(g)	Fresh weig(g)ht	Dry weight(g)
		Concentration of nutrient solution (EC)		
1 EC	783.0 B	117.5 B	826.5 B	125.6 B
1.5 EC	833.9 A	126.2 A	889.5 A	135.1 A
2 EC	672.3 C	98.8 C	711.5 C	105.8 C
2.5 EC	476.7 D	69.3 D	501.3 D	74.3 D
		Substrate volume		
Big	739.2 A	110.4 A	780.4 A	118.8 A
Small	643.8 B	95.5 B	684.0 B	101.7 B
		plant extraction spraying		
O	693 A	103 AB	726.8 A	109.5 A
H	694 A	106 A	737.1 A	112.5 A
C	688 A	100 B	732.7 A	108.7 A

Treatment		First season		Second season	
		Fresh weight(g)	Dry weight(g)	Fresh weigt(g)ht	Dry weight(g)
			EC * Substrate volume		
1.EC	Big	813.3 ab	123.2b	844.8 b	130.1 b
	Small	752.7 c	111.8 c	808.1 bc	121.2 c
1.5 EC	Big	878.2 a	129.6 a	931.6 a	140.0 a
	Small	789.6 b	122.8 b	847.4 b	130.2 b
2 EC	Big	723.8 c	113.1 c	781.4 c	124.1 bc
	Small	620.7 d	84.4 d	641.6 d	87.6 d
2.5EC	Big	541.4 e	75.7 e	563.7 e	81.0 d
	Small	412.1 f	62.9 f	439.0 f	67.7 e
			EC * plant extraction spraying		
1 EC	O	720.6 c	105.4 d	748.2 b	109.6 c
	H	825.6 ab	124.2 b	876.2 a	130.8 b
	C	802.8 b	122.9 b	855.0 a	136.6 b
1.5 EC	O	831.2 ab	121.5 b	878.5 a	128.5 b
	H	856.2 a	131.0 a	904.0 a	139.9 a
	C	814.2 ab	126.0 ab	886.1 a	137.0 ab
2 EC	O	708.5 c	112.0 c	753.2 b	119.8 b
	H	628.3 d	93.3 e	663.3 c	100.3 cd
	C	680.0 c	91.0 e	718.0 bc	97.3 d
2.5 EC	O	509.9 e	73.3 f	527.2 d	80.1 e
	H	467.1 e	74.6 f	505.0 d	79.0 e

Cont. Table (5) :

	C	453.1 e	60.1 g	471.7 d	63.9 f
		Substrate volume * plant extraction spraying			
Big	O	734.4 a	110.1 ab	771.3 a	116.2 a
	H	745.8 a	113.0 a	791.0 a	121.8 a
	C	737.4 a	108.1 b	778.8 a	118.5 a
Small	O	650.7 b	96.0 cd	682.2 b	102.8 b
	H	642.8 b	98.5 cd	683.3 b	103.2 b
	C	637.7 b	91.9 d	686.6 b	99.0 b

Treatment			**First season**		**Second season**	
			Fresh weight(g)	**Dry weight(g)**	**Fresh weigt(g)ht**	**Dry weight(g)**
			EC * Substrate volume * plant extraction spraying			
1 EC	Big	O	729.4 cd	106.7 d	756.2 c	107.5 cd
		H	869.4 ab	131.2 ab	897.7 ab	135.2 b
		C	840.9 b	131.7 ab	880.6 ab	147.5 ab
	Small	O	711.7 d	104.2 de	740.1 cd	111.6 cd
		H	781.7 c	117.2 c	854.7 b	126.4 bc
		C	764.7 cd	114.2 cd	829.4 bc	125.6 bc
1.5 EC	Big	O	873.8 ab	124.6 bc	913.3 ab	131.1 bc
		H	903.8 a	137.1 a	952.9 a	150.1 a
		C	856.8 ab	127.1 b	928.5 ab	138.9 ab
	Small	O	788.6 bc	118.4 bc	843.6 bc	125.8 bc
		H	808.6 bc	124.9 bc	855.0 b	129.7 bc
		C	771.6 c	124.9 bc	843.7 bc	135.1 b
2 EC	Big	O	762.2 cd	126.4 b	823.4 bc	137.3 ab
		H	697.7 de	106.4 d	757.0 c	119.6 c
		S	711.7 d	106.4 d	763.7 c	115.4 cd
	Small	O	654.9 de	97.6 e	683.0 cd	102.4 d
		H	558.9 fg	80.1 fg	569.6 e	81.0 e
		C	648.4 e	75.6 fg	672.3 d	79.3 e
2.5 EC	Big	O	572.1 f	82.7 f	592.5 de	88.7 de
		H	512.1 g	77.2 fg	556.2 e	82.2 e
		C	540.1 fg	67.2 g	542.5 ef	72.0 e
	Small	O	447.7 h	63.9 g	462.0 fg	71.5 e
		H	422.2 hi	71.9 g	453.9 g	75.8 e
		C	366.2 i	52.9 h	401.0 g	55.9 f

0: without spraying, **H**: Henna extraction, **C**: Camphor extraction

Table (6): Effect of concentration of nutrient solution (EC), volume of substrate and plant extraction spraying on oil % and total voltial oil per plant

Treatment	First season		Second season	
	Oil %(100g)	Total Oil per plant	Oil %(100g)	Total Oil per plant
Concentration of nutrient solution (EC)				
1 EC	0.62 B	0.74 B	0.63 B	0.80 B
1.5 EC	0.72 A	0.91 A	0.72 A	0.99 A
2 EC	0.72 A	0.70 C	0.73 A	0.76 B
2.5 EC	0.72 A	0.50 D	0.73 A	0.54 C
Substrate volume				
Big	0.70 A	0.77 A	0.72 A	0.85 A
Small	0.69 B	0.66 B	0.68 B	0.70 B
plant extraction spraying				
O	0.45 C	0.47 C	0.46 C	0.51 C
H	0.94 A	0.99 A	0.94 A	1.05 A
C	0.70 B	0.68 B	0.71 B	0.76 B

Treatment		First season		Second season	
		Oil %(100g)	Total Oil per plant	Oil %(100g)	Total Oil per plant
EC * Substrate volume					
1.EC	Big	0.58 f	0.72 c	0.59 c	0.78 c
	Small	0.66 e	0.75 c	0.66 b	0.82 c
1.5 EC	Big	0.73 b	0.96 a	0.74 ab	1.06 a
	Small	0.70 c	0.87 b	0.70 b	0.91 bc
2 EC	Big	0.75 a	0.83 b	0.76 a	0.93 b
	Small	0.70 cd	0.57 d	0.70 b	0.60 d
2.5EC	Big	0.76 a	0.57 d	0.78 a	0.62 d
	Small	0.68 d	0.44 e	0.68 b	0.47 e
EC * plant extraction spraying					
1 EC	O	0.44 i	0.46 g	0.43 h	0.48 f
	H	0.86 c	1.05 b	0.85 c	1.11 b
	C	0.57 g	0.70 e	0.59 f	0.81 cd
1.5 EC	O	0.45 i	0.54 f	0.45 h	0.58 ef
	H	1.04 a	1.36 a	1.05 a	1.47 a
	C	0.66 f	0.83 c	0.66 e	0.91 c
2 EC	O	0.51 h	0.58 f	0.52 g	0.63 e
	H	0.84 c	0.78 d	0.86 c	0.85 cd
	C	0.81 d	0.75 d	0.82 c	0.81 cd
2.5 EC	O	0.42 i	0.31 h	0.44 h	0.35 g
	H	1.01 b	0.75 d	0.99 b	0.78 d
	C	0.74 e	0.45 g	0.76 d	0.50 f

Cont. Table (6) :

Treatment			First season		Second season	
			Oil %(100g)	Oil per plant	Oil %(100g)	Oil per plant
			Substrate volume * plant extraction spraying			
	Big	O	0.49 e	0.54 d	0.49 e	0.58c
		H	0.87 b	0.98 a	0.88 b	1.08 a
		C	0.75 c	0.79 b	0.78 c	0.89b
	Small	O	0.42 f	0.40 e	0.43 f	0.44 d
		H	1.00 a	0.99 a	0.99 a	1.03 a
		C	0.64 d	0.58 c	0.63 d	0.62 c
			EC * Substrate volume * plant extraction spraying			
1 EC	Big	O	0.47 j	0.51 i	0.46 g	0.50 fg
		H	0.70 g	0.91 de	0.70 ef	0.94 cd
		C	0.57 i	0.75 fg	0.61 f	0.90 d
	Small	O	0.40 l	0.41 j	0.41 g	0.46 fg
		H	1.02 ab	1.19 c	1.00 ab	1.27 b
		C	0.57 i	0.65 gh	0.57 f	0.72 e
1.5 EC	Big	O	0.47 j	0.58 h	0.47 g	0.62 ef
		H	1.03 ab	1.41 a	1.07 a	1.61 a
		C	0.69 g	0.87 e	0.69 ef	0.96 cd
	Small	O	0.43 k	0.51 i	0.42 g	0.53 f
		H	1.05 a	1.31 b	1.03 ab	1.34 b
		C	0.64 h	0.79 f	0.63 ef	0.85 de
2 EC	Big	O	0.56 i	0.71 g	0.57 f	0.78 de
		H	0.76 f	0.81 ef	0.79 d	0.95 cd
		C	0.92 d	0.97 d	0.93 bc	1.07 c
	Small	O	0.47 j	0.45 ij	0.47 g	0.48 fg
		H	0.92 d	0.74 fg	0.92 bc	0.74 e
		C	0.70 g	0.53 hi	0.71 e	0.56 f
2.5 EC	Big	O	0.45 jk	0.37 jk	0.47 g	0.41 fg
		H	0.99 c	0.77 fg	0.98 b	0.80 de
		C	0.84 e	0.56 hi	0.89 c	0.64 ef
	Small	O	0.38 l	0.24 l	0.41 g	0.30 g
		H	1.02 b	0.73 fg	1.00 ab	0.76 de
		C	0.65 h	0.34 k	0.63 f	0.35 g

0: without spraying, **H**: Henna extraction, **C**: Camphor extraction

Table (7): Effect of concentration of nutrient solution (EC), volume of substrate and plant extraction spraying on the main components of volatile oil (%)

Treatments			The main components Volatile oil (%)				
Concentration	Volume	Plant extraction	Linalool	Eugenol	Methyl chavicol	1,8-Cineole	Methyl-Eugenol
1 EC	Big	0	40.5	22.01	12.21	5.1	4.6
		H	42.5	23.12	11.56	5.91	5.12
		C	40.91	22.41	12.55	5.3	4.81
	Small	0	40.2	21.4	12.5	5.2	4.8
		H	41.2	23.1	11.6	5.8	5.2
		C	40.1	21.2	12.5	5.35	4.9
1.5 EC	Big	0	42.3	23.2	12.4	5.61	4.81
		H	46.32	25.22	12	6.21	5.51
		C	43.11	24.21	12.66	5.88	4.9
	Small	0	41.5	21.9	12.8	5.2	4.78
		H	44.3	24.5	12.7	5.9	5.45
		C	43.1	24.1	12.4	5.5	4.35
2.0 EC	Big	0	43.8	24.12	13.75	6.12	5.13
		H	46.71	26.31	12.01	6.95	5.89
		C	44.02	24.51	13.91	6.44	5.39
	Small	0	43.3	23.2	13.8	6.14	5.2
		H	45.2	24.5	12.2	6.8	5.78
		C	43.2	24.1	13.8	6.5	5.4
2.5 EC	Big	0	44.11	25.13	14.21	6.68	5.62
		H	47.1	26.99	13.41	6.96	6.03
		C	44.39	25.28	14.5	6.9	5.71
	Small	0	43.8	24.8	14.3	6.5	5.58
		H	47	26.5	14	6.8	6.1
		C	44.1	24.9	14.8	6.7	5.8

0: without spraying, **H**: Henna extraction, **C**: Camphor extraction

These results held true in both seasons. The higher fresh and dry weight also recorded in plants grown in big volume of substrate compared with those grown in small volume. In addition, there was no significant different among all foliar spry plant extractions treatments in both seasons, the same results were obtained with dry weight except in the first season foliar spry by camphor extract gave the lowest value with significant different with the other foliar spry plant extractions treatments

Regarding the first order interactions, used nutrient concentration 1.5EC combined with big volume of substrate gave the highest fresh and dry weight. On the contrary, application of 2.5 EC combined with small volume gave the lowest values. Also, used 1.5 EC with foliar spry of Henna extract gave highest fresh and dry weight. While the lowest values of fresh weight were recorded by application of 2.5 EC with foliar spry of camphor extract, on the other hand the lowest dry weight were estimated by using 2.5 EC with all foliar spry of plant extractions treatments. In addition, the big volume of substrata culture has been given higher average of fresh weight with all foliar spry of plant extractions treatments. While the higher average of dry weight was recorded with big volume of substrata culture combined with foliar spry of henna extract or without foliar spry and the lowest values of in fresh and dry weight were obtained from small volume of substrate combined with all foliar spry plant extractions treatments. These results held true in both seasons.

As for the second order interaction among concentration of nutrient solution, volume of substrate culture and foliar spry of plant extractions, the combination among 1.5 EC, big volume of substrate and Henna extract gave the highest fresh and dry weight while, the lowest values were recorded by the combination 2.5 EC, small volume of substrate and foliar spry of camphor extract.

Data in Table (6) illustrate the effect of different concentration of nutrient solution (1, 1.5, 2 and 2.5 EC), volume of substrate culture (6 and 8 L) and different foliar spry of plant extractions (Henna and Camphor extract) on volatile oil percentage, total volatile oil per plant.

Data showed that, application of 1.5 EC of nutrient solution gave the higher average of plant's length and branches numbers compared with application of 2.5 EC which gave the lowest average in both seasons. While, the higher average of plant's length and branches numbers were also recorded in plants grown in big volume of substrate (8L) flowed by small volume of substrate (6L) without significant different between them in plant's length and with significant different between them in branches numbers. In addition, highest average of plant's length and branches numbers were recorded by used Henna extract spray flowed by camphor extracts spray without significant different between them in plant's length while with significant different between them in branches numbers compared with the treatment without sparing in both seasons.

Data revealed that. For the effect of the concentration of the nutrient solution, the results showed that the best percentage of volatile oil was resulted with the concentration 1.5, 2 and 2.5 EC without any significant deferent among them while, the best average of total volatile oil yield was recorded by concentration 1.5 EC, but the plants which growing in concentration 1 EC recorded the lowest percentage of volatile oil and total volatile oil yield. For the effect of volume's substrate, the big volume gave the highest percentage of volatile oil and total volatile oil yield however; the lowest values were estimated with small volume. For plant extracts spraying, the henna extract spraying gave the highest percentage of volatile oil and total volatile oil yield in both seasons, but the lowest percentage of volatile oil and total volatile oil yield were with the control (without spraying) in both seasons.

Regarding the first order interactions, firstly for the effect of nutrient solution concentrations factor and the volume of substrate culture the results showed that, the highest percentage of volatile oil was occurred with the concentration of 2 and 2.5 EC in the big substrate volume, while total volatile oil yield was recorded highest value with 1.5 EC combined with big substrate volume however, the lowest percentage of volatile oil acted with the concentration of 1 EC in the small substrate volume but the lowest total volatile oil yield recorded with the treatment 2.5 EC in the small volume of substrate in both seasons. For the combination between nutrient solution concentrations and plant extracts spraying, the application of nutrient solution concentration 1.5 E combined with foliar spry of henna extract gave the highest percentage of volatile oil and total volatile oil yield, on the contrary, the lowest percentage of volatile oil was estimated by all nutrient solution concentration combined without plant extractions spraying treatments. As for the interaction between volumes of substrate culture and plant extractions spraying, the small volume of substrate followed by big volume with henna extraction gave the highest percentage of volatile oil with significant different between them however, no significant different between them showed in total volatile oil yield. On the other hand, the small volume of substrate combined with no plant extraction spraying gave the lowest percentage of volatile oil and volatile oil yield in both seasons.

Concerning the second order interaction among concentration of nutrient solution, volume of substrate culture and plant extractions spraying, the highest percentage of volatile oil was achieved with concentration 1.5 EC with plants growing in small substrate volume which sprayed with henna extraction while, the combination among 1.5 EC in big substrate volume which sprayed with henna extraction recorded the highest value total volatile oil yield. On the contrary, the lowest result was resaved by 2.5 EC in small substrate volume without plant extractions spraying treatment.

Data in Table (7) illustrate the effect of different concentration of nutrient solution (1, 1.5, 2 and 2.5 EC), volume of substrate culture (6 and 8 L) and different foliar spry of plant extractions (Henna and Camphor extract) on volatile oil percentage, total volatile oil per plant.

Data showed that, increasing concentration of the nutritional solution increased the percentage of active ingredients in volatile oil (Linalool, Eugenol, 1, 8-Cineole, Methyl chavicol and Methyl- Eugenol). In addition, the volume of substrate showed an increase in the previous active components of volatile oil except Methyl chavicol with big volume of substrate comparing with small volume which increased the Methyl chavicol percentage. Also, the spraying of plant extracts led to increase the active ingredients in volatile oil comparing with no spraying treatment. However, spraying with henna extract increase the most of active ingredients greater than the increasing that caused by spraying with camphor extract. On the other hand, the results showed that spraying with henna extract decrease the of Methyl chavicol percentage in the volatile oil.

DISCUSSION

Growth and yield parameters such as plant height, numbers of branches, fresh and dry weight were increase with an increase in the nutrient solution concentration from 1 dS/m up to 1.5 dS/m . This can be explained by the insufficient availability of nutrients at low of EC as 1 dS/m. which agreement with Sonneveld, (1989) who reported that the fertilizer solution at lower EC have lesser nutrients which may induce nutrient deficiency in the plants and led to negative influence on the plant growth parameters. However, the decrease in plant fresh and dry weight at an EC higher than 1.5 dS/m up to 2.5 EC may be due to attribute to the nutrient imbalance in the plant system these results agree with Bugbee, 2004 and Schwarz, 1995 whose reported that at higher concentrations, the availability of nutrients increases which may lead to more absorption of some ions present in higher quantities than others, thereby, creating a nutrient imbalance in the plant system. Also, Tesi, *et al*., 2003 suggested that a higher solution concentration is known to suppress the uptake of water and nutrients due to higher osmotic potential which can adversely affect the plant growth, In a study conducted by Miceli and D'anna (2003), reported that the plant fresh and dry weight of lettuce decreased as EC was increased from 1.6 to 4.6 dS/m in a coir dust culture. Similar trends in change in fresh weight of lettuce over an EC range of 1.5-3.5 dS/m were also reported by Serio *et al*., 2000. In addition, increased the nutrient solution concentration from 1 dS/m up to 2.5 dS/m increased the volatile oil percentage these results may due to the stress which acted by the increasing of the salinity of the nutrient solution that promoted the plants to increase the volatile oil content these results were mentioned by Adams, 1991 who indicated that a high rate of salinity suppresses volatile oil biosynthesis in *mitha specata* L. The high nutrient salts concentration solution has a positive impact on the oil content. On the contrary the total oil yield per plant was decrease with increasing of nutrient solution which may due to a decreasing of fresh and dry weight of the plant which occurred as a results to nutrient solution increasing. In a study conducted by Miceli, *et al*., (2003), reported that the plant fresh and dry weight of lettuce decreased as EC was increased from 1.6 to 4.6 dS/m in a coir dust culture. Similar trends in change in fresh weight of lettuce over an EC range of 1.5-3.5 dS/m were also reported by Serio *et al*., 2001.Also the previous results agree with Gershenzon *et al*., 1989 who mentioned that, the benefit of increased volatile oil concentration as a reaction of the increased nutrient salts concentration would be offset by any reduction in biomass production in high nutrient salts concentrations treated plants. Although volatile oil concentration was affected due to higher nutrient salts levels (2.5 EC), a significant adverse effect of high nutrient salts concentration was observed when data for volatile oil concentration were transformed into per plant fresh weight. Therefore, total yield of oil in higher nutrient salts concentrations fell due to the production of the reduced fresh weight. A high reduction in total yield of oil of these crops could imply maintaining the nutrient salts concentrations of solution at an appropriate level.

As for the effect of substrate volumes the previous results in that study indicated that the big volume (8L) of substrate gave the best values of growth and yield variables which agree with many studies; where Kemble *et al*., 1994 and Oagile *et al*., 2016 reported that bigger container size enhanced tomato seedlings growth and development with respect to plant height, leaf number, leave area, and shoot fresh & dry weights when compared to smaller containers. Furthermore NeSmith and Duval, 1998 mentioned to plants undergo many physiological and morphological changes in response to reduced rooting volume, which can affect transplant quality and performance, where root and shoot growth, biomass accumulation and partitioning, photosynthesis, leaf chlorophyll content, plant water relations, nutrient uptake, respiration, flowering, and yield all are affected by root restriction and container size. Also, Neveen, 2016 mentioned to increased containers size from 2.5 liters to 5 liters increased plant height, number of leaves, aerial parts fresh and dry weights of hot pepper plants.

For the effect of plant extraction spraying treatments, the study indicated that the growth and yield parameters were increased with spraying Henna extraction compared with the other spraying application also, henna extraction spraying has a positive effect of total oil yield per plant and the mean components of the volatile oil. On the other hand, henna extraction application has a good effect of decreasing Methyl chavicol percentage which raise the marketing value of the herb and volatile oil of the basil which may due to the henna extraction component such as triterpenes , flvonoids and cardiac glycoside. Also, henna extracts generally may enhanced growth hormones content and depressed apssicic acid ABA in the plant buds which may du to promote the growth in the basil plants in our investigation. The obtained results were agreement with Hamouda and Gehan, 2012. In addition the extraction applications may promote the synthesis of growth hormones which promote the vegetative growth and yield parameters, it is well known that vegetative growth of plants is promoted by foliar application of gibberellins in many vegetable crops. Increase in the length of leaf-stalk and fresh weight of field grown celery plant following gibberellins application has proved to bring profit Gehan, 2004. Growth promoting hormones are commonly used in agriculture to increased productivity, where gibberllic acid is used as a growth stimulating substance for promoting cell elongation, cell division which leads to promote growth of many plant species.

