565
Annals
Agric. Sci.,
Ain Shams Univ.,
Cairo, 52(2), 565-586, 2007

RESPONSE OF MAIZE TO MINERAL AND BIO-PHOSPHORUS FERTILIZATION UNDER DIFFERENT IRRIGATION INTERVALS

[45]

Abdo, Fatma[1] A.
1- Crop Physiology Res., Dep., Field Crops Res. Institute, Agric. Res. Center, Giza, Egypt

Keywords: Maize, Phosphorus, Phosphorein, Proline, Chlorophyll fluorescence, Relative water content

ABSTRACT

A field experiment was conducted at Giza Agricultural Research Station, ARC, in 2005 and 2006 seasons to study the response of maize single cross SC 123 to mineral phosphorus and bio-fertilization under different irrigation intervals. Treatments applied were three irrigation intervals (14, 21 and 28 days), two rates of phosphorus (15 and 30 Kg P_2O_5 / faddan*) in the form of calcium super-phosphate (15.5 % P_2O_5) and uninoculation or inoculation of seeds with bio-fertilizer "phosphorein". Experimental design was spilt-plot, where irrigation intervals were assigned to the main plots and phosphorein and phosphorus treatments in the sub-plots. Prolonged irrigation interval from 14 to 21 days did not affect most of the studied growth and yield traits. However, increasing irrigation interval up to 28 days significantly reduced all the studied traits, except for proline content, which was increased. Data also indicated that raising the rate of phosphorus fertilizer from 15 to 30 kg P_2O_5 per faddan induced significant increases in plant height, dry weight of shoot / plant, specific leaf weight, maximum quantum yield, ears weight / plant, 100-grain weight, grains and stover weights / plant as well as per faddan (fad). Also, percentages of carbohydrates, total sugars, crude protein and phosphorus in mature grains were significantly increased as a result of raising phosphorus fertilizer rate. Phosphorein inoculation showed significant increases in all growth and yield traits under investigation compared with uninoculated grains. Bio-fertilizer treatment induced significant increase of 22.69 and 21.78 % for grains yield/faddan and 28.28and 24.43 % for stover yield / faddan in the first and second seasons, respectively. Also, total carbohydrates, total sugars, non-soluble carbohydrates, crude protein and phosphorus in grains were significantly increased in the second season by 6.21, 12.39, 4.67, 11.39 and 23.08 %, respectively. The interaction between irrigation intervals and phosphorus fertilizer and / or bio-fertilizer revealed significant effects on all growth and yield traits under investigation in both seasons. The maximum values of these traits were recorded when maize plants were irrigated every 14 days and received 30 kg P_2O_5 / fad in the presence of phosphorein. The highest values for water consumptive use during the two growing seasons were recorded when maize plants were irrigated every 14 days and received 30 kg P_2O_5 / fad in the presence of phosphorein. Whereas, water use efficiency reached its highest value with irrigation every 21 days. Irrigation every 21 days, to plants received 15 kg P_2O_5 / fad in the presence of phosphorein is considered the best treatment combination.

* One faddan = 4200 m^2

(Received September 10, 2007)
(Accepted November 3, 2007)

INTRODUCTION

Maize (*Zea mays* , L.) is one of the most important cereal crops in Egypt and it ranks the third important cereal crop after wheat and rice. Water supply is considered to be a limiting factor for production and highly desirable to obtain high yield of maize by using the best amount of irrigation water due to its sensitivity to drought. Insufficient water supply as a result of prolonging irrigation intervals or decreasing the available moisture in the soil clearly inhibits plant growth.

El-Noemani *et al* (1990) found that maize plants exposed to water stress (irrigation every 18 days instead of 12 days) significantly inhibited plant growth, ear length, ear diameter, ear weight, number of grains / row, number of rows / ear, 1000 grains weight, grains and straw yields as well as shelling percentage. **Sinclair *et al* (1990)** stated that water deficits at anthesis resulted in a large decrease in accumulated biomass, which resulted in turn a directly loss in grain yield of maize. **Mahrous (1991)** found that increasing irrigation interval from 15 to 21 days was not effective. Whereas, significant decreases in yield traits were occurred at 28 and 35 days intervals. **Ibrahim *et al* (1992)** reported that plant height, total leaf area / plant, No. of ears / plant, grain yield / plant and per faddan of maize were significantly increased with the decrease in irrigation period.

Abu-Grab and Othman (1999) subjected maize plants to drought at vegetative growth, flowering or grain filling stages. The check treatment was regularly irrigated. Drought at flowering reduced grain yield by 34.39 % and stover yield by 18.3 %. **Khalifa *et al* (2002)** found that relative water content (RWC) of plant leaves was lower under water stress than under normal irrigation. Water stress resulted in a reduction in grain yield, No. of ears / 100 plants, ear length and ear diameter, No. of rows / ear, No. of kernels / row, 100 – kernel weight and plant height. **Abdel-Aziz and El-Bialy (2004)** reported that plant height, leaf area, ear length, ear diameter, number of rows / ear, ear weight, ear grain weight and 100-grain weight of maize (Single cross 10) were decreased under dry conditions of soil moisture (75 – 80 %).

Phosphorus is one of the major essential macronutrients for plant growth and production. Under Egyptian conditions, a great attention is being devoted to reduce the higher rates of mineral fertilizers by using bio-fertilized farming system. Many investigators demonstrated that bio-fertilization with phosphate dissolving micro-organisms might be comparable to a treatment with chemical phosphate fertilizer.

Ragab and Rashad (2003) observed that bio-fertilizer inoculation treatment reduced proline accumulation and increased total chlorophyll content in leaves of sorghum plants which were grown under water stress and received half of recommended rate of phosphorus compared to control treatment. **Rashad and Ragab (2003)** indicated that bio-fertilizer inoculation treatment led to significant increases in leaf area and yield components of sorghum under water stress and received half of recommended rate of phosphorus fertilizer compared to control treatment.

Therefore, the present investigation aimed to study the enhancement effect of bio-fertilizer for improving phosphorus use efficiency under different irrigation intervals on growth, chlorophyll fluorescence, leaf proline concentration, relative water content percentage, grain yield and its attributes as well as certain chemical contents in grains of maize.

MATERIALS AND METHODS

The present investigation was carried out at Giza Experimental Station, Agricultural Research Center, during the two successive summer seasons of 2005 and 2006 to study the effect of inoculation with phosphate dissolving bacteria (PDB)* and mineral phosphorus fertilization under different irrigation intervals on growth, grain yield and some chemical constituents of maize single cross 123. Treatments were:

1. Three irrigation intervals (14, 21 and 28 days).
2. Two phosphorein (uninoculation and inoculation) as well as two phosphorus rates (15 and 30 kg P_2O_5 / fad).

Experimental design was split–plot with four replications. Irrigation intervals were assigned in the main plots, whereas phosphorus rates and bio-fertilizer treatments were in the sub-plots. Plots were separated from each other to avoid the interference between irrigation treatments, 3.0 meter beds were left among the main plots. Plot size was 1/200 faddan (6 x 3.5 m^2), which included 6 rows, 5 m long and 70 cm apart. Hills were spaced 30 cm apart. Maize grains, two to three kernel / hill, were hand planted on June 11 and 14 in the first and second seasons, respectively. Thinning to one plant per hill was done before the first irrigation, which was applied 21 days after planting.

* Commercial product namely phosphorein, related by Ministry of Agriculture, Giza, Egypt.

Soil physical and chemical properties were conducted according to **Jackson (1967)** and presented in **Table (1)**.

Irrigation treatments were applied after the second irrigation. Calcium super phosphate (15.5 % P_2O_5) at the rate of 100 kg / fad (half of the recommended rate) or 200 kg / fad (recommended rate) were added during seed bed preparation. Maize grains were un-inoculated or inoculated with bio-fertilizer phosphorein (*Bacillus Sp.*) at the rate of 5 gm phosphorein / 100 gm grains before planting using Arabic gum (20 %) as an adhesive agent. Nitrogen fertilizer, in the form of ammonium nitrate (33.5 % N), at the rate of 120 kg N / fad was applied in two equal doses before the first and second irrigations. Potassium fertilizer at the rate of 50 kg / fad as potassium sulphate (48 % K_2O) was added before the first irrigation. All other cultural practices were carried out as recommended.

Harvest was done on October 1 and 3 in the first and second seasons, respectively.

Recording of data

I. Growth traits

At mid-silking (68 days after planting), five individual plants were chosen from the second row of each sub-plot to study the following measurements:

1. Plant height (cm).
2. Number of full expanded green leaves per plant.
3. Dry weight of shoot / plant (g), plant parts were dried at 70°C using an electric oven until the constant weight.
4. Total leaf area/plant (cm^2) according to **Strickler (1964)** using the following formula:

Leaf area = leaf length x maximum leaf width x 0.75

5. Specific leaf weight (SLW) in mg/cm^2, according to the following formula of **Hunt (1990)**:

SLW = leaf dry weight / leaf area.

II. Physiological traits

1. Chlorophyll fluorescence was determined in the second season only, in the leaf just below the main ear. Determination of the maximum quantum yield of photo-system II (PS II) was made using Chlorophyll Fluorometer (OS – 30, Opti – Sciences, Inc. USA.) of four plants in each treatment by the formula according to **Maxwell and Johnson (2000)** as follows:

$$Fv / Fm = \frac{Fm - Fo}{Fm}$$

Where:

F_v / F_m is the maximal quantum efficiency of PS II (M.Q.E.), F_m is the maximal chlorophyll fluorescence and F_o is the minimum chlorophyll fluorescence (in the dark).

After measuring chlorophyll fluorescence, the same leaf was used to determine proline concentration and relative water content percentage (RWC %).

