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ORIGINAL ARTICLE

EFFECT OF WATER STRESS AND ORGANIC FERTILIZATION SOURCES ON MAIZE GROWTH AND YIELD

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Abstract : A field experiment was conducted at the Experimental Station Farm, Faculty of Agriculture, Mansoura University, Egypt, during 2017 and 2018 seasons to study the effect of water stress (skipping of some irrigations) and organic fertilization sources (without, farmyard manure "FYM", poultry manure "PM" and compost) as well as their interactions on growth, yield and its components and grains quality of maize. The experiment was carried out in strip-plot design with three replications. The obtained results from this investigation illustrate that giving maize plants 7200 m^3/ha irrigation water divided equally in 6 irrigations gave the highest values of all studied characters of growth, yield and its attributes as well as grains quality in both seasons while skipping second and third irrigations, respectively (giving maize plants 4800 m^3/ha irrigation water divided equally in 4 irrigations was accompanied with the least values of these characters in both seasons. Organic fertilizing maize with poultry manure (PM) gave the highest values of growth characters, yield and its attributes, grains quality characters, and followed by organic fertilizing with compost then organic fertilizing with farmyard manure (FYM) in both seasons. It can be recommended that giving maize plants 7200 m^3/ha irrigation water divided equally in 6 irrigations and organic fertilizing with poultry manure at the rate of 20 m^3/h in order to maximize its growth, productivity and grain quality and giving plants 4800 m^3/ha irrigation water divided equally in 4 irrigations by skipping second and third irrigations, respectively and organic fertilizing with poultry manure at the rate of 20 m^3/h to save irrigation water (2400 m^3/ha) and maintain highest productivity and grain quality under the environmental conditions of Egypt.

Key words : *Zea mays*, Drought, Skipping irrigations, Farmyard manure, Compost.

1. Introduction

The importance of cereal grains to the nutrition of millions of people around the world is widely recognized. After the wheat and rice, maize (*Zea mays* L.) is the most important cereal grain in the world, providing nutrients for humans and animals. In industrialized countries, a larger proportion of the grain used as livestock feed and as industrial raw material for food and nonfood uses. In developing countries it is used mainly as human food, although its use as animal feed is increasing. It has great nutritional value as it contain about 66.70% starch, 10% protein, 4.8% oil, 8.5% fiber, 3% sugar and 7% ash [Chaudhary (1983)]. Therefore, a great attention should be paid to raise maize productivity either by increasing the cultivated area or maximizing yield per unit area in order to reduce the gap between its production and consumption. Among factors that enhance maize productivity under drought stress, using suitable organic fertilizer.

Water stress is one of the important factors which restricts agriculture production and reduce the use efficiency of dry lands. Therefore, recognition and utilization crops tolerant to water stress and the special crops improvement methods make it possible to use semi arid region. The maize crop requires adequate water in all stages of its physiological development to attain optimum productivity. But, like other cereal crops there are critical points in its growth stages where lack of soil moisture greatly impacts grain production and yield. Thus, safety measures must be taken to prevent