(Masror *et al.*, 2006). GA3 is an established phytohormone used commercially in improving the productivity and quality of a number of crop plants

CONCLUSION

The previous study recommended that using substrate systems in rooftop garden to produce the medicinal and aromatic plants. In addition, using big substrate value (8 L) and Henna extraction spraying maximize the productivity of sweet basil plant which makes our studied system appear as a promising system with medicinal and aromatic plants around the year.

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تأثير استخدام مزارع البيئات بالمدن والرش بمستخلصات نباتية على نمو وانتاج الريحان الحلو

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أجريت تلك الدراسة فى السطح الخاص بالمعمل المركزى للمناخ الزراعى – مركز البحوث الزراعية – وزارة الزراعة – جمهورية مصر العربية. تم إجراء التجربة خلال عامى2015 / 2016 وكان الهدف منها دراسة تأثير اربع تركيزات للمحلول المغذى (1، 1.5، 2، 2.5 مليموز) وحجمين بيئة زراعة (6 و 8 لتر) والرش ببعض المستخلصات النباتية الطبيعية (بدون رش ومستخلص الحناء و مستخلص الكافور) على الصفات المورفولوجية والانتاجية لنبات الريحان الحلو (الريحان فرنساوى) وقد تم تصميم التجربة كقطعة منشقة مرتان فى ثلاث مكررات.

وقد تم قياس طول النبات ، عدد الافرع، الوزن الطازج، الوزن الجاف، نسبة الزيت، وزن الزيت للنبات ونسب مكونات الزيت .

وقد اظهرت النتائج ان تركيز 1.5 مليموز هو الافضل فى التأثير على الصفات المورفولوجية للنبات وعلى انتاجية الزيت. النتائج وكان افضل حجم بيئة زراعية هو الحجم الاكبر (8 لتر بيئة) كما كان استخدام الرش بمستخلص الحناء اعطى اعلى تأثيرايجابيا على النتائج مقارنتا بمعاملات الرش الاخرة. كما اعطى التداخل بين العوامل السابقة التأثير الافضل النتائج.

وفى نفس السياق زاد تركيز المواد الفعالة الرئيسة فى الزيت الطيار بزيادة تركيز المحلول المغذى مع الرش بمستخلص الحناء فيماعدا مركب الميثيل شافيكول الذى تأثر عكسيا مع الرش بمستخلص الحناء.

THE CABBAGE PRODUCTIVITY IN SUBSTRATE CULTURE UNDER EGYPTIAN CONDITION

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Abstract

Currently, soilless culture take more attention in Egypt regarding to the expected climate change impacts, water shortage and food security demands that create the drive force for investigating more the suitable soilless culture techniques under Egyptian conditions. Substrate culture is one of the most promising techniques of soilless culture. The experiment was carried out during two successive winter seasons of 2015/2016 and 2016/2017 under unheated double span net house (18 x 60 x 4.5 m) at Central Laboratory for Agricultural Climate (CLAC), Agriculture Research Centre, Egypt. The aim of this study was to assess the effect of applying different substrate mixtures Sand + Pet moss (S: P 1:1 *v/v*), Sand + Pet moss (S : p 1:2 % *v/v*), Pet moss + perlite (P : Per 1:1% *v/v*), Sand + Pet moss + Vermicompost (S : P: V 2:2:1% *v/v*) and Sand + Vermicompost (S: V 4:1% *v/v*) , pot volumes (6 and 8 L) and drainage systems (open and close) on vegetative growth and yield characteristics of cabbage and the Economic considerations of the different treatments. The experimental design was split split plot. The obtained results indicated that both of the higher pot volume (8 L) and open drainage system recorded the highest vegetative and yield characteristics of cabbage. The combination among open system with pot volume (8 liters) and substrate mixture Pet moss + perlite (P: Per 1:1% *v/v*) gave the highest average of vegetative growth and yield per plant (1961.7g). On the contrary the economic efficiency had a different orientation, sand + Vermicompost (S: V 4:1 *v/v*) with pot volume 8 L with close drainage system recorded the highest profit per plant (4.2 EL). While, the highest benefit cost ratio (BCR) per plant was recorded by sand + vermicompost (S: V 4:1 *v/v*) with pot volume 6 L with close drainage system (2.14). The study offer applicable guide for enhancing the food security of leafy vegetables in soilless culture technique, while provide the need to enhance the management of close drainage system that saving the water and fertilizers uses to improving the productivity. Moreover, the economic factors promoted the use of close drainage with both pot vol. 6 and 8 L combined with (S: V 4:1% *v/v*).

Key words: Soilless Culture, substrate culture, drainage system, pot volume, economic consideration and cabbage

INTRODUCTION

One of the largest challenges of this century will be maintaining supplies of freshwater fit for human use Simonovic 2002. This perceived challenge is largely associated with projected global population growth estimates and subsequent increase in food demand. Currently, 70% of freshwater usage is attributable to agricultural practices Wallace 2000; Despommier 2010. Considering that the agricultural activity is the world's leader in freshwater consumption, it follow that decreasing the water used by this activity will have the greatest impact Wallace 2000. Therefore, to prepare for the challenges associated with water scarcity, it is imperative that we develop and implement technologies and processes that maximize agricultural outputs while minimizing inputs.

.Grillas *et al*., 2001 reported that soilless culture systems guarantee flexibility, intensification and provide high crop yield and high quality products, even in areas with adverse growing conditions. Furthermore, Burrage, 1992 reported that, soilless cultivation represented a breakthrough and permitting to achieve high yields and a very standardized production. Abul-Soud *et al*., 2014 and Gruda 2009 mentioned that soilless culture systems, the most intensive production method, are based on environmentally friendly technology, which can result in higher yields, even in areas with adverse growing conditions (shortage of available agricultural soil and water).

Substrate culture is the cultivation of crops in any media except soil. Under such a system, plant roots develop in a solid medium. The obvious advantage for using substrate culture unlike many forms of water culture is that there is no problem in supporting the plants above the solution FAO, 1990. The difficulty and cost of controlling soil born pests and diseases, soil salinity, lack of fertile soil and water shortage have led to the development of many soilless substrates. Using substrate culture can be used as an alternative to methyl bromide for soil disinfection FAO, 1990. Stable and high quality production is the main advantage of soilless substrate culture, which has already been proved by many studies in various crop plants Yashuba *et al*., 1995 and Veys, 1997.

Nesmith and Duval 1998 mentioned that plants undergo many physiological and morphological changes in response to reduced rooting volume, which can affect transplant quality and performance, where root and shoot growth, biomass accumulation and partitioning, photosynthesis, leaf chlorophyll content, plant water relations, nutrient uptake, respiration, flowering, and yield all are affected by root restriction and container size. Also, Neveen Metwally, 2016 mentioned that increased containers size from 2.5 liters to 5 liters increased plant height, number of leaves, aerial parts fresh and dry weights of hot pepper plants. Abul-Soud, 2015 found that, using pot volume 8 Liters recorded the higher vegetative, yield characteristics and N, P and K contents results of lettuce, celery, salad and red cabbage compared to pot volume 6.

Abul-Soud, 2015 and Ahmed *et al.,* 2017 investigated that the use of vermicompost as a substrate amendment instead of peat moss and also the implement sand as local cheap substrate in producing leafy vegetables. Substrate culture systems can be classified into open and closed systems depending on whether the drained nutrient solution is discarded or recalculated. Due to them economy in water and nutrients and the low probability of environmental pollution by NO,-N in the drainage of the substrates, there has been a transition from the open to the closed system Vernooij 1992.

Many studies were investigated the use of substrate culture in producing leafy vegetables under Egyptian conditions such as lettuce, celery, salad and red cabbage Abul-Soud, 2015, Celery and Red Cabbage Ahmed, *et al*., 2017, and white cabbage Abdrabbo *et al*., 2015,. While these studies didn't concern on the comparison between the open and close drainage system that take in consider under this study. The aim of this research was study the effect of different drainage systems and pot volumes in different substrate mixtures on vegetative growth and yield of cabbage and the Economic benefits considerations of the different treatments.

MATERIALS AND METHODS

The experiment was conducted in the experimental station at the Central Laboratory for Agricultural Climate (CLAC), Agricultural Research Center (ARC), Egypt, during the winter seasons of 2015/2016 and 2016/2017 under unheated double span net house (18 x 60 x 4.5m).

The vermicomposting process:

The Epigiec earthworms *Lumbriscus Rubellus* (Red Worm), *Eisenia Fetida* (Tiger Worm), *Perionyx Excavatus* (Indian Blue) and *Eudrilus Eugeniae* (African Night Crawler) were used. Container (bed) system of vermicomposting was used in this investigation for producing the vermicompost. The vermicomposting process and vermicompost production were done according to Abul-Soud *et al.,* 2009, 2014, 2015. Mixing the different raw materials: cattle manure (C. M) + vegetable and fruit wastes (V. F. W) + shredded paper (Sh. P) in the rate of 2: 2: 1 (v/v) respectively was done by using turning machine for 3 days before vermicomposting process. The composition of the different organic wastes presented in Table (1). The physical and chemical properties of vermicompost were illustrated in Table (2).

Table (1): The chemical composition (%) of the different agricultural wastes.

Raw material	C/N ratio	Macro elements %				
		N	P	k	Ca	Mg
C. M	22.0	1.83	0.56	1.38	1.13	1.06
V. F. W	62.6	0.34	0.19	0.64	0.81	0.43
Sh. P	166.8	0.016	0.01	0.00	0.20	0.01
The mix	67.26	0.90	0.31	0.73	0.81	0.59

Table 2: The physical and chemical properties of vermicompost.

Analysis	UNITS		Analysis	UNITS	
B.D	Kg/m^3	715	P	%	1.27
O. M	%	33.22	K	%	0.59
C/N ratio	%	1:12.27	Fe	ppm	802
pH		8.17	Mn	ppm	143
EC	dS/m	6.67	Zn	ppm	37.0
N	%	1.57	Cu	ppm	14.0
N-NH4	ppm	65	Pb	ppm	9.0
N-NO3	ppm	81	Cd	ppm	n.d.

Plant:

Cabbage (*Brassica oleraceae var.capitata, cv*. Gazella F1) seeds were sown on first week of September in both cultivated seasons 2015/2016 and 2016/2017 in polystyrene trays. After four weeks from sowing, cabbage seedlings were transplanted different black plastic pots (volume and substrate type). One seedlings transplanted in each pot. The pots arranged in two rows per bed. The final plant spacing was 30 cm in the row, 40 cm between the rows, and 90 cm in between the double rows.

System materials:

Sand was primarily washed with diluted nitric acid to get rid from the undesirable salts, then with running tap water to wash nitric acid compounds from the sand. After sand was getting dry, it mixed with peat moss and/or vermicompost in different proportion depending on the different treatments under the investigation. Plastic pots volumes 8 and 6 L were filled by different sand substrate mixes and placed in open and close drainage system. The pots arranged in beds constructed from bricks to create the dimensions (8 x 0.8 x 0.3 m) filled by gravels and mulched with black polyethylene plastic sheets (0.5 ml thickness) for collecting the drainage in both drainage systems.

Nutrient solution pumped via submersible pump (40 watt). Water tanks 120 L were used in open system of substrate pots culture. The nutrient solution used in the experiment was adapted from Cooper, (1979) depending on the analysis of the local water by El-Behairy, (1994). Plants were irrigated by using drippers of 4 l/hr capacity. The fertigation was programmed to work 5 times / day and the duration of irrigation time depended on the season. The EC of the nutrient solution was adjusted by using EC meter to the required level (2mmhos^{-1}). The chemical composition of chemical nutrient solution was illustrated in Table (3).

Table (3): The chemical composition of chemical nutrient solutions

Chemical nutrient solution	Macro nutrients (ppm)					Micro nutrients (ppm)					
	N	P	K	Ca	Mg	Fe	Mn	Cu	Zn	B	Mo
	200	70	300	190	50	5.0	1.0	0.039	0.044	0.17	0.1

The study treatments:

Two drainage systems combined with two pot volume and fife different substrate mixed to present 20 treatments as follow:

Drainage system:

Two type of drainage system have been used in this study as follow:

1. Open system
2. Close system

Pot volume (P.Vol.)

1. Pot Vol. (6 L)
2. Pot Vol. (8 L)

Substrate culture:

Five substrate mixtures as follow:

1. Sand + Pet moss (S: P 1:1 *v/v*)
2. Sand + Vermicompost (S: V 4:1% *v/v*)
3. Sand + Pet moss + Vermicompost (S : P: V 2:2:1% *v/v*)
4. Sand + Pet moss (S : p 2:1 % *v/v*)
5. Pet moss + perlite (P : Per 1:1% *v/v*) as control

The experimental design was a split split plot design with three replicates. The main plots, subplots and sub-subplots were assigned to drainage system, Pot volume and substrates mixes, respectively. Each plot consisted of 12 plants.

The measurements

The physical and chemical properties of Substrate mixtures

Physical properties i.e. bulk density (**B.D**), total pore space (**T.P.S**), water hold capacity % (**W.H.C**) and air porosity % (**A.P**) for substrate mixtures were estimated according to **Wilson, 1983 and Raul, 1996**.

The pH of the potting mixtures were determined using a double distilled water suspension of each potting mixture in the ratio of 1:10 (*w: v*) **Inbar *et al.*, 1993** that had been agitated mechanically for 2 h and filtered through filter paper no.1. The same solution was measured for electrical conductivity (EC) with a conductance meter that had been standardized with 0.01 and 0.1M KCl were illustrated in Table (4).

Table (4): The physical and chemical properties of different substrates.

Substrate	Physical				Chemical	
	B.D Kg/L	T.P.S %	W.H.C %	A.P %	PH (1:10)	EC dsm^{-1}
S : P (1:1 *v/v*)	0.89	60.1	43.2	16.9	6.9	0.35
S: V (4:1 *v/v*)	1.44	35.6	27.5	8.1	7.7	1.8
S:P: V (4:4:2 *v/v*)	0.91	58.6	51.5	7.1	7.4	0.79
S : P (2:1 *v/v*)	1.14	59.4	47.6	12	7.15	0.57
P : Per (1:1 *v/v*)	0.41	69.50	55.0	14.5	7.9	2.38

Bulk density (B.D), Total poor space (T.P.S), Water holding capacity (W.H.C), Air porosity (A.P)

The vegetative growth and yield parameter:

Samples of three plants of each experimental plot were taken to determine growth and yield measurements at the end of seasons as follows: Total fresh weight for plant (g) head fresh weight (g) (After removing the outer leaves), head dry weight (g) were determined after oven-drying the samples at 70 ºC for 48 hours, head volume (cm3), stem diameter and total chlorophyll content reading was measured using Minolta chlorophyll meter Spad-502 .

The Chemical analysis:

For mineral analysis of plant (N, P and K,) were estimated in Central Laboratory for Agricultural Climate (CLAC) , Three plant samples of each plot were dried at 70o C in an air forced oven for 48 h. Dried plants were digested in H_2SO_4 according to the method described by Allen (1974) and N, P and K contents were estimated in the acid digested solution by colorimetric method (ammonium molybdate) using spectrophotometer and flame photometer Chapman and Pratt, (1961). Total nitrogen was determined by Kjeldahl method according to the procedure described by FAO (1980). Phosphorus content was determined using spectrophotometer according to Watanabe and Olsen (1965). Potassium content was determined photo-metrically using Flame photometer as described by Chapman and Pratt (1961).

The economic study

Total cost per plant determined by the Investment costs (substrate (calculated in 3 years) + plastic pot (calculated in 3years)) + Production costs (seedling + nutrient solution + water + electric + labor).

The net Profit determined by the yield market price per plant (depending on the physical quality) – Total cost per plant

The benefit cost ratio (BCR) determined by the yield market price per plant (depending on the physical quality) / Total cost per plant

Data analysis

Data were statistically analyzed using the analysis of variance method one way ANOVA with SAS package software version 6 SAS Institute, 1990. Tukey test was used to compare the significant differences among means of the treatments at 0.05 level of probability

RESULTS

The effect of drainge system, pot volume and substate type and their interaction on vegetative growth and yield characteristics of cabbage

Data in Tables (5 and 6) illustrated the effect of different drainage system, pots volume and different substrate mixture on vegetative growth and yield characteristics "total fresh weight per plant, head fresh weight and dry weight head volume, stem diameter and total chlorophyll content reading ". The results were as follow.

Concerning the drainage system, data showed that using open drainage system gave higher vegetative growth and yield characteristics compared to close drainage system. However, used pot volume (8 L) produced higher vegetative growth and yield characteristics compared to pot volume (6 L). Concerning the substrate mixtures, total fresh weight per plant, head fresh weight, head volume and stem diameter gave the highest values with substrate mixed S: P (2: 1% *v/v*) while, the higher dry weight was recorded in plant grown in substrate mixed P: Per (1: 1% *v/v*) on the other hand, substrate mixed S: P: V (2:2:1% *v/v*) recorded the heights total chlorophyll content reading. On the contrary, the lowest vegetative growth and yield characteristics were presented by substrate mixed" S: P (1:1% *v/v*) and S: V (4:1% *v/v*)" except chlorophyll reading was gave the lowest value with P: Per (1: 1% *v/v*)

Referring to the interactions between drainage system and pots volume, open drainage system with pot volume (8 L) gave the highest values of vegetative growth and yield characteristics. The lowest values were estimated by close drainage system with pot volume (6 L).

Regarding to the interactions between drainage system and substrate mixture, cabbage plants grown in open drainage system combined with substrate mixed S: P (2: 1% *v/v*) was obtained in total fresh weight per plant, head fresh weight, head volume and stem diameter whereas open drainage system with P: Per (1:1% *v/v*) gave the highest dry weight and the highest total chlorophyll content reading was recorded in open drainage system combined with substrate mixed S:P:V (2:2:1% *v/v*). On the contrary, all vegetative growth and yield characteristics recorded the lowest values with the combination of close drainage system and substrate S: V (4:1% *v/v*) except total chlorophyll content reading which recorded the lowest value in close drainage system with substrate mixed S:P (1:1% *v/v*).

As for the interaction between pots volume and substrate mixture, applied pot volume (8L) combined with substrate mixed S: P (2: 1% *v/v*) produced highest values of all vegetative growth and yield characteristics. On the other hand, applied pot volume (6 L) with S: V (4:1% *v/v*) gave the lowest values all vegetative growth and yield characteristics except head volume and total chlorophyll content reading which recorded the lowest values with application pot volume (6L) with S:P (1:1% *v/v*).

Respecting the interaction among drainage system, pots volume and substrate mixture, the combination among open drainage system, pot volume (8 L) and P: Per (1:1% *v/v*) recorded the highest values of all vegetative growth and yield characteristics but the highest total chlorophyll content reading was estimated by open drainage system, pot volume (8 L) and S: P: V (2:2:1% *v/v*). On the contrary, the lowest vegetative growth and yield characteristics were recorded by close drainage system, pot volume (6 L) and S: V (4:1% *v/v*) but the lowest value of total chlorophyll content reading was recorded by close drainage system, pot volume (6 L) and S:P (1:1% *v/v*) .

Table (5): Effect of different drainage system, pots volume and substrate mixture on total fresh weight per plant, head fresh weight and dry weight.