2. Leaf proline concentration (LPC), in mg /g fresh weight (FW).
   Proline was quantified spectrophotometrically by the method of **Bates *et al* (1973)**.
3. Relative water content percentage:
   The used leaves were immediately weighed (FW) then transferred to sealed flasks, then rehydrated in water for 5 h until fully turgid at 4° C, surface dried and reweighed (turgid weight, TW). The leaf samples were then oven dried at 70° C for 48 h and reweighed (dry weight, DW) according to **Lazcano – Ferrat and Lovatt (1999)**. The RWC % was calculated as follows:

$$RWC(\%) = \frac{(FW - DW)}{(TW - DW)} X 100$$

III. Yield and yield components

At harvest, ten guarded plants were randomly chosen from the third central row in each sub-plot and the following plant traits were measured:

1. Ear length (cm).
2. Ear diameter (cm).
3. Number of rows / ear.
4. Number of kernels / row.
5. Ears weight / plant (g).
6. 100 – grain weight (g).
7. Grains weight / plant (g).
8. Stover weight / plant (g).

At harvest, all plants in the fourth and fifth rows in each sub-plot were harvested and adjusted to 15.5 % moisture to estimate:

9. Grain yield in ardab* (ard) / fad.
10. Stover yield / fad (ton).

* One ardab = 140 kg.

Table 1. Some physical and chemical properties of the experimental sites

Seasons	Particle size distribution				Texture class	Organic matter %	PH	Ec soil paste extract ds/m	Available nutrients (ppm)		
	Coarse sand %	Fine Sand %	Silt %	Clay %					N	P	K
2005	3.40	28.50	29.90	38.20	Clay loam	1.64	7.6	0.62	49	8.9	486
2006	3.48	28.12	30.80	37.60	Clay loam	1.58	7.4	0.68	52	9.2	481

IV- Chemical composition of maize grains

At harvest time, sample of mature grains (in the second season only) was preparated to chemical analysis in three replicates. The following determinations were conducted:

1. Total carbohydrates were determined as glucose % according to **Dubois *et ul* (1956).**
2. Total sugars were determined by extraction from dried grains with ethanol 80 % **(A.O.A.C., 1990).**
3. Non-soluble carbohydrate was calculated as the difference between the concentration of total carbohydrate and total sugars.
4. Crude protein percentage was calculated by multiplying total nitrogen percentage by 6.25 **(A.O.A.C., 1990).**
5. Phosphorus percentage was determined colourmetrically according to **Moore and Chapman (1986).**

V– Water Relations

1. Water consumptive use (WCU)

Soil samples were taken with a regular auger at planting time, just before and after 48 hours of each irrigation and at harvest time for soil moisture determination. Soil moisture constants i.e. field moisture capacity (FMC), permanent wilting point (PWP) were determined gravimetrically and calculated on oven dry basis as well as bulk density for the experimental sites and recorded as shown in **Table (2).**

Water consumptive use for each irrigation treatment was calculated via soil samples taken from successive four layers from 0 - 15 cm. up to depth 45 - 60 cm, depth of soil profile according to **(Israelsen and Hansen, 1962):**

$$\mathbf{CU = D \times Bd \times e_2 - e_1 / 100}$$

Where :

CU : Water consumptive use (ET) in cm.
D : Soil layer depth (cm).
Bd : Bulk density (g / cm^3).
e_1 , e_2 : % Soil moisture content by weight before and after irrigation; respectively. .

Table 2. Bulk density and some soil moisture constants of the experimental site

Soil depth cm	Bulk density gm/cm^3	FMC %, W/W	PWP %, W/W	Available moisture %
0 – 15	1.14	34.50	16.50	18.00
15 –30	1.20	32.00	15.80	16.20
30 – 45	1.18	29.40	14.90	14.50
45 - 60	1.23	26.50	13.40	13.10

2. Water use efficiency (WUE)

Water use efficiency, in the present trial, is expressed as kg of maize grain produced due to the consumption of 1 cm water depth per faddan

Water use efficiency was calculated for each irrigation treatment according to the formula described by **Pierre *et ül* (1965)** as follows:

WUE = grain yield (kg /fed) / seasonal water consumptive in cm.

Statistical analysis

The estimated data were subjected to the appropriate statistical analysis and means were compared using LSD values at 5 % level of probability **(Snedecor and Cochran 1982).**

RESULTS AND DISCUSSION

I. Growth traits

Data presented in **Tables (3 and 4)** show the effect of irrigation intervals, phosphorus and phosphorein on some growth traits of maize plant at 68 days after planting, including plant height, number of green leaves / plant, dry weight of shoot / plant, total leaf area / plant and specific leaf weight.

Results clearly showed that prolonged irrigation intervals decreased the values of the previous traits in both seasons. The reduction due to prolonging irrigation interval from 14 to 21 days was insignificant, except for specific leaf weight. However, prolonging interval to 28 days caused a significant reduction in all investigated traits. Such reduction was estimated by 12.87 and 15.60 % for plant height, 8.33 and 5.80 % for number of leaves / plant, 28.69 and 30.47 % for dry weight of shoot / plant, 7.22 and 7.19 % for total leaf area / plant and 16.85 and 12.15 % for specific leaf weight of maize in the first and second seasons, respectively. The obtained results are in agreement with those reported by **El-Noemani *et al* (1990), Mahrous (1991), Ibrahim *et al* (1992), Khalifa *et al* (2002) and Abdel-Aziz and El-Bialy (2004).** They stated that increasing irrigation intervals significantly decreased growth traits. In this connection, **Kozolowski (1988),** found that extending the irrigation intervals more than 20 days caused a progressive and consistent increase in osmotic pressure of the soil solution. This may resulted in a decrease in synthesis of metabolites, translocation of nutrients from soil to plants and within plants, and cell division and elongation, and thus decreased the growth traits.

Data presented in **Tables (3 and 4)**, revealed that raising the rate of phosphorus fertilizer induced significant increases of 5.90 and 8.21 % for plant height, 6.44 and 10.51 % for dry weight of shoot / plant and 7.48 and 3.27 % for specific leaf weight of maize plant in the first and second seasons, respectively.

The role of phosphorus as a major nutrient element, where phosphorus compounds are of absolute necessity for all living organisms, nucleoproteins constituting the essential substances of the cell and for cell division and development of meristematic tissues. These effects reflected on vigorous vegetative growth such as plant height and specific leaf weight. In this respect, **Hajabbasi and Schumacher (1994)**, showed that phosphorus deficiency severely reduced the leaf area and biomass accumulation of maize plant.

Regarding the effect of bio-fertilizer, data in **Tables (3 and 4)** indicated that inoculation of grains with phosphorein had significant increase in all investigated growth traits in both studied seasons compared with plants obtained from uninoculated grains. The beneficial effect of inoculation with phosphate dissolving bacteria was mainly by improving the release of P in the soil, which reflected in increasing P activity and growth promoting substances produced by it. Bio-fertilizer may lead to the activation of cell division and cell enlargement and finally increasing the growth parameters. The increments in growth traits of maize plant due to bio-fertilization treatment were 16.29 and 14.57 % for plant height, 3.72 and 3.03 % for number of leaves / plant, 15.78 and 13.72 for dry weight of shoot / plant, 4.85 and 4.62 % for leaves area / plant, and 7.71 and 12.85 % for specific leaf weight in the first and second seasons, respectively.

Hassan *et al* (2006) stated that the enhancing effect of bio-fertilizer on growth traits in plants may be attributed to many factors such as (a) its ability to release plant promoting substances, mainly Indole acetic acid (IAA), Gibberellic acid (GA_3) and cytokinin, like substances, which might be stimulated plant growth, (b) synthesis of some vitamins: e.g., B_{12} (c) increasing amino acids content (d) enhancing the production of biologically active fungistatical substances which may change the micro-flora in the rhizosphere and affect the balance between harmful and beneficial organisms, (e) increasing water and minerals uptake from soil. This might be ascribed to increasing root surface area, root hairs and root elongation as affected by bio-fertilizer.

The interaction between phosphorus fertilizer and bio-fertilizer revealed significant effects on plant height, shoot dry weight / plant, leaf area / plant and specific leaf weight. Increasing the phosphorus rate either by using bio-fertilizer or mineral fertilizer induced significant increases in most growth traits in both seasons. The increases in growth traits were more pronounced in the presence of bio-fertilizer. In this connection, **Rashad and Ragab (2003)** on sorghum plants reported that plant height and dry weight of leaves increased significantly by using bio-fertilizer under different levels of mineral fertilizers. They stated that bio-fertilizer saved about 25 to 50 % of the used mineral fertilizers especially phosphorus.

Table 3. Growth traits of maize at the age of 68 days as affected by the bio-fertilizer phosphorein and phosphorus fertilizer under different irrigation intervals in 2005 season

