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Effect of FYM and Phosphorus Fertilization on Yield and its Components of Maize

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ABSTRACT

In order to maximize the productivity of maize several investigators indicated the need of maximizing the use of mineral and organic fertilizers. Therefore, this investigation was conducted for two summer seasons (2010 and 2011) in the Experimental Farm of the Faculty of Agriculture (Gazala site), Zagazig University, Egypt. The study aimed at finding out the response of maize yield and its components to five levels of P fertilization (0, 20, 40, 60 and 80 kg P_2O_5 ha^{-1}) and three rates of FYM (0, 40 and 80 m^3 ha^{-1}). A randomized complete block design of four replicates was used where planting was made in hills 25 cm apart in ridge 70 cm apart and one plant was left per hill after thinning (21 days after planting). The results indicated the response of maize grain yield ha^{-1} to the increase of P level up to 60 kg P_2O_5 ha^{-1}. This response was expressed in plant height, number of grains row^{-1}, 100-grain weight and hence the grain weight ear^{-1}. Neither the number of rows ear^{-1} or shelling percentage was affected by P addition. Similar positive effect was observed due to addition of FYM on the aforementioned yield components and hence the final grain yield ha^{-1} up to the addition of 80 m^3 ha^{-1}. These two factors acted independently where their interaction did not affect the grain yield ha^{-1} and almost all grain yield attributes. The response equation of grain yield ha^{-1} indicated a diminishing increase with increase of P level up to 80 kg P_2O_5 ha^{-1} and FYM rate up to 80 m^3 ha^{-1}.

Key words: Maize, FYM, P fertilization, yield, yield components

INTRODUCTION

Maize (*Zea mays*, L.) is one of the most widely grown cereals in the world. In Egypt, there is a wide gab between the ever growing increase of consumption and local production. This could be narrowed through the use of high yielding varieties and as well optimizing the cultural practices particularly organic and mineral fertilization. Maize has been reported to respond high levels of nitrogen. However, this response could be maximized through the addition of levels of phosphorus (Mengel and Kirkby, 2001). The role of phosphorus in enhancing plant growth through promoting root multiplication and extension where more soil surfaces are ramified and hence more nutrients and water uptake is expected (Fagaria *et al.*, 1997). Many factors are affecting phosphorus availability include soil pH, soil texture, organic matter, soil content of Fe, Zn and Ca, microbial activity and time of application (Yach *et al.*, 1992). Maize hybrids which produce higher dry matter yield usually more responded to phosphorus (Fageria and Baligar, 1993). If the phosphorus supply to cereals is insufficient during the early growth stages, a reduction in the number of spikes per unit area results and hence a depression in total crop yield (Mengel and Kirkby, 2001). In this connection several research workers got significant response to phosphorus fertilization up to 35 kg P_2O_5 ha^{-1} (Diab *et al.*, 1990; El-Far, 1996; Hegazy *et al.*, 1996). However, others got higher response when they added 71 kg P_2O_5 ha^{-1} (Badawi and El-Moursy, 1997; Salem, 2000). Moreover, Hussain *et al.* (2006), Hussein (2009) and Amanullah and Khalil (2010) found this response reaching 90 kg P ha^{-1}. Furthermore, Masood *et al.* (2011) got more higher response when they added 100 kg P ha^{-1}. In all these responses, the significant increase of yield attributes. Yosefi *et al.* (2011) reported that application of 50 kg P ha^{-1} with 100 g bio-phosphate gave the highest yield in Iran. On the other hand, Mazengia (2011) found that P fertilizer rates had no significant effect on maize yield and its components under Ethiopia conditions.

Organic manuring play a direct role in sustaining soil fertility through various processes and mechanisms i.e., providing nutrients after decomposition and acting an energy source for soil organisms, increasing the soil cation-extchange capacity and thereby improving nutrient retention against leaching (El-Fakharani, 1999). Studies conducted by many researchers showed that the application of fertilizers both from organic and inorganic sources significantly improved the maize growth, yield and its component (Enwezor *et al.*, 1995; Okoruwa, 1998; Boateng *et al.*, 2006). Nofal *et al.* (2005) in Egypt, found that applying 40 m^3 $feddan^{-1}$ (95.2 m^3 ha^{-1}) of organic manure increased maize grain yield and its components as compared with without organic manuring. Hassanein and Abul-Soud (2010) obtained the highest grain and straw yields of maize by applying cucumber canopy compost compared with either rice straw or maize stalks compost. Akongwubel *et al.* (2012) in Nigeria, tested ten rates of poultry manure on growth and yield of maize. The obtained data showed that addition of 20 t ha^{-1} from poultry manure gave the highest averages of plant height and stem diameter and, hence highest averages of 1000 grain weight and grain yield were obtained by application of 18 t ha^{-1} from poultry manure. El-Naggar *et al.* (2012) in Egypt, reported that application of FYM up to 40 m^3 $feddan^{-1}$ (95.2 m^3 ha^{-1}) significantly increased ear grain weight $plant^{-1}$ and grain yield while, grain index responded to only 20 m^3 $feddan^{-1}$ (46.6 m^3 ha^{-1}) under clay soil conditions.