Treatments		First season			Second season		
		T.F. weight	H.F. weight	Dry weight	T.F. weight	H.F. weight	Dry weight
Drainage system							
Open		1573.9 A	1042.3 A	89.1 A	1689.2 A	1135.3 A	95.8 A
Close		1280.5 B	823.9 B	71.3 B	1347.9 B	858.7 B	74.5 B
Pots volume							
Pot Vol. 6 L		1358.01 B	889.2 B	77.9 B	1434.8 B	949.2 B	81.7 B
Pot Vol. 8 L		1496.4 A	977.0 A	82.5 A	1602.2 A	1044.9 A	88.7 A
Substrate mixture							
S: P (1:1)		1300.8 C	840.3 C	71.3 C	1376.0 C	887.1 C	74.9 D
S: V (4:1)		1306.6 C	834.7 C	74.1 B	1382.0 C	872.7 C	77.2 C
S: P: V (2:2:1)		1477.3 B	986.0 B	84.0 A	1584.3 B	1057.7 B	89.7 B
S: P (2:1)		1561.4 A	1032.4 A	85.7 A	1661.5 A	1124.6 A	92.4 A
P: Per (1:1)		1490.0 B	972.1 B	85.8 A	1588.9 B	1042.8 B	91.7 A
Drainage system * Pots volume							
Open	Pot Vol. 6 L	1460.4 b	965.7 b	84.7 b	1543.5 b	1051.5 b	89.1 b
	Pot Vol. 8 L	1687.4 a	1118.9 a	93.5 a	1834.8 a	1219.1 a	102.5 a
Close	Pot Vol. 6 L	1255.6 d	812.6 d	71.2 c	1326.2 d	846.8 d	74.3 c
	Pot Vol. 8 L	1305.4 c	835.1 c	71.4 c	1369.6 c	870.6 c	74.8 c
Drainage system * Substrate mixture							
Open	S: P (1:1)	1305.9 d	848.8 e	71.1 d	1386.0 d	913.8 e	73.7 e
	S: V (4:1)	1475.6 b	961.6 c	83.1 b	1568.1 b	1024.6 c	89.2 b
	S: P: V (2:2:1)	1683.8 a	1128.8 b	96.5 a	1821.8 a	1232.9 b	105.6 a
	S: P (2:1)	1707.3 a	1152.5 a	97.3 a	1832.0 a	1268.9 a	105.3 a
	P: Per (1:1)	1697.0 a	1120.0 b	97.4 a	1838.0 a	1236.5 ab	105.2 a
Close	S: P (1:1)	1295.8 de	831.8 ef	71.6 cd	1365.9 e	860.5 f	76.2 d
	S: V (4:1)	1137.5 f	707.9 g	65.1 e	1195.9 g	720.9 g	65.2 f
	S: P: V (2:2:1)	1270.8 e	843.2 ef	71.4 d	1346.8 ef	882.5 ef	73.8 e
	S: P (2:1)	1415.5 c	912.3 d	74.1 cd	1491.1 c	980.4 d	79.5 c
	P: Per (1:1)	1282.9 de	824.2 f	74.3 c	1339.9 f	849.2 f	78.1 c

Cont

			Pots volume * Substrate mixture					
	Pot Vol. 6 L	S: P (1:1)	1285.0 f	823.6 e	70.9 e	1355.8 f	861.4 d	71.9 h
		S: V (4:1)	1216.2 g	783.2 f	70.4 e	1292.2 g	834.4 d	73.7 g
		S: P: V (2:2:1)	1472.3 b	990.8 b	84.8 b	1565.2 c	1070.3 b	89.1 bc
		S: P (2:1)	1473.0 b	984.9 b	82.8 bc	1547.3 c	1064.0 b	88.2 c
		P: Per (1:1)	1343.5 d	863.2 d	80.7 c	1413.7 e	915.7 c	85.5 d
	Pot Vol. 8 L	S: P (1:1)	1316.6 e	857.0 d	71.8 e	1396.1 e	912.9 c	77.9 f
		S: V (4:1)	1396.9 c	886.2 c	77.8 d	1471.8 d	911.1 c	80.7 e
		S: P: V (2:2:1)	1482.3 b	981.1 b	83.2 bc	1603.3 b	1045.1 b	90.3 b
		S: P (2:1)	1649.7 a	1079.9 a	88.6 a	1775.8 a	1185.2 a	96.6 a
		P: Per (1:1)	1636.4 a	1080.9 a	91.0 a	1764.1 a	1170.0 a	97.8 a
			Drainage system * Pots volume * Substrate mixture					
Open	Pot Vol. 6 L	S: P (1:1)	1270.2 ij	803.1 ij	66.8 g	1330.4 k	861.8 g	64.9 o
		S: V (4:1)	1386.7 g	921.5 g	78.7 e	1476.8 g	986.4 e	87.2 h
		S: P: V (2:2:1)	1591.3 cd	1069.2 d	94.3 c	1680.6 cd	1163.1 c	98.0 e
		S: P (2:1)	1621.5 c	1099.4 c	96.0 bc	1695 .4 c	1206.7 c	102.1 d
		P: Per (1:1)	1432.3 f	935.1 fg	87.5 d	1534.4 f	1039.7 d	93.4 f
	Pot Vol. 8 L	S: P (1:1)	1341.6 h	894.4 gh	75.3 ef	1441.6 h	965.7 ef	82.5 l
		S: V (4:1)	1564.6 d	1001.6 e	87.5 d	1659.4 d	1062.7 d	91.2 g
		S: P: V (2:2:1)	1776.3 b	1188.3 b	98.7 b	1962.9 b	1302.8 b	113.3 b
		S: P (2:1)	1793.0 b	1205.5 b	98.7 b	1968.5 b	1331.1 b	108.6 c
		P: Per (1:1)	1961.7 a	1304.9 a	107.3 a	2141.6 a	1433.3 a	117.1 a
Close	Pot Vol. 6 L	S: P (1:1)	1299.9 i	844.1 hi	75.0 ef	1381.2 i	861.1 g	79.0 jk
		S: V (4:1)	1045.7 l	645.0 k	62.2 h	1107.6 n	682.3 i	60.3 b
		S: P: V (2:2:1)	1353.3 gh	912.4 g	75.2 ef	1449.8 gh	977.6 e	80.2 j
		S: P (2:1)	1324.6 hi	870.3 h	69.7 g	1399.2 i	921.3 f	74.4 l
		P: Per (1:1)	1254.7 j	791.4 ij	73.8 f	1293.1 l	791.7 h	77.6 k
	Pot Vol. 8 L	S: P (1:1)	1291.6 i	819.6 i	68.2 g	1350.6 j	860.0 g	73.3 l
		S: V (4:1)	1229.2 j	770.8 j	68.0 g	1284.2 l	759.5 h	70.1 m
		S: P: V (2:2:1)	1188.4 k	774.0 j	67.7 g	1243.7 m	787.3 h	67.3 n
		S: P (2:1)	1506.4 e	954.3 f	78.5e	1583.0 e	1039.4 d	84.6 i
		P: Per (1:1)	1311.1 hi	856.9 h	74.7 f	1386.7 i	906.7 fg	78.6 jk

Total fresh weight per plant (**T.F. weight**), head fresh weight (**H.F. weight**), total chlorophyll **(T. Chlorophyll),** Sand 50% + Pet moss 50% (**S: P (1:1)**), Sand 80% + Vermicompost 20% **(S: V (4:1)),** Sand 66.66%+ Pet moss 33.33% (S: **P (2:1)**), Pet moss 50%+ perlite50% (P**: Per (1:1)**), Sand 40% + Pet moss40% + Vermicompost 20% (**S: P: V (2:2:1)**)

Table (6): Effect of different drainage system, pots volume and substrate mixture on head volume (cm^3), stem diameter (cm) and total chlorophyll .

Treatments		First season			Second season		
		Head Volume	Stem diameter	T. Chlorophyll	Head volume	Stem diameter	T. Chlorophyll
Drainage system							
Open		1183.5 A	3.3 A	65.6 A	1289.4 A	3.6 A	68.6 A
Close		874.4 B	3.0 B	61.4 B	923.4 B	3.1 B	64.3 B
Pots volume							
Pot Vol. 6 L		983.1 B	3.1 B	62.7 B	1046.9 B	3.3 B	65.8 B
Pot Vol. 8 L		1074.8 A	3.3 A	64.3 A	1165.8 A	3.5 A	67.2 A
Substrate mixture							
S: P (1:1)		884.2 E	3.1 C	60.9 D	933.6 E	3.2 C	63.2 C
S: V (4:1)		911.3 D	3.0 C	63.4 B	962.1 D	3.2 C	66.4 B
S: P: V (2:2:1)		1104.2 B	3.2 B	65.5 A	1198.2 B	3.5 B	68.6 A
S: P (2:1)		1183.4 A	3.4 A	65.2 A	1289.6 A	3.6 A	68.4 A
P: Per (1:1)		1061.6 C	3.2 B	62.3 C	1148.3 C	3.5 B	65.8 B
Drainage system * Pots volume							
Open	Pot Vol. 6 L	1095.2 b	3.2 b	64.5 b	1192.9 b	3.6 b	67.7 b
	Pot Vol. 8 L	1271.8 a	3.4 a	66.6 a	1385.8 a	3.7 a	69.5 a
Close	Pot Vol. 6 L	871.0 c	3.0 d	60.8 d	900.9 b	3.1 d	63.8 c
	Pot Vol. 8 L	877.8 c	3.1 c	61.9 c	945.9 c	3.2 c	64.9 c
Drainage system * Substrate mixture							
Open	S: P (1:1)	897.8 e	3.1 d	65.2 c	966.7 e	3.2 ef	67.6 c
	S: V (4:1)	1084.4 c	3.3 c	66.3 cd	1155.5 c	3.6 c	69.3 bc
	S: P: V (2:2:1)	1330.2 a	3.4 b	70.5 a	1452.8 a	3.8 ab	73.4 a
	S: P (2:1)	1339.4 a	3.6 a	66.7 b	1474.7 a	3.8 a	70.0 b
	P: Per (1:1)	1265.5 b	3.4 ab	59.2 d	1397.1 b	3.8 b	62.6 d
Close	S: P (1:1)	870.6 fg	3.1 d	56.6 e	900.6 f	3.2 ef	58.8 e
	S: V (4:1)	738.2 h	2.8 e	60.5 d	768.7 g	2.7 g	63.5 d
	S: P: V (2:2:1)	878.3 f	3.0 d	60.5 d	943.7 e	3.1 f	63.8 d
	S: P (2:1)	1027.4 d	3.2 cd	63.8 c	1104.4 d	3.4 d	66.7 c
	P: Per (1:1)	857.8 g	3.0 d	65.5 bc	899.5 f	3.2 e	68.9 bc
Pots volume * Substrate mixture							
Pot Vol. 6 L	S: P (1:1)	854.6 g	3.1 c	60.8 d	893.5 g	3.1 e	63.8 cd
	S: V (4:1)	870.7 g	2.9 d	63.9 c	893.7 g	3.0 f	67.3 bc
	S: P: V (2:2:1)	1139.6 c	3.2 bc	64.9 bc	1231.3 c	3.6 b	68.1 b
	S: P (2:1)	1122.4 c	3.3 b	62.7 cd	1213.3 c	3.6 b	65.0 c
	P: Per (1:1)	928.3 f	3.1 c	61.1 d	1002.7 ef	3.3 c	64.6 cd
Pot Vol. 8 L	S: P (1:1)	913.8 f	3.1 c	60.9 d	973.8 f	3.2 d	62.6 d
	S: V (4:1)	951.9 e	3.1 c	63.0 c	1030.5 e	3.4 c	65.5 c
	S: P: V (2:2:1)	1068.9 d	3.2 bc	66.1 b	1165.1 d	3.3 c	69.2 b
	S: P (2:1)	1244.4 a	3.5 a	67.8 a	1365.8 a	3.7 a	71.8 a
	P: Per (1:1)	1195.0 b	3.4 ab	63.6 c	1294.0 b	3.7 a	67.0 bc

Cont

			Drainage system *			**Pots volume*** **Substrate mixture**		
Open	Pot Vol. 6 L	S: P (1:1)	819.1 n	3.0 d	63.7 cd	879.0 g	3.1 g	66.1 bc
		S: V (4:1)	1034.0 h	3.2 cd	67.1 bc	1106.9 e	3.6 g	70.5 ab
		S: P: V (2:2:1)	1266.0 d	3.3 bc	69.8 a	1377.0 c	3.8 bc	73.3 a
		S: P (2:1)	1294.5 c	3.4 b	65.6 c	1420.8 c	3.8 bc	68.4 b
		P: Per (1:1)	1062.1 g	3.2 c	56.3 f	1181.0 d	3.6 de	60.3 d
	Pot Vol. 8 L	S: P (1:1)	976.5 i	3.2 cd	66.7 bc	1054.4 ef	3.3 g	69.1 b
		S: V (4:1)	1134.8 e	3.3 bc	65.5 c	1204.1 d	3.7 c	68.1 bc
		S: P: V (2:2:1)	1394.3 b	3.4 b	71.1 a	1528.6 b	3.8 b	73.6 a
		S: P (2:1)	1384.3 b	3.7 a	67.7 bc	1528.7 b	3.9 ab	71.7 ab
		P: Per (1:1)	1468.9 a	3.7 a	62.1 d	1613.2 a	4.0 a	65.0 c
Close	Pot Vol. 6 L	S: P (1:1)	890.0 l	3.1 cd	57.9 e	908.0 g	3.2 f	61.4 d
		S: V (4:1)	707.4 o	2.6 e	60.6 de	680.5 i	2.4 i	64.2 cd
		S: P: V (2:2:1)	1013.2 h	3.2 cd	59.9 e	1085.7 e	3.4 ef	62.8 cd
		S: P (2:1)	950.2 j	3.1 cd	59.8 e	1005.9 f	3.3 f	61.6 d
		P: Per (1:1)	794.4 no	3.0 d	65.8 c	824.3 h	3.1 g	68.9 b
	Pot Vol. 8 L	S: P (1:1)	851.1 m	3.1 cd	55.2 f	893.1 g	3.2 fg	56.1 e
		S: V (4:1)	769.0 op	3.0 d	60.4 de	857.0 gh	3.1 g	62.9 cd
		S: P: V (2:2:1)	743.4 p	2.9 d	61.1 de	801.7 h	2.9 h	64.7 cd
		S: P (2:1)	1104.5 f	3.3 bc	67.8 b	1202.9 d	3.5 e	71.9 ab
		P: Per (1:1)	921.2 k	3.1 cd	65.1 c	974.8 f	3.4 ef	68.9 b

Total fresh weight per plant (**T.F. weight**), head fresh weight (**H.F. weight**), total chlorophyll **(T. Chlorophyll),** Sand 50% + Pet moss 50% (**S: P (1:1)**), Sand 80% + Vermicompost 20% **(S: V (4:1)),** Sand 66.66%+ Pet moss 33.33% (S**: P (2:1)**), Pet moss 50%+ perlite50% (P**: Per (1:1)**), Sand 40% + Pet moss40% + Vermicompost 20% (**S: P: V (2:2:1)**)

The effect of drainge system, pot volume and substate type and their interaction on N, P and K (%) contents of cabbage.

Data in Table (7) illustrate the effect of different drainage system, pots volume and different substrate mixture on nitrogen, phosphorus and potassium content (%). The results were as the follow.

Plants growing in open drainage system recorded the highest values of nitrogen and potassium content but there was no significant different between open and close drainage systems in phosphorus content. On the other hand, pot volume (6 L) gave the highest values of nitrogen, phosphorus and potassium content compared to pot volume (8 L). In addition, substrate mixed S: P: V (2:2:1% *v/v*) recorded the highest nitrogen and potassium content but substrate mixed S: V (4:1% *v/v*) gave the highest phosphorus content on the contrary, the lowest value of nitrogen and potassium were recorded with S: P (1:1% *v/v*) while, the lowest phosphorus was estimated by S: P (2:1% *v/v*).

Regarding to the interactions between drainage system and pots volume, open drainage system combined with pot volume (6 L) gave the highest nitrogen and phosphorus content while the application close drainage system recorded the highest potassium content. On the other hand, the lowest values of nitrogen, phosphorus and potassium were recorded by close drainage system with pot volume (8 L).

Concerning to the interactions between drainage system and substrate mixture, the highest nitrogen and potassium were recorded with plants were growing in combination between open drainage system and S: P: V (2:2:1% *v/v*) and the highest phosphorus content was recorded in open drainage system with S: V (4:1% *v/v*). On the contrary, using open drainage system combined with S: P (1:1% *v/v*) gave the lowest nitrogen and potassium while using open drainage system combined with S: P (2:1% *v/v*) or P: Per (1:1% *v/v*) gave the lowest phosphorus content.

Regarding to the interactions between, pots volume and substrate mixture data showed that. Plants growing in pot volume (6L) combined with S: V (4:1% *v/v*) gave the highest phosphorus and potassium content while the highest nitrogen content was recorded in pot volume (6 L) with S:P:V (2:2:1% *v/v*). On the other hand, the lowest values of nitrogen, phosphorus and potassium were estimated by pot volume (8 L) combined with S: P (1:1% *v/v*).

As for the interaction among all treatments, drainage system, pots volume and substrate mixture data showed that. The combination among open drainage system, pot volume (6 L) and S: P: V (2:2:1% *v/v*) gave the highest nitrogen content while open drainage system, pot volume (6 L) and S: V (4:1% *v/v*) gave the highest phosphorus content on the other hand the highest potassium content was estimated by the combination among open drainage system, pot volume (8 L)and S: P: V (2:2:1% *v/v*). On the contrary, the lowest nitrogen content was recorded in the combination among close drainage system, pot volume (6 and 8 L) and S: P (1:1% *v/v*) whereas, the lowest phosphorus content was recorded by in the combination among close or open drainage system, pot volume (8 L) and all substrate mixture except the treatment close drainage system, pot volume (8 L) and S: V (4:1% *v/v*).In addition, the combination among open drainage system, pot volume (8 L) and substrate mixed S:P(1:1% *v/v*) gave the lowest potassium content.

Table (7): Effect of different drainage system, pots volume and substrate mixture on N, P and K content (%) in cabbage plant.

Treatment		First season			Second season		
		N%	P%	K%	N%	P%	K%
Drainage system							
Open		3.07 A	1.04 A	1.01 A	2.95 A	1.11 A	1.06 A
Close		2.91 B	1.04 A	0.91 B	2.68 B	1.07 A	0.94 B
Pots volume							
Pot Vol. 6 L		3.10 A	1.26 A	1.16 A	2.94 A	1.32 A	1.21 A
Pot Vol. 8 L		2.88 B	0.83 B	0.76 B	2.68 B	0.86 B	0.79 B
Substrate mixture							
S: P (1:1)		2.28 E	1.01 BC	0.78 D	2.14 E	1.06 BC	0.82 D
S: V (4:1)		3.32 B	1.15 A	0.92 C	3.12 B	1.21 A	0.95 C
S: P: V (2:2:1)		3.39 A	1.06 B	1.06 A	3.19 A	1.11 B	1.10 A
S: P (2:1)		3.10 C	0.97 C	1.05 A	2.92 C	1.02 C	1.09 A
P: Per (1:1)		2.85 D	1.02 BC	1.00 B	2.68 D	1.07 BC	1.04 B
Drainage system * Pots volume							
Open	Pot Vol. 6 L	3.19 a	1.28 a	1.15 a	3.10 a	1.37 a	1.22 a
	Pot Vol. 8 L	2.94 c	0.81 b	0.87 b	2.79 b	0.86 c	0.91 b
Close	Pot Vol. 6 L	3.00 b	1.23 a	1.16 a	2.79 b	1.28 b	1.20 a
	Pot Vol. 8 L	2.82 d	0.84 b	0.66 c	2.56 c	0.87 c	0.68 c
Drainage system * Substrate mixture							
Open	S: P (1:1)	2.46 g	1.05 bc	0.74 f	2.36 f	1.12 b	0.78 f
	S: V (4:1)	3.38 a	1.21 a	0.93 d	3.24 a	1.29 a	0.97 cd
	S: P: V (2:2:1)	3.41 a	1.05 bc	1.20 a	3.27 a	1.12 bc	1.26 a
	S: P (2:1)	3.20 b	0.96 c	1.11 b	3.07 b	1.02 c	1.16 b
	P: Per (1:1)	2.90 e	0.96 c	1.08 b	2.78 d	1.02 c	1.14 b
Close	S: P (1:1)	2.10 h	0.97 c	0.83 e	1.93 g	1.00 c	0.85 e
	S: V (4:1)	3.26 b	1.09 b	0.91 d	3.00 c	1.13 b	0.93 d
	S: P: V (2:2:1)	3.37 a	1.06 bc	0.92 d	3.10 b	1.10 bc	0.94 d
	S: P (2:1)	3.01 d	0.99 c	0.98 c	2.77 d	1.02 c	1.01 c
	P: Per (1:1)	2.81 f	1.08 bc	0.92 d	2.58 e	1.12 bc	0.95 b
Pots volume * Substrate mixture							
Pot Vol. 6 L	S: P (1:1)	2.30 g	1.26 ab	1.06 c	2.18 h	1.33 ab	1.11 c
	S: V (4:1)	3.52 b	1.35 a	1.25 a	3.35 b	1.43 a	1.30 a
	S: P: V (2:2:1)	3.62 a	1.31 ab	1.11 b	3.44 a	1.38 ab	1.16 b
	S: P (2:1)	3.13 cd	1.12 c	1.22 a	2.97 c	1.18 c	1.27 a
	P: Per (1:1)	2.93 e	1.24 b	1.15 b	2.78 f	1.30 b	1.20 b
Pot Vol. 8 L	S: P (1:1)	2.26 g	0.76 e	0.51 g	2.10 i	0.79 e	0.52 g
	S: V (4:1)	3.11 cd	0.95 d	0.58 f	2.90 de	0.99 d	0.60 f
	S: P: V (2:2:1)	3.16 c	0.80 e	1.00 d	2.94 cd	0.84 e	1.04 d
	S: P (2:1)	3.08 d	0.82 e	0.87 e	2.87 e	0.86 e	0.90 e
	P: Per (1:1)	2.78 f	0.80 e	0.86 e	2.59 g	0.83 e	0.89 e

			Drainage system * Pots volume* Substrate mixture					
Open	Pot Vol. 6 L	S: P (1:1)	2.47 k	1.37 ab	1.04 d	2.40 ij	1.46 ab	1.09 d
		S: V (4:1)	3.63 b	1.48 a	1.25 ab	3.52 b	1.58 a	1.32 ab
		S: P: V (2:2:1)	3.72 a	1.29 bc	1.10 c	3.61 a	1.38 b	1.16 c
		S: P (2:1)	3.20 e	1.10 c	1.19 b	3.10 de	1.17 c	1.25 b
		P: Per (1:1)	2.96 h	1.18 c	1.20 b	2.87 g	1.26 bc	1.26 b
	Pot Vol. 8 L	S: P (1:1)	2.44 k	0.74 e	0.45 h	2.32 j	0.78 e	0.47 h
		S: V (4:1)	3.13 ef	0.94 de	0.60 g	2.97 f	0.99 d	0.63 e
		S: P: V (2:2:1)	3.10 f	0.81 e	1.30 a	2.94 fg	0.86 de	1.35 a
		S: P (2:1)	3.20 e	0.82 e	1.02 de	3.04 ef	0.87 de	1.07 dc
		P: Per (1:1)	2.84 i	0.74 e	0.97 e	2.70 h	0.78 e	1.01 c
Close	Pot Vol. 6 L	S: P (1:1)	2.12 l	1.16 c	1.09 cd	1.97 k	1.20 c	1.12 cd
		S: V (4:1)	3.42 d	1.22 bc	1.25 ab	3.18 d	1.27 bc	1.29 b
		S: P: V (2:2:1)	3.52 c	1.33 b	1.12 c	3.27 c	1.39 b	1.16 c
		S: P (2:1)	3.05 fg	1.14 c	1.25 ab	2.84 g	1.19 c	1.29 b
		P: Per (1:1)	2.89 hi	1.29 bc	1.09 cd	2.69 h	1.35 b	1.13 cd
	Pot Vol. 8 L	S: P (1:1)	2.07 l	0.78 e	0.57 g	1.88 l	0.80 e	0.58 e
		S: V (4:1)	3.10 f	0.96 d	0.56 g	2.82 g	0.99 de	0.57 e
		S: P: V (2:2:1)	3.22 e	0.80 e	0.71 f	2.93 fg	0.82 e	0.73 d
		S: P (2:1)	2.97 gh	0.83 e	0.72 f	2.70 h	0.85 e	0.74 d
		P: Per (1:1)	2.72 j	0.86 de	0.75 f	2.48 i	0.89 de	0.77 d

Total fresh weight per plant (**T.F. weight**), head fresh weight (**H.F. weight**), total chlorophyll **(T. Chlorophyll),** Sand 50% + Pet moss 50% (**S: P (1:1)**), Sand 80% + Vermicompost 20% (**S: V (4:1)),** Sand 66.66%+ Pet moss 33.33% (S**: P (2:1)**), Pet moss 50%+ perlite50% (P**: Per (1:1)**), Sand 40% + Pet moss40% + Vermicompost 20% (**S: P: V (2:2:1)**)

The Economic study of drainge system, pot volume and substate type and their interaction in cabbage production.