Irrigation interval (days)	Phosphorus (kg / fad)	Plant height (cm) Bio-fertilizer inoculation Non	Plant height (cm) Bio-fertilizer inoculation Inoculation	Plant height (cm) Mean	No. of leaves / plant Bio-fertilizer inoculation Non	No. of leaves / plant Bio-fertilizer inoculation Inoculation	No. of leaves / plant Mean	Dry weight of shoot / plant (g) Bio-fertilizer inoculation Non	Dry weight of shoot / plant (g) Bio-fertilizer inoculation Inoculation	Dry weight of shoot / plant (g) Mean	Total Leaf area / plant (cm^2) Bio-fertilizer inoculation Non	Total Leaf area / plant (cm^2) Bio-fertilizer inoculation Inoculation	Total Leaf area / plant (cm^2) Mean	Specific leaf weight (mg / cm^2) Bio-fertilizer inoculation Non	Specific leaf weight (mg / cm^2) Bio-fertilizer inoculation Inoculation	Specific leaf weight (mg / cm^2) Mean
14	15	209.75	235.25	**222.50**	16.00	16.50	**16.25**	148.54	168.49	**158.52**	8335	9041	**8688**	4.96	5.37	**5.17**
	30	211.75	240.75	**226.25**	16.25	17.00	**16.63**	154.99	173.24	**164.12**	8379	9147	**8763**	5.61	5.89	**5.75**
	Mean	**210.75**	**238.00**	**224.38**	**16.13**	**16.75**	**16.44**	**151.77**	**170.87**	**161.32**	**8357**	**9094**	**8726**	**5.29**	**5.63**	**5.46**
21	15	180.25	228.50	**204.38**	15.75	16.25	**16.00**	139.86	156.65	**148.26**	8229	8592	**8411**	4.62	5.12	**4.87**
	30	202.00	229.25	**215.63**	16.00	16.50	**16.25**	148.52	160.68	**154.60**	8275	8754	**8515**	4.89	5.22	**5.06**
	Mean	**191.13**	**228.88**	**210.01**	**15.88**	**16.38**	**16.13**	**144.19**	**158.67**	**151.43**	**8252**	**8673**	**8463**	**4.76**	**5.17**	**4.97**
28	15	160.54	209.40	**184.97**	14.50	15.25	**14.88**	90.15	125.15	**107.65**	7958	8009	**7984**	4.21	4.56	**4.39**
	30	200.60	211.50	**206.05**	15.00	15.50	**15.25**	110.95	133.87	**122.41**	8194	8221	**8208**	4 50	4.88	**4.69**
	Mean	**180.57**	**210.45**	**195.51**	**14.75**	**15.38**	**15.07**	**100.55**	**129.51**	**115.03**	**8076**	**8115**	**8096**	**4.36**	**4.72**	**4.54**
Mean	15	183.51	224.38	**203.95**	15.42	16.00	**15.71**	126.18	150.10	**138.14**	8174	8547	**8361**	4.60	5.02	**4.81**
	30	204.78	227.17	**215.98**	15.75	16.33	**16.04**	138.15	155.93	147.04	8283	8707	**8495**	5.00	5.33	5.17
Bio-fertilizer mean		**194.15**	**225.78**	**209.97**	**15.59**	**16.17**	**15.88**	**132.17**	**153.02**	**142.59**	**8228**	**8627**	**8428**	**4.80**	**5.17**	**4.99**
L.S.D. (0.05) For :																
Irrigation	(I)		**18.80**			**1.29**			**13.17**			**510**			**0.36**	
Phosphorus	(P)		*			**NS**			*			**NS**			**	
Bio-fertilizer	(B)		**			*			**			*			**	
P x B			**13.26**			**NS**			**9.29**			**360**			**0.22**	
I x P			**16.24**			**1.12**			**11.38**			**435**			**0.31**	
I x B			**16.24**			**1.12**			**11.38**			**435**			**0.31**	
I x P x B			**22.96**			**1.58**			**16.08**			**623**			**0.44**	

* , ** and NS indicate significant at 0.05, 0.01 and insignificant. respectively.

Table 4. Growth traits of maize at the age of 68 days as affected by the bio-fertilizer phosphorein and phosphorus fertilizer under different irrigation intervals in 2006 season

Irrigation interval (days)	Phosphorus (kg / fad)	Plant height (cm)			No. of leaves / plant			Dry weight of shoot / plant (g)			Total Leaf area / plant (cm²)			Specific leaf weight (mg / cm²)		
		Bio-fertilizer inoculation		Mean	Bio-fertilizer inoculation		Mean	Bio-fertilizer inoculation		Mean	Bio-fertilizer inoculation		Mean	Bio-fertilizer inoculation		Mean
		Non	Inoculation		Non	Inoculation		Non	Inoculation		Non	Inoculation		Non	Inoculation	
14	15	231.50	250.50	**241.00**	17.0	17.5	**17.25**	163.28	176.45	**169.87**	8806	9493	**9150**	4.95	5.59	**5.27**
	30	233.50	255.50	**244.50**	17.0	17.5	**17.25**	171.12	184.14	**177.63**	8881	9596	**9238**	5.04	5.80	**5.42**
	Mean	**232.50**	**253.00**	**242.75**	**17.0**	**17.5**	**17.25**	**167.20**	**180.30**	**173.75**	**8844**	9544	**9194**	**5.00**	**5.70**	5.35
21	15	**181.00**	235.50	**208.25**	16.5	17.0	**16.75**	145.05	160.54	**152.80**	8655	8947	**8801**	4.48	5.03	**4.76**
	30	221.00	245.50	**233.25**	16.5	17.0	**16.75**	165.26	181.72	**173.49**	8715	9147	**8931**	4.65	5.28	**4.97**
	Mean	**201.00**	**240.50**	**220.75**	**16.5**	**17.0**	**16.75**	**155.16**	**171.13**	**163.15**	**8685**	**9047**	**8866**	**4.57**	**5.16**	**4.87**
28	15	170.00	215.50	**192.75**	16.0	16.5	**16.25**	95.70	128.67	**112.19**	8324	8483	**8404**	4.36	4.92	**4.64**
	30	209.00	225.00	**217.00**	16.0	16.5	**16.25**	116.18	142.65	**129.42**	8603	8722	**8662**	4.50	4.99	**4.75**
	Mean	**189.50**	**220.25**	**204.88**	**16.0**	**16.5**	**16.25**	**105.94**	**135.66**	**120.81**	**8464**	**8602**	**8533**	**4.43**	**4.96**	**4.70**
Mean	15	194.17	233.83	**214.00**	16.5	17.0	**16.75**	134.68	155.22	**144.95**	8595	8974	**8785**	4.60	5.18	**4.89**
	30	221.17	242.00	**231.58**	16.5	17.0	16.75	150.85	169.50	160.18	8733	9155	**8944**	4.73	5.36	5.05
Bio-fertilizer MEAN		**207.67**	**237.92**	**222.79**	**16.5**	**17.0**	**16.75**	**142.77**	**162.36**	**152.57**	**8664**	**9064**	**8864**	**4.67**	**5.27**	**4.97**
L.S.D. (0.05) For :																
Irrigation (I)			22.55			0.79			14.29			538			0.37	
Phosphorus (P)			**			NS			**			NS			**	
Bio-fertilizer (B)			**			*			**			*			**	
P x B			15.53			NS			10.78			380			0.23	
I x P			19.20			0.74			12.56			460			0.32	
I x B			19.20			0.74			12.56			460			0.32	
I x P x B			27.03			0.97			17.45			694			0.45	

* , ** and NS indicate significant at 0.05, 0.01 and insignificant, respectively.

Concerning the interaction between irrigation intervals and phosphorus fertilizer, it had significant effects on all growth traits under investigation. However, results indicated that increasing irrigation interval from 14 to 21 days at the high rate of phosphorus fertilizer (30 kg P_2O_5 / fad) showed no significant effect on all studied traits except specific leaf weight in both seasons. However, prolonging irrigation interval up to 28 days caused a significant reduction in all traits. On the contrary, increasing irrigation interval from 14 to 28 days induced significant reduction in all traits under the low rate of phosphorus.

The interaction effect between irrigation intervals and bio-fertilizer revealed significant effects on all growth traits in both seasons. At the same irrigation interval plant height, dry weight of shoot / plant and specific leaf weight were remarkably increased with bio-fertilizer. Increasing irrigation interval from 14 to 21 days increased plant height to different extents with and without bio-fertilizer. This increase in plant height did not reach the significant level with the inoculation of bio-fertilizer.

The interaction among the three studied factors (irrigation intervals x phosphorus rates x bio-fertilizer) proved significant effects on all growth traits in both seasons **Tables (3 and 4)**. The highest values of all traits were obtained when maize plants irrigated every 14 days, received 30 kg P_2O_5 / fad, and treated with bio-fertilizer.

It is evident that increasing phosphorus fertilizer either by using bio-fertilizer or mineral phosphorus induced significant increases in most growth traits at the same irrigation interval. It is worth to note that using bio-fertilizer with the low rate of mineral phosphorus increased the studied growth traits to the level or even higher than that increases obtained with the high rate of mineral fertilizer. This means that the recommended rate of mineral phosphorus could be reduced to the half by adopting the technique of bio-fertilizer inoculation "phosphorein". In other words, phosphorus bio-fertilizer could substitute half of the recommended rate of phosphorus fertilizer. This reflects directly on reducing fertilizer cost and decreased the environmental pollution.

II. Physiological traits

Chlorophyll fluorescence, leaf proline concentration (LPC) and relative water content percentage (RWC %) were considered as physiological indicators for the plant status under water stress treatments.

Data presented in **Table (5)**, show that increasing irrigation intervals significantly decreased chlorophyll fluorescence and RWC %, but increased LPC. Prolonged irrigation intervals from 14 to 21 or 28 days caused significant reduction of 9.49 and 28.86 % for maximum quantum yield (MQY) of maize plants in the second season; respectively. In this connection, **Rohacek and Bartak (1999), Maxwell and Johnson (2000), Hunt (2003) and Manetas (2004)** reported that chlorophyll fluorescence is very useful to study the effect of water stress on plants since photosynthesis is often reduced in plants experiencing adverse conditions. The reduction value of this quantum yield of photosynthesis indicated damage of PS II that may have arisen from the environmental factors or the application of inhibitors. Worthy to mention that raising the rate of phosphorus fertilizer from 50 to 100 % of the recommended rate resulted in a significant increase of 8.64 % in maximum quantum yield of maize plants.

Regarding the effect of bio-fertilizer, leaves of maize plants obtained from inoculated grains with phosphorein had 22.26 % more level of MQY than those obtained from uninoculated grains. All interactions were significantly affected chlorophyll fluorescence. The highest value was obtained when maize plants were irrigated at 14 days interval and received the recommended dose of phosphorus in the presence of bio-fertilizer.

Results presented in **Table (5)**, indicate that prolonged irrigation intervals from 14 to 21 or 28 days caused significant increase of 45.57 and 83.30 % for leaf proline concentration; respectively. These results are similar with those obtained by **Voetberg and Sharp (1991), Lazcano–Ferrat and Lovatt (1999), Khalifa *et al* (2002)** and **Ragab and Rashad (2003)**. They suggested that proline is the most actively accumulated amino acid, both in terms of the total amount accumulated and the percentage which, increases during drought stress.