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loss of crop productivity due to avoidable circumstances. Water stress affects every aspect of plant growth and is mainly responsible for limiting yield of maize [Golbashy *et al*. (2010)]. Payero *et al*. (2008) indicated that water stress can affect growth, development and physiological processes of maize plants, which reduce biomass yield. Nejad *et al.* (2010) showed that effects of water stress on maize include the visible symptoms of reduced growth, delayed maturity and reduced crop yield. For instance, water stress has been shown to reduce plant and ear height, stalk diameter, ear leaf area and root growth. Hirich *et al*. (2012) concluded that yield and crop water productivity are crucial issues in sustainable agriculture, especially in high-demand resource crops such as maize. Khodarahmpour (2012) stated that water stress is believed to be one of the most important environmental factors that reduce growth, development and production of maize plants. Lee (2012) found that water deficit conditions prior to or during anthesis often resulted in early tassel silk emergence. The resulted ears had few kernels develop near the base of the ear that ultimately lead to lowers the yield. Rasheed and Rahman (2013) found that highly significant differences among the water stress treatments (at two reproductive stages (*i.e.* flowering and grain filling) were observed for grain yield. The average grain yield for drought stress treatment during flowering was 4480 kg/ha. However, the average grain yield for water stress treatment at grain filling was 4745 kg/ha. Seadh *et al*. (2014) stated that giving maize plants 3600 m^3 irrigation water divided equally in 6 irrigations produced the highest values of growth, yield and its attributes and grains quality characters. However, skipping second and fifth irrigations came in the second rank after normal irrigation treatment. Ghassemi-Golezani *et al*. (2018) showed that maximum number of grains per plant, 1000 grains weight, ear weight, grain yield and harvest index significantly decreased with increasing irrigation intervals (irrigations after 60, 80, 100 and 120 mm evaporation). Admasu *et al*. (2019) reported that moisture stress levels (full irrigation, 85% ETc, 75% ETc, 65% ETc, 55% ETc, 45% ETc, 35% ETc and 25% ETc) had a highly significant effect on maize grain yield. The highest grain yield was obtained from full irrigation (5524.8 kg/ ha), which was not significantly different with 85% ETc application (5206.5 kg/ha). Organic manure increases soil fertility, where in the short-term stimulates microbial activity that improves soil structure and in the long-term supplies NO_3 and NH_4 to aid crop production [Edwards and Someshwar (2000)]. Farmyard manure (FYM) is most important as it contains all the nutrients needed for crop growth including trace elements, albeit in small quantities. Poultry manure contains a large mass of easily fermentable organic matter. It is a prime source of major nutrients such as nitrogen, phosphorus and potassium. Poultry manure also plays an important role in maintaining soil health by improving soil structure, root movement and retention of water which facilitating the plant growth. The compost itself is beneficial for the land in many ways, including as a soil conditioner, a fertilizer, addition of vital humus or humic acids, and as a natural pesticide for soil. There are many investigations with respect to the effect of organic fertilization on maize growth. In this concern, Nofal and Hinar (2005) noticed that applying 10 m^3/fed of chicken manure or rice straw compost increased maize growth as compared with the control treatment. This increment may be attributed to organic manure contains of microorganisms, which fix and release phytohormones, which stimulate plant growth. Mohamed (2006) showed that un-mineral fertilizers detected significant changes in plant height, ELA, LA/plant, LAI, biomass/plant and first ear height. The highest values of these characters were resulted from application organic fertilizer (compost) at a rate of 2 t/fed. Hati *et al.* (2007) indicated that modest improvements in the nitrogen availability in organic fertilizers could be a result in a major cost saving for the farmers by reducing the requirement for mineral nitrogen fertilizer and reduce the risk of environmental pollution. Adejumo *et al.* (2010) observed that compost application significantly increased the vegetative growth of maize and performed better than inorganic fertilizer. Seadh *et al*. (2013) found that all studied characters exerted significant effect as a result of applying organic fertilization treatments. Applying the compost gave the highest values of all studied characters as compared with other treatments (without and FYM). Soro *et al*. (2015) revealed that positive impact of the manure on the growth and development of maize crop and highlighted the possibility of improving maize productivity by using poultry manure. Baddour *et al*. (2017) indicated that the highest mean values of vegetative growth, yield and its components and quality recorded with using chicken manure. Mahmood *et al*. (2017) showed that growth and yield of maize were substantially improved by fertilizer application alongside organic manures, whereas soil total organic C and total N, P, K contents increased when inorganic fertilizers were applied alone or in combined with organic manures. Mukhtiar *et al*. (2018) reported that use of organic manures for crop productivity not only improve crop production but also improving soil physicochemical properties. It also reduces soil and water pollution by acting as chelating agent for inorganic nutrients. Czekala *et al*. (2019) stated that organic fertilizers are gaining popularity due to the fact that the problems of deficiency of not only nutrients in plants, but also organic matter are more and more often noticed. Organic fertilizers are opening a way to solve these problems, especially considering that their price is much lower than that of mineral fertilizers, and production can take place on almost every farm.

Therefore, this investigation was done to study the water stress and organic fertilization sources as well as their interactions on growth, yield and its components as well as grain quality of maize hybrid TWC B 3521.