Table (8) shows the economic study of cabbage production on substrate culture system under Egyptian condition during seasons of 2015 - 2016 and 2016-2017. Data showed that the total cost and total return with substrate mixed P: Per (1:1), pot volume (8 L) with open drainage systems recorded the highest total cost and total return (9.4 and 10 EL respectively) while; the lowest were recorded by the combined among S: V (4:1), pot volume (6 L) and close drainage systems (3.3 and 7 EL respectively). On the other hand, the highest net profit was recorded with the combined among S: V (4:1), pot volume (8 L) and close drainage systems (4.2 EL) and the lowest was estimated by S: P (1:1), pot volume (8 L) and open drainage system combination (-0.2 EL). In addition, S: V (4:1), pot volume (6 L) and close drainage systems gave the highest benefit cost ratio (2.14) and the lowest was recorded by S: P (1:1), pot volume (8 L) and open drainage systems (0.79).

Table (8) Effect of different drainage system, pots volume and substrate mixture on economic study per cabbage plant.

Treatments			Investment costs	Production costs	Total cost	Total yield (Kg)	Marketing price	Net Profit	Benefit cost ratio
Open systems	Pot volume (6L)	S: P (1:1)	1.9	5.9	7.8	1.3	8.0	0.2	1.03
		S: V (4:1)	1.4	5.9	7.2	1.4	8.0	0.8	1.11
		S: P: V (2:2:1)	2.0	5.9	7.8	1.6	9.0	1.2	1.15
		S: P (2:1)	1.8	5.9	7.7	1.7	9.0	1.4	1.18
		P: Per (1:1)	2.8	5.9	8.6	1.5	9.0	0.4	1.05
	Pot volume (8 L)	S: P (1:1)	2.4	5.9	8.2	1.4	8.0	-0.2	0.97
		S: V (4:1)	1.6	5.9	7.5	1.6	8.0	0.5	1.07
		S: P: V (2:2:1)	2.5	5.9	8.3	1.9	10.0	1.7	1.20
		S: P (2:1)	2.2	5.9	8.1	1.9	10.0	1.9	1.24
		P: Per (1:1)	3.5	5.9	9.4	2.1	10.0	0.6	1.07
Close systems	Pot volume (6L)	S: P (1:1)	2.1	2.2	4.2	1.3	8.0	3.8	1.88
		S: V (4:1)	1.5	1.7	3.3	1.1	7.0	3.7	2.14
		S: P: V (2:2:1)	2.1	2.3	4.4	1.4	8.0	3.6	1.81
		S: P (2:1)	2.0	2.2	4.2	1.4	8.0	3.8	1.91
		P: Per (1:1)	2.9	2.1	5.0	1.3	8.0	3.0	1.60
	Pot volume (8 L)	S: P (1:1)	2.5	2.1	4.7	1.3	8.0	3.3	1.71
		S: V (4:1)	1.8	2.0	3.8	1.3	8.0	4.2	2.08
		S: P: V (2:2:1)	2.6	2.0	4.6	1.2	7.0	2.4	1.52
		S: P (2:1)	2.4	2.5	4.9	1.5	9.0	4.1	1.83
		P: Per (1:1)	3.7	2.2	5.9	1.3	8.0	2.1	1.37

Price for: 1- 1.25 Kg= **7 LE**, 1.25- 1.5 Kg = **8 LE**, 1.5- 1.75 Kg = **9 LE**. and 1.75- 2 Kg = **8 LE**

DISCUSSION

From the overall results, the use of open drainage system had significant effect on the vegetative growth parameter, yield and N, P and K contents of cabbage plants comparing with close drainage system. These results may be due to the management of close drainage system needed to improve under Egyptian condition while open drainage system needs less technical management. Open drainage system presented continuous supply of essential nutrients in constant concentration while the nutrients concentrations in the nutrient solution changed dramatically regarding to the plant prefer ability of nutrient uptake, growth stage, nutrient behavior and form, climate condition and etc… in close drainage system. These results agreement with Abd-Elmoniem *et al*. 2006 and Jones, 2005, they found that the management of nutrient solution in open system type provides maintenance of nutrient solution eliminates needed by plant and reduces the risk of infection. Also Bartosik *et al*., 1993 when compared between open and closed growing systems reported that it is possible to prevent leaching by using closed growing system, but not without disadvantages (less yield).

The substrate treatment which offered the best physical and chemical properties that led to the highest yield. Moreover, referring to the different mixtures, the results agreed with those reported by Litterick *et al*., 2004 who found that using organic compost can improve the physical, chemical an Central Laboratory for Agricultural Climate (CLAC) biological properties of growing medium. Replacement of peat with moderate amounts of vermicompost produces beneficial effects on plant growth due to the increase on the bulk density of the growing, and decrease on total porosity and amount of readily available water in the pots Bachman and Metzger, 2007; Grigatti *et al*., 2007. Such changes in the physical properties of the substrates might be responsible for the better plant growth with the lower doses of compost and vermicompost as compared to the peat-based substrate. Furthermore, plant growth is enhanced through the addition of vermicompost to a potting substrate or as a soil amendment.

Regarding to pot volume effect, the pot volume had a significant positive effect on the growth and yield of the leafy vegetables under the study while this effect was not significant on N, P and k contents of celery, lettuce, salad and red cabbage plants. The positive effect resulting from improves the root system that increases the water and nutrients uptake by increasing the pot volume Abul-Soud 2015. Increase the substrate volume per plant can greatly affect plant growth. These results were agreement with many studies; where Kemble *et al*., (1994) and Oagile *et al*., 2016 reported that bigger container size enhanced tomato seedlings growth and development with respect to plant height, leaf number and area, and shoot fresh and dry weights when compared to smaller containers. This signifies that for quality seedlings, bigger containers are the most desirable. Furthermore NeSmith and Duval 1998 mentioned that plants undergo many physiological and morphological changes in response to reduced rooting volume, which can affect transplant quality and performance, where root and shoot growth, biomass accumulation and partitioning, photosynthesis, leaf chlorophyll content, plant water relations, and yield all are affected by root restriction and container size. Also, Neveen Metwally 2016 mentioned that increased containers size from 2.5 liters to 5 liters increased plant height, number of leaves, aerial parts fresh and dry weights of hot pepper plants. On the contrary, increased pots volume lead to decreased N, P and K contents. This result may be due to increasing the vegetative growth that causes the dilution factor of higher vegetative growth for the N, P and K contents. The same results were obtained by Ahmed *et al*., 2017

Otherwise, the economic factor results reflect the agronomy study while promoted the use of close drainage with both pot vol. 6 and 8 L combined with (S: V 4:1% *v/v*) as a results of good yield, cheap substrate that led to give the highest net profit and benefit cost ratio. Similar results were found by Abul-Soud 2015 and Ahmed *et al.,* 2017 who investigated the use of local substrate such as sand and vermicompost mixtures.

CONCLUSION

To increase the efficiency of close drainage system in vegetable production, more investigation concern the management instead of open drainage system to match the adaptation and mitigation procedures of climate change impacts. The economic sound demonstrated the use of close drainage with both pot vol. 6 and 8 L combined with (S: V 4:1% *v/v*) instead of the agronomy results. More research needs to investigate substitute the chemical nutrient solution by organic nutrient solution.

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إنتاجية الكرنب فى مزراع البيئات تحت الظروف المصرية

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تهدف هذه الدراسة الى تقيم تأثير تطبيق خلطات زراعية مختلفة رمل: بيت موس (1:1) ، رمل : بيت موس (2: 1)، بيت موس: بيرلاليت (1:1)، رمل: بيت موس : مكمورة دودة الأرض (1:2:2) و رمل : مكمورة دودة الارض(1:4) و حجمين من الأصص (6و 8 لتر) و نظامين للصرف (مفتوح ومغلق) على النمو الخضرى ومحصول الكرنب و الجدوي الاقتصادية (تكاليف ثابتة ، تكاليف تشغيل ، العائد الكلى و صافى الربح) للعوامل تحت الدراسة. تم اجراء التجربة خلال موسمين متتالين من فصل الشتاء 2016/2015 و 2017/2016 تحت صوبه غير مدفأة مزدوجه الأقبية مغطأة بالشبك (18 *60 * 4.5 متر) فى المعمل المركزى للمناخ الزراعى ، مركز البحوث الزراعية'جيزة' مصر.وكان تصميم التجربة قطعة منشقة مرتين.

اوضحت النتائج ان استخدام حجم الأصص الاكبر(8 لتر) و نظام الصرف المفتوح مع خلطة بيئة بيت موس : برليت 1:1 اعطت اعلى قيم لنمو الخضرى والمحصول(2.1 كجم/ نبات) يليها الرمل : بيت موس 1:2 (1.9 كجم/ نبات) يليها رمل: بيت موس : مكمورة دودة الارض 1:2:2 (1.9 كجم/نبات). وعلى العكس من ذلك كانت الجدوة الاقتصادية فى اتجاه اخر. استخدام رمل : مكمورة دودة الارض (1:4) مع حجم الأصص 8 لتر فى نظام الصرف المغلق كان صافى العائد (2. 4 جنية مصرى) بينما معدل العائد الى التكاليف كان اعلى مع استخدام بيئة رمل : مكمورة دودة الارض (1:4) مع حجم الأصص 6 لتر فى نظام الصرف المغلق(2.14 جنية مصرى). وتقدم الدراسة دليلا قابلا للتطبيق لتعزيز الأمن الغذائى للخضر الورقية فى تقنية الزراعة بدون تربة .فى حين تعزيز الحاجة الى تحسين ادارة نظم الزراعة المغلقة لحفظ الماء والاسمدة المستخدمة.

PERFORMANCE OF SUGARCANE TRANSPORT EQUIPMENT

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Abstract

Sugarcane transport is one of the major operation required during the activities of sugarcane delivery process. Sugarcane transport equipment includes the main delivery system (decauvelle slide lines and wagons), lorries and tractor-trailers. The use of lorries as alternative system for cane to mill delivery have been increasing dramatically. The increasing role of lorries for cane to mill delivery is mainly due to the problems facing the operation of the main delivery system (decauvelle slide lines and wagons). The low rate and longer delivery time of decauvelle system is one of the major reason to use trucks. The net of slide lines on which the decauvelle move is becoming older and accidents of decauvelle wagons turn up while the train moving more frequently occurred. The loaded wagons may turn a side on the slide line and cane drop out of the wagon causing multiple problems. More cost required to reset the turn wagon on the slide line and to reload the cane, which has to be done immediately to release the line for other trains. Therefore problems such as cane delay and intensive cane losses occurred due to the accidents of wagons turn a side while moving to the mill. The current research aims to evaluate the field performance of the main transport equipment found in the sugarcane production regions in Upper Egypt to determine efficiency at most prevailing conditions. Transport cane from that temporary storage area to the mill. Lorries of variable sizes loaded by loader and transport cane from stores at variable distances from the mill. For lorry capacities ranged from 8 to 16 ton, deliver cane with rate from about 2.4 to 4.8 ton/h for store to mill distances of 10, 20 Km respectively. Transport rate decreased suddenly from 30 ton/day for the 10 ton capacity lorry to 22 ton /day for that of 11 ton capacity. For mechanical loading of lorries of given capacities and store to mill distances more than 40 Km, vehicles may complete only 2 cycles and transport a quantity of cane equivalent to double load per day.

INTRODUCTION

Sugarcane is considered the main source for sugar production in Egypt and several countries in the world. The cultivated area of sugarcane crop in Egypt reached up to 332,000 Feddans, with average production of 48.9 Mg/acre, (CCSC, 2015). Sugarcane plantations are concentrated in the area of Upper Egypt specifically in Assiut, Minia, Qena, Luxor and Aswan. Approximately third million Feddans of cane planted for sugar industry produces about 16 million Tons of cane have to be delivered to cane mills within operation season (about four months).

Delivery process activities performed according to schedules that determine the date of harvesting and the main vehicle for transport to cane mills. Small scale holdings and narrow infield roads represent the prevailing conditions in the sugarcane growing area in southern Egypt.

Sugarcane loading process includes sequence of operations represented in harvesting, infield loading, infield transport, site loading and to mill transport. Therefore, the same quantity of cane is loaded two times the first is in the field and the second takes place in the site. The main system established for cane to mill delivery is the decauvelle slide lines and wagons. Other additional systems that transport limited cane quantities are railway wagons that transport cane production of fields near to the main railway line and ships that transport cane cross Nile. Such transport systems perform single trip per day and considered the traditional cane to mill delivery systems. These wagons act as storage bins in the mill yard to secure 24 hours of mill operation. Grab loaders may be used to load cane on either decauvelle wagons or on rail way wagons. Cane mechanization companies in Aswan and Qena in addition to machinery service stations and cooperatives have been custom operate grab loaders for cane loading. Operating the loader inside fields meet several problems such as poor stability of the loader while moving across furrows, rapid wear of tires and low efficiency. Therefore loaders are only operated for cane loading to the main transport vehicles in the stores.

The South African sugar industry is of significant local and international importance and covers an area in excess of 450,000 hectares. This area yields approximately 21 million tons of sugarcane per annum which is transported almost exclusively by road, from farms to the sugar mills. The industry is under increasing economic pressures to improve its productivity and competitiveness and sugarcane transport in the sugarcane supply chain has been identified as one area where large improvements and associated cost reductions can be made. This is mainly due to the excess in number of vehicles in the inbound transport system, the high relative cost of transport compared to other production costs in producing sugarcane, and the high fixed costs associated with truck fleet operations (Giles RC., 2009).

Abdel-Mawla, 2000 summarized that the duration from the time of cane harvesting to the time of unloading inside the mill may become critical. It has been recommended to deliver cane to the mill in short time because more delay in cane delivery may mean more losses in sugar production. Cane harvesting-transport-processing system is very complex comprising an integrated chain of activities that stretch from the grower to transport and mill processing. Cane transport mostly accomplished in two stages infield transport and to mill). Elements of infield transport systems may be: a) Camels, b) Carets (pulled by donkeys) and c) Trailers pulled by tractors. Increasing field to store transport rate may facilitate increasing the part of vehicle load delivered to the mill within one day. A tractor drown trailer should be designed to replace camels and carts from infield sugarcane transport. The new trailer should be of proper size compatible with infield roads and easy to be loaded for shorter transport cycle time and for higher field to store transport rate.

There are several advantages of using small trailers to replace animal power for infield sugarcane transport. The major advantages may be represented in the ability of these trailers to move over more than 80% of the infield roads with reasonable travel speed Abdel-Mawla, 2012. Kepner *et al.*, 1980 reported that transport of sugarcane from the fields to the mills is major element of the cost of sugar production. Many different transport systems are used, such as narrow gauge railway systems, and the use of trucks in various forms and fashions. However, the use of the agricultural tractor, with trailers of various forms, is the main method of hauling cane in many sugar estates throughout the world. If we consider a typical mill, which might grind, 1.5 million tons of cane in season, perhaps lasting 200 days, then it is necessary to haul an average of 7,500 tons of cane per day. Depending upon the average haul distance, the capacity of the trailers, the number of hours worked per day, and the percentage availability, then such an estate might need 50 or more tractor-trailer combinations, of 10 ton capacity with each combination averaging 15 loads per day.

De Beer *et al.*, 1989 said that after cutting, the cane is loaded by hand, mechanical grab loaders, or continuous loaders. Cane is transported to the mills using trailers, trucks, railcars, or barges, depending upon the relative location of the cane fields and the processing plants. When the cane is cut, rapid deterioration of the cane begins by enzymic, chemical, and microbial processes. Therefore, unlike sugar beets, sugarcane cannot be stored for later processing without excessive deterioration of the sucrose content; the cane must be processed within a short time after cutting. (Eggleston *et al.*, 2001) explained that an industrial increase of their level of mechanization, lower cane quality is often observed with an increase in trash, however overall efficiency is normally improved and costs reduced. The authors conducted intensive studies on the problems of deterioration due to cane delay. The authors highlighted the problems caused by deterioration different processing stages and recommended to accelerate transport process to reduce delivery delay. Abdel-Mawla, 2010 reported that free choice of cane transport equipment and transport systems exists in the most conditions around cane production area. Limited conditions may obligate the farmer to use certain type of transport equipment. The major remarks may be concluded as follow:

Even though the score of camels as infield transport mean is low compared to that of other means, camels have to be used for may be 5 to 10 % (depend on the location) of the total cane production area because of the lack of wide road on which a carte or a trailer cane move. The farmer may decide to transport cane directly from the field to the mill. At this condition an equipped trailer pulled by a suitable tractor has to be used.

1- Gradual reduction of carts as infield transport is predicted by their lower grade compared to that of tractor trailer. Also camels have been gradually withdrawn from infield transport not only because of their lower transport rate but also because of their higher price.
2- If the cane delivery system included a loader for loading the main vehicle, slow infield transport means should not be used otherwise system elements will be incompatible.
3- Decauvelle transport system (with any infield transport mean) may represent the first choice if the slide line passes at the head of the field.
4- Common size equipped trailers pulled by tractors (with the available infield transport) may be the first choice in the general field conditions which may represent more than 70% of the total cane production area.
5- Large equipped trailers or large lorry (with flat-trailer for infield transport) may represent the first choice in case of cane fields far from the field.

Bezuidenhout, 1993 reported that in the South African sugar industry, sugarcane is usually transported from field to mill in speller vehicles. At the mill, spilling of the load is effected by chains, on to which the cane bundles are loaded in the field. The system may result in revenue loss from cane lost en route, cane remaining in the vehicle after spillage, littering penalties and cleaning costs and time lost in vehicle cleaning. Experiments were conducted in which the chains were replaced by a wide canvas blanket supported by nylon straps. Better efficiency and cost savings were achieved. The estimated cost savings are conservative, but undoubtedly the potential revenue is high. Further tests are required to ascertain whether a synthetic medium can be used to replace the well tested chains. The durability of the synthetic medium has to be established for wear and tear, and for corrosion from sugar juice. Cane spillage on freeways is a hazard to other road traffic, and often uncomplimentary comments are frequently leveled at the sugar industry in this regard. While, Donawa, 1978 studied a system for handling sugarcane in Trinidad and stated that, it is evident that each area has to develop its own Transloading and transport systems to service its mechanical harvesting developments. It is not always possible for a ready-made system to be transferred from one country to another. Certain basic principles must remain but, in the context of each country's soils, labor, weather, costs, environmental conditions and regulations, each system would be developed and become unique to that area. Although part of any system could be used in another place, it would always contain an element not seen in the original country.
(Dias *et al.*, 1994) evaluated vehicles used for road transportation of sugarcane and discussed the conditions and parameters affecting transport operation and compared the performance for efficient combinations. Transport planning and organization in the sugar industry must be based on the progress already made, so as to reach a degree of perfection that guarantees rapid and secure movement of the harvested cane at low cost. The role of alternative sugarcane delivery systems represented in lorries and tractor-trailers equipped for cane to mill transportation have been increased because of problems that face the main system (decauvelle slide lines and wagons). Cane transported from fields to stores at the main asphalt roads at which lorries of variable sizes are loaded and travel to the mill.

According to the annual reports of the "Sugar Crops Counsel" the percentage of cane delivered by lorries and tractor-trailers to all sugar mills was 11.4% at 1985/86 season increased to 25% at 96/97 season and finally to more than 38% at 2000/2001 mills operation season. Average lorry load increased from 6.6 ton at 85/86 season to more than 9 ton at 99/2000 delivery season which mean that larger lorries have been introduced for cane transport. The Sugar and Integrated Industries Company established a special unloading line for lorries and tractor trailers in all sugar mills. The sugar mills deal with lorries and tractor-trailers as the same and average load reported as general average considering neither lorries nor tractor-trailers.

MATERIALS AND METHODS

Equipment used for sugarcane transport were tested in sugarcane fields in Abo-Tesht, Naga-Hamady and Qous during 2016/2017 sugarcane delivery seasons.