It is confirmed that neither phosphorus nor bio-fertilizer inoculation had any significant effect on LPC.

Statistical analysis revealed that the interaction between irrigation intervals, phosphorus fertilizer and bio-fertilizer had a significant effect on leaf proline content and the lowest value was obtained when maize plants irrigated at 14 days intervals and received the recommended dose of phosphorus in the presence of bio-fertilizer.

Table 5. Chlorophyll fluorescence, leaf proline concentration and relative water content of maize at the age of 68 days as affected by the bio-fertilizer phosphorein and phosphorus fertilizer under different irrigation intervals in 2006 season

Irrigation interval (days)	Phosphorus (kg / fad)	Maximum quantum yield			Leaf proline concentration (mg/ gf.w)			*Relative water content %*		
		Bio-fertilizer inoculation		*Mean*	Bio-fertilizer inoculation		*Mean*	Bio-fertilizer inoculation		*Mean*
		Non	Inoculation		Non	Inoculation		Non	Inoculation	
14	15	0.634	0.884	**0.759**	0.713	0.557	**0.635**	86.385	88.530	**87.458**
	30	0.746	0.896	**0.821**	0.554	0.473	**0.514**	87.131	88.857	**87.994**
	Mean	**0.690**	**0.890**	**0.790**	**0.634**	**0.515**	**0.575**	**86.758**	**88.694**	**87.726**
21	15	0.602	0.745	0.674	0.893	0.855	**0.874**	81.764	83.076	**82.420**
	30	0.656	0.854	0.755	0.827	0.773	**0.800**	82.974	85.606	**84.290**
	Mean	**0.629**	**0.800**	**0.715**	**0.860**	**0.814**	**0.837**	**82.369**	**84.341**	**83.355**
26	15	0.538	0.558	0.548	1.109	1.066	**1.088**	76.264	79.576	77.920
	30	0.541	0.611	0.576	1.056	0.981	**1.019**	77.974	80.106	**79.040**
	Mean	**0.540**	**0.585**	**0.562**	**1.083**	**1.024**	**1.054**	**77.119**	**79.841**	**78.480**
Mean	15	0.591	0.729	0.660	0.905	0.826	**0.866**	81.471	83.727	**82.599**
	30	0.648	0.787	0.717	0.812	0.742	**0.777**	82.693	84.856	**83.775**
Bio-fertilizer mean		**0.620**	**0.758**	**0.689**	**0.859**	**0.784**	**0.822**	**82.082**	**84.292**	**83.187**
L.S.D. (0.05) For:										
Irrigation (I)			**0.044**			**0.186**			**3.014**	
Phosphorus (P)			**			**NS**			**NS**	
Bio-fertilizer (B)			**			**NS**			**NS**	
P x B			**0.055**			**NS**			**NS**	
I x P			**0.060**			**0.254**			**4.16**	
I x B			**0.060**			**0.254**			**4.16**	
I x P x B			**0.086**			**0.365**			**5.895**	

*, ** and NS indicate significant at 0.05, 0.01 and insignificant, respectively.

As shown from the data presented in **Table (5)**, prolonged irrigation intervals from 14 to 21 or 28 days decreased relative water content of maize leaf by 4.98 and 10.54 %; respectively. However, raising phosphorus fertilizer or inoculated grains with bio-fertilizer did not exhibit any significant effect on this trait.

The interaction effect between phosphorus fertilizer and bio-fertilizer was not significant on RWC %. Irrigation x phosphorus x bio-fertilizer interaction had significant effect on RWC %. The highest value was obtained from plants obtained from inoculated grains with phosphorein and received the recommended rate of phosphorus under 14 days water interval.

In this respect, **Matin *et al* (1989), Lazcano–Ferrat and Lovatt (1999)** and **Khalifa *et al* (2002),** reported that RWC represents the leaf plant water status, it was decreased from nearly 100 % at turgid state to become less according to water scarcity in the surrounding plant environment.

III. Yield and yield components

Data presented in **Tables (6, 7, 8, 9 and 10)**, reveal that prolonged irrigation intervals, decreased all investigated yield traits of maize in both studied seasons.

Generally, the same trend was observed in the both seasons, the reduction in some traits such as ear length, ear diameter, number of rows / ear and grains weight / plant was not significant when plants were irrigated every 21 days compared to plants irrigated every 14 days. While, irrigation every 28 days produced significantly lower values than the irrigation every 14 days.

It is realized that increasing irrigation interval from 14 to 28 days brought about significant decrease of 10.47 and 11.11 % for ear length, 7.68 and 6.62 % for ear diameter, 9.70 and 11.53 % for No. of rows / ear, 17.09 and 14.79 % for No. of kernels/ ear , 38.80 and 36.34 % for ears weight / plant , 21.57 and 21.56 % for 100 – grain weight, 36.76 and 33.10 % for grains weight / plant, 33.13 and 34.55 % for stover weight / plant, 33.o8 and 32.78 % for grains yield / fad, and 14.98 and 19.92 % for stover yield / fad in the first and second seasons, respectively. These results are in agreement with the findings of **El–Noemani *et al* (1990), Mahrous (1991), Ibrahim *et al* (1992), Abu–Grab and Othman (1999), Khalifa *et al* (2002) and Abdel Aziz and El-Bialy (2004).** It should be mentioned that water stress markedly reduced physiological processes due to the reduction in water availability, which led to inhibition in photosynthetic activities of maize plants. Therefore, the whole plant growth and grain yield are affected.

Significant increase in ears weight / plant, 100 grain weight, grains and stover weights / plant, grains and stover yields / fad in both studied seasons were detected when phosphorus fertilizer was raised from 50 to 100 % of the recommended rate. Worthy to note that raising the rate of phosphorus fertilizer induced significant increase of 10.86 and 10.53 % for ears weight / plant, 4.23 and 3.96 % for 100 – grain weight, 8.89 and 9.31 % for grain weight / plant, 7.08 and 7.61 % for stover weight / plant, 8.37 and 8.75 % for grains yield / fad, and 9.07 and 8.84 % for stover yield / faddan in the first and second seasons, respectively.

The present findings are in harmony with those reported by **Rashad and Ragab (2003)** on sorghum. They observed that grains and straw yields were significantly increased with increasing phosphorus fertilizer rates.

Regarding the effect of bio-fertilizer, results in **Tables (6, 7, 8, 9 and 10)** clearly show that maize plants obtained from bio-fertilized grains with phosphorein gave significant increases in all yield traits under investigation in both studied seasons compared with plants, which obtained from uninoculated grains. The increments in yield traits due to bio-fertilization treatment were 13.78 and 9.54 % for ear length, 6.34 and 6.39 % for ear diameter, 9.19 and 9.63 % for number of rows / ear, 7.62 and 7.47 % for number of Kernels / row, 21.81 and 19.64 % for ears weight / plant, 7.16 and 6.45 % for 100 – grain weight, 20.53 and 18.76 % for grains weight / plant, 19.92 and 16.89 % for stover weight / plant, 22.69 and 21.78 % for grains yield / fad and 28.28 and 24.43 % for stover yield / faddan in the first and second seasons, respectively. The beneficial effect of bio-fertilizer on grain yield and its components might be attributed to the vigorous growth of bio-fertilized plants and to the increase in the amount of metabolites synthesis of these plants as well as to the role of bio-fertilizer in improving the absorption of the nutrients especially P, Fe, Zn, Mn and Cu which play important role in activation of the metabolic processes **(Mohamed, 2000)**. The present results are in line with those reported by **Rashad and Ragab (2003)** on sorghum.

The effect of all studied interactions were significant on all investigated traits with two exceptions, i.e ear diameter and number of rows/ear.

Table 6. Ear length and ear diameter of maize as affected by the bio-fertilizer phosphorein and phosphorus fertilizer under different irrigation intervals in 2005 and 2006 seasons

Irrigation interval (days)	Phosphorus (kg / fad)	Ear length (cm)						Ear diameter (cm)					
		2005			2006			2005			2006		
		Bio-fertilizer inoculation		Mean	Bio-fertilizer inoculation		Mean	Bio-fertilizer inoculation		Mean	Bio-fertilizer inoculation		Mean
		Non	Inoculation		Non	Inoculation		Non	Inoculation		Non	Inoculation	
14	15	18.25	20.00	19.13	19.20	21.20	20.20	4.30	4.60	4..45	4.43	4.83	4.63
	30	18.50	20.00	19.25	20.30	22.10	21.20	4.55	4.78	4.67	4.53	4.93	4.73
	Mean	**18.38**	**20.00**	**19.19**	**19.75**	**21.65**	**20.70**	**4.43**	**4.69**	**4.56**	**4.48**	**4.88**	**4.68**
21	15	16.75	19.25	18.00	18.67	20.80	19.74	4.20	4.58	4.39	4.33	4.60	4.47
	30	17.50	19.75	18.63	20.13	21.20	20.67	4.30	4.60	4.45	4.43	4.70	4.57
	Mean	**17.13**	**19.50**	**18.32**	**19.40**	**21.00**	**20.20**	**4.25**	**4.59**	**4.42**	**4.38**	**4.65**	**4.52**
28	15	15.10	18.20	16.65	16.90	19.03	17.97	4.07	4.20	4.14	4.27	4.40	4.34
	30	16.20	19.20	17.70	18.00	19.67	18.84	4.15	4.40	4.28	4.30	4.47	4.39
	Mean	**15.65**	**18.70**	**17.18**	**17.45**	**19.35**	**18.40**	**4.11**	**4.30**	**4.21**	**4.29**	**4.44**	**4.37**
Mean	15	16.70	19.15	17.93	18.26	20.34	19.30	4.19	4.46	4.33	4.34	4.61	4.48
	30	17.40	19.65	18.53	19.48	20.99	20.24	4.33	4.59	4.46	4.42	4.70	4.56
Bio-fertilizer mean		17.05	19.40	18.23	18.87	20.67	19.77	4.26	4.53	4.40	4.38	4.66	4.52
L.S.D. (0.05) For:													
Irrigation (I)			1.23			1.33			0.32			0.33	
Phosphorus (P)			NS			NS			NS			NS	
Bio-fertilizer (B)			**			**			*			*	
P x B			1.42			1.54			NS			NS	
I x P			1.60			1.73			0.43			0.45	
I x B			1.60			1.73			0.43			0.45	
I x P x B			2.26			2.44			0.61			0.63	

* , ** and NS indicate significant at 0.05, 0.01 and insignificant, respectively.