2. Materials and Methods

In order to study the effect of water stress and organic fertilization sources as well as their interactions on growth, yield and its components and grains quality of maize hybrid TWC B 3521, a field experiment was conducted at the Experimental Station Farm, Faculty of Agriculture, Mansoura University, Egypt, during 2017 and 2018 seasons. The Three-Ways Cross B 3521 (TWC B 3521) hybrid that used in this investigation was obtained from Maize Research Department, Field Crop Research Institute, Agriculture Research Center, Ministry of Agriculture and Land Reclamation, Egypt.

The experiment was carried out in strip-plot design with three replications. The vertical-plots were occupied with three water stress treatments (skipping of some irrigations) as follows: normal irrigation (6 irritations) *i.e.* control treatment (7200 m^3/ha), skipping second and third irrigations (4 irrigations) *i.e.* 4800 m^3/ha and skipping second and fifth irrigations (4 irrigations) *i.e.* 4800 m^3/ha. The first irrigation (Mohayah irrigation) was carried out after 21 days from sowing, then the other irrigations were followed every 15 days intervals. The water quantity in each irrigation was 1200 m^3/ha, therefore, in normal irrigation treatment plants received 7200 m^3/ha, while in second irrigation treatment (skipping second and third irrigations) and third irrigation treatment (skipping second and fifth irrigations) plants received 4800 m^3/ha, except sowing irrigation. The horizontal-plots were assigned to organic fertilization sources *i.e.* without organic fertilization (control treatment), farmyard manure (FYM) at the rate of 45 m^3/ha, poultry manure (PM) at the rate of 20 m^3/ha and compost at the rate of 9.5 t/ha.

Farmyard manure (FYM) and poultry manure (PM) were added in each experiment area before soil preparation. Whereas, compost was added after plowing and leveling and before ridging. Chemical analysis of farmyard manure, poultry manure and compost used in both seasons is presented in Table 1. Each experimental basic unit included five ridges, each of 70 cm width and 3.0 m length, resulted an area of 10.5 m^2. The preceding winter crop was Egyptian clover (*Trifolium alexandrinum* L.) in both seasons.

Table 1 : Chemical analysis of farmyard manure, poultry manure and compost used in both seasons.

Properties	Farmyard manure	Poultry manure	Compost
Weight (kg/m^3)	433	338	403
Moisture %	19.4	11.1	12.8
Organic matter %	59.5	83.6	64.6
Ash %	40.5	16.4	25.3
Total N %	1.19	4.06	2.66
Organic carbon %	34.3	48.3	41.52
C : N ratio	28:1	12:1	19 :1

Soil samples were taken at random from the experimental field area at a depth of 0-15 and 15-30 cm from soil surface before soil preparation during the growing seasons to measure the physical and chemical soil properties as shown in Table 2.

The experimental field well prepared for each experiment through two ploughing, leveling, compaction, ridging and then divided into the experimental units (10.5 m^2). Calcium superphosphate (15.5% P_2O_5) was applied during soil preparation at the rate of 350 kg/ha. Nitrogen fertilizer in the form of urea (46.0% N) was added at the rate of 280 kg N/ha in two portions, two-thirds after thinning (before the first irrigation) and the other third before the fourth irrigation. Potassium sulphate (48% K_2O) at the rate of 120 kg/ha was applied with the first dose of nitrogen fertilizer.

Table 2 : Mechanical and chemical analyses of the experimental soil in both seasons.

Soil analysis	**2017**	**2018**
A: Mechanical analysis		
Clay (%)	49.86	49.05
Silt (%)	27.18	27.38
Fine sand (%)	20.31	20.84
Coarse (%)	2.65	2.73
Texture class	Clayey	Clayey
B: Chemical analysis		
$CaCO_3$ (%)	3.65	3.61
Organic matter (%)	1.55	1.63
Available nitrogen (ppm)	28.15	30.25
Available phosphate (ppm)	7.25	9.35
Exchangeable potassium (ppm)	145.10	155.20
EC (ds/m) at 25 °C	1.95	1.82
pH	7.65	7.60

Maize seeds were hand sown in hills 25 cm apart at the rate of 2-3 seeds/hill using dry sowing method (Afir) on one side of the ridge during the last week of April in both seasons. The plants were thinned to one plant per hill before the first irrigation. The other agricultural practices were kept the same as normally practiced in maize fields according to the recommendations of Ministry of Agriculture and Land Reclamation, except for the factors under study.