Materials:

Sugarcane transport equipment used in this study:

I- The main delivery system (decauvelle slide lines and wagons).

Sugar Company uses the decauvelle in transportation, that considered the principle system for cane delivery. Fig. (1) shows decauvelle system.

Fig. (1): Decauvelle wagons loaded with sugarcane.

The specifications of decauvelle wagon are shown in Figs. (2, 3) and Table (1).

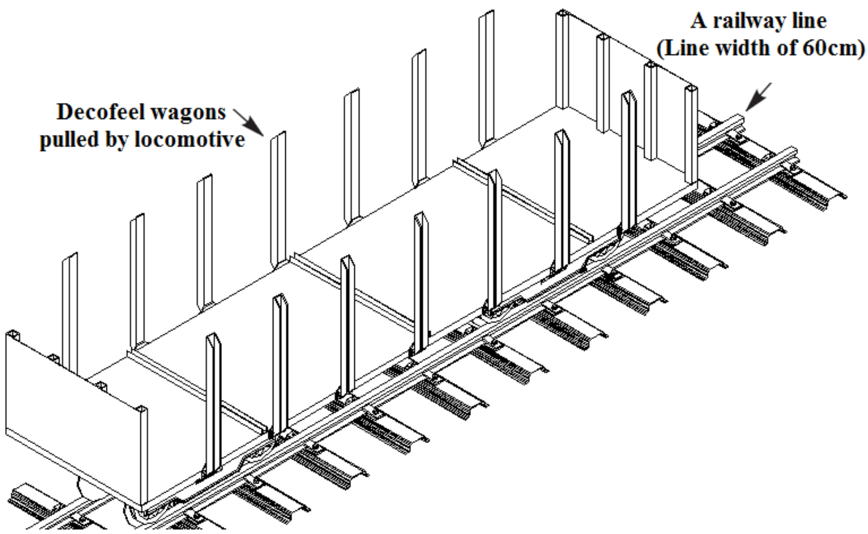

Fig. (2): Diagram of the decauvelle wagons and slide line.

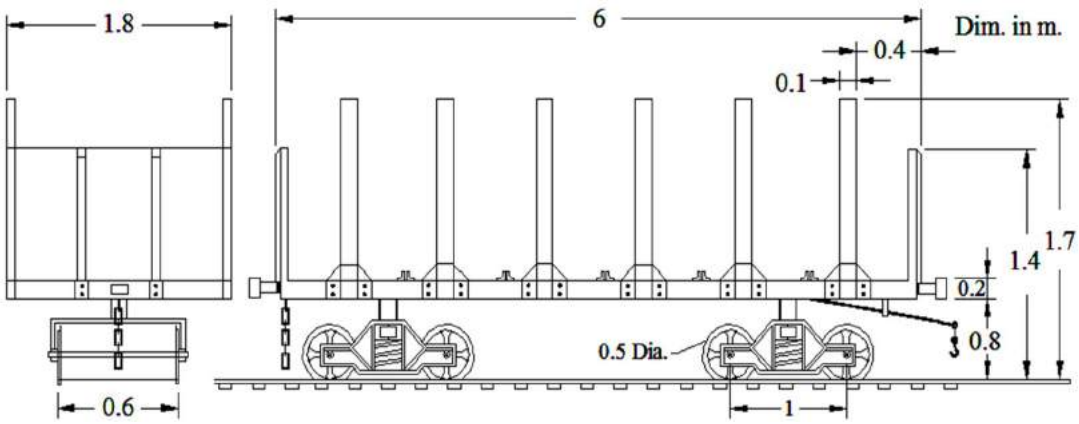

Fig. (3): Side view of the decauvelle wagon.

Table (1): The specifications of the decauvelle wagon.

Manufacture	Egypt
Length, "m"	6
Width, "m"	1.8
Height, "m"	1.2
Ground clearance, "m"	0.6
Wheels number.	8
Wheel diameter, "m"	0.5

Decauvelle wagons pulled by locomotives of 188 to 203 kW power move on a narrow railway line (60cm). Decauvelle lines were designed to have a minimum distance of 2 km between each two parallel lines. The sugar mill administration wagon distributes wagon next to field. Sugar cane loading start at 5 to 6 O'clock before sunrise. The wagon may be loaded by 3 workers (2 workers and knife man).

I- Railway wagons equipped for cane transport.

Temporary storages were established at a certain locations at the main railway lines. Railway wagons are equipped for cane transportation. The railway wagon is similar in design to the decauvelle. The size of the railway wagon is larger than that of the decauvelle wagon. The average capacity of railway wagon is 8 ton. Table (2) and Fig. (4) Show specifications and schematic drawing of the railway wagon equipped for cane transportation.

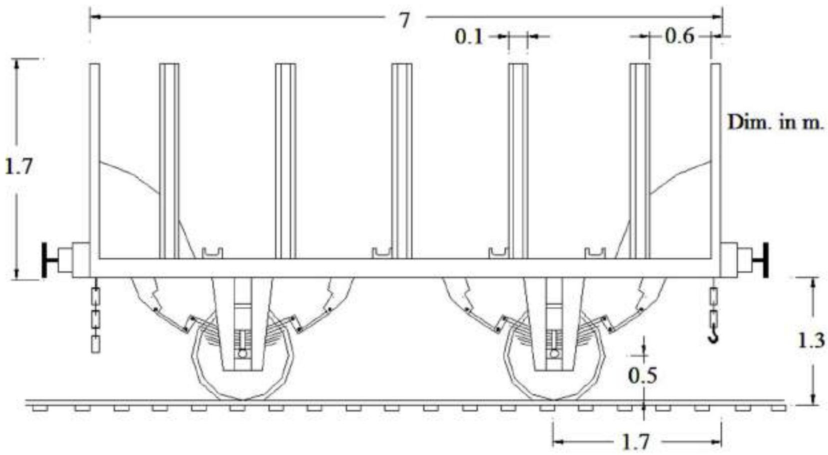

Fig. (4): Dimensions of the railway wagon.

Table (2): The specifications of the railway wagon.

Manufacture	Egypt
Length, “m”	7
Width, “m”	2.5
Height, “m”	1.7
Ground clearance, “m”	1.3
No. Axial.	2
Wheel diameter, “m”	1

II- Lorries.

The lorries were prepared for sugarcane transportation by disassemble the steel side vertical bars of steel channels were welded to both side of the lorry .The height of vertical column may be 1.5 to 2 m according to the lorry size. Table (3) shows that specifications of lorries used for sugarcane transport. Fig. (5) shows schematic drawing of some lorry types equipped for sugarcane transport used in this study.

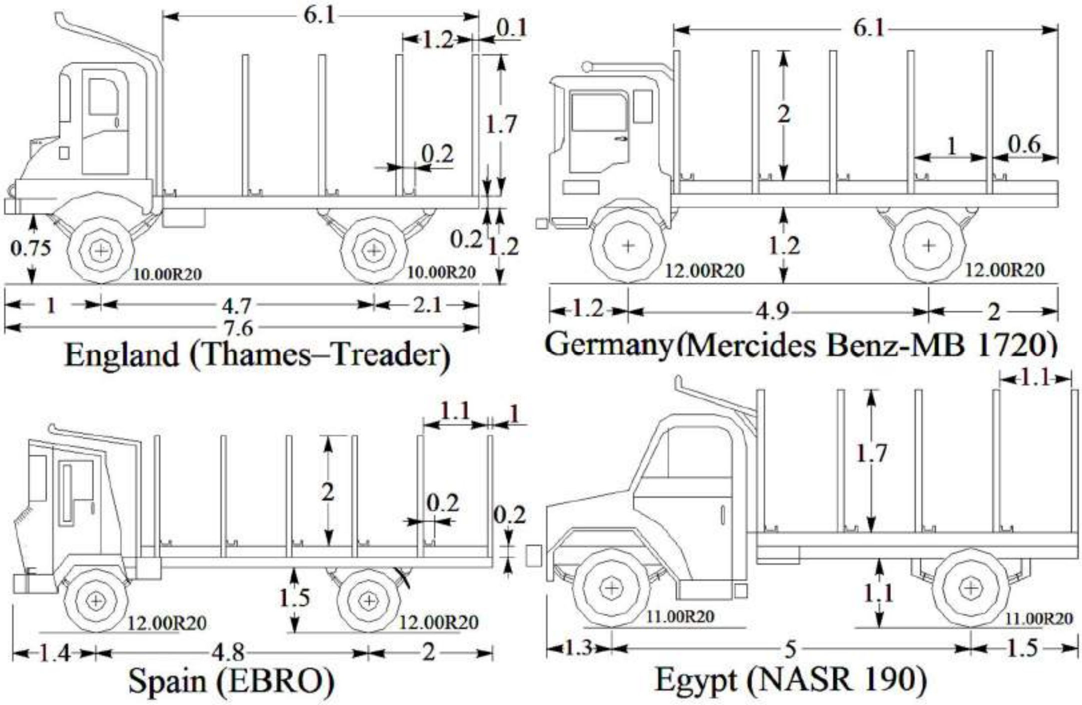

Fig. (5): Schematic drawing of some lorry types equipped for cane transport (Dim in m).

III- Trailers.

Trailers equipped for transport sugarcane from the temporary storage area to the mill. Total length of the trailer box is 6 m and total width is 2.4 m. Height of side stands is 1.5 m. Average capacity of this type of trailers from 15 to 20 ton. Trailer has 8 wheels 20 *x* 900. Trailer used to transport cane from the storage area to the mill is shown in Figs. (6 and 7).

Table (3): Specifications of the lorries according to actual measurements.

Feature	**Specification**			
Source of manufacture.	England	Germany	Spain	Egypt
Model	Thames – Treader	Mercides Benz-MB 1720	EBRO	NASR 190
Engine power “kW”	135 (6 -cylinders)	187.5 (8-cylinders)	112.5 (6-cylinders)	142.5 (6-cylinder)
Dim. “m” Overall length. Overall width. Box length. Box width. Stand	 7.8 2.4 6.1 2.5 1.7	 8.1 2.5 6.1 2.5 2.0	 8.1 2.5 6.0 2.5 2.0	 7.8 2.4 5.2 2.4 1.7
- Front tires. - Rear tires.	10.00R20 (2 wheel) 10.00R20 (4 wheel)	12.00R20 (2 wheel) 12.00R20 (4 wheel)	12.00R20 (2 wheel) 12.00R20 (4 wheel)	11.00R20 (2 wheel) 11.00R20 (4 wheel)

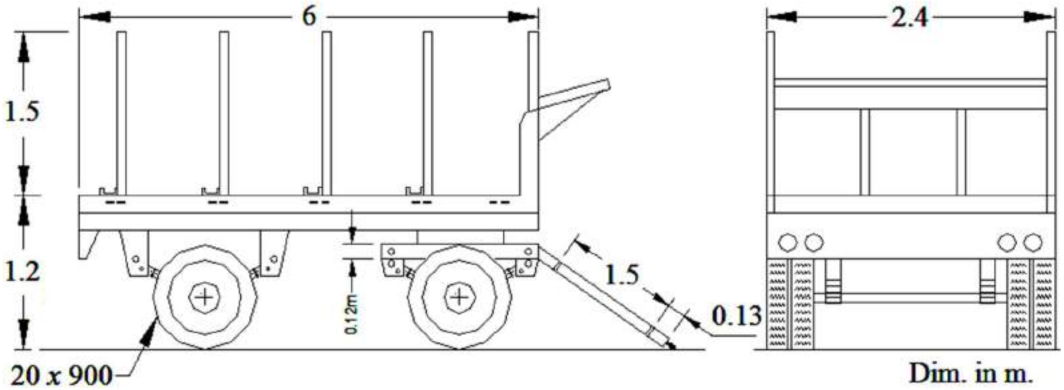

Fig. (6): Schematic drawing of trailer equipped for cane transport.


Fig. (7): Trailer ready to transport cane to mill.

Methods:

According to Abdel-Maula 2012, transport vehicle may travel more than one trip depending on the cycle time. Transport vehicle may have to wait for some time either at the store before start

$$SMT_{CT} = S_T + L_T + R_T + (\frac{2d}{v_2}) \qquad (1)$$

loading and in the mill reception before unloading. Transport cycle time may be computed as follow:

Where:

SMT_{CT} = store to mill transport cycle time, *h*

S_T = Time the vehicle wait for loading in the store, *h*

L_T = Loading time, *h*

R_T = Reception waiting time including unloading and other time, *h*.

d = Travel distance, *km*.

v_2 = Average speed of travel and return trips a vehicle (km/h)

$$D_R = \frac{V_{2L}}{SMT_{CT}} \qquad (2)$$

Delivery rate (ton/h) may then be computed as follow:

Where:

D_R = Delivery rate of the vehicle (ton)

V_{2L} = Load of cane to mill transport vehicle, *ton*

Compensating SMT_{CT} from equation 1 to equation 2, delivery rate is:

$$D_R = \frac{V_{2L}}{S_T + L_T + R_T + (2d / v_2)} \qquad (3)$$

Where:

D_R = Store to mill delivery rate, *ton/h.*

v_2 = Average travel and return speed, *km/h.*

$$SMT_R = V_{2L} \times N_3 \qquad (4)$$

Rate of cane (ton/day) transported to the mill by a vehicle is:

Where:

SMT_R = Transport rate, *ton/day*

N_3 = Number of complete transport, *cycles/day.*

RESULTS AND DISCUSSION

Cane stores at which lorries loaded are located at a main asphalt road. Farmers transport cane from fields to be loaded either manually or mechanically. Vehicle transport cane from distances up to 50 km from the mill and travel at average speed 40 Km while trailers travel up to 20 Km at average speed 10 Km for travel and return trips. Both lorry and tractor-trailers work for up to 12 hours, depend on the number of cycles/day. Trailers are of same size with an average load is about 7 tons and lorries are of variable types and sizes where load may vary from 9-16 ton. Cycle time components are store waiting time, loading time, reception waiting time and trip (travel and return) time. Waiting time in the store are in the field for loading was considered zero in case of manual loading and may be as much as 0.5 h in case of mechanical loading. Loading time may vary according to the vehicle load and average reception waiting time was estimated as 1.5 h.

1. Decauvelle and railway wagons:

Temporary storage was established at a certain locations at the main railway lines. Railway wagons are equipped for cane transportation. The wagon is similar in design to the decauvelle. An approximated cycle time (labor and mechanical loading) for decauvelle wagon used to transport cane from the storage area to the mill is shown in Figs. (8) and (9).

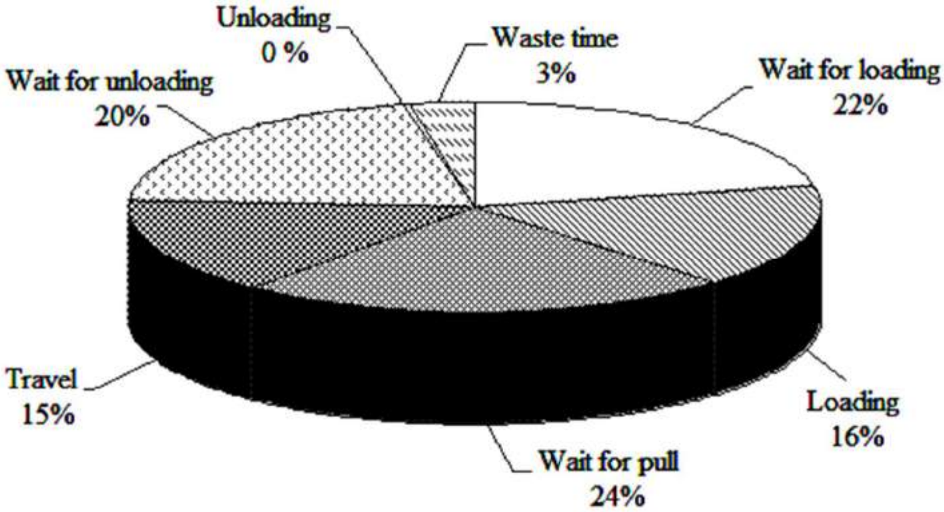

Fig. (8): An approximated cycle time for decauvelle wagon labor loading.

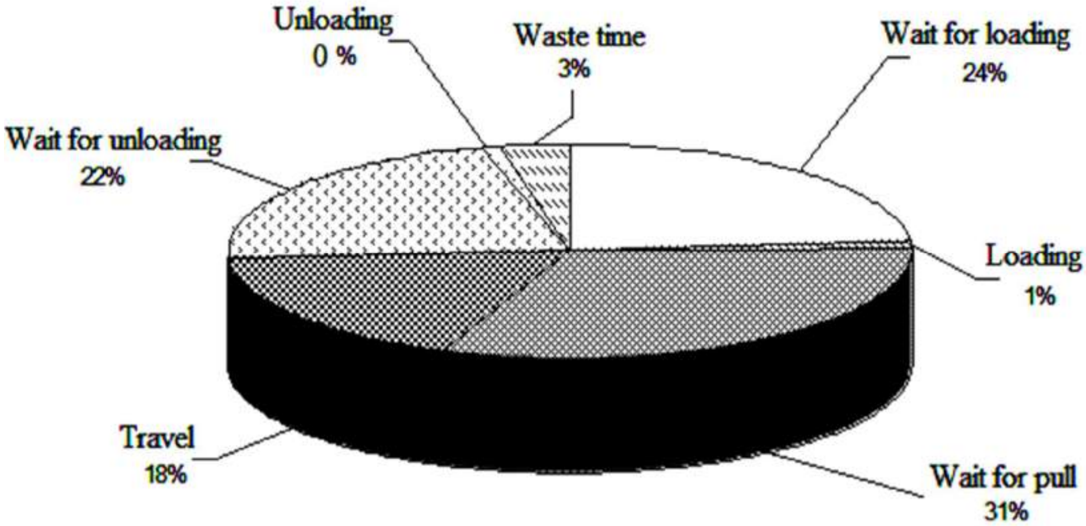

Fig. (9): An approximated cycle time for decauvelle wagon mechanical loading.

2. Lorry delivery rate (ton/day) labor loading:

Lorry delivery rate was computed on the bases of vehicle load and cycle time to reflect the rate of cane delivered to the mill along the operational hours. Transport rate (ton/day) computed as the total quantity of cane transported by a lorry at full operational day which represent the total productivity of a lory per day under the given conditions. Transport rate of a lorry of certain size depends on the number of trips from store to mill. Trip time (travel and return) is the variable component of cycle time that may determine number of lorry trips per day either for mechanical or labor loading. Figs. (10 and 11) show transport rate (ton/day) for lorries that loaded by labors and mechanical respectively. Mechanical loading reduces one of the most important components of a lorry transport cycle, which is loading time.

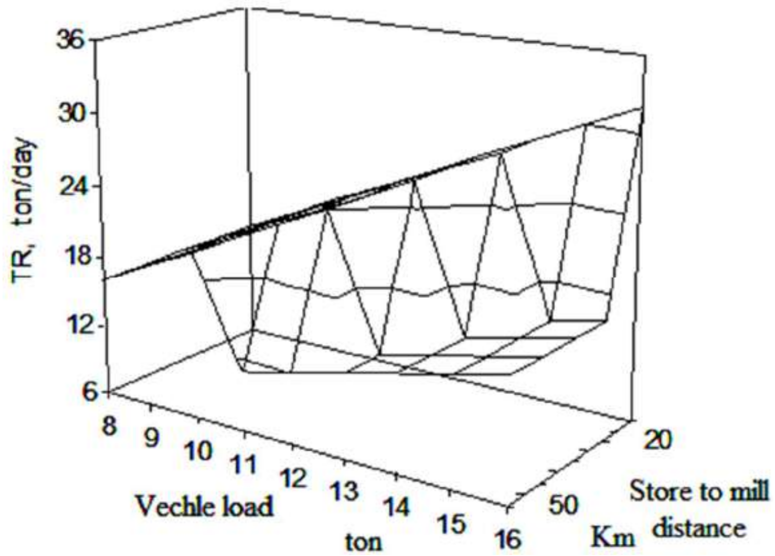

Fig. (10): Transport rate (ton/day) for lorries that loaded by labors.

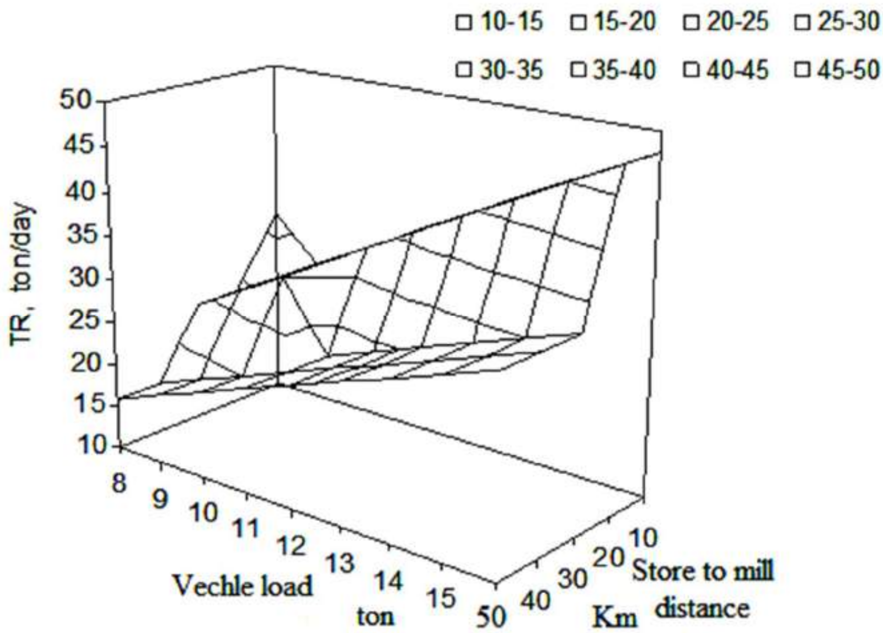

Fig. (11): Transport rate (ton/day) for lorries that loaded by mechanical.