Table 7. Number of rows/ear and number of kernels/row of maize as affected by the bio-fertilizer phosphorein and phosphorus fertilizer under different irrigation intervals in 2005 and 2006 seasons

Irrigation interval (days)	Phosphorus (kg / fad)	No. of rows / ear						No. of kernels / row					
		2005			2006			2005			2006		
		Bio-fertilizer inoculation		Mean	Bio-fertilizer inoculation		Mean	Bio-fertilizer inoculation		Mean	Bio-fertilizer inoculation		Mean
		Non	Inoculation		Non	Inoculation		Non	Inoculation		Non	Inoculation	
14	15	12..50	14.00	**13.25**	12.67	14.33	**13.50**	41.75	43.25	**42.50**	41.67	44.67	**43.17**
	30	13.00	14.50	**13.75**	13.33	14.83	**14.08**	42.50	43.75	**42.13**	42.00	45.33	**43.67**
	Mean	**12.75**	**14.25**	**13.50**	**13.00**	**14.58**	**13.79**	**42.13**	**43.50**	**42.82**	**41.84**	**45.00**	**43.42**
21	15	12.00	13.25	**12.63**	12.00	13.33	**12.67**	37.75	42.50	**40.13**	40.33	42.67	**41.50**
	30	12.75	13.50	**13.12**	12.50	13.67	**13.09**	37.75	43.00	**40.38**	40.33	44.67	**42.50**
	Mean	**12.38**	**13.38**	**12.88**	**12.25**	**13.50**	**12.88**	**37.75**	**42.75**	**40.25**	**40.33**	**43.67**	**42.00**
28	15	11.50	12.50	**12.00**	11.33	12.47	**11.90**	33.00	36.00	**34.50**	35.00	38.00	**36.50**
	30	12.00	12.75	**12.38**	12.33	12.67	**12.50**	35.67	37.33	**36.50**	36.67	38.33	**37.50**
	Mean	**11.75**	**12.63**	**12.19**	**11.83**	**12.57**	**12.20**	**34.34**	**36.67**	**35.50**	**35.84**	**38.17**	**37.00**
Mean	15	12.00	13.25	**12.63**	12.00	13.38	**12.69**	37.50	40.75	**39.13**	39.00	41.78	**40.39**
	30	12.58	13.58	13.08	12.72	13.72	13.22	38.64	41.19	**39.92**	39.67	42.78	**41.22**
Bio-fertilizer mean		**12.29**	**13.42**	**12.86**	**12.36**	**13.55**	**12.96**	**38.07**	**40.97**	**39.52**	**39.34**	**42.28**	**40.81**
L.S.D. (0.05) For:													
Irrigation	(I)		**0.82**			**1.79**			**2.35**			**2.43**	
Phosphorus	(P)		**NS**			**NS**			**NS**			**NS**	
Bio-fertilizer	(B)		**			*			**			**	
P x B			**NS**			**NS**			**2.72**			**2.81**	
I x P			**1.07**			**1.08**			**3.21**			**3.32**	
I x B			**1.07**			**1.08**			**3.21**			**3.32**	
I x P x B			**1.51**			**1.53**			**4.33**			**4.48**	

* , ** and NS indicate significant at 0.05, 0.01 and insignificant, respectively

Table 8. Ears weight / plant and 100-grain weight of maize as affected by the bio-fertilizer phosphorein and phosphorus fertilizer under different irrigation intervals in 2005 and 2006 seasons

Irrigation interval (days)	Phosphorus (kg / fad)	Ears weight / plant (g)						100-grain weight (g)					
		2005			2006			2005			2006		
		Bio-fertilizer inoculation		Mean	Bio-fertilizer inoculation		Mean	Bio-fertilizer inoculation		Mean	Bio-fertilizer inoculation		Mean
		Non	Inoculation		Non	Inoculation		Non	Inoculation		Non	Inoculation	
14	15	275.04	345.38	310.21	281.31	347.61	314.46	40.18	41.33	40.76	41.29	42.24	41.77
	30	313.85	377.88	345.87	326.02	380.25	353.14	40.59	43.06	41.83	41.84	43.85	42.85
	Mean	294.45	361.63	328.04	303.67	363.93	333.80	40.39	42.20	41.30	41.57	43.05	42.31
21	15	262.20	302.87	282.54	271.86	309.28	290.57	37.13	40.31	38.72	37.64	40.88	39.26
	30	268.52	315.45	291.98	279.18	322.12	300.65	37.98	41.39	39.69	38.50	41.94	40.22
	Mean	265.36	309.16	287.26	275.52	315.70	295.61	37.56	40.85	39.21	38.07	41.41	39.74
28	15	162.42	200.05	181.24	173.53	216.02	194.78	29.81	32.35	31.08	30.96	32.97	31.97
	30	189.57	250.93	220.25	201.33	259.12	230.23	32.24	35.15	33.70	33.01	35.80	34.41
	Mean	176.00	225.49	200.75	187.43	237.57	212.50	31.03	33.75	32.39	31.99	34.39	33.19
Mean	15	233.22	282.77	258.00	242.23	290.97	266.60	35.71	38.00	36.85	36.63	38.70	37.67
	30	257.31	314.75	286.03	268.84	320.50	294.67	36.94	39.87	38.41	37.78	40.53	39.16
Bio-fertilizer mean		245.27	298.76	272.02	255.54	305.73	280.64	36.33	38.93	37.63	37.21	39.61	37.21
L.S.D. (0.05) For:													
Irrigation (I)			31.76			33.31			1.59			1.62	
Phosphorus (P)			*			*			*			*	
Bio-fertilizer (B)			**			**			**			**	
P x B			36.80			38.59			1.85			1.88	
I x P			42.39			44.46			2.06			2.10	
I x B			42.39			44.46			2.06			2.10	
I x P x B			53.48			56.09			2.86			2.91	

*, ** Indicate significant at 0.05 and 0.01, respectively

Table 9. Grain weight / plant and stover weight / plant of maize as affected by the bio-fertilizer phosphorein and phosphorus fertilizer under different irrigation intervals in 2005 and 2006 seasons

Irrigation interval (days)	Phosphorus (kg / fad)	Grain weight / plant (g)						Stover weight / plant (g)					
		2005			2006			2005			2006		
		Bio-fertilizer inoculation		Mean	Bio-fertilizer inoculation		Mean	Bio-fertilizer inoculation		Mean	Bio-fertilizer inoculation		Mean
		Non	Inoculation		Non	Inoculation		Non	Inoculation		Non	Inoculation	
14	15	183.87	209.56	**196.72**	188.64	213.28	**200.96**	645.98	752.43	**699.21**	698.80	787.40	**743.10**
	30	201.45	211.59	**206.52**	208.39	217.50	**212.95**	697.38	787.19	**742.29**	769.50	846.28	**807.89**
	Mean	**192.66**	**210.58**	**201.62**	**198.52**	**215.39**	**206.96**	**671.68**	**769.81**	**720.75**	**734.15**	**816.84**	**775.50**
21	15	165.88	202.05	**183.97**	171.09	206.91	**189.00**	557.47	690.84	**624.16**	594.30	707.80	**651.05**
	30	168.75	207.52	**188.14**	176.97	210.51	**193.74**	626.98	716.64	**671.81**	654.70	746.22	**700.46**
	Mean	**167.32**	**204.79**	**186.06**	**174.03**	**208.71**	**191.37**	**592.23**	**703.74**	**647.99**	**624.50**	**727.01**	**675.76**
28	15	103.93	121.19	**112.56**	113.78	132.12	**122.95**	390.89	537.10	**463.99**	428.50	557.26	**492.88**
	30	110.53	174.35	**142.44**	122.62	185.29	**153.96**	447.29	552.44	**499.87**	466.70	577.70	**522.20**
	Mean	**107.23**	**147.77**	**127.50**	**118.20**	**158.71**	**138.46**	**419.09**	**544.77**	**481.93**	**447.60**	**567.48**	**507.54**
Mean	15	151.23	177.60	**164.42**	157.84	184.10	**170.97**	531.45	660.12	**595.79**	573.87	684.15	**629.01**
	30	160.24	197.82	**179.03**	169.33	204 43	**186.88**	590.55	685.42	637.99	630.30	723.40	676.85
Bio-fertilizer mean		**155.74**	**187.71**	**171.73**	**163.58**	**194.27**	**178.93**	**561.00**	**672.77**	**616.89**	**602.08**	**703.78**	**652.93**
L.S.D. (0.05) For:													
Irrigation (I)			**22.07**			**23.08**			**33.15**			**34.52**	
Phosphorus (P)			*			*			**			**	
Bio-fertilizer (B)			**			**			**			**	
P x B			25.57			26.74			38.67			40.27	
I x P			28.67			29.94			45.74			48.09	
I x B			28.67			29.94			45.74			48.09	
I x P x B			38.34			50.00			61.04			63.58	

*, ** Indicate significant at 0.05 and 0.01, respectively.