This study was carried out to study the response of maize to five phosphorus fertilizer levels and organic manuring with three rates of FYM.

MATERIALS AND METHODS

Experimental site and treatments: Two field experiments are conducted in the Agricultural Research Stations of the Faculty of Agriculture, Zagazig University in Ghzala site, Sharkia Governorate, Egypt (30°34'N, 31°31'E) during summer seasons of 2010 and 2011. The study aimed to investigate the response of maize hybrid TWC 321 to five phosphorus levels (0, 20, 40, 60 and 80 kg P_2O_5 ha^{-1}) and three farmyard manure rates (check or without FYM, 40 and 80 m^3 ha^{-1}). Soil mechanical and chemical analysis of the experimental sites in both seasons are presented in Table 1.

Experimental design: A randomized complete block design with four replicates was used. Plot area was 14 m^2 consisting of 5 ridges (70 cm apart×4 m length).

Agricultural practices: The preceding crop was wheat in both seasons. The grains of three way cross hybrid 321 (T.W.C.321) were sown in May 16 th in hills 25 cm apart in both seasons. The plants were thinned into one plant $hill^{-1}$ after 21 days from sowing. Potassium sulphate (48% K_2O) was added during seed bed preparation at a level of 60 kg K_2O ha^{-1}. Phosphorus fertilizer as ordinary super phosphate (15.5% P_2O_5) was added before sowing according to each trial level. Farmyard manure was incorporated before sowing according to each trial rate. The chemical

Table 1: Mechanical and chemical properties of the upper 20 cm soil depth of the experimental sites

Soil properties	2010	2011
Mechanical properties		
Clay (%)	43.49	43.24
Silt (%)	9.10	9.25
Fine sand (%)	13.52	13.70
Coarse sand (%)	33.89	33.81
Texture	Clay	Clay
Chemical properties		
pH	8.02	7.94
Organic matter (%)	0.52	0.54
Available N (ppm)	34.20	36.40
Available P (ppm)	8.40	9.40
Available K (ppm)	276.1	273
EC (mmohs cm^{-1})	0.95	0.93

Table 2: Chemical analysis of used FYM in 2010 and 2011 seasons

Characters	2010	2011
Organic matter (%)	18.03	18.20
pH	6.88	6.92
Macronntrients		
Available N (ppm)	506	512
Available P (ppm)	746	753
Available K (ppm)	1436	1449
Micronntrients		
Available Fe (ppm)	3.40	3.25
Available Mn (ppm)	32.10	33.05
Available Zn (ppm)	73.50	77.00

compositions of the used FYM are shown in Table 2. Nitrogen fertilizer was added in form of urea (46.5% N) at a level of 250 kg N ha^{-1} in three equal doses (after thinning and at 35 and 50 days after sowing). All other culture practices were conducted as recommended.

Data recorded: At harvest (120 days from sowing) five guarded plants were taken at random from the second ridge in each plot to determine the following traits: Plant height (cm), ear length (cm), ear diameter (cm), number of rows ear^{-1}, number of grains row^{-1}, 100 grain weight (g) and shelling%. Thereafter, a bulk sample which included all maize plants of the third and fourth central ridges of each plot (5.6 m^2) was taken estimate grain yield (t ha^{-1}). Yield was adjusted to moisture content of 15.5%.

Statistical analysis: Data were analyzed according to Snedecor and Cochran (1988). Treatment means were compared using Least Significant Differences (LSD) test at 0.05 level of probability (Waller and Duncan, 1969). Statistical analysis was performed by using analysis of variance technique of (MSTAT-C, 1991) computer software package. The response of grain yield to P fertilizer levels and FYM rates were calculated using orthogonal polynomial tables according to Snedecor and Cochran (1988) and the following equation was used:

$$Y = a+bx-cx^2$$

where Y is the yield (dependent variable), x is the fertilizer levels as independent variable, a is the intercept and b and c are the linear and quadratic regression coefficients. X_{max} = b/2c (u), Y_{max} = $a+b^2/4c$, where u = The interval between levels of fertilizer.

RESULTS AND DISCUSSION

Plant growth attributes: Table 3 shows plant height, ear length and ear diameter of maize as affected by P fertilization levels and FYM application rates and their interaction in the two seasons and their combined analysis.