This results show transport rates of lorries of variable sizes loaded by loader and transport cane from stores at variable distances from the mill. For lorry capacities from 8 to 16 ton, deliver range from about 2.8 to 4.8 ton/h and from 2.4 to 4.2 ton/h for store to mill distances of 10, 20 Km respectively. For the same range of lorry sizes, delivery rate ranged from 2 to 3.7, from 1.8 to 3.3 and from 1.6 to 3 ton/h at field to store distances 30, 40 and 50 Km respectively. A lorry of an average size (12 ton) may transport 3.7, 3.3, 2.9, 2.6 and 2.3 ton/h at field to store distances 10, 20, 30, 40 and 50 Km respectively. The reduction of delivery rate is due to the increase of cycle time because of longer trip time.

In case of the smaller lorry size (8 ton capacity), transport rate was 32 ton/day only at 10 km store to mill distance. At these particular conditions the vehicle may travel 4 trips per day. At store to mill distance 10, Km/h except for the above mentioned case, transport rate ranged from 27 to 48 ton/day for lorries of sizes from 9 to 16 ton which mean that each vehicle may achieve 3 successive cycles/day.

It is clear that transport rate directly increased at store to mill distance of 20 Km at which all lorry sizes within the given range may complete 3 trips along the operation day. For store to mill distance up to 40 Km, lorries within 10 ton capacity may complete 3 successive trips. Larger size may only complete two trips. Transport rate decreased suddenly from 30 ton/day for the 10 ton capacity lorry to 22 ton /day for that of 11 ton capacity.

For mechanical loading of lorries of given capacities and store to mill distances more than 40 Km, vehicles may complete only 2 cycles and transport a quantity of cane equivalent to double load per day.

3. Trailers:

Tractor-trailers equipped for transporting cane from temporary storage area to the mill with average capacity 7 tons work for maximum 10 hours per day. The trailer cycle time depends on storage area to mill distance, loading time, and reception time. Number of 4 labors can load the trailer within 2 hours and the trailer may wait for 1.5 hour in the mill reception. Since average speed of the trailer (travel and return) about 10 Km/h, therefore cycle time may be within 4.5 and 5.5 h at 5 and 10 Km field to mill distances where 2 trips may be achieved within an operational day of 10⁃1 hours. At longer storage area to mill distances, one trip only may be achieved per day. Maximum storage area to mill distance at which the trailer pulled by tractor may travel a successive trip within 10 hours may be 35 Km.

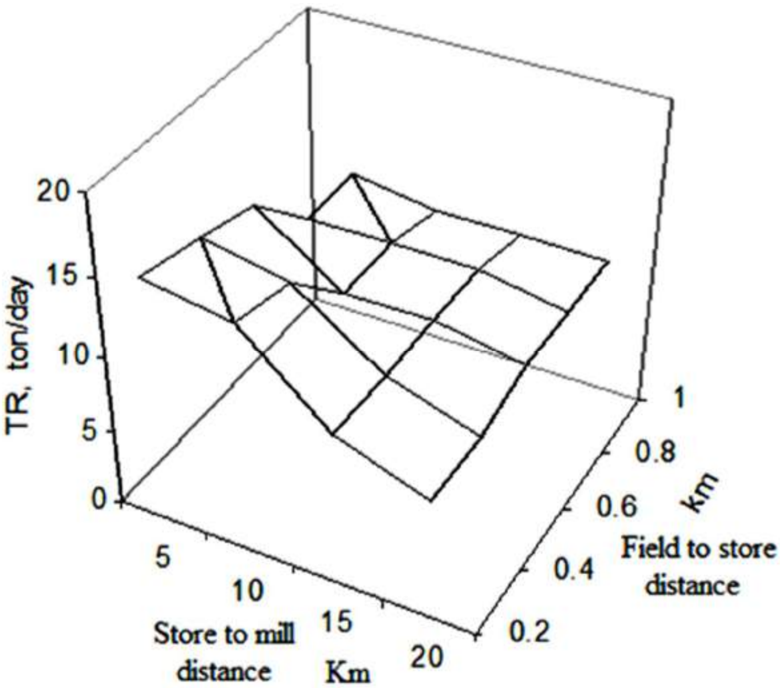

Fig. (12): Performance of trailers equipped for transporting cane.

Fig. (12) shows that transport rate (ton/day) decreased from 14 ton/day at storage area to mill distance 10 Km to 7 ton/day and stay constant for longer storage area to mill distance. The difference may be in the total operational hours per day where a complete trailer cycle was 6.5, 8.5 and 10.5 hours at storage area to mill distances 15, 25 and 35 Km respectively. Whenever the day time permit, farmers may delay starting the trip to certain time to harvest a part of the trailer load which may be delivered to the mill at the same day. Time available for harvesting a part of trailer load at the same day of transport depend upon the difference between maximum operation hours/day and cycle time multiplied by number of cycles. The quantity harvested at that time related number of harvesting labors. A number of 5 labors (house labors) or a number of 10 labors may be used to harvest cane for a trailer travel 1 or 2 cycles per day respectively.

CONCLUSION

The results of performance of sugarcane transport equipment may be concluded as follow:

1- Vehicle transport cane from distances up to 50 km from the mill and travel at average speed 40 Km while trailers travel up to 20 Km at average speed 10 Km for travel and return trips. Both lorry and tractor-trailers work for up to 12 hours, depend on the number of cycles/day. Trailers are of same size with an average load is about 7 tons and lorries are of variable types and sizes where load may vary from 9-16 ton.
2- Transport rates of lorries of variable sizes loaded by loader and transport cane from stores at variable distances from the mill. For lorry capacities from 8 to 16 ton, deliver range from about 2.8 to 4.8 ton/h and from 2.4 to 4.2 ton/h for store to mill distances of 10, 20 Km respectively.
3- In case of the smaller lorry size (8 ton capacity), transport rate was 32 ton/day only at 10 km store to mill distance. At these particular conditions the vehicle may travel 4 trips per day. At store to mill distance 10, Km/h except for the above mentioned case, transport rate ranged from 27 to 48 ton/day for lorries of sizes from 9 to 16 ton which mean that each vehicle may achieve 3 successive cycles/day.
4- Transport rate decreased suddenly from 30 ton/day for the 10 ton capacity lorry to 22 ton /day for that of 11 ton capacity. For mechanical loading of lorries of given capacities and store to mill distances more than 40 Km, vehicles may complete only 2 cycles and transport a quantity of cane equivalent to double load per day.
5- Tractor-trailers equipped for transporting cane from temporary storage area to the mill with average capacity 7 tons work for maximum 10 hours per day.
6- A number of 4 labors can load the trailer within 2 hours and the trailer may wait for 1.5 hour in the mill reception. Since average speed of the trailer (travel and return) about 10 Km/h, therefore cycle time may be within 4.5 and 5.5 h at 5 and 10 Km field to mill distances where 2 trips may be achieved within an operational day of 10-12 operation hours. At longer storage area to mill distances, one trip only may be achieved per day. Maximum storage area to mill distance at which the trailer pulled by tractor may travel a successive trip within 10 hours may be 35 Km.

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آداء معدات نقل محصـول قصب السـكر

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2. *معهد بحوث الهندسة الزراعية – الدقى – مصر.*

محصول قصب السكر يعتبر ذو أهميه كبيره و يزرع بصفة رئيسيه فى الوجه القبلى و تبلغ المساحه المنزرعه بالقصب حاليا حوالى 350 ألف فدان . و يمثل محصول القصب الماده الخام لصناعة السكر و الصـناعات التكامليه الأخرى المتمثلة فى صناعة الخشـب و صـناعة الاعلاف و كذلك صناعة المخمرات و الكحولات . و يواجه المحصول صعوبات و مشكلات كثيره فى موسم الحصاد و التوريد إلى المصانع حيث يستخدم المزارعون وسائل حيوانية أو مجروره بالحيوانات لنقل القصب من داخل الحقول إلى أماكن تسمى الوحسات التى يتم فيها تحميل القصب على وسائل النقل الرئيسية التى تنقله إلى المصانع . كما يقوم العمال بتحميل و شـحن تلك الوسائل بالقصب يدوياً مما يستغرق وقتاً طويلاً و يؤدى إلى تأخر تسليم القصب للمصانع و يترتب على ذلك تدهور محتويات عود القصـب من المواد السـكريه و أيضا إنخفاض الرطوبة بالمحصول و بالتالى إنخفاض الوزن و بالتالى قلة الربحية من المحصول .

و يهدف البحث الحالى إلى تقييم الوسـائل اليدوية و المكانيكية المسـتخدمة فى نقل القصـب للمصـانع و تقدير معدلات النقل و معدلات الآداء لتكون نتائج جاهزة لتطوير تلك المنظومة . و قد أظهرت النتائج أن معدلات النقل تتأثر بزمن دورة النقل وأن زمن دورة النقل يتأثر كثيراً بوسـائل شحن القصب على معدات النقل و فى حالة النقل باللورى أو المقطورات فقد تستطيع المعده تكرار دورة النقل فى ذات اليوم و فى حالة النقل من مسافات مجاوره للمصنع و الشحن الآلى قد يصل معدل النقل باللورى إلى 30 طن /يوم أما فى حالة الشحن بالعمال فإن هذا المعدل ينقص ليكون 10طن / يوم على إعتبار أن اللودر سيؤدى دورة نقل واحده. كما أنه يوصى بأستخدام المقطورات المجروره بالجرارات فى نقل القصب المجاور للمصنع و اللوارى فى نقل انتاج المساحات البعيده عن المصنع و ذلك فى حالة الشحن اليدوى .أما فى حالة المناطق التى تستخدم الديكوفيل فإن معدل النقل لا يتأثر بمسافة النقل أو طريقة الشحن لأن المعده تقوم بآداء دورة نقل واحده كل يوم.

دراسة اقتصادية لكفاءة إنتاج محصول القطن والمشاكل التى تواجهه بمناطق الإصلاح الزراعى بمحافظة البحيرة

عاصِم كُرَيّم عبد الحميد ، على أبو ضيف محمد و عمرو حسين احمد حامد الشيبانى

1. كلية الزراعة جامعة الأزهر بالقاهرة
2. بالهيئة العامة لمشروعات التعمير والتنمية الزراعية

مقدمة

شهد قطاع القطن المصرى العديد من التطورات والتدخلات الحكومية خلال نصف القرن الماضى حيث كانت تجارة القطن وتسويقه داخلياً وخارجياً حرة وذلك فيما قبل عام 1961، حيث كانت عمليات البيع والشراء تتم من خلال المضاربة فى البورصة وكان السعر فى السوق المحلى يرتبط بالتغيرات فى الأسعار العالمية للقطن، وفى بداية الستينيات وتحديداً فى عام 1961 بدأ تأميم قطاع القطن المصرى من خلال سلسلة لا تنتهى من التدخلات الحكومية حيث بدأت بإدخال نظام التسويق التعاونى للقطن والذى تزامن معه نظام التوريد الإجبارى للقطن فضلاً عن ذلك التحكم فى الرقعة المزروعة قطناً من خلال نظام الدورة الزراعية، وقد ترتب على السياسات الحكومية المتعلقة بمحصول القطن عزوف المزارعون عن زراعته وعدم الاهتمام به، وتعتبر السياسة القطنية أحد الفروع الرئيسية للسياسة الزراعية، التى تعتبر ركناً رئيسياً من أركان السياسة الاقتصادية التى تقود الاقتصاد القومى، مما يعطى أهمية خاصة لدراسة تلك التحولات و مدى استجابة المزارعين لها والتفاعل مع تلك المتغيرات.

ويعتبر محصول القطن من المحاصيل الإستراتيجية في مصر، حيث يحتل القطن مكانة رئيسية بين مختلف الزروع فى مصر ، باعتباره احد الدعامات الرئيسية للبنيان الاقتصادي القومي ، حيث تقوم علية الكثير من الصناعات المحلية مثل صناعات الحلج والغزل والنسيج والزيوت والصابون والعلف الحيواني وغيره من الصناعات ، بالإضافة إلى استيعابه إلي ما يزيد عن مليون عامل ما بين الزراعة والتصنيع ، وقد بلغ عدد الجمعيات التعاونية فى أراضى الإصلاح الزراعى فى الجمهورية عام 2011 / 2012 حوالى 659 جمعية محلية، ونحو 70 جمعية مشتركة بالإضافة إلى 19 جمعية مركزية. تأتى محافظة البحيرة فى المرتبة الأولى من حيث عدد مناطق الإصلاح حيث بلغ عدد المناطق بها نحو 12 منطقة كما تأتى فى المرتبة الأولى من حيث عدد الجمعيات حيث قدر عدد الجمعيات بها بحوالى 152 جمعية تتضمن 139 جمعية محلية وحوالي 12 جمعية مشتركة، وجمعية مركزية واحدة بالإضافة أنها تحتل المرتبة الأولى من حيث المساحة التى تشرف عليها هيئة الإصلاح الزراعى حيث قدر إجمالى أراضى الإصلاح الزراعى بالمحافظة عام 2011 /2012 بحوالى 188,5 الف فدان.

مشكلة البحث

على الرغم من أهمية الدور المحوري لجمعيات الإصلاح الزراعى فى تحسين الحالة الاقتصادية والإجتماعية لكافة المزارعين على مستوى الجمهورية، وخاصة بعد تطبيق سياسات الإصلاح الاقتصادى الأمر الذى أدى لزيادة دور جمعيات الإصلاح الزراعى فى خدمة أعضائها بتوفير مستلزمات الإنتاج وقيامها بتسويق المحاصيل خاصة المحاصيل الهامة كالقطن والقمح والأرز .إلا أن جمعيات الإصلاح الزراعى لم تستطع أن تواجه التراجع المستمر فى المساحات المزروعة بمحصول القطن مقارنة بالمحاصيل الأخرى. والذى قد يرجع إلى إنحراف النظام التعاونى عن تطبيق الأساليب المثلى والأكثر كفاءة فى إنتاج وتسويق القطن، بل واجهت تعاونيات القطن العديد من المشكلات أهمها عدم تكاملها مع الجمعيات التعاونية المختلفة داخل البنيان التعاونى . الأمر الذى قد ينعكس أثره بالسلب على المساحات المزروعة والصناعات القائمة على محصول القطن وتأثر سوق العمل الخاص بمحصول القطن والذى كان يعمل فيه حوالى مليون عامل .

هدف البحث

يستهدف البحث دراسة الكفاءة الإنتاجية لمحصول القطن بمحافظة البحيرة، وكذلك التعرف على المشكلات والمعوقات التى تواجه مزارعى القطن بجمعيات الإصلاح الزراعى بمحافظة البحيرة.

الطريقة البحثية

تم إستخدام أسلوبى التحليل الوصفى والكمى حيث تم الاستعانة ببعض الأساليب الإحصائية مثل المتوسط الحسابى والمتوسط الهندسى، والاتجاه الزمني العام والانحدار المتعدد. واعتمدت الدراسة على البيانات المنشورة بوزارة الزراعة واستصلاح الأراضى، كما اعتمدت الدراسة بصفة رئيسية على البيانات الأولية التى تم جمعها من محافظة البحيرة، عن طريق البيانات التي تم الحصول عليها من استمارة الاستبيان التى تم تصميمها لهذا الغرض الخاصة بدور جمعيات الاصلاح الزراعى فى انتاج وتسويق القطن بمحافظة البحيرة، حيث تم جمع عدد (77) مفردة من محافظة البحيرة من مراكز أبو حمص ، والخزان ، وايتاى البارود ، وابو المطامير ، ودمنهور ، وقد تم تجميع البيانات خلال الموسم الزراعى 2013/2012 .

نتائج البحث ومناقشتها

أولاً: كفاءة إنتاج محصول القطن في محافظة البحيرة:

أ- العوامل المؤثرة على إنتاج محصول القطن في محافظة البحيرة:

تتعدد العوامل التى تؤثر على إنتاج محصول القطن في أماكن إنتاجه ولعل أهم تلك العوامل مايتعلق بأسعار القنطار من القطن وهو مايبنى عليه المزارع توقعاته من الدخل المتحصل عليه في نهاية الموسم الإنتاجى، ويرتبط سعر القنطار من محصول القطن بعوامل عديدة أهمها الظروف التسويقية المحلية لمحصول القطن وكذلك التجارة الخارجية له.

إلا أن عناصر الإنتاج المستخدمة في إنتاج هذا المحصول قد تُعتبر من أهم العوامل المؤثرة على إنتاجه والمساحة المزروعة منه، وفيما يلى عرضاً للعوامل المؤثرة على كمية الإنتاج من هذا المحصول خلال الموسم الزراعى 2012/ 2013م في مناطق الإصلاح الزراعى بمحافظة البحيرة.

1- العلاقة بين كمية الإنتاج للفدان من القطن وكمية التقاوى:

توضح المعادلة رقم (1) بالجدول رقم (1) العلاقة بين كمية الإنتاج من القطن وكمية التقاوى المستخدمة خلال فترة الدراسة ، حيث تبين أن تزايد كمية التقاوى المستخدمة بمقدار كجم سنوياً أدى إلى تزايد كمية الإنتاج من محصول القطن حوالى 0,247الف قنطار سنويا. وقد ثبت معنوية هذه العلاقة عند المستوى الإحتمالى 0,05، ويوضح معامل التحديد أن نحو 76 % من التغير فى كمية الإنتاج من القطن يعود إلى عوامل مرتبطة بكمية التقاوى المستخدمة ، وذلك إلى حد معين من كمية التقاوى المضافة.

2- العلاقة بين كمية الإنتاج للفدان من القطن وكمية السماد البلدى :

كما تبين من المعادلة رقم (2) بين كمية الإنتاج من القطن وكمية السماد البلدى المستخدم خلال فترة الدراسة، أن تزايد كمية السماد البلدى المستخدمة بمقدار كجم سنوياً أدى إلى تزايد كمية الإنتاج من محصول القطن بحوالى 0,29 الف قنطار سنوياً.

وقد ثبت معنوية هذه العلاقة عند المستوى الإحتمالى 0,05، و يوضح معامل التحديد أن نحو 28 % من التغير فى كمية الإنتاج من القطن يعود إلى عوامل مرتبطة بكمية السماد البلدى المستخدمة ، وذلك إلى حد معين من كمية السماد المضافة .

3- العلاقة بين كمية الإنتاج للفدان من القطن وكمية السماد الآزوتى :

توضح المعادلة رقم (3) بالجدول رقم (1) العلاقة بين كمية الإنتاج من القطن وكمية السماد الآزوتى المستخدم خلال فترة الدراسة ، أن تزايد كمية السماد الآزوتى المستخدمة بمقدار كجم سنوياً أدى إلى تزايد كمية الإنتاج من محصول القطن بنحو 0,11 الف قنطار سنوياً. وقد ثبت معنوية هذه العلاقة عند المستوى الإحتمالى 0,05، ويوضح معامل التحديد أن نحو 63 % من التغير فى كمية الإنتاج من القطن يعود إلى عوامل مرتبطة بكمية الآزوتى المستخدمة، وذلك إلى حد معين من كمية السماد المضافة.

جدول رقم (1) معادلات الإنحدار البسيط لأهم المؤشرات الاقتصادية لمحصول القطن
بمناطق الإصلاح الزراعى في محافظة البحيرة خلال فترة الدراسة

م	البيان	وحدة القياس	المعادلة	R2	F
1	كمية التقاوى	بالكجم	Y = 0,321 + 0,247 X (15,6)*	0,76	243
2	كمية السماد البلدى	بالكجم	Y = 4,8 + 0,29 X (5,4)*	0,28	29
3	كمية السماد الآزوتى	بوحدة مادة فعالة	Y = 0,98 + 0,11 X (11,4)*	0,63	129
4	كمية السماد الفوسفاتى	بوحدة مادة فعالة	Y = 2,26 + 0,04 X (9,8)*	0,56	97.3
5	كمية السماد البوتاسى	بوحدة مادة فعالة	Y = 1,34 + 0,235 X (10,2)*	0,58	104
6	كمية المبيدات	باللتر	Y = 1,52 + 1,02 X (10,5)*	0,59	110
7	العمل البشرى	رجل/يوم	Y = -1,30 + 0,153 X (16,4)*	0,77	267
8	العمل الآلى	بالساعة	Y= -2,18 + 0,685 X (13,3)*	0,69	172
9	كمية ماء الرى	بالساعة	Y= -2,18 + 0,71X (11,1)*	0,63	123,4

المصدر: جمعت وحسبت من بيانات الإستبيان لعينة الدراسة 2012/ 2013 م.

- Y = تشير إلي القيمة التقديرية لكمية الإنتاج.
- X = تشير إلي المتغير المستقل موضع الدراسة.

القيمة ما بين( ) تشير لقيمة t المحسوبة حيث * المعنوية الإحصائية.

4- العلاقة بين كمية الإنتاج للفدان من القطن وكمية السماد الفوسفاتى :

تشير المعادلة رقم (4) بالجدول رقم (1) إلى العلاقة الانحدارية بين كمية الإنتاج من القطن وكمية السماد الفوسفاتى المستخدم خلال فترة الدراسة، أن تزايد كمية السماد الفوسفاتى المستخدمة بمقدار كجم سنوياً أدى إلى تزايد كمية الإنتاج من محصول القطن بنحو 0,04 الف قنطار سنوياً. و قد ثبت معنوية هذه العلاقة عند المستوى الإحتمالى 0,05، و يوضح معامل التحديد أن نحو 56 % من التغير فى كمية الإنتاج من القطن يعود إلى عوامل مرتبطة بكمية الفوسفاتى المستخدمة، وذلك إلى حد معين من كمية السماد المضافة .