Table 10. Grain yield (ard / fad) and stover yield (ton / fad) of maize as affected by the bio-fertilizer phosphorein and phosphorus fertilizer under different irrigation intervals in 2005 and 2006 seasons

Irrigation interval (days)	Phosphorus (kg / fad)	Grain yield (ard / fad)						Stover yield (ton / fad)					
		2005			2006			2005			2006		
		Bio-fertilizer inoculation		Mean	Bio-fertilizer inoculation		Mean	Bio-fertilizer inoculation		Mean	Bio-fertilizer inoculation		Mean
		Non	Inoculation		Non	Inoculation		Non	Inoculation		Non	Inoculation	
14	15	22.73	27.01	**24.87**	23.93	28.25	**26.09**	9.38	13.09	**11.24**	10.03	13.65	**11.84**
	30	23.54	27.90	**25.72**	24.85	29.46	**27.15**	10.73	14.29	**12.51**	11.52	14.98	**13.25**
	Mean	**23.14**	**27.46**	**25.30**	**24.39**	**28.86**	**26.63**	**10.06**	**13.69**	**11.88**	**10.78**	**14.32**	**12.55**
21	15	19.11	24.31	**21.71**	19.84	24.85	**22.35**	9.04	12.61	**10.83**	9.55	12.61	**11.08**
	30	21.21	25.01	**23.11**	21.95	25.96	**23.96**	10.29	12.90	**11.60**	10.58	12.95	**11.77**
	Mean	**20.16**	**24.66**	**22.41**	**20.90**	**25.41**	**23.16**	**9.67**	**12.76**	**11.22**	**10.07**	**12.78**	**11.43**
28	15	13.15	17.78	**15.47**	14.22	18.56	**16.39**	8.76	10.59	**9.68**	9.12	10.22	**9.67**
	30	16.34	20.43	**18.39**	17.26	21.53	**19.40**	9.93	11.10	**10.52**	9.81	11.04	**10.43**
	Mean	**14.75**	**19.11**	**16.93**	**15.74**	**20.05**	**17.90**	**9.35**	**10.85**	**10.10**	**9.47**	**10.63**	**10.05**
Mean	15	18.33	23.03	**20.68**	19.33	23.89	**21.61**	9.06	12.10	**10.58**	9.57	12.16	**10.86**
	30	20.36	24.45	22.41	21.35	25.65	23.50	10.32	12.76	11.54	10.64	12.99	11.82
Bio-fertilizer mean		**19.35**	**23.74**	**21.55**	**20.34**	**24.77**	**22.56**	**9.69**	**12.43**	**11.06**	**10.11**	**12.58**	**11.34**
L.S.D. (0.05) For:													
Irrigation (I)			**0.95**			**1.00**			**0.60**			**0.62**	
Phosphorus (P)			**			**			**			**	
Bio-fertilizer (B)			**			**			**			**	
P x B			**1.12**			**1.18**			**0.70**			**0.72**	
I x P			**1.29**			**1.36**			**0.83**			**0.86**	
I x B			**1.29**			**1.36**			**0.83**			**0.86**	
I x P x B			**1.78**			**1.87**			**1.11**			**1.15**	

* , ** Indicate significant at 0.05 and 0.01, respectively.

In respect to the interaction between phosphorus fertilizer and bio-fertilizer results revealed that increasing P either by using bio-fertilizer or raising the rate of phosphorus induced significant increases in both seasons. To save time and space the discussion here will be mainly concerned on both grain and stover yields / fad. The highest values of such traits were obtained from plants treated with bio-fertilizer and fertilized with the highest rate of phosphorus.

The increases in both grain and stover yields / fad due to the increases in P rate were more pronounced in the absence of bio-fertilizer. In respect to the effect of interactions between irrigation intervals and phosphorus fertilizer (mineral or bio-fertilizer) revealed significant effects on yield and yield components under study in both seasons. Maximum values of these traits were recorded with the high rate of mineral phosphorus in the presence of bio-fertilizer under the 14 days of irrigation interval.

IV. Chemical constituent of maize grains

The following traits were determined in the second season only

1. Total carbohydrates content

Prolonged irrigation intervals from 14 to 21 or 28 days had a significant reduction of 8.76 and 14.47 % respectively, for the percentage of carbohydrates in maize grains **(Table 11)**. Similar results on maize plant were obtained by **El-Kalla *et al* (1985).** They explained such result as a water shortage caused stomatal closure and this in turn prevents CO_2 diffusion into the air inside the tissue of plants and consequently the photosynthetic efficiency became low. In this respect **Abdel - Aziz and El-Bialy (2004)** on maize found similar results.

Regarding the effect of phosphorus fertilizer, data revealed that increasing phosphorus fertilizer from 50 to 100 % of the recommended rate induced significant increase of 3.79 % in total carbohydrates content of maize grains. The same trend was observed by **Abdo (2003),** who mentioned that soil application of P (7.75 or 15.5 kg P_2O_5 / fad) showed significant increase in carbohydrates percentage of mungbean seeds. Such increase may be due to the important role of phosphorus for stimulating chlorophyll synthesis enzymes, which reflected on inducing the formation of chlorophyll molecules.

As for the effect of bio-fertilizer, total carbohydrates, content in maize grains increased as a result of inoculation with phosphate dissolving bacteria by 6.21 % compared with the uninoculated.

2. Total sugars

Prolonged irrigation intervals from 14 to 21 or 28 days caused a relative increase in total sugars by about 57.14 and 80.99 %, respectively (**Table 11**). The recommended rate of P (30 kg P_2O_5 / fad) induced significant increase by 14.70 % in total sugars of maize grains. Likewise, bio-fertilizer application induced significant increase of 12.39 % for total sugars.

3. Non–soluble carbohydrate

Data given in **Table (11)** show that water deficit significantly decreased non-soluble carbohydrate. This result may be ascribed to the increase in total sugars. Data indicated that prolonged irrigation intervals from 14 to 21 or 28 days caused a relative decrease in non-soluble carbohydrate by 18.77 and 29.97 %, respectively. Phosphorus fertilizer had no significant effect on non-soluble carbohydrate of maize grains. However, bio-fertilizer caused a significant increase in this trait by 4.67 % more than maize grains, which obtained from uninoculated treatment. No significant effects were found in all interactions for total carbohydrates, total sugars and non-soluble carbohydrate.

4. Crude protein content

Data on crude protein content of maize grains as affected by water deficit, phosphorus fertilizer and bio-fertilizer are presented in **Table (11)**. Results clearly show that increasing the irrigation intervals induced significant increase of 5.02 % (at 21 days) and 20.33 % (at 28 days) in protein percentage of maize grains compared with irrigation every 14 days. In this respect, **Abdel-Aziz and El-Bialy (2004)** concluded that crude protein percentage of maize grains increased under severe water stress. Increasing the rate of phosphorus fertilizer from 50 to 100 % of the recommended rate induced significant increase of 5.99 % in protein percentage.

The previous result could be attributed to the role of P in plant metabolism, which plays as a constituent for nuclear protein molecules and it participates through ATP in stimulating amino acids for the assimilation of protein molecular.

Table 11. Chemical composition of maize grains as affected by the bio-fertilizer phosphorein and phosphorus fertilizer under different irrigation intervals in 2006 season

Irrigation interval (days)	Phosphorus (kg / fad)	Total carbohydrates %			Total sugars g / 100 g			Non soluble carbohydrate g / 100 g			Crude protein %			Phosphorus %		
		Bio-fertilizer inoculation		Mean	Bio-fertilizer inoculation		Mean	Bio-fertilizer inoculation		Mean	Bio-fertilizer inoculation		Mean	Bio-fertilizer inoculation		Mean
		Non	Inoculation		Non	Inoculation		Non	Inoculation		Non	Inoculation		Non	Inoculation	
14	15	64.68	70.99	67.84	7.59	8.99	8.29	57.09	62.00	59.55	8.02	8.69	8.36	0.40	0.52	0.46
	30	69.16	71.50	70.33	9.42	10.37	9.90	59.74	61.13	60.44	8.36	9.14	8.75	0.45	0.55	0.50
	Mean	66.92	71.25	69.09	8.51	9.68	9.10	58.42	61.57	60.00	8.19	8.92	8.56	0.43	0.54	0.48
21	15	60.60	63.06	61.83	12.77	14.30	13.54	47.83	48.76	48.30	8.02	9.69	8.86	0.34	0.47	0.41
	30	62.83	65.66	64.25	14.44	15.68	15.06	48.39	49.98	49.19	8.69	9.53	9.11	0.44	0.50	0.47
	Mean	61.72	64.36	63.04	13.61	14.99	14.30	48.11	49.37	48.74	8.36	9.61	8.99	0.39	0.49	0.44
28	15	55.31	60.66	57.99	14.30	16.30	15.30	41.01	44.36	42.69	9.36	10.25	9.81	0.32	0.41	0.37
	30	58.30	62.06	60.18	16.55	18.71	17.63	41.75	43.35	42.55	10.20	11.36	10.78	0.41	0.42	0.42
	Mean	56.81	61.36	59.09	15.42	17.51	16.47	41.38	43.86	42.62	9.78	10.81	10.30	0.37	0.42	0.40
Mean	15	60.20	64.90	62.55	11.55	13.20	12.38	48.64	51.71	50.18	8.47	9.54	9.01	0.35	0.47	0.41
	30	63.43	66.41	64.92	13.47	14.92	14.20	49.96	51.49	50.73	9.08	10.01	9.55	0.43	0.49	0.46
Bio-fertilizer mean		61.82	65.66	63.74	12.51	14.06	13.29	49.30	51.60	50.45	8.78	9.78	9.28	0.39	0.48	0.44
L.S.D. (0.05) For:																
Irrigation	(I)		2.85			1.57			3.16			0.42			0.03	
Phosphorus	(P)		**			**			NS			**			**	
Bio-fertilizer	(B)		**			**			*			**			**	
P x B			NS			NS			NS			0.52			0.04	
I x P			NS			NS			NS			0.64			0.05	
I x B			NS			NS			NS			0.64			0.05	
I x P x B			NS			NS			NS			0.80			0.06	

*, ** and NS indicate significant at 0.05, 0.01 and insignificant, respectively.

Data also indicated that bio-fertilizer was associated with a significant increase in protein percentage of maize grains by 11.39 % more than the uninoculated treatment.