2.1 Studied characters

2.1.1 Growth characters

After 100 days from sowing, random samples of five guarded plants were taken randomly from each plot to determine the following characters:

1. Plant height (cm).
2. Ear height (cm).
3. Ear leaf area (cm^2), it was calculated by the following formula according to **Gardner *et al.* (1985)**

Ear leaf area = Ear leaf length × maximum width of ear leaf × 0.75

2.1.2 Yield and its attributes

At harvest time (after 120 days from sowing) random samples of five guarded plants were taken at random from each plot to determine the following characters:

1. Ear length (cm) 2. Ear diameter (cm)

3. Ear weight (g) 4. Number of rows/ear

5. Number of grains/row

6. Ear grains weight (g).

7. 100-grain weight (g).

8. Grain yield (t/ha) : It was determined by the weight of grains per kilograms adjusted to 15.5% moisture content of each plot, then converted to tons per hectare.

9. Stover yield (t/ha) : The stover resulted from previous sample was weighted in kg/plot and then it was converted to tons per hectare.

2.1.3 Grains quality

1. Crude protein percentage: It was estimated by the improved Kjeldahl - Method according to A.O.A.C. (1990), modified by distilling the ammonia into saturated boric solution and titration in standard acid. Crude protein percentage was calculated by multiplying the total nitrogen values in maize flour by 5.75.

2. Oil percentage (%): It was estimated in dried seeds sample (50 g) taken from each sub-plot, cleaned and ground into very fine powder by grinder to determine seed oil percentage as described by A.O.A.C. (1990) using Soxhelt apparatus and petroleum hexane as an organic solvent.

All obtained data were statistically analyzed according to the technique of analysis of variance (ANOVA) for the strip - plot design as published by Gomez and Gomez (1984) by using "MSTAT-C" computer software package. Least significant difference (LSD) test was used to compare the differences among treatment means at 5% level of probability as described by Snedecor and Cochran (1980).

3. Results and Discussion

3.1 Effect of Water Stress Treatments

Results obtained from Tables 3 and 4, growth characters (plant height, ear height and ear leaf area), yield and its attributes (ear length, ear diameter, ear weight, number of rows/ear, number of grains/row, ear grains weight, 100-grain weight, grain and stover yields/ ha) and grains quality characters (crude protein and oil percentages) of maize were significantly affected by different studied water stress treatments *i.e.* normal irrigation (6 irritations, 7200 m^3/ha), skipping second and third irrigations (4 irrigations, 4800 m^3/ha) and skipping second and fifth irrigations (4 irrigations, 4800 m^3/ha) in the two growing seasons. There were substantial differences in all studied characters among various water stress treatments, despite giving plants the same previous quantity of irrigation water and number of irrigations in both seasons. Control treatment (giving maize plants 7200 m^3/ha irrigation water divided equally in 6 irrigations) gave the highest values of all studied characters of growth, yield and its attributes as well as grains quality in both seasons. However, skipping second and third irrigations, respectively (giving maize plants 4800 m^3/ha irrigation water divided equally in 4 irrigations) was accompanied with the least values of all studied characters in both seasons. It is worthy to mention that skipping second and fifth irrigations (giving maize plants 4800 m^3/ha irrigation water divided equally in 4 irrigations) arranged between aforementioned water stress treatments with respect to their effect on growth, yield and its attributes as well as grains quality characters in both seasons. This increase in growth characters due to decreasing irrigation stress by giving maize plants 7200 m^3/ha irrigation water divided equally in 6 irrigations may be due to moisture for maize plants continuously, which allows better growth, thereby enhancement vegetative growth attributes and resulting in taller plants. Also, these increases in grain yield are mainly due to the increments in ear length and diameter, ear grains weight and 1000-grain weight. However, these increases in growth and yield attributes of maize due to reduced water stress and securing sufficient moisture throughout the growing season may be attributed to enhance photosynthesis process, consequently improvement growth and yields of maize. On the contrary, inadequate supply of water at critical development stages (elongation and flowering) and high sensitivity of maize to water stress are of immense importance. Where, water is also important for the plant for maintaining its turgidity [Rasheed and Rahman (2013)]. These findings are in good conformity with those reported by Seadh *et al*. (2014), Ghassemi-Golezani *et al*. (2018) and Admasu *et al*. (2019).