5- العلاقة بين كمية الإنتاج للفدان من القطن وكمية السماد البوتاسي

أتضح من دراسة المعادلة رقم (5) بنفس الجدول العلاقة بين كمية الإنتاج من القطن وكمية السماد البوتاسى المستخدم خلال فترة الدراسة، أن تزايد كمية السماد البوتاسى المستخدمة بمقدار كجم سنوياً أدى إلى تزايد كمية الإنتاج من محصول القطن حوالى 0,235 الف قنطار سنويا. وقد ثبت معنوية هذه العلاقة عند المستوى الإحتمالى 0,05، ويوضح معامل التحديد أن نحو 58 % من التغير فى كمية الإنتاج من القطن يعود إلى عوامل مرتبطة بكمية البوتاسي المستخدمة.

6- العلاقة بين كمية الإنتاج للفدان من القطن وكمية المبيدات :

كما أكدت المعادلة رقم (6) العلاقة الانحدارية بين كمية الإنتاج من القطن وكمية المبيدات المستخدمة خلال فترة الدراسة، أن تزايد كمية المبيدات المستخدمة بمقدار لتر سنوياً أدى إلى تزايد كمية الإنتاج من محصول القطن حوالى 1,02 الف قنطار سنوياً. وقد ثبت معنوية هذه العلاقة عند المستوى الإحتمالى 0,05، ويوضح معامل التحديد أن نحو 59 % من التغير فى كمية الإنتاج من القطن يعود إلى عوامل مرتبطة بكمية المبيدات المستخدمة . وذلك إلى حد معين من الكمية المضافة من المبيدات حيث أن الزيادة عن القدر الكافى قد تضر المحصول .

7- العلاقة بين كمية الإنتاج للفدان من القطن والعمل البشرى :

توضح المعادلة رقم (7) بالجدول رقم (1) العلاقة الانحدارية بين كمية الإنتاج من القطن وقوة العمل البشرى المستخدم خلال فترة الدراسة، أن تزايد قوة العمل البشرى بمقدار رجل/يوم سنوياً قد أدى إلى تزايد كمية الإنتاج من محصول القطن حوالى 0,15 الف قنطار سنويا. و قد ثبت معنوية هذه العلاقة عند المستوى الإحتمالى 0,05، ويوضح معامل التحديد أن نحو 77 % من التغير فى كمية الإنتاج من القطن يعود إلى عوامل مرتبطة بالعمل البشرى المستخدم، وذلك إلى حد معين حيث ان زيادة العمالة بالقدر الزائد عن الحد المطلوب يؤدى إلى زيادة التكاليف.

8- العلاقة بين كمية الإنتاج للفدان من القطن والعمل الآلى :

أشارت المعادلة رقم (8) إلى العلاقة الانحدارية بين كمية الإنتاج من القطن والعمل الآلى المستخدم خلال فترة الدراسة، أن تزايد كمية العمل الآلى بمقدار ساعة سنوياً أدى إلى تزايد كمية الإنتاج من محصول القطن حوالى 0,69 الف قنطار سنويا. وقد ثبت معنوية هذه العلاقة عند المستوى الإحتمالى 0,05، ويوضح معامل التحديد أن نحو 69 % من التغير فى كمية الإنتاج من القطن يعود إلى عوامل مرتبطة بالعمل الآلى المستخدم .

9- العلاقة بين كمية الإنتاج للفدان من القطن وماء الرى :

كما توضح المعادلة رقم (9) بالجدول رقم (1) العلاقة الانحدارية بين كمية الإنتاج من القطن وكمية مياه الرى المستخدمة خلال فترة الدراسة ، أن تزايد كمية مياه الرى بمقدار ساعة سنوياً أدى إلى تزايد كمية الإنتاج من محصول القطن حوالى 0,71 الف قنطار سنوياً. وقد ثبت معنوية هذه العلاقة عند المستوى الإحتمالى 0,05، ويوضح معامل التحديد أن نحو 63 % من التغير فى كمية الإنتاج من القطن يعود إلى عوامل مرتبطة بكمية ماء الرى ، وذلك إلى حد معين حيث أن زيادة كمية ماء الرى عن الحد المعين يؤدى إلى هلاك المحصول .

ب- مؤشرات الكفاءة الإنتاجية لمحصول القطن فى محافظة البحيرة باستخدام الدالة الإنتاجية:

اعتمد تقدير دوال الإنتاج فى هذا البحث على بيانات عينة من مزارعى القطن بجمعيات الإصلاح الزراعى بمحافظة البحيرة للموسم الزراعى 2013/2012 .

كما تم إستخدام الأسلوب الإحصائي المعروف بالانحدار المتعدد المرحلي وذلك باستخدام النموذج اللوغاريتمى المزدوج، وذلك لتمثيل العلاقة بين الإنتاجية الفدانية من المحصول كعامل تابع (Y) ، وكميات عناصر الإنتاج المستخدمة فى عملية الإنتاج كعوامل مستقلة على النحو التالى:

-إنتاج الفدان لمحصول القطن بالقنطار كمتغير تابع.(Y)

-الموارد المزرعية المستغلة فى الإنتاج كمتغيرات مستقلة، والتى أمكن تصنيفها كما يلى:

-كمية التقاوى بالكيلو جرام للفدان (X1).

-كمية السماد البلدى المضافة للفدان فى الموسم بالمتر مكعب (X2).

-كمية الأسمدة الآزوتية بالكيلو جرام/ للفدان، وتم تحويل هذه الكمية إلى وحدات مادة فعالة (X3).

-كمية الأسمدة الفوسفاتية وحمض الفوسفوريك بالكيلو جرام/فدان،وتم تحويل هذه الكمية إلى وحدات مادة فعالة (x4).

-كمية البوتاسيوم المضافة للفدان فى الموسم فى صورة الأسمدة البوتاسية بالكيلو جرام/فدان، وتم تحويل هذه الكمية إلى وحدات مادة فعالة (x5).

-كمية المبيدات المضافة للفدان باللتر (x6).

-عدد العمالة البشرية المشتغلة فى الفدان (رجل/يوم) (x7).

-عدد ساعات العمل الآلى (x8).

-كمية مياه رى الفدان بالمتر مكعب/الموسم الزراعى

(x9) = (معدل تصرف ماكينة الرى المستخدمة فى الرفع م3/ساعة x زمن الرية الواحدة x عدد مرات الرى المستخدمة خلال فترة مكث المحصول.

-المساحة المنزرعة بالقيراط (x10).

1- تقدير الدالة الإنتاجية للفئة الحيازية (اقل من فدان) بعينة الدراسة :

بتقدير دالة الإنتاج للفئة الحيازية (اقل من فدان) بعينة الدراسة والتى اشتملت على حوالى 23 مفردة من إجمالى77 مفردة بمناطق الإصلاح الزراعى بمحافظة البحيرة أظهرت نتائج المعادلة (1) أن الإشارة الموجبة لمعاملات إنحدار عناصر العمل البشرى، المساحة تدل على أنها ذو تأثير طردى على كمية الإنتاج، أى أنه بزيادة الكمية المستخدمة من كل منهما بنسبة 1% تؤدى إلى زيادة إنتاجية الفدان بحوالى 0,32%، 2,17% على الترتيب، مما يشير إلى أن عنصر العمل البشرى يتم استخدامه في المرحلة الإقتصادية بينما يتم إستخدام عنصر المساحة في المرحلة الأولى وهو مايشير إلى ضرورة الاهتمام بالمساحات الكبيرة فهى الأكثر كفاءة إنتاجية.

بينما أظهرت الإشارة السالبة لعناصر الرى، العمل الآلى ، السماد العضوي أنهم ذو تأثير سلبى على كمية الإنتاج، أى أن زيادة الكمية المستخدمة من كل منهم بنسبة 1% تؤدى إلى نقص المحصول بنحو 0,48% ، 0,41% ، 0,24% وذلك بفرض ثبات العوامل الأخرى المؤثرة على كمية الإنتاج، أى أن هذه العناصر تستخدم بأكثر من اللازم، وبالتالى يجب حساب معدلات جديدة لاستخدامها بالمستوى الذى يعود بإنتاجيتها إلى المرحلة الإقتصادية.

معادلة (1) تحليل الانحدار للدالة الإنتاجية للفئة الحيازية (اقل من فدان) بعينة الدراسة
خلال فترة الدراسة

$$Y=-4,5 -0,243X_2 +0,321X_7+0,411X_8 - 0,480X_9 + 2,17X_{10}$$

$$(-2,35)^{**} \quad (-2,7)^{**} \quad (5,47)^{**} \quad (-2,3)^{**} \quad (7.2)^{**}$$

$$R^{-2} = 0,89 \qquad F = 38^{**}$$

ويشير معامل التحديد المعدل R^{-2} إلى أن حوالى 89% من تغيرات كمية الإنتاج تفسرها المتغيرات المستقلة التى شملها النموذج، كما أكدت قيمة (F) المحسوبة على معنوية النموذج المستخدم.

ولقد تبين أن المرونة الإجمالية والبالغة حوالى 1,6 وهى أكبر من الواحد الصحيح وتشير إلى تزايد العائد على السعة، أى أنه بزيادة كمية هذه المدخلات بنسبة 1% فإن كمية الإنتاج تزيد بنحو 1,6%.

2- تقدير الدالة الإنتاجية للفئة الحيازية (اكبر من فدان) بعينة الدراسة :

بتقدير الدالة الإنتاجية للفئة الحيازية اكبر من فدان بعينة الدراسة والتى اشتملت على نحو 54 مفردة من إجمالى77 مفردة بمناطق الإصلاح الزراعى بمحافظة البحيرة أظهرت نتائج المعادلة (2) أن الإشارة الموجبة لمعاملات إنحدار عناصر الرى ، العمل البشرى، كمية المبيدات ، المساحة تدل على أنها ذو تأثير طردى على كمية الإنتاج، أى أنه بزيادة الكمية المستخدمة من كل منهما بنسبة 1% تؤدى إلى زيادة المحصول بحوالى 0,21% ، 0,14% ، 0,35% ، 0,98% لكل منهم على الترتيب، أى أن هذه العناصر لا تستخدم بالكمية المثلى لذا يجب العمل على زيادة الكمية المستخدمة منها.

بينما أظهرت الإشارة السالبة لعناصر السماد الفوسفاتى ، السماد الآزوتى أنهما ذو تأثير سلبى على كمية الإنتاج، أى أن زيادة الكمية المستخدمة من كل منهما بنسبة 1% تؤدى إلى نقص المحصول بنحو 0,32% ، 0,18% أى أن هذه العناصر تستخدم بأكثر من اللازم، أو قد يتم استخدامها فى التوقيت غير المناسب مما يؤدى إلى زيادة المجموع الخضرى على حساب المجموع الثمرى ، وبالتالى يجب حساب معدلات جديدة لاستخدامها بالمستوى الذى يعود بإنتاجيتها إلى المرحلة الإقتصادية.

معادلة (2) تحليل الانحدار للدالة الإنتاجية للفئة الحيازية (اكبر من فدان) بعينة الدراسة
خلال فترة الدراسة

$$Y=-0,449-0,175X3-0,321X4+0,354X6+0,141X7+0,208X9+0,967X10$$

(1,87)* (2,14)** (6,2)** (-2,5)** (-1,43) (4,9)**

$R^{-2} = 0,84$ F = 50**

ويشير معامل التحديد المعدل R^{-2} إلى أن حوالى 84% من تغيرات كمية الإنتاج تفسرها المتغيرات المستقلة التى شملها النموذج، كما أكدت قيمة (F) المحسوبة معنوية النموذج المستخدم.

ولقد أوضحت المرونة الإجمالية والبالغة حوالى 2.1 وهى أكبر من الواحد الصحيح وتشير إلى تزايد العائد على السعة، أى أنه بزيادة كمية هذه المدخلات بنسبة 1% فإن كمية الإنتاج تزيد بحوالى 2.1%.

3- تقدير دالة الإنتاج على مستوى إجمالى العينة :

بدراسة دالة الإنتاج فى عينة الدراسة بجمعيات الإصلاح الزراعى بمحافظة البحيرة أظهرت نتائج المعادلة (3) أن الإشارة الموجبة لمعاملات إنحدار عناصر العمل البشرى ، المبيدات ، المساحة تدل على أنها ذو تأثير طردى على كمية الإنتاج، أى أنه بزيادة الكمية المستخدمة منها بنسبة 1% تؤدى إلى زيادة المحصول بحوالى 52.0% ، 22.0% ، 03.1% لكل منها على الترتيب. أى أن هذه العناصر لا تستخدم بالكمية المثلى لذا يجب العمل على زيادة الكمية المستخدمة منها.

بينما أظهرت الإشارة السالبة لعنصرى الرى ، العمل الآلى أنهما ذو تأثير سلبى على كمية الإنتاج، أى أنه بزيادة الكمية المستخدمة من كل منهما بنسبة 1% تؤدى إلى نقص المحصول بنحو 32.0% ، 26.0% ، أى أنهما يستخدمان بكمية أكبر من اللازم ، وبالتالى يجب حساب معدلات جديدة لإستخدامها بالمستوى الذى يعود بإنتاجيتها إلى المرحلة الإقتصادية.

معادلة (3) تحليل الانحدار للدالة الإنتاجية على مستوى إجمالى العينة
خلال فترة الدراسة

$$Y=-2,28+0,223X6+0,517X7-0,264X8-0,320X9+1,03X10$$

(-2,1)** (-2,19)** (5,5)** (4,3)** (6,13)**

$R^{-2} = 0,90$ F = 143**

ويشير معامل التحديد المعدل R^{-2} إلى أن حوالى 90% من تغيرات كمية الإنتاج تفسرها المتغيرات المستقلة التى شملها النموذج، كما أكدت قيمة (F) المحسوبة معنوية النموذج المستخدم.

ولقد أوضحت المرونة الإجمالية والبالغة حوالى 2.1 وهى أكبر من الواحد الصحيح وتشير إلى تزايد العائد على السعة، بمعنى أنه بزيادة كمية هذه المدخلات بنسبة 1% فإن كمية الإنتاج تزيد بحوالى 2.1%.

ج: التقدير الإحصائي لدوال تكاليف محصول القطن فى عينة الدراسة :

1- هيكل بنود التكاليف لمحصول القطن فى عينة الدراسة :

تبين من دراسة الجدول رقم (2) الذى يوضح أهم بنود هيكل التكاليف الإنتاجية الكلية (التكاليف الثابتة والتكاليف المتغيرة) لمحصول القطن بعينة الدراسة والأهمية النسبية لكل منها، أن التكاليف الإنتاجية الثابتة للفدان فى السنة تتضمن إيجار فدان القطن فى الموسم الزراعى (مدة مكث المحصول) من الزراعة حتى الحصاد. بينما تشمل التكاليف الإنتاجية المتغيرة ثمن شراء مستلزمات الإنتاج (التقاوى، الأسمدة البلدية والكيماوية ، و المبيدات،...الخ)،

جدول رقم (2) الأهمية النسبية لأهم بنود التكاليف الإنتاجية لفدان القطن في مناطق الإصلاح الزراعى بمحافظة البحيرة للموسم الزراعى 2013/2012.

بنود التكاليف	متوسط القيمة بالجنيه	% من إجمالى		
		مستلزمات الإنتاج	التكاليف المتغيرة	التكاليف الكلية
التكاليف المتغيرة :				
• مستلزمات الإنتاج:				
1. التقاوى	120	6,8	3,01	1,95
2. الأسمدة	1032	58,7	25,9	17
3. المبيدات	605	34,5	15,20	9,95
إجمالى مستلزمات الإنتاج (1)	1757	100	44,15	28,90
• تكاليف العمليات الإنتاجية				
1. العمل البشرى (2)	1882	84,7	47,29	30,96
2. العمل الآلى (3)	340,4	15,3	8,55	5,60
إجمالى تكاليف العمليات الإنتاجية (4)	2222,4	100	55,85	36,56
إجمالى التكاليف المتغيرة (5)	3979,4		100,00	65,46
التكاليف الثابتة :				
إيجار الفدان (6)	2100			34,54
إجمالى التكاليف الكلية (7)	6079,4			100,00

(4) + (1) = (5)

(6) + (5) = (7)

المصدر: جمعت وحسبت من بيانات الإستبيان لعينة الدراسة 2012/ 2013 م.

وتكاليف العمليات الإنتاجية التى تتضمن كل من أجور العمل البشرى المنفق على العمليات الزراعية التى تجرى فى الحقل ومنها إعداد الأرض للزراعة (الحرث – التزحيف – التسوية – التخطيط)، نقل ونثر السماد البلدى والكيماوى – مقاومة الحشائش والآفات والأمراض– الرى- الجنى او الحصاد ، وأجر العمل الآلى ويشمل عمليات إعداد الأرض للزراعة (الحرث – التزحيف – التسوية – التخطيط)- نقل ونثر السماد البلدى والكيماوى- الرى– العزيق- مقاومة الحشائش والآفات والأمراض- الجنى والتعبئة).

يتضح من نفس الجدول أن التكاليف الثابتة للفدان فى الموسم (إيجار الفدان) قدرت بحوالى 2100 جنيهاً تمثل نحو 34,5% من إجمالى التكاليف الكلية، فى حين بلغت التكاليف الإنتاجية المتغيرة حوالى 3979 جنيهاً تمثل نحو 65,5% من إجمالى التكاليف الكلية للفدان والمقدرة بحوالى 6079 جنيهاً. بينما تُقدر تكاليف العمليات الزراعية لمحصول القطن والمتمثلة فى تكلفة العمالة البشرية ، والعمل الآلى بحوالى 2222 جنيهاً، تعادل نحو 55,9%، 36,6% من كل من التكاليف المتغيرة والتكاليف الكلية على التوالي.

كما يتضح أن عنصر الأسمدة الكيماوية يأتى فى مقدمة عناصر التكاليف من حيث الأهمية النسبية، فقد بلغت قيمته حوالى 1032 جنيهاً، يمثل نحو 58,7%، 25,9%، 17 % من إجمالى كل من قيمة مستلزمات الإنتاج والتكاليف المتغيرة والتكاليف الكلية على التوالى، وتقدر تكلفة العمل الآلى والعمل البشرى بحوالى 340، 1882 جنيهاً، تمثل نحو 8,6%، 47,3% على الترتيب من إجمالى التكاليف المتغيرة، كما يمثل كل من عنصر العمل الآلى والعمل البشرى نحو 5,6%، 31% على التوالى من إجمالى تكلفة الفدان.

2- التقدير الإحصائي لدالة التكاليف الكلية لمحصول القطن للفئة الحيازية (اقل من فدان) في عينة الدراسة:

توضح نتائج المعادلة رقم (1) بالجدول رقم (3) وجود علاقة طردية بين التكاليف الكلية لمحصول القطن والإنتاج الفعلى لمزارعى العينة حيث اتضح أن زيادة الإنتاج بمقدار قنطار واحد سنويا يؤدى إلى زيادة التكاليف بمقدار 386 جنيه، وقد ثبتت معنوية هذه العلاقة عند مستوى معنوية 0,01، و يوضح معامل التحديد أن نحو 58 % من التغير فى التكاليف الكلية لمحصول القطن بالعينة يعود إلى عوامل مرتبطة بالإنتاج .

جدول رقم (3) التقدير الاحصائى لدالة التكاليف الكلية لمحصول القطن جدول
للفئة الحيازية (اقل من فدان) في عينة الدراسة في مناطق الإصلاح الزراعى بمحافظة البحيرة

دوال التكاليف	R^2	F	الحجم المدنى	الحجم المعظم	الصورة الرياضية
TC= 1220 + 386 X …(1) (5,3)**	0,58	28,4**			الخطية
TC= 450 + 1148 X – 77,9 X^2 ….(2) (1,96)* (-2,24)**	0,61	15,3**	14,6	22,3	التربيعية
TC= –181 + 956 X – 35 X^2 – 3,1 X^3 …(3) (0,9) (-1,04) (-0,7)	0,61	9,8			التكعيبية

حيث : ** معنوى عند المستوى الإحتمالى 0,01 ، * معنوى عند المستوى الإحتمالى 0,05

Y = القيمة التقديرية لتكاليف الإنتاج الكلية بالجنيه.

X = حجم الإنتاج بالقنطار

المصدر: جمعت وحسبت من بيانات الإستبيان لعينة الدراسة 2012/ 2013 م.

كما أتضح من نتائج المعادلة رقم (2) بالجدول رقم (3) والتى تعبر عن الصورة التربيعية لدالة التكاليف الكلية لمحصول القطن فى مناطق العينة أن معامل التحديد المعدل R^{-2} يشـير إلى أن التغيرات فى الإنتاجية تفسـر نحو 61% من التغيرات التى تحدث فى التكاليف الكلية.

كما أمكن إشتقاق دالة متوسط التكاليف بالقسمة على متغير الإنتاج X كما يلي:-

$$A.C = \frac{T.C}{X} = \frac{450}{X} + 1148 - 77,9X$$

حيث يمكن إيجاد قيمة متوسط التكاليف عند مستويات الإنتاج المختلفة بالتعويض بقيم X المختلفة . كذلك أمكن إشتقاق دالة التكاليف الحدية بإيجاد المشتقة التفاضلية الأولي للمعادلة بالنسبة لمتغير الإنتاج X .

$$M.C = \frac{d\,T.C}{d\,X} = 1148 - 155,8X$$

حيث يمكن إيجاد التكاليف الحدية عند مستويات الإنتاج المختلفة بالتعويض بقيم X .
وبمساواة دالة التكاليف الحدية بالتكاليف المتوسطة أمكن الوصول إلى الحجم المدنى للتكاليف والذى يقدر بحوالى 14,6 قنطار/فدان، وهذا يعنى صعوبة الوصول إلى الحجم الذى يدنى التكاليف في ضوء الإنتاجية الحالية، الأمر الذى يتطلب المحافظة على الأصناف عالية الجودة والتى تتمتع بسعر مرتفع عالمياً للحصول على أعلى ربح ممكن.