Phosphorus level effect: It is quite evidence from Table 3 that addition of phosphorus had a significant effect on plant height, ear length and ear diameter in both seasons and their combined analysis except ear diameter in the second seasons where the differences did not reach to the level of significance. The maximum plant height average (321.82, 330.22 and 326.02 cm in both seasons and their combined analysis, respectively) was recorded by application of 40 kg P_2O_5 ha^{-1} where the further increase of P level did not add a significant increase in height. Ear dimension (length and diameter) responded to lower addition of only 20 kg P_2O_5 ha^{-1}. The positive effect of P fertilization on plant height and ear dimensions could be attributed to the important role of P in root multiplication hence extension where more nutrients and water were more available for absorption. This in turn promoted plant growth as expressed herein in height and ear dimensions. These results are in harmony with those obtained by Badawi and El-Moursy (1997), Salem (2000), Hussain *et al*. (2006) and Yosefi *et al*. (2011). However, Mazengia (2011) reported that P application had no significant effect on maize plant height.

FYM effect: It is clear from Table 3 that addition of FYM was without significant effect on plant height, ear length and ear diameter in both seasons and their combined except ear diameter in the

Table 3: Plant height, ear length and ear diameter of maize as affected by P and FYM fertilization levels in the two seasons and their combined

	Plant height (cm)			Ear length (cm)			Ear diameter (cm)		
Treatments	1st	2nd	Comb.	1st	2nd	Comb.	1st	2nd	Comb.
P levels (kg P_2O_5 ha^{-1}), P									
0	290.28	323.04	306.66	18.73	20.73	19.73	4.17	4.7	4.44
20	308.63	315.75	312.19	19.79	21.52	20.66	4.38	4.77	4.57
40	321.82	330.22	326.02	19.98	21.91	20.95	4.42	4.75	4.59
60	319.28	327.77	323.52	19.89	21.69	20.79	4.38	4.77	4.58
80	322.48	328.02	325.25	20.02	21.87	20.95	4.39	4.74	4.57
f-test	**	*	**	*	*	**	**	n.s	**
LSD0.05	10.52	10.44	7.3	0.82	0.74	0.54	0.06	-	0.08
FYM (m^3ha^{-1}), F									
0	312.7	323.85	318.27	19.66	21.44	20.55	4.32	4.7	4.51
40	309.43	324.14	316.78	19.42	21.59	20.5	4.33	4.74	4.54
80	315.37	326.89	321.13	19.98	21.6	20.79	4.39	4.8	4.6
f-test	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s	*
LSD0.05	-	-	-	-	-	-	-	-	0.06
Interaction									
P×F	*	n.s	**	n.s	n.s	n.s	n.s	n.s	n.s

*, **and n.s: Indicate significant at 0.05, 0.01 and insignificant, respectively

combined analysis which showed significant response to this addition. The highest average of ear diameter (4.60 cm) was obtained by addition of 80 m^3 ha^{-1}. In this regard, Achieng *et al*., 2010 found that FYM was not significantly different from other inorganic fertilizer treatments on plant height. While, Nofal *et al*., (2005) reported that addition of FYM at a rate of 95.2 m^3 ha^{-1} caused significant increase in plant height, ear diameter under sandy soil conditions.

Interaction effect: The interaction between P levels and FYM rates had a significant effect on plant height in the first season and the combined analysis (Fig. 1). As shown in Fig, the tallest maize plants were obtained when fertilized with 20 kg P_2O_5 ha^{-1} and 80 m^3 ha^{-1} with insignificant differences with plants which fertilized with any highest P levels i.e., 40, 60 and 80 kg P_2O_5 ha^{-1}.

Grain weight ear^{-1} and its components

Phosphorus level effect: Table 4 and 5 shows number of rows ear^{-1}, number of grains row^{-1}, ear grains weight as well as 100-grain weight and shelling percentage as affected by P levels and FYM rates in the two seasons and their combined. It is clear that P levels had no significant effect on number of rows ear^{-1} in both seasons and their combined. The failure of the number of rows ear^{-1} to respond to P application might be attributed to its control mainly by genetic rather than environmental condition (Yosefi *et al*., 2011). However, the number of grains row^{-1}, 100-grain weight and ear grains weight were significantly affected by P levels in both seasons and their combined. According to combined analysis, number of grains row^{-1}, 100-grain weight and ear grains weight were increased due to the increase in P levels up to 40 kg P_2O_5 ha^{-1}. Increasing P level from 0-40 kg P_2O_5 ha^{-1} increased number of grains row^{-1} from 39.75 to 46.07, ear grains weight (g) from 148.875-175.967 and 100-grain weight (g) from 31.396-34.505, respectively in the combined analysis. Further increments of phosphorus (beyond 40 kg P_2O_5 ha^{-1}) did not affect significantly grain weight ear^{-1} as its two main components did not respond to increasing P addition beyond this level. The decrease in each of number of grains ear^{-1} and grains weight in check P treatment might be due to the role of P in crop maturation, flowering and fruiting including seed formation (Alias *et al*., 2003).