All interactions between factors under study had significant effects on protein percentage of maize grains. It is worthy to mention that the maximum value of protein percentage was noticed when maize plants were irrigated at 28 days and received 100 % of the recommended rate of phosphorus fertilizer under inoculation with bio-fertilizer.

5. Phosphorus

From **Table (11)**, increasing irrigation intervals from 14 to 21 or 28 days caused significant reduction of 8.33 and 16.67 %, respectively in phosphorus percentage of maize grains.

Worthy to mention that increasing the level of phosphorus fertilizer from 50 to 100 % of the recommended rate induced significant increase of 12.2 % in phosphorus percentage of maize grains. In this respect, **Abdo (2003)** stated that increasing P rate from 7.75 up to 23.25 kg P_2O_5 / fad increased seed phosphorus content of mungbean, being in agreement with the present findings.

Regarding the effect of bio-fertilizer, data revealed that using of bio-fertilizer induced significant increase of 23.08 % in phosphorus percentage of maize grains. The same result was observed by **Abdo (2003)** on mungbean.

All interactions between factors under study revealed significant effects on phosphorus content in maize grains. It is worthy to mention that the maximum value of phosphorus percentage was gained when plants were irrigated at 14 days and received 100 % of the recommended rate of phosphorus fertilizer in the presence of bio-fertilizer.

Crop-water relations

I. Water consumptive use (WCU)

Data of WCU values for maize crop as affected by irrigation interval, phosphatic fertilizer rate and bio-fertilizer treatments are shown in **Table (12)**. Data revealed that WCU values for maize crop were ranged from 36.00 to 55.20 cm in the first season and from 35.60 to 58.40 cm in the second one, according to the adopted treatments. The highest WCU values (53.43 and 54.10 cm) were attained as irrigation was practiced at 14 days interval, while the lowest ones (38.40 and 37.68 cm) were obtained with irrigating at 28 days interval, in the first and second seasons, respectively. Data also illustrated that irrigating maize crop at 21 days interval exhibited intermediate WCU values, which comprised 43.33 and 41.81 cm, in the first and second seasons, respectively. The higher WCU values under irrigation at 14 days interval may be attributed to the higher available soil moisture in the root zone, which is exposed to luxurious extraction by the plant roots and to the higher evaporation from the soil surface as well. These results are in accordance with those reported by **Abdel-Aziz and El-Bialy (2004)**, who stated that the increase in evapotranspiration rate, due to frequent irrigation, is attributed to maintaining the soil moisture at higher level which, enhanced water absorption by plant root and higher soil surface evaporation.

Regarding P fertilization effect on WCU for maize crop, data in **Table (12)**, indicated that higher P fertilization rate resulted in higher WCU values for maize crop. The increase reached 4.63 and 3.85 %, in the first and second seasons, respectively more than those obtained under lower P fertilization rate, this trend was true in the two seasons of study. Higher WCU values under the highest P fertilization rate could be attributed to the increases in plant growth and transpired area. These results are in parallel with those of **El-Sayed and Youssef (2003)**, on beanut, who recorded that the highest WCU was obtained at 30 kg P_2O_5 / fad, while the lowest WCU was obtained without phosphorus fertilizer.

Data also revealed that treating the grains with bio-fertilizer (phosphorein) exerted a positive influence to increase WCU values for maize crop, which increased by 5.94 and 9.14 %, in the first and second seasons, respectively compared with the uninoculated. These results may be due to the increases in both plant growth and transpired area.

Regarding the interaction effect for the adopted treatments on WCU values for maize crop, data illustrated that the highest WCU values were obtained with irrigation at 14 days interval as interacted with the highest P rate in addition to bio-fertilizer inoculation.

II. Water use efficiency (WUE)

Data in **Table (12)** revealed that the highest WUE values were recorded with irrigating at 21 days interval, since the figures comprised 72.24 and 77.37 kg grains / cm / faddan, in the first and the second seasons, respectively. Practicing irrigation at 28 days interval exhibited lower WUE values, which were 61.40 and 66.22 kg grains / cm / faddan, in the first and second seasons,

Table 12. Seasonal water consumptive use and water use efficiency of maize as affected by the bio-fertilizer phosphorein and phosphorus fertilizer under different irrigation intervals in 2005 and 2006 seasons

Irrigation interval (days)	Phosphorus (kg / fad)	Seasonal water consumptive use (cm)						Water use efficiency (kg / cm / fad)					
		2005			2006			2005			2006		
		Bio-fertilizer inoculation		Mean	Bio-fertilizer inoculation		Mean	Bio-fertilizer inoculation		Mean	Bio-fertilizer inoculation		Mean
		Non	Inoculation		Non	Inoculation		Non	Inoculation		Non	Inoculation	
14	15	52.2	53.50	**52.85**	50.2	56.9	**53.55**	60.96	70.68	**65.82**	66.74	69.51	**68.13**
	30	52.8	55.20	**54.00**	50.9	58.4	**54.65**	62.42	70.76	**66.59**	68.35	70.62	**69.49**
	Mean	**52.5**	**54.35**	**53.43**	**50.55**	**57.65**	**54.10**	**61.69**	**70.72**	**66.21**	**67.55**	70.07	**68.81**
21	15	40.4	43.60	**42.00**	40.0	41.83	**40.92**	66.22	78.06	**72.14**	69.44	83.17	**76.31**
	30	42.9	46.40	**44.65**	41.2	44.19	**42.70**	69.22	75.46	**72.34**	74.59	82.25	**78.42**
	Mean	**41.65**	**45.00**	**43.33**	**40.6**	**43.01**	**41.81**	**67.72**	**76.76**	**72.24**	**72.02**	**82.71**	**77.37**
28	15	36.0	38.50	**37.25**	35.6	37.6	**36.60**	51.14	64.65	**57.89**	55.92	69.11	**62.52**
	30	38.2	40.90	**39.55**	37.6	39.9	**38.75**	59.88	69.93	**64.91**	64.27	75.54	**69.91**
	Mean	**37.1**	**39.70**	**38.40**	**36.6**	**38.75**	**37.68**	**55.51**	**67.29**	**61.40**	**60.09**	**72.33**	**66.22**
Mean	15	42.87	45.20	**44.03**	41.93	45.44	**43.69**	59.44	71.13	**65.28**	64.03	73.93	**68.99**
	30	44.63	47.50	**46.07**	43.23	47.50	**45.37**	63.84	72.05	**67.95**	69.07	76.14	**72.61**
Bio-fertilizer mean		**43.75**	**46.35**	**45.05**	**42.58**	**46.47**	**44.53**	**61.64**	**71.59**	**66.62**	**66.55**	**75.03**	**70.80**

respectively. Intermediate WUE values i.e. (66.21 and 68.81 kg grains / cm / faddan, in the first and second season, respectively) for maize crop were obtained due to irrigating at 14 days interval. Similar results were recorded by **El-Sayed and Youssef (2003)** on peanut.

Data also revealed that increasing P rate from 15 to 30 kg P_2O_5 / fad resulted in higher WUE values for maize crop. The increase reached 4.09 and 5.25 % in the first and second seasons, respectively.

Treating the grains, before planting, with the bio-fertilizer improved WUE since the values increased by 16.14 and 12.76 % in the first and second seasons, respectively as compared with the values recorded under the absence of bio-fertilizer. Concerning the interaction effect, of the adopted treatments, on WUE for maize crop, data revealed that higher WUE values were obtained when maize crop was irrigated at 21 days interval as well as applying 15 kg P_2O_5 / fad and treating the grains with the bio-fertilizer (phosphorein).

CONCLUSION

Maximum grain yield was achieved when maize plants irrigated every 14 days and received 30 kg P_2O_5 / fad in the presence of bio-fertilizer. It is worthy to not that the treatment of 15 kg P_2O_5 / fad in the presence of bio-fertilizer phosphorein surpassed the treatment of 30 kg P_2O_5 / fad in the absence of the bio-fertilizer. This means that bio-fertilizer substituted half of the recommended rate from the used mineral phosphorus fertilizer.

Higher WUE values were obtained when maize plants were irrigated every 21 days interval and received 15 kg P_2O_5 / fad in presence of bio-fertilizer phosphorein.

ACKNOWLEDGMENTS

The authores owes much to Professor Dr. **Hamadah H. Abdel-Maksoud**, Head of Water Requirements and Field Irrigation Department, Soil Water and Environment Research Institute, Agricultural Research Center for his valuable help concerning water relations study in this paper.

REFERENCES

Abdel-Aziz, El-Set. A. and U.S. El-Bialy (2004). Response of maize plant to soil moisture stress and foliar spray with potassium. **J. Agric. Sci., Mansoura Univ., 29(6): 3599 – 3619.**

Abdo, Fatma A. (2003). Effect of bio-fertilizer with phosphate dissolving bacteria under different levels of phosphorus fertilization on mungbean plant. **Zagazig J. Agric. Res., 30(1): 187 – 211.**

Abu-Grab, O.S. and Sanna, A. Othman (1999). Sensitivity of maize plant to drought at different growth stages in relation to potassium fertilization. **J. Agric. Sci., Mansoura Univ., 24(3): 959 – 971.**

A.O.A.C., (1990). Official Methods of Analysis 15th, Ed., Association of Official Agricultural Chemists, Washington, D.C., USA.