كما لم تثبت المعنوية الإحصائية للدالة التكعيبية و الموضحة بالمعادلة رقم (3) بالجدول رقم (3) وذلك باستخدام بيانات الإنتاج والتكاليف الكلية بالفئة الحيازية اقل من فدان بالعينة.

3- التقدير الإحصائى لدالة التكاليف الكلية لمحصول القطن للفئة الحيازية (اكبر من فدان) في عينة الدراسة:

تشير نتائج المعادلة رقم (1) بالجدول رقم (4) إلى وجود علاقة طردية بين التكاليف الكلية لمحصول القطن والإنتاج الفعلى لمزارعى العينة حيث أتضح أن وجود زيادة الإنتاج بمقدار قنطار واحد سنويا يؤدى إلى زيادة التكاليف مقدار 396 جنيه .

وقد ثبتت معنوية هذه العلاقة عند المستوى الإحتمالى 0,01، ويوضح معامل التحديد أن نحو 79 % من التغير فى التكاليف الكلية لمحصول القطن بالعينة يعود إلى عوامل مرتبطة بالإنتاج .

وبدراسة المعادلة رقم (2) بالجدول رقم (4) والتى تعبر عن الصورة التربيعية لدالة التكاليف الكلية لمحصول القطن فى مناطق العينة للفئة الحيازية اكبر من فدان . يتضح أن قيمة معامل التحديد المعدل R^{-2} قد بلغت حوالى 0,80 مما يشير إلى أن التقلبات فى الإنتاجية تفسر نحو 80% من التقلبات فى التكاليف الكلية.

كما أمكن إشتقاق دالة متوسط التكاليف بالقسمة على متغير الإنتاج X كما يلي:-

$$A.C = \frac{T.C}{X} = \frac{2220}{X} + 193 + 8,75X$$

حيث يمكن إيجاد قيمة متوسط التكاليف عند مستويات الإنتاج المختلفة بالتعويض بقيم X المختلفة كذلك أمكن إشتقاق دالة التكاليف الحدية بإيجاد المشتقة التفاضلية الأولي للمعادلة بالنسبة لمتغير الإنتاج X .

$$M.C = \frac{d\,T.C}{d\,X} = 193 + 17,5X$$

حيث يمكن إيجاد التكاليف الحدية عند مستويات الإنتاج المختلفة بالتعويض بقيم X .

وبمساواة دالة التكاليف الحدية بمتوسط التكاليف الكلية أمكن الحصول على حجم الإنتاج الذى يدنى التكاليف والذى قُدر بحوالى 15,9 قنطار/فدان.

كما لم تثبت المعنوية الإحصائية للدالة التكعيبية و الموضحة بالمعادلة رقم (3) بالجدول رقم (4) وذلك باستخدام بيانات الإنتاج والتكاليف الكلية بالفئة الحيازية اقل من فدان بالعينة.

جدول رقم (4) التقدير الاحصائى لدالة التكاليف الكلية لمحصول القطن
للفئة الحيازية (اكبر من فدان) في عينة الدراسة في مناطق الإصلاح الزراعى بمحافظة البحيرة

الصورة الرياضية	الحجم المعظم	الحجم المدنى	F	R^2	دوال التكاليف
الخطية			191**	0,79	TC= 1176 + 396 X …(1) (13,8)**
التربيعية	29	20,5	100**	0,80	TC= 2220 + 193 X + 8,75 X^2 ….(2) (2,55)** (2,68)**
التكعيبية			65,5	0,80	TC= 2964 – 28 X + 28,5 X^2 – 0,53 X^3 …(3) (-1,8) (0,6) (-1,3)

** معنوى عند المستوى الإحتمالى 0,01
حيث :Y = القيمة التقديرية لتكاليف الإنتاج الكلية بالجنيه .
X = حجم الإنتاج بالقنطار.

المصدر: جمعت وحسبت من بيانات الإستبيان لعينة الدراسة 2012/ 2013 م.

4- التقدير الإحصائي لدالة التكاليف الكلية لمحصول القطن لإجمالي عينة الدراسة :

توضح نتائج المعادلة رقم (1) بالجدول رقم (5) وجود علاقة طردية بين التكاليف الكلية لمحصول القطن والإنتاج الفعلى لمزارعى العينة حيث أتضح أن زيادة الإنتاج بمقدار قنطار واحد سنوياً يؤدى إلى زيادة التكاليف بحوالى 396 جنيه .

وقد ثبت معنوية هذه العلاقة عند المستوى الإحتمالى 0,05، و يوضح معامل التحديد أن نحو 84 % من التغير فى التكاليف الكلية لمحصول القطن بالعينة يعود إلى عوامل مرتبطة بالإنتاج .

جدول رقم (5) التقدير الاحصائى لدالة التكاليف الكلية لمحصول القطن لإجمالى عينة الدراسة
في مناطق الإصلاح الزراعى بمحافظة البحيرة

الصورة الرياضية	الحجم المعظم	الحجم المدنى	F	R^{-2}	دوال التكاليف
الخطية	-	-	404**	0,84	TC= 1182+ 396 X …(1) (20)**
التربيعية	34,8	26,6	203**	0,85	TC= 1466 + 324 X + 3,74 X^2 ….(2) (5,1)** (2,17)**
التكعيبية			136**	0,85	TC= 899 + 551 X – 21,1 X^2 + 0,76 X^3 …(3) (1,5) (-1,04) (1,08)

حيث : **Y = القيمة التقديرية لتكاليف الإنتاج الكلية بالجنيه .**
X = حجم الإنتاج بالقنطار.

كما أوضحت نتائج المعادلة رقم (2) بالجدول رقم (5) والتى تعبر عن الصورة التربيعية لدالة التكاليف الكلية لمحصول القطن فى مناطق العينة حيث يشـير معامل التحديد المعدل R^{-2} إلى أن التقلبات فى الإنتاجية تفسـر نحو 85% من التقلبات فى التكاليف الكلية.

كما أمكن إشتقاق دالة متوسط التكاليف بالقسمة على متغير الإنتاج X كما يلي:-

$$A.C = \frac{T.C}{X} = \frac{1466}{X} + 324 + 3,74X$$

حيث يمكن إيجاد قيمة متوسط التكاليف عند مستويات الإنتاج المختلفة بالتعويض بقيم X المختلفة كذلك أمكن إشتقاق دالة التكاليف الحدية بإيجاد المشتقة التفاضلية الأولي للمعادلة بالنسبة لمتغير الإنتاج X .

$$M.C = \frac{d\,T.C}{d\,X} = 324+7,48X$$

حيث يمكن إيجاد التكاليف الحدية عند مســتويات الإنتاج المختلفة بالتعويض بقيم X ، وبمســاواة دالة التكاليف الحدية بمتوسط التكاليف الكلية أمكن الحصول على حجم الإنتاج الذى يدنى التكاليف والذى قُدر بحوالى 19,8 قنطار للفدان.

و توضــح المعادلة رقم (3) بالجدول رقم (5) التقدير الإحصــائي لدالة التكاليف الكلية لمحصــول القطن فى الصــورة التكعيبية باســتخدام بيانات الإنتاج والتكاليف الكلية بالعينة، حيث جاءت إشــارات الثوابت متفقة مع المنطق الاقتصــادي الذى توضــحه النظرية الإقتصادية من حيث أن تكاليف الإنتاج تزيد أولاً بمعدل متناقص ثم تزيد بعد ذلك بمعدل متزايد. ولكن لم تثبت المعنوية الإحصائية لكل المعالم المقدرة .

ثانياً : أهم المشكلات التى تواجه مزارعى القطن فى عينة الدراسة :

يواجه البنيان الزراعى المصرى مجموعة من المشاكل التى من شأنها أن تعوق العملية الإنتاجية الزراعية من ناحية وتقلل من كفاءة استخدام الموارد من ناحية أخرى، ويتضمن هذا البحث أهم المشاكل والصعوبات التى تواجه الزراع فى عينة الدراسة، مع اقتراح وإيجاد الحلول الممكنة لهذه المشاكل من وجه نظر المزارع والمهتمين بهذا المجال.

وقد أظهرت نتائج الدراسة الميدانية وجود بعض المشكلات التى تواجه منتجى القطن بعينة الدراسة بمناطق الإصلاح الزراعى والتى تتمثل في:

أ- المشاكل الإنتاجية:

تشير البيانات الواردة فى الجدول رقم (6) إلى أن مشكلة إرتفاع أسعار مستلزمات الإنتاج وعدم توافرها تتبوأ المقدمة بين مشاكل هذه المجموعة، حيث أكد على وجودها حوالى 100% من مزارعى عينة الدراسة ، كما تأكد إحصائياً وجود كل من المشكلة المتعلقة بإرتفاع تكاليف العمليات الزراعية، والمشكلة المتعلقة بإنخفاض إنتاجية الصنف المزروع بالإضافة إلى مشكلة طول فترة مكث المحصول بالتربة ، وانخفاض ربحية المحصول حيث أكد على وجود هذه المشاكل نحو 91%، 54,5%، 84%، 77% على التوإلى من إجمالى عدد المزارعين فى عينة البحث، ولم يتأكد إحصائياً وجود باقى مشاكل هذه المجموعة.

وتشير نتائج استبيان آراء المزارعين بعينة الدراسة إلى وجود مشكلات أخرى على نفس الدرجة من الأهمية، والتى تتمثل في وجود مشاكل بالتربة، وضعف مياه الرى، وارتفاع تكاليف الرى، وعدم نظافة التقاوى، وعدم توافر المبيدات و ارتفاع تكاليف الجني والعمليات الزراعية، وعدم توافر الخدمات الإرشادية، ونقص الخدمات بالجمعية .

جدول رقم (6) المشاكل الإنتاجية للقطن فى مزارع عينة الدراسة
خلال الموسم الزراعى 2013/2012

م	المشكلة	موافق		غير موافق		مربع كاى X^2
		عدد	%	عدد	%	
1	ارتفاع تكاليف العمليات	70	91	7	9	*21,4
2	ارتفاع أسعار مستلزمات الإنتاج	77	100	-	-	*44,2
3	كثرة الإصابات والمبيدات غير فعالة	63	80,5	14	19,5	3,6
4	انخفاض إنتاجية الصنف المزروع	42	54,5	35	44,5	*9,6
5	عدم توفر الأيدي العاملة وارتفاع أجرها	40	52	37	48	3,27
6	طول فترة مكث المحصول بالتربة	65	84	12	16	*11,5
7	انخفاض ربحية المحصول بالنسبة للمحاصيل الأخرى	59	77	18	33	*18,3

حيث: * تشير للمعنوية الإحصائية.

المصدر: جمعت وحسبت من بيانات استبيان عينة الدراسة للموسم الزراعى 2013/2012.

وقد أكد المزارعون على ضرورة فرض رقابة على تجارة الأسمدة والمبيدات، والعمل على دعم مستلزمات الإنتاج لإعطاء الزراع الفرصة لإضافة الكميات المقررة من الأسمدة والمبيدات وغيرها من عناصر الإنتاج فى المواعيد المناسبة، كما أكد المزارعون أيضاً على أهمية تطوير وتحسين الأصناف المزروعة من الأقطان فائقة الطول وزراعة أصناف ذات إنتاجية أعلى من الأصناف الحالية، وأشار الزراع أيضاً إلى أهمية استنباط أصناف ذات أعمار أقصر من الأصناف المزروعة حتى يمكن لمحصول القطن المنافسة مع باقى المحاصيل الصيفية على الرقعة المتاحة للزراعة.

ب- مشاكل التسويق والتمويل :

1- مشاكل التسويق :

- اعتماد المنتجين على الأسواق الداخلية بسبب الحماية الجمركية (الضرائب، رسوم التصدير) مما جعلهم يفضلون السوق الداخلية عن التصدير.
- إرتفاع الرسوم الجمركية على مستلزمات الإنتاج اللازمة لعملية التصدير الأمر الذى ترتب عليه إرتفاع تكلفة الإنتاج وبالتالى ضعف القدرة التنافسية للمنتجات الزراعية.
- تذبذب الإنتاج المحلى بما لايسمح بإجراء تعاقدات طويلة الأجل تضمن التواجد المستمر بالأسواق الخارجية.
- عدم إلتزام المنتجين بمواعيد الزراعة والجمع فى الفترة الزمنية المناسبة للوفاء بإحتياجات الأسواق الخارجية.
- إرتفاع تكاليف النقل ومشاكل عدم إنتظامه.

2-**مشاكل تمويلية** : يعانى منتجي القطن من مشكلة التمويل نتيجة إحجام البنوك عن التمويل نظراً لانخفاض الأسعار العالمية.

- إحجام البنوك التجارية عن تمويل الصادرات الزراعية وتفضيل تصريف الناتج فى السوق المحلى.
- عدم قدرة الجهاز المصرفي على فتح الإعتمادات أو تظهير خطابات الاعتماد بالسداد مما أدى إلى لجوء بعض المصدرين إلى شركات التأمين فى الدول المتقدمة لتمويل التجارة.
- عدم توفير رأس المال اللازم لتمويل الصادرات سواء عن طريق البنوك التجارية أو عن طريق بنك تنمية الصادرات الذى يمنح المصدرين القروض بنفس القواعد والأسس التى تسير عليها البنوك التجارية دون أى تسهيلات إضافية سواء من ناحية شروط السداد أو سعر الفائدة أو فترة السماح.
- سعر الصرف، ويتمثل فى توفير العملات الأجنبية فى إستيراد المستلزمات اللازمة لعملية التصدير وإن أختلف تأثير سعر الصرف بسبب تحريره مما أدى لضعف تأثيره على الصادرات.
- الضرائب، حيث تأتى فى الترتيب الأخير بسبب دعم الدولة لبعض الصادرات وتوحيد الضريبة خاصة على صادرات بعض السلع الزراعية، وبالرغم من ذلك فكلما زادت حجم التجارة تزيد نسبة الضرائب عليها.

3- اتجاه المصانع المصرية إلى الإستيراد من الخارج :

فى تقرير أعدته اللجنة العامة لتنظيم تجارة القطن حول الموقف الحالي لمحصول القطن، حيث حذر التقرير من خطورة الاتجاه إلي استيراد أقطان أجنبية من الخارج، حيث تشير الأرقام إلي استيراد نحو مليوني قنطار بأسعار تقل عن أسعار الأقطان المصرية لدعمها من دولها تقل صفاتها الغزلية كثيرا عن الصفات الغزلية للأقطان المصرية.

أوضح التقرير أن المغازل المحلية تستخدم الأقطان المستوردة وتحصل علي دعم من الحكومة قدره 225 مليون جنيه علي الغزول والأقمشة المصنعة من هذه الأقطان، وذلك مقابل الدعم الذي وافقت عليه الحكومة لكامل محصول موسم2009/2008 وقدره 225 مليون جنيه، ومعني ذلك عدم اقبال المغازل المحلية علي استخدام القطن المصري، الأمر الذي يتطلب حتمية إيقاف الدعم للغزول والأقمشة الناتجة عن تصنيع الأقطان المستوردة، وقصر هذا الدعم علي الغزول والأقمشة المصنعة من الأقطان المصرية، وذلك حتي يمكن تصريف الأقطان المصرية والحد من الاستيراد من الخارج .

الملخص والتوصيات

تبين من نتائج الدراسة أن هناك العديد من العوامل التى تؤثر على إنتاج محصول القطن في مناطق الإصلاح الزراعى والتى تتمثل في عناصر الإنتاج التى تبين وجود علاقة طردية بين الكمية المستخدمة منها والكمية المنتجة من محصول القطن، والتى تمثلت في العمالة البشرية والأسمدة البلدية وغيرها من تلك العوامل التى تتطلب التوسع في إستخدامها.

وبتقدير دوال الإنتاج الفيزيقية لمحصول القطن فى مناطق الإصلاح الزراعى بمحافظة البحيرة أظهرت النتائج أن الإشارة

الموجبة لمعاملات إنحدار عناصر العمل البشرى، المبيدات، المساحة تدل على أنها ذو تأثير طردى على كمية الإنتاج، أى أنه بزيادة الكمية المستخدمة منها بنسبة 1% تؤدى إلى زيادة المحصول بنحو 0,52% ، 0,22% ، 1,03% لكل منهم على الترتيب، وذلك بفرض ثبات العوامل الأخرى المؤثرة على كمية الإنتاج، أى أن هذه العناصر لا تستخدم بالكمية المثلى لذا يجب العمل على زيادة الكمية المستخدمة منها كما أشارت النتائج التى تم الحصول عليها من تقدير دوال التكاليف إلى صعوبة الوصول إلى الحجم الأمثل الذى يدنى تكاليف الإنتاج وضرورة الاهتمام بالأصناف ذات السمعة والسعر العالمى المرتفع لتحقيق الربح المناسب للمزارع.

وقد أظهرت نتائج الدراسة الميدانية لآراء المزارعين بعينة الدراسة أن من أهم المشكلات التى يعانون منها، وجود مشاكل بالتربة، ضعف مياه الرى، ارتفاع تكاليف الرى، عدم نظافة التقاوى ، وعدم توافر المبيدات وارتفاع تكاليف الجنى والعمليات الزراعية ، عدم توافر الخدمات الإرشادية ، نقص الخدمات بالجمعية .

وقد أكد المزارعون على ضرورة فرض رقابة على تجارة الأسمدة والمبيدات، والعمل على دعم مستلزمات الإنتاج لإعطاء الزراع الفرصة لإضافة الكميات المقررة من الأسمدة والمبيدات وغيرها من عناصر الإنتاج فى المواعيد المناسبة، كما أكد الزراع على أهمية تطوير وتحسين الأصناف المزروعة من الأقطان فائقة الطول وزراعة أصناف ذات إنتاجية أعلى من الأصناف الحالية، وأشار الزراع أيضاً إلى أهمية إستنباط أصناف ذات أعمار أقصر من الأصناف المزروعة حتى يمكن لمحصول القطن المنافسة وقد أظهرت نتائج الدراسة الميدانية لآراء المزارعين بعينة الدراسة أن من أهم المشكلات التى يعانون منها، وجود مشاكل بالتربة، وضعف مياه الرى، وارتفاع تكاليف الرى، وعدم نظافة التقاوى ، وعدم توافر المبيدات وارتفاع تكاليف الجنى والعمليات الزراعية ، عدم توافر الخدمات الإرشادية ، ونقص الخدمات بالجمعيات التعاونية بمناطق الإصلاح الزراعى.

وفى ضوء ماتوصل إليه البحث من نتائج فقد أمكن التوصل إلى التوصيات التالية:

- الإهتمام بالمساحات الكبيرة التى أثبتت كفاءة إنتاجية مرتفعة في إنتاج محصول القطن.
- ضرورة تفعيل دور التعاونيات فى أراضى الإصلاح بما يكفل لها الحفاظ على مكانتها فى النهوض بوضع الزراع وتحقيق أعلى إنتاج.
- ضرورة توفير مراكز تجميع للمحصول وتشديد الرقابة عليها للحفاظ على المحصول بعد الجنى وإجراء مزاد علني لضمان تحقيق أعلى سعر للزراع .
- ضرورة توفير الأصناف الجيدة والمحسنة والرقابة على المزارعين لمنع اختلاط الأصناف مما يؤدى لتدهور الإنتاج .
- ضرورة توفير المستلزمات من الأسمدة الكيماوية للمزارعين وتوزيعها وفقا لخصوبة التربة وليس وفقا للمساحة .

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AN ECONOMIC STUDY ON THE PRODUCTIVITY EFFICIENCY, AND THE PROBIEM OF COTTON FARMERS IN AGRICULTURAL REFORM ZONE IN Al-BEHEIRA GOVERNORATE

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Abstract

The study aimed to identify the economics of producing Egyptian cotton in the agricultural reform zone and to know the opinions of farmers in the Egyptian cotton policy and the changes that have occurred. Such study should evaluate the production efficiency of cotton crop in the reform areas by estimating the production functions, For production and the most important cost items, in addition to studying the production efficiency of cotton crop and encouraging farmers to continue production. the study relied mainly on preliminary data obtained from the field study carried out on a sample of farmers in Al-Beheira governorate. The results showed that the positive indication of the regression coefficients of human labor, pesticides, and area indicated that it had a direct effect on the quantity of production, by increasing the quantity used. The farmers stressed the need to impose control on the trade of fertilizers and pesticides, and to support the production requirements to give farmers the opportunity to add the prescribed quantities of fertilizers, pesticides and other elements of production on the appropriate dates. The farmers stressed the importance of developing and improving varieties of high-length cotton, Higher than the current varieties. The farmers also pointed to the importance of cultivating varieties of shorter life than cultivars so that the cotton crop can compete with the rest of the summer crops on the area available for agriculture.

In Light of the findings of the research results as it has been possible to research the following Recommendations :

- The necessity of activating the role of cooperatives in the areas of reform so as to ensure that they maintain their position in promoting the status of farmers and achieving the highest production.
- The need to provide collection centers for the crop and tighten control to maintain the harvest after the Ginny and conduct an auction to ensure the highest price for agriculture.
- The need to provide good and improved varieties and control of farmers to prevent the mixing of varieties, which leads to the deterioration of production.
- The need to provide the chemical requirements for the farmer and distributed according to soil fertility and not according to the area.