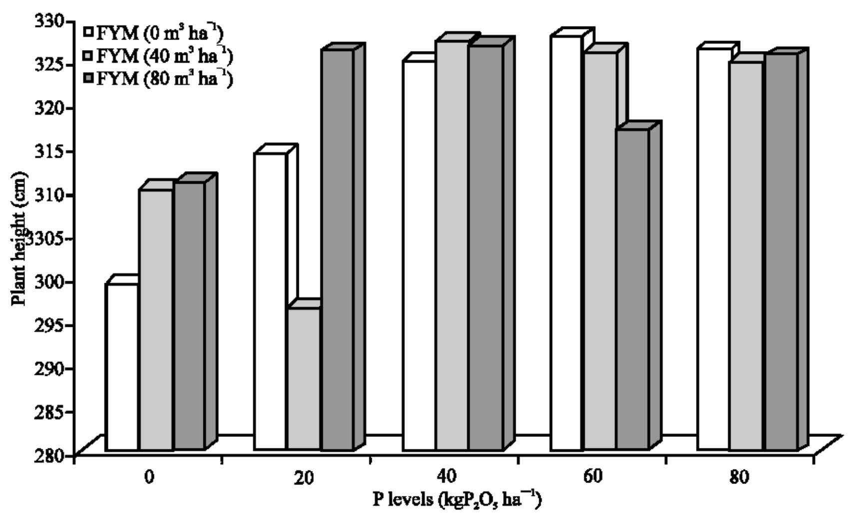

Fig. 1: Interaction effect between P levels and FYM (farmyard manure) rates on plant height (cm), $L.S.D_{0.05}$ =12.65 (Combined analysis)

Table 4: Number of rows ear^{-1}, number of grains row^{-1} and ear grains weight of maize as affected by P and FYM fertilization levels in the two seasons and their combined

	No. of rows ear^{-1}			No. of grains row^{-1}			Ear grains weight (g)		
Treatments	1st	2nd	Comb.	1st	2nd	Comb.	1st	2nd	Comb.
P levels (kg P_2O_5 ha^{-1}), P									
0	12.68	13.3	12.99	39.35	40.15	39.75	140.717	157.033	148.875
20	13.3	13.17	13.23	43.67	45.72	44.7	165.467	173.25	169.358
40	13.33	13.2	13.27	45.13	47.02	46.07	174.6	177.333	175.967
60	13.45	13.53	13.5	42.78	46.23	44.51	172.783	180.083	176.433
80	13.5	13.27	13.38	44.12	46.78	45.45	174.867	180.75	177.808
f-test	n.s	n.s	n.s	**	**	**	**	**	**
LSD0.05	-	-	-	1.99	1.33	1.18	9.737	8.807	6.332
FYM (m^3 ha^{-1}), F									
0	13.01	13.44	13.22	41.79	44.25	43.02	157.76	163.1	160.43
40	13.28	13.07	13.17	42.64	45.23	43.93	166.91	173.7	170.305
80	13.48	13.37	13.42	44.6	46.06	45.33	172.39	184.27	178.33
f-test	n.s	n.s	n.s	**	**	**	**	**	**
LSD0.05	-	-	-	1.54	1.03	0.92	7.542	6.822	5.009
Interaction									
P×F	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s

*, **and n.s: Indicate significant at 0.05, 0.01 and insignificant, respectively

Table 5: Hundred grain weight and shelling (%) of maize as affected by P and FYM fertilization levels in the two seasons and their combined

	Hundred grain weight (g)			Shelling (%)		
Treatments	1st	2nd	Comb.	1st	2nd	Comb.
P levels (kg P_2O_5 ha^{-1}), P						
0	30.034	32.758	31.396	81.18	80.86	81.02
20	33.441	33.732	33.586	79.5	80.88	80.19
40	33.498	35.511	34.505	80.38	81.83	81.11
60	33.728	35.78	34.754	79.99	81.78	80.88
80	33.523	35.83	34.676	79.74	80.99	80.36
f-test	**	**	**	n.s	n.s	n.s
LSD0.05	1.201	0.92	0.745	-	-	-
FYM (m^3 ha^{-1}), F						
0	32.012	33.406	32.709	80.49	81	80.75
40	33.039	35.146	34.093	79.98	81.28	80.63
80	33.482	35.614	34.548	80	81.53	80.77
f-test	**	**	**	n.s	n.s	n.s
LSD0.05	0.93	0.713	0.577	-	-	-
Interaction						
P×F	n.s	n.s	n.s	n.s	n.s	n.s

*, ** and n.s: Indicate significant at 0.05, 0.01 and insignificant, respectively