3.2 Effect of Organic Fertilization Sources.

Data presented in Tables 3 and 4 illustrate that, the effect of organic fertilization sources *i.e.* without organic fertilization (control treatment), farmyard manure (FYM) at the rate of 45 m^3/ha, poultry manure (PM) at the rate of 20 m^3/ha and compost at the rate of 9.5 t/ha on growth characters (plant height, ear height and ear leaf area), yield and its attributes (ear length, ear diameter, ear weight, number of rows/ear, number of grains/row, ear grains weight, 100-grain weight, grain

Table 3 : Plant and ear heights, ear leaf area, ear length and diameter, number of rows/ear and number of grains/row of maize as affected by water stress treatments and organic fertilization sources as well as their interactions during 2017 and 2018 seasons.

Characters / Treatments	Plant height (cm)		Ear height (cm)		Ear leaf area (cm^2)		Ear length (cm)		Ear diameter (cm)		Number of rows/ear		Number of grains/row	
	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
A- Water stress treatments														
Normal irrigation	208.8	240.5	128.5	128.8	676.3	765.1	18.36	19.06	4.34	4.91	15.25	15.71	33.15	38.72
Skipping 2nd and 3rd irrigations	185.6	228.7	116.6	123.5	539.1	643.3	16.42	18.03	4.18	4.79	14.00	13.23	31.75	36.27
Skipping 2nd and 4th irrigations	187.9	238.9	124.0	126.7	634.8	713.6	18.00	18.95	4.30	4.89	14.86	14.32	32.84	38.33
LSD at 0.05	5.7	4.2	3.3	2.3	12.6	11.6	0.50	0.40	0.04	0.06	0.21	0.25	0.62	0.82
B- Organic fertilization sources														
Without	179.3	225.9	114.6	118.1	505.2	638.4	16.63	17.51	4.12	4.55	13.69	12.86	30.40	34.76
Farmyard manure "FYM"	191.5	234.6	121.9	126.1	580.3	687.0	17.35	18.52	4.24	4.84	14.42	14.32	31.86	36.73
Poultry manure "PM"	206.8	245.5	132.2	133.9	729.3	770.2	18.60	19.79	4.43	5.19	15.67	16.18	35.07	41.51
Compost	198.9	238.0	123.7	127.2	652.1	733.6	17.79	18.91	4.30	4.88	15.04	14.32	33.00	38.08
LSD at 0.05	7.5	7.5	2.7	2.1	23.7	22.9	0.52	0.21	0.17	1.07	0.59	0.61	1.01	0.94
C- Interaction (F-test)														
A × B	NS	NS	*	NS	NS	*	NS	NS	NS	NS	NS	*	NS	*

and stover yields/ha) and grains quality characters (crude protein and oil percentages) of maize was significant in both seasons of this investigation. There were substantial differences in all studied characters among various studied organic fertilization sources in both seasons. Organic fertilizing maize with poultry manure (PM) at the rate of 20 m^3/ha gave the highest values of growth characters, yield and its attributes and grains quality characters under study in both seasons. It is worthy to mention that organic fertilizing maize with compost at the rate of 9.5 t/ha arranged after aforementioned organic fertilization treatment (PM treatment) and followed by organic fertilizing maize with farmyard manure (FYM) at the rate of 45 m^3/ha with respect to their effect on growth characters, yield and its attributes and grains quality characters in both seasons. However, control treatment (without organic fertilization) was accompanied with the least values of growth characters, yield and its attributes and grains quality characters in the two growing seasons. Such superiority of fertilizing maize by poultry manure in increasing growth characters may be due to poultry manure contains a large mass of easily fermentable organic matter and main source of major nutrients such as nitrogen, phosphorus and potassium, besides plays an important role in maintaining soil health by improving soil structure, root movement and retention of water which facilitating the plant growth [Mukhtiar *et al.* (2018)]. In addition, compost improves action of organic matter on physical, biological and chemical properties of soil, soil organic matter, nitrogen content and exchangeable cations consequently enhanced photosynthesis and the other bio-chemical processes inside maize plants. Also, farmyard manure is most important as it contains all the nutrients needed for crop growth including trace elements, albeit in small quantities. Comparable results were reported by several researchers such as Nofal *et al*. (2005), Mohamed (2006), Adejumo *et al*. (2010), Seadh *et al*. (2013), Soro *et al*. (2015) and Baddour *et al*. (2017).