Bates, L.S. ; R.P. Waldren and I.D. Teare (1973). Rapid determination of free proline for water-stress studies. **Plant and Soil, 39: 205 – 207.**

Dubois, M.; K.A. Gilles; J.K. Hamilton; P.A. Rebers and F. Smith (1956). Colorimetric Method For Determination Of Sugars And Related Substances. **Analytical Chemistry, 28(3): 350 – 356.**

El-Kalla, S.E.; M.H. El-Hindi; A.S. Hanna and N.G. Alner (1985). Maize growth, yield and yield components and chemical of grains as affected by different irrigation levels and plant population. **Agric. Res. Rev., 63(7): 167 – 176.**

El-Noemani, A.A.; A.K. Abd El-Halem and H.A. El-Zeiny (1990). Response of maize (*Zea mays* L.) to irrigation intervals under different levels of nitrogen fertilization. **Egypt. J. Agron., 15(1-2): 147 – 158.**

El-Sayed, M.A. and H.Y. Youssef (2003). Effect of phosphorus fertilizer rates on peanut productivity under some irrigation intervals in sandy soil. **Egypt. J. Appl. Sci., 18(5): 184 – 199.**

Hajabbasi, M.A. and T.E. Schumacher (1994). Phosphorus effect on root growth and development in two maize genotypes. **Plant and Soil, 158: 39 – 46.**

Hassan, H.R.; D.M. Nassar and M.H. Abou-Bakr (2006). Effect of mineral and bio-fertilizers on growth, yield components, chemical constituents and anatomical structure of moghat plant (*Glossostemon bruguieri* Desf.) growth under reclaimed soil conditions. **J. Agric. Sci. Mansoura Univ., 31(3): 1433 –1455.**

Hunt, R. (1990). Basic Growth Analysis. pp. 55 – 72. Published by the Academic Division of Unwin Hyman Ltd., London.

Hunt, S. (2003). Measurements of photosynthesis and respiration in plants. **Physiologia Plantarum, 117: 314 – 325.**

Ibrahim, M.E ; H.M.M. El-Nagar and A.A. El-Hosary (1992). Effect of irrigation intervals and plant densities on some varieties of corn. Menofiya **J. Agric. Res., 17(3): 1083 – 1098.**

Israelsen, O.W. and V.E. Hansen (1962). Irrigation Principles and Practices. Third Ed. John Willey and Sons. Inc. New York.

Jackson, M.L. (1967). Soil Chemical Analysis pp. 326 - 338. New Delhi, Prentice Hall of India Private Limited New Delhi.

Khalifa. K.I.; G.M.A. Mahgoub and A.M. Tarrad (2002). Maize hybrids as influenced by drought stress under drip irrigation at Nubaria region. **J. Agric. Sci., Mansoura Univ., 27(4): 2041 – 2052.**

Kozlowski, T.T. (1988). Water Deficits and Plant Growth. Hand book, pp. 85–125. Acad. Press. New York.

Lazcano–Ferrat, I. and C. J. Lovatt (1999). Relationship between relative water content, nitrogen pools, and growth of *Phaseolus vulgaris* L. and *P. acutifolius A. Gray* during water deficit. **Crop Sci., 39 (March – April) : 467 – 475.**

Mahrous, N.M. (1991). Performance of some corn cultivars under some water stress treatments. **Bull. Fac. Agric., Cairo Univ., 42(4): 1117-1132.**

Manetas, Y. (2004). Probing corticular photosynthesis through in vivo chlorophyll fluorescence measurements: evidence that high internal CO_2 levels suppress electron flow and increase the risk of photoinhibition. **Physiologia Plantarum, 120: 509 – 517.**

Matin, M.A.; J.H. Brown and H. Ferguson, (1989). Leaf water potential, relative water content and diffusive resistance as screening techniques for drought resistance in barley. **Agron. J. 81: 100 – 105.**

Maxwell, K. and G.N. Johnson (2000). Chlorophyll fluorescence. A-a practical guide. **J. Exper. Bot, 51 (345): 659 – 668.**

Mohamed, S.A. (2000). Effect of mineral and bio-fertilization on growth, yield, chemical constituents and anatomical structure of wheat (*Triticum aestivum* L.) and broad bean (*Vicia faba* L.) plants grown under reclaimed soil conditions. **Annals of Agric . Sci., Moshtohor, 38(4): 2039 – 2063.**

Moore, P.D. and S.B. Chapman (1986). Methods in Plant Ecology. 2 Ed., p. 344. Blackwell Scientific Publications, London.

Pierre, W.H.; D. Kirkham; J. Pessek and R. Shaw (1965). Plant Environment and Efficient Water Use, pp. 259-274. Amer. Soc. Agron., Madison.

Ragab, A.A. and M.H. Rashad (2003). Enhancement of nutrients uptake and metabolism efficiency of sorghum (*sorghum bicolor* L) plants by bio-fertilizer under water stress. **Zagazig J. Agric. Res., 30(1): 147 – 166.**

Rashad, M.H. and A.A. Ragab (2003). Use of bio-fertilizer as effective tool for growth and yield in sorghum (*Sorghum bicolor* L) plants under different soil moisture. **Zagazig J. Agric. Res., 30 (1): 167 – 185.**

Rohacek, K. and M. Bartak (1999). Technique of the modulated chlorophyll fluorescence basic concepts, useful parameters, and some applications. **Photosynthetica, 37: 339 – 363.**

Sinclair, T.R.; J.M. Bennett and R.C. Muchow (1990). Relative sensitivity of grain yield and biomass accumulation to drought in field – grown maize. **Crop Sci., 30 (May – June) : 690 – 693.**

Snedecor, G.W. and W.G. Cochran (1982). Statistical Methods. 7th Ed., 2nd printing, 507 pp. Iowa State Univ. Press., Ames., Iowa.

Strickler, F.C. (1964). Row width & plant population studies with corn. **Agron. J. 56: 438 – 441.**

Voetberg, G.S. and R.E. Sharp (1991). Growth of the maize primary root at low water potential. III. Role of increased proline deposition in osmotic adjustment. **Plant Physiol., 96: 1125-1130.**

حوليات العلوم الزراعية
جامعة عين شمس، القاهرة
مجلد(٥٢)، عدد (٢)، ٥٦٥-٥٨٦، ٢٠٠٧

أستجابة الذرة الشامية للتسميد الفوسفاتى المعدنى والحيوى تحت فترات رى مختلفة [٤٥]

فاطمه عبد المنصف عبده[١]

١- قسم بحوث فسيولوجيا المحاصيل - معهد بحوث المحاصيل الحقلية - مركز البحوث الزراعية - الجيزة - مصر

أجريت تجربة حقلية بمحطة البحوث الزراعية بالجيزة - مركز البحوث الزراعية ، خلال موسمى صيف ٢٠٠٥ ، ٢٠٠٦ لدراسة إستجابة الذرة الشامية (هجين فردى ١٢٣) للسماد الفوسفاتى المعدنى والحيوى تحت فترات رى مختلفة.

طبقت ثلاثة فترات للرى (١٤ ، ٢١ ، ٢٨ يوم) ، بينما أضيف الفوسفور بمعدل ١٥ أ، ٣٠ كجم فو٢ا٥ للفدان فى صورة سوبر فوسفات الكالسيوم (١٥,٥ % فو٢ا٥) فى وجود وعدم وجود التسميد الحيوى "فوسفورين".

صممت التجربة فى قطاعات منشقة مرة واحدة ، حيث معاملات الرى فى القطع الرئيسية بينما معاملات الفوسفور والفوسفورين فى القطع المنشقة.

وفيما يلى أهم النتائج المتحصل عليها

- أوضحت النتائج أنه عند إطالة الفترة بين الريات من ١٤ إلى ٢١ يوم لم تتأثر صفات النمو والمحصول بينما أدت إطالة الرى كل ٢٨ يوم إلى نقص معنوى فى قيم جميع الصفات المدروسة بينما زاد مستوى الحمض الأمينى البرولين فى الأوراق.
- أدت زيادة معدل السماد الفوسفاتى من ١٥ إلى ٣٠ كجم فو٢ا٥ للفدان إلى زيادة معنوية فى إرتفاع النبات، الوزن الجاف للمجموع الخضرى للنبات، الوزن النوعى للورقة ، أعلى كفاءة كوانتم للكلوروفيل ، وزن كيزان النبات ، وزن ١٠٠ حبة، ومحصول كلا من الحبوب والعيدان للنبات وكذلك للفدان. كما لوحظت زيادة معنوية فى محتوى حبوب الذرة من الكربوهيدرات والسكريات والبروتين ، وكذلك الفوسفور بزيادة معدل السماد الفوسفاتى.
- أظهرت المعاملة بالمخصب الحيوى الفوسفورى (الفوسفورين) زيادة معنوية فى جميع الصفات المدروسة مقارنة بنباتات الذرة المتحصل عليها من الحبوب غير المعاملة بالفوسفورين. وكانت الزيادة فى محصول الحبوب للفدان بمقدار ٢٢,٦٩ و ٢١,٧٨ % ، وكذلك بنسبة ٢٨,٢٨ و ٢٤,٤٣ % لمحصول عيدان النباتات للفدان فى الموسم الأول والثانى على الترتيب ، وأيضاً زيادة محتوى الحبوب بمقدار ٦,٢١ % للكربوهيدرات الكلية و١٢,٣٩ % للسكريات الكلية و٤,٦٧ % للكربوهيدرات الغير ذائبة و ١١,٣٩ % للبروتين و ٢٣,٠٨ % للفوسفور وتم تقديرهم فى الموسم الثانى.
- أظهر التفاعل بين فترات الرى والتسميد الفوسفاتى منفرداً أو مع التسميد الحيوى تأثيرا معنوياً على صفات النمو والمحصول تحت الدراسة فى موسمى النمو ، وأعلى قيم لهذه الصفات عند تسميد الذرة بمعدل ٣٠ كجم فو٢ا٥ للفدان والرى كل ١٤ يوماً مع وجود التسميد الحيوى ، وكان لنفس هذه المعاملة أعلى قيمة للإستهلاك المائى (سم) ، بينما وصلت أعلى قيمة لكفاءة إستخدام المياه (كجم / فدان / سم) لنباتات الذرة عند الرى كل ٢١ يوماً.

الرى كل ٢١ يوماً والتسميد الفوسفاتى ١٥ كجم فو٢ا٥ / فدان مع وجود التسميد الحيوى يعتبر الأفضل مقارنة بالمعاملات الأخرى تحت الدراسة.

تحكيم: أ.د توكل يونس رزق
أ.د جلال محمد عبد المنعم محجوب