FYM effect: It is clear that from Table 4 and 5 that addition of FYM was without significant effect on number of rows ear^{-1} and shelling percentage in both seasons and their combined. However, the number of grains row^{-1} was not significantly increased unless the level of FYM was increased to 80 m^3 ha^{-1}, though the 100-grain weight was increased by the addition of only 40 m^3 ha^{-1}. Finally, the grain weight ear^{-1} was significantly increased due to each increment of FYM up to the higher rate as observed in second season and combined analysis. Increasing FYM rates from 0 (check FYM treatment) to 80 m^3 ha^{-1} increased number of grains row^{-1} from 43.02-45.33 (5.37%) and ear grains weight from 160.430-178.330 (11.15%), respectively according to the combined analysis. These results are quite interesting as they indicate the grain set as expressed in the number of grains row^{-1} was more need in higher rates of FYM than grain growth as expressed in the 100-grain weight. The results further indicate that the number of grains row^{-1} had more contribution to grain weight ear^{-1} than the 100-grain weight. This was expressed in the trend of response of these two traits to the increase of FYM rate. The favorable FYM effect could be attributed to its role providing adequate and balanced supply of nutrients (Achieng *et al*., 2010). Similar results were reported by Nofal *et al*. (2005) and El-Naggar *et al*. (2012).

Interaction effect: The grain weight ear^{-1} and its components were not significantly affected by the interaction between P levels and FYM rates in both seasons and their combined.

Grain yield (t ha^{-1})

Phosphorus level effect: Table 6 shows grain yield ha^{-1} of maize as affected by P level and FYM rate and their interactions in the two seasons and their combined. Each increase in P level up to 60 kg P_2O_5 ha^{-1} caused a significant increase in grain yield ha^{-1} in both seasons and their combined analysis. The grain yield (t ha^{-1}) due to increasing P level up to 60 kg P_2O_5 ha^{-1} were 8.443, 9.198 and 8.820 in both seasons and their combined analysis. These results refer to an accumulation effect to P level increase on the main components of maize grain yield ha^{-1} though the grain weight ear^{-1} did not response to the increase of P level beyond 40 kg P_2O_5 ha^{-1}. The results obtained herein indicate the response of grain yield to 60 kg P_2O_5 ha^{-1}. This clearly indicate that the insignificant increase in grain weight ear^{-1} beyond the addition of 40 kg P_2O_5 ha^{-1}did add a significant increase to the grain yield ha^{-1}. The percentage increase in grain yield ha^{-1} due to the addition of 60 kg P_2O_5 ha^{-1} compared with check treatment (without P application) amounted to 27.36% in the combined analysis of two seasons. The increase in grain yield probably may be due to the increase in number of grains row^{-1}, 100-grain weight and ear grains weight. In this connection, Badawi and El-Moursy (1997) reported that the increase in maize grain yield due to the high dose of P application (71 kg P_2O_5 ha^{-1}) could be attributed to enhancing photosynthesis and translocation rate of photosynthates from the leaves to the ear and grain. Positive response of grain yield of maize and its components reported by many researchers (El-Far, 1996; Salem, 2000; Alias *et al*., 2003; Khan *et al*., 2005; Hussain *et al*., 2006; Hussein, 2009; Amanullah and Khalil, 2010; Yosefi *et al*., 2011).

FYM effect: It is obvious from Table 6 that addition of FYM up to 80 m^3 ha^{-1} caused a significant increase in grain yield ha^{-1} in both seasons and their combined. The percentage increase in grain yield ha^{-1} due to addition of 40 and 80 m^{3}FYM ha^{-1}compared with check FYM treatment (without application) amounted to 7.93 and 12.66%, respectively according to combined analysis. These results clearly indicate that addition FYM caused a significant increase in maize growth as expressed in ear diameter (Table 3) and grain yield components (Table 4 and 5) and hence could account for the increase of grain yield ha^{-1} observed herein. These results confirmed those obtained by others (Nofal *et al*., 2005; Badr and Authman, 2006; Hassanein and Abul-Soud, 2010; Akongwubel *et al*., 2012; El-Naggar *et al*., 2012).

Table 6: Grain yield of maize as affected by P and FYM fertilization levels in the two seasons and their combined

	Grain yield (t ha^{-1})			
Treatments	1st	2nd	Comb.	Difference (%)
P levels (kg P_2O_5 ha^{-1}), P				
0	6.602	7.248	6.925	-
20	7.619	8.403	8.011	15.68
40	8.032	8.532	8.282	19.59
60	8.443	9.198	8.82	27.36
80	8.548	9.408	8.978	29.64
f-test	**	**	**	
LSD0.05	0.242	0.307	0.193	
FYM (m^3 ha^{-1}), F				
0	7.288	8.065	7.676	-
40	7.959	8.612	8.285	7.93
80	8.299	8.997	8.648	12.66
f-test	**	**	**	
LSD0.05	0.188	0.238	0.15	
Interaction				
P×F	n.s	n.s	n.s	

*, ** and n.s: Indicate significant at 0.05, 0.01 and insignificant, respectively

Interaction effect: The grain yield ha^{-1} was not significantly affected by the interaction between P level and FYM rate in both seasons and their combined indicating masked any interaction effect.