3.3 Effect of Interaction

Regarding the effect of interaction, there are many significant effect of the interaction between water stress treatments and organic fertilization sources on the studied characters. We present only the effect of significant interaction on grain yield and its quality (grain yield/ha, crude protein and oil percentages in maize grains) as presented in Table 4.

Table 4 : Ear weight, ear grains weight, 100-grain weight, grain and stover yields/ha, crude protein and oil percentages in maize grains as affected by water stress treatments and organic fertilization sources as well as their interactions during 2017 and 2018 seasons.

Characters / Treatments	Ear weight (g)		Ear grains weight (g)		100-grain weight (g)		Grain yield (t/ha)		Stover yield (t/ha)		Protein(%)		Oil(%)	
	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
A- Water stress treatments														
Normal irrigation	231.8	348.3	189.8	297.4	41.47	41.65	6.942	9.411	**29.833**	**24.674**	9.75	10.03	4.39	4.48
Skipping 2nd and 3rd irrigations	207.9	284.0	147.4	226.8	36.34	36.99	6.047	7.178	**23.922**	**22.134**	8.17	8.73	2.05	2.14
Skipping 2nd and 4th irrigations	218.8	329.2	168.4	280.4	39.78	39.78	6.488	8.873	**26.937**	**23.195**	9.48	9.67	3.91	4.00
LSD at 0.05	10.5	9.2	11.4	12.4	1.15	1.12	0.324	0.522	0.532	0.626	0.06	0.07	0.30	0.25
B- Organic fertilization sources														
Without	186.0	243.8	139.7	201.3	33.63	36.01	5.379	6.370	**21.430**	**20.042**	8.65	8.99	2.80	2.897
Farmyard manure "FYM"	215.7	320.6	162.4	271.5	37.72	39.45	6.257	8.591	**24.562**	**21.428**	9.11	9.45	3.35	3.449
Poultry manure "PM"	246.3	388.6	192.7	324.1	45.00	41.88	7.424	**10.257**	**32.688**	**27.316**	9.59	9.93	4.08	4.181
Compost	229.9	328.9	179.3	276.0	40.44	40.56	6.908	8.731	**28.909**	**24.552**	9.18	9.53	3.56	3.661
LSD at 0.05	16.0	14.8	18.3	19.8	2.20	1.65	0.706	0.823	4.407	4.774	0.23	0.22	0.11	0.16
C- Interaction (F. test)														
A × B	NS	*	NS	*	NS	*	*	*	*	*	*	*	*	*