Grain yield response analysis: According to the combined data of two seasons, regarding grain yield ha^{-1} a response analysis was performed according to (Snedecor and Cochran, 1988) where the response equations were calculated and are presented herein.

Grain yield response to P fertilization: Results in Table 6 showed that the grain yield ha^{-1} responded to the increase of P level where each P increment resulted in a significant increase in yield up to the addition of 60 kg P_2O_5 ha^{-1}. The question which could be raised herein is there a possibility of more grain in grain yield ha^{-1} if the P level could have been further increased? To give an answer for this question, the response equation of grain yield ha^{-1} due to the increase of P level was calculated and is shown as following: $Y = 6.993+0.946x-0.114x^2$. This equation clearly indicates a diminishing increase in the grain yield with the progressive increase in P level up to 80 kg P_2O_5 ha^{-1}. The maximum predicted yield (Ymax) was calculated when (Xmax) would have been added. This calculation predicted a grain yield maximum of 8.956 t ha^{-1} which could have been obtained due to addition of 83 kg P_2O_5 ha^{-1} i.e., 3 kg P_2O_5 ha^{-1} more than the maximum P level tried herein i.e., 80 kg P_2O_5 ha^{-1}, which already recorded yield of 8.978 t ha^{-} . [1]The differences between the predicated and actual obtained yield therefore was 0.016 t ha^{-1} which is less than the least significant differences (0.193 t ha^{-1}). According to this yield analysis, the maximum P level tried in this study i.e., 80 kg P_2O_5 ha^{-1} was adequate and quite enough to maximize the grain yield of maize. This is illustrated by the diminishing return of grain yield ha^{-1} due to the increase of P level in Fig. 2. Similar trend were obtained by Abdul Galil *et al.* (2008).

Grain yield response to FYM manuring: Data in Table 6 indicated that the grain yield ha^{-1} responded to the increase in FYM rates up to the addition of 80 m^3 ha^{-1}. This response was, also diminishing as indicated from the following equation: $Y = 7.676+0.732x-0.123x^2$. The calculation

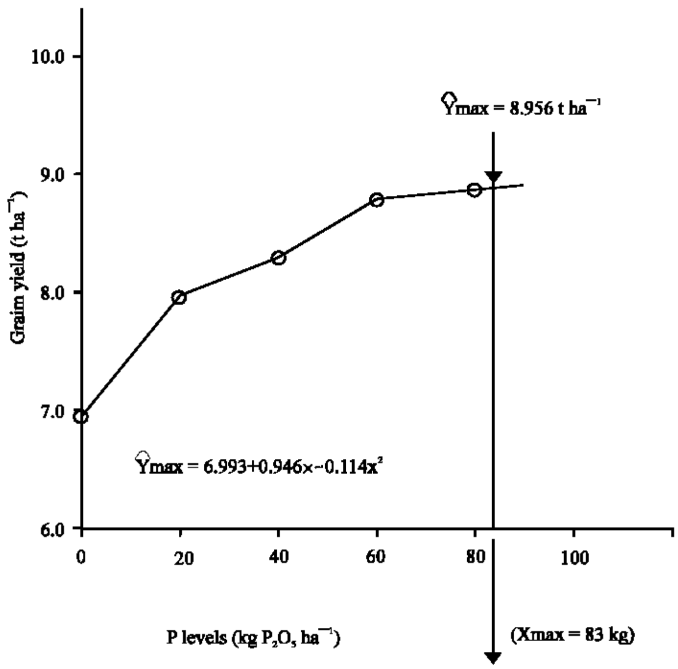

Fig. 2: Response of maize grain yield ha^{-1} to P fertilization level (combined data), Ymax: Predicted maximum grain yield, Xmax: Predicted maximum P level

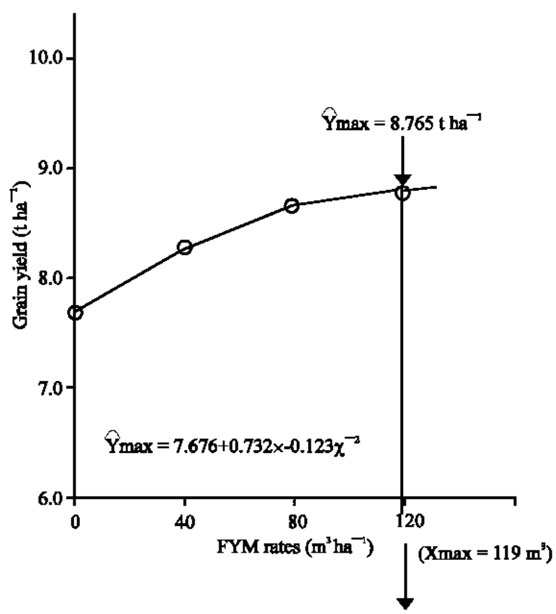

Fig. 3: Response of maize grain yield ha^{-1} to FYM rates (combined data), FYM: Farmyard manure, Ymax: Predicted maximum grain yield, Xmax: Predicted maximum FYM rate

of the predicated maximum FYM rate indicated the need for one more FYM increment when the yield could have been maximized to 8.765 t ha^{-1} if the rate of manuring increased to 119 m^3 ha^{-1}. The increase of yield over the actual yield obtained was only 0.117 t ha^{-1} which was also less than the L.S.D. (0.150 t ha^{-1}) indicating the insignificancy of this predicated increase in grain yield which certainly not compensate more increment in FYM rate. This response is illustrated in Fig. 3.

Interaction effect: The grain yield ha^{-1} was not significantly affected by the interaction between P level and FYM rate. This clearly indicates their independence in affecting grain yield. Similar insignificant interaction effects were observed in almost all yield attributes except plant height according to the combined analysis. However, the response of grain yield to P fertilization was more than that to FYM manuring. This could be indicating by the maximum response to added P which amounted to 1.963 t ha^{-1} and the maximum response to added FYM which was only 1.089 t ha^{-1} could be safely concluded that P fertilization was more effective than organic manuring as far as grain yield ha^{-1} is concerned. This effect directly might have had increased nutrient uptake particularly nitrogen which is the yield limiting factor in sustaining the yield potentiality of cereals particularly maize. Phosphorus fertilization might have reflected also, an indirect effect in making more nitrogen available from FYM. Ordinary super phosphate has a high content from gypsum ($CaSO_4$), which through its reaction with released ammonia during FYM decomposition, forms ammonia sulphate. This in turn increases the soil contents from available nitrogen (Tisdale and Nelson, 1975) and hence could account for the higher response to added phosphorus than to added FYM.

CONCLUSION

Results of this experiments revealed that fertilizing maize plants with phosphorus fertilizer up to 60 kg P_2O_5 ha^{-1} and adding FYM rates up to 80 m^3 ha^{-1} could be recommended to maximize the maize grain yield.

REFERENCES

Abdul Galil, A.A., S.A. Mowafy, A.E. Omar and T.S. Mokhtar, 2008. Nodulation, growth and yield of faba been as affected by irrigation interval, organic manuring and P and K fertilization levels under sandy soil conditions. Agric. Res. J. Suez Canal Univ., 8: 31-48.

Achieng, J.O., G. Ouma, G. Odhiambo and F. Muyekho, 2010. Effect of farmyard manure and inorganic fertilizers on maize production on Alfisols and Ultisols in Kakamega, Western Kenya. Agric. Biol. J. N. Am., 1: 430-439.

Akongwubel, A.O., U.B. Ewa, A. Prince, O. Jude, A. Martins, O. Simon and O. Nicholas, 2012. Evaluation of agronomic performance of maize (*Zea mays* L.) under different rates of poultry manure application in an Ultisol of Obubra, cross river state, Nigeria. Int. J. Agric. Forest., 2: 138-144.

Alias, A., M. Usman, E. Ullah and E.A. Warraich, 2003. Effects of different phosphorus levels on the growth and yield of two cultivars of maize (*Zea mays* L.). Int. J. Agric. Biol., 5: 632-634.

Amanullah, Z.M. and S.K. Khalil, 2010. Timing and rate of phosphorus application influence maize phenology, yield and profitability in Northwest Pakistan. Int. J. Plant Prod., 4: 281-291.

Badawi, M.A. and S.A. El-Moursy, 1997. Nitrogen phosphorus requirements for maize, (*Zea mays* L.), grown in a newly reclaimed sandy soil. J. Agric. Sci. Mansoura Univ. 22: 659-671.

Badr, M.M. and S.A. Authman, 2006. Effect of plant density, organic manure, bio and mineral nitrogen fertilizers on maize growth and yield and soil fertility. Ann. Agric. Sci., 44: 75-88.

Boateng, S.A., J. Zickermann and M. Kornahrens, 2006. Poultry manure effect on growth and yield of maize. West Afr. J. Ecol., 9: 1-11.

Diab, M., M.I. Katta, M.S. Zeid and S.H.M. Abdel-Rassoul, 1990. Corn response of the rate and placement of phosphate fertilization. J. Agric. Sci. Mansoura Univ., 15: 2182-2187.