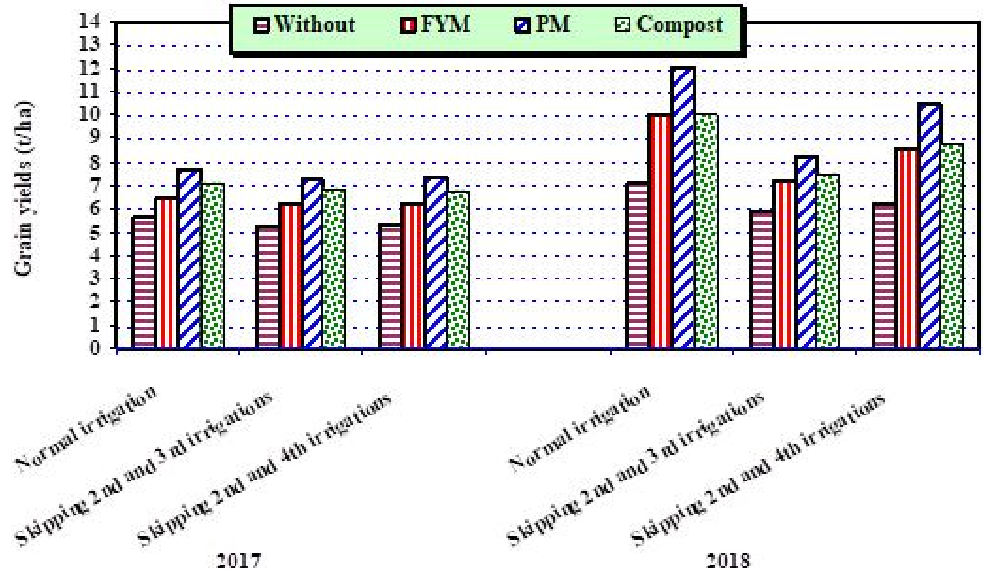

Fig. 1 : Grain yields/ha of maize as affected by the interaction between water stress treatments and organic fertilization sources during 2017 and 2018 seasons.

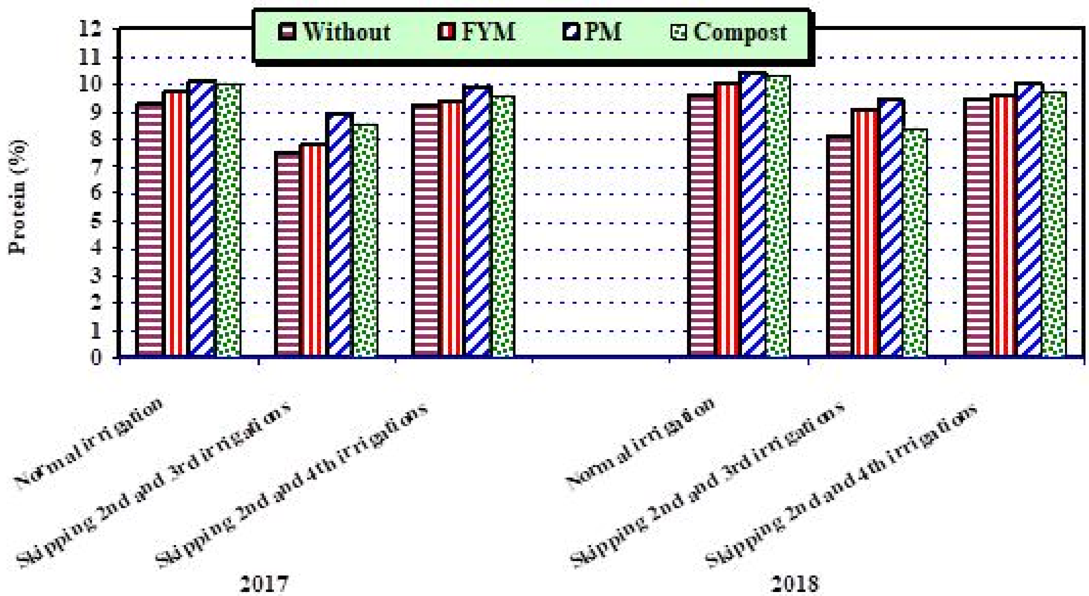

Fig. 2 : Crude protein percentage in maize grains as affected by the interaction between water stress treatments and organic fertilization sources during 2017 and 2018 seasons.

Grain yield was significantly affected by the interaction between water stress treatments and organic fertilization sources in both seasons. The maximum values of grain yield/ha were obtained from giving maize plants 7200 m^3/ha irrigation water divided equally in 6 irrigations and organic fertilizing with poultry manure at the rate of 20 m^3/h in the two growing seasons as shown in Fig. 1. The second best interaction treatment was organic fertilizing with compost at the rate of 9.5 t/ha and giving maize plants 7200 m^3/ha irrigation water divided equally in 6 irrigations in both seasons. While, increasing water stress by skipping second and third irrigations, respectively (giving plants 4800 m^3/ha irrigation water divided equally in 4 irrigations) without organic fertilization resulted in the lowest values of grain yield in both seasons.

The interaction between water stress treatments and organic fertilization sources showed significant effect on crude protein percentage in maize grains in both seasons. The highest values of crude protein percentage in maize grains were obtained from organic fertilizing with poultry manure at the rate of 20 m^3/h and giving maize plants 7200 m^3/ha irrigation water divided equally in 6 irrigations as shown from data

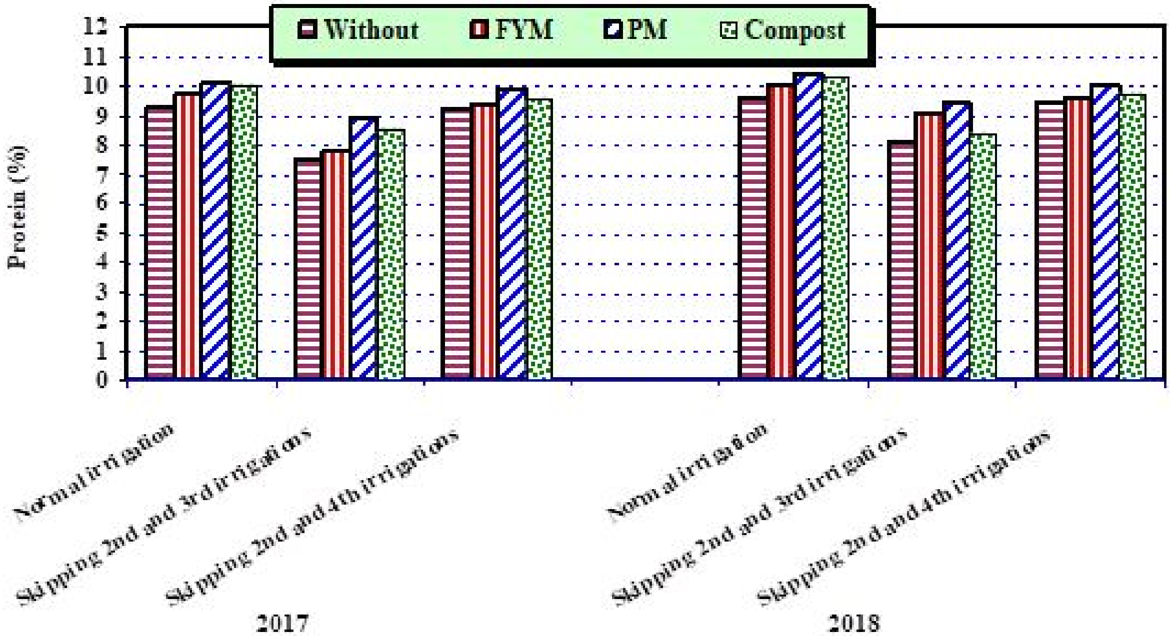

Fig. 3 : Oil percentage in maize grains as affected by the interaction between water stress treatments and organic fertilization sources during 2017 and 2018 seasons.

shown in Fig. 2. This treatment followed by organic fertilizing with compost at the rate of 9.5 t/ha and giving maize plants 7200 m^3/ha irrigation water divided equally in 6 irrigations in both seasons. Whilst, skipping second and third irrigations, respectively (giving plants 4800 m^3/ha irrigation water divided equally in 4 irrigations) without organic fertilization resulted in the lowest values of crude protein percentage in maize grains in both seasons.

Oil percentage in maize grains was significantly affected by the interaction between water stress treatments and organic fertilization sources in both seasons. The highest values of oil percentage in maize grains were obtained from organic fertilizing with poultry manure at the rate of 20 m^3/h and giving maize plants 7200 m^3/ha irrigation water divided equally in 6 irrigations as shown from data shown in Fig. 3. Organic fertilizing with compost at the rate of 9.5 t/ha and giving maize plants 7200 m^3/ha irrigation water divided equally in 6 irrigations was the second best interaction treatment in both seasons. Whilst, giving plants 4800 m^3/ha irrigation water divided equally in 4 irrigations by skipping second and third irrigations, respectively without organic fertilization resulted in the lowest values of oil percentage in maize grains in both seasons.

4. Conclusion

It can be recommended that giving maize plants 7200 m^3/ha irrigation water divided equally in 6 irrigations and organic fertilizing with poultry manure at the rate of 20 m^3/h in order to maximize its growth, productivity and grain quality and giving plants 4800 m^3/ha irrigation water divided equally in 4 irrigations by skipping second and third irrigations, respectively and organic fertilizing with poultry manure at the rate of 20 m^3/h to save irrigation water (2400 m^3/ha) and maintain highest productivity and grain quality under the environmental conditions of Egypt.

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