El-Fakharani, Y.M., 1999. Combined effect of P-fertilization and organic manuring on barley in sandy soils. Fayoum J. Agric. Res. Dev., 13: 81-97.

El-Far, H.A.R., 1996. Effect of some cultural practices on growth and yield of maize (*Zea mays* L.). M.Sc. Thesis, Faculty of Agriculture, Mansoura University, Egypt.

El-Naggar, N.Z.A., M.A. Mohamed, S.A. Mowafy and I.M. Abd El-Hameed, 2012. Effect of FYM and N fertilizer on photosynthetic partitioning parameter, yield and yield attributes of maize-soybean intercropping. Zagazig J. Agric. Res., 39: 589-604.

Enwezor, W.A., E.J. Udo, K.A. Ayotunde and J.A. Adepetu, 1995. Effect of organic fertilizer on the yield of maize. Field Crop Res., 65: 132-136.

Fagaria, N.K., V.C. Baligar and C.A. Jones, 1997. Growth and Mineral Nutrition of Field Crops. Marcel, Dekker, Inc., New York.

Fageria, N.K. and V.C. Baligar, 1993. Screening crop genotypes for mineral stresses. Proceedings of the Workshop on Adaptation of Plants to Soil Stresses, University of Nebraska, Lincoln, INTSORMIL, pp: 152-159.

Hassanein, M.K. and M. Abul-Soud, 2010. Effect of different compost types and application methods on growth and yield of three maize hybrids. J. Applied Sci. Res., 6: 1387-1399.

Hegazy, M.H., S.A. Genaidy, A.A. Abd El-Magid and K.M. Khalil, 1996. Nitrogen and phosphorus fertilization for corn (*Zea mays* L.) in relation to some untraditional fertilizer at Kafr El-Shikh soil. J. Agric. Sci. Mansoura Univ., 21: 3367-3372.

Hussain, N., A.Z. Khan, H. Akbar and S. Akhtar, 2006. Growth factors and yield of maize as influence by phosphorus and potash fertilization. Sarhard J. Agric., 22: 579-583.

Hussein, A.H.A., 2009. Phosphorus use efficiency by two varieties of corn at different phosphorus fertilizer application rates. Res. J. Applied Sci., 4: 85-93.

Khan, M.A., M. Abid, N. Hussain and M.U. Masood, 2005. Effect of phosphorous levels on growth and yield of maize (*Zea mays* L.) cultivars under saline conditions. Int. J. Agric. Biol., 7: 511-514.

MSTAT-C, 1991. A microcomputer program for the design, management and analysis of agronomic research experiment. MSTAT Development Team, Michign State University.

Masood, T., R. Gul, F. Munsif, F. Jalal, Z. Hussain and N. Noreen, 2011. Effect of different phosphorus levels on the yield and yield components of maize. Sarhad J. Agric., 27: 167-180.

Mazengia, W., 2011. Effects of methods and rates of phosphorus fertilizer application and planting methods on yield and related traits of maize (*Zea mays* L.) on soil of Hawassa area. Innovation Syst. Des. Eng., 2: 315-335.

Mengel, K. and E.A. Kirkby, 2001. Principles of Plant Nutrition. 5th Edn., Kluwer Academic Publishers, Dordrecht, Boston, London, ISBN: 1402000081.

Nofal, F.A.E., M.S.M. Soliman and M.M. Abdel-Ghani, 2005. Effect of irrigation at different water depletions levels, nitrogen and manure applications on water use efficiency and maize grain yield in sandy soils. Minufiya J. Agric. Res., 30: 1159-1177.

Okoruwa, E.A., 1998. Effects of NPK fertilizer and organic manure on the growth and yield of maize (*Zea mays* L.) hybrid. Crop Sci., 22: 119-124.

Salem, M.A., 2000. Response of maize (*Zea mays* L.) growth and yield to chemical and biofertilization. Zagazig J. Agric. Res., 24: 845-858.

Snedecor, G.W. and W.G. Cochran, 1988. Statistical Methods. 7th Edn., The Iowa State University Press, Ames, Iowa, USA, ISBN: 0813815606.

Tisdale, S.L. and W.L. Nelson, 1975. Soil Fertility and Fertilizer. Macmillan, New York, USA.

Waller, R.A. and D.B. Duncan, 1969. A bays rule for the symmetric multiple comparison problem. J. Am. Stat. Assoc., 64: 1484-1503.

Yach, S., W. Rakish and K. Sing, 1992. Phosphorus availability under different soil pH. Indian Agric., 23: 124-128.

Yosefi, K., M. Galavi, M. Ramrodi and S.R. Mousavi, 2011. Effect of bio-phosphate and chemical phosphorus fertilizer accompanied with micronutrient foliar application on growth, yield and yield components of maize (Single Cross 704). Aust. J. Crop Sci., 5: 175-180.