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EFFECT OF FARMYARD MANURE, PHOSPHORUS AND ZINC ON YIELD, AND GRAIN QUALITY OF MAIZE (*Zea mays l.*)

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ABSTRACT

Two field experiments were carried out during the summer seasons of 2013 and 2014 on maize plants (c.v. single hybrid 30K8) grown on a sandy loam soil at El-kassasin, Farm(30º 33′ 31″ N- 30° 56′ 7″ E, elev. 15.8 m), Ismailia Governorate, Egypt, to study the effect of FYM (0 and 10 m^3 /fed), P (15, 30 and 45 kg P_2O_5/fed) and Zn as foliar spraying (0 and 100 mg Zn/L) and their combinations on growth, yield and its components as well as grain quality of maize. The experiments were laid out in a split- split plot, arranged in a randomized complete block design with three replications. The obtained results showed that application of FYM significantly increased the yield, yield components as well as some grain mineral contents and grain quality. All the studied characteristics were significantly affected by P- fertilizer. Application of P at the rate of 30 kg P_2O_5/fed resulted in the maximum plant height (250.75 cm), cob weight (306.08g), 100-grain weight (43.50 g), grain weight/ear (255.44 g), grain yield (3769.25 kg/ fed) and protein yield (478kg fed^{-1}) as compared with the other P- fertilizer rates .Foliar application of zinc led to significant response of all studied characteristics. Application of FYM, p-fertilizer and foliar spraying of Zn in combination gave the best yield, yield components as well as some grain mineral contents and grain quality. Therefore, it could be concluded that the application of 10 m^3 FYM/fed +30 kg P_2O_5/fed + foliar spraying of Zn (100 mg Zn/L) is the best formula for achieving the best crop and improving yield quality.

Keywords: Foliar spraying of Zn, FYM, grain quality, maize, p-fertilizer, yield, yield components

INTRODUCTION

In Egypt, maize (*Zea mays* L.) is the most important cereal crop after wheat and rice. It is widely used in bread making in rural areas of the country. It conforms the basis for several industries such as starch, fructose and corn oil, as well as, the main component (about 70%) of animal feed. The total production is insufficient to meet local consumption due to low productivity per unit area and relatively, the limited cultivated area. Therefore, efforts are focused to increase its productivity to fill the gap between the local production and human consumption of cereals through growing high producing varieties under the most favorable cultural conditions.

Organic matter application to soils is crucial to improve soil properties and consequently the plant growth. Among the types of organic matter, farmyard manure could be one of the most economical ways to increase organic matter content in soil. Several investigators indicated that the application of FYM increased plant growth and dry matter production (Khalil *et al.,* 2000). Organic fertilizer is considered as an important source of humus, macro and microelements carrier and at the same time increases the activity of the beneficial microorganisms (El-Gizy, 1994). Dahdouh *et al.,* (1999), found that organic manures play an important role in nutrients solubility as activate physiological and biochemical processes in plant leading to increase the plant growth and nutrients uptake. The best means of maintaining soil fertility and productivity level could be achieved through periodic addition of proper organic materials in combination with inorganic fertilizer (El-Fayoumy *et al.,* 2001).

Phosphatic fertilization is important for different crops .This, in fact due to the fundamental role of P in a large number of enzymatic reaction depending on phosphorylation and in the synthesis of various organic compounds in the plant (Nassar *et al*., 2001).Moreover P has an enhancing impact on plant growth and the resultant crop through its importance as energy storage and transfer necessary for the metabolic processes (Omran, *et al*., 1999 and Nassar *et al*., 2005)

Zinc is an essential component of various enzyme systems, (more than 80 enzymes), for energy production, protein synthesis, growth regulation and lowering toxicity effect of boron, cadmium and lead. Zinc plays a key role in pollination and seed set processes; so that its deficiency can reduce seed formation and subsequent yield reduction (Ziaeyan and Rajaie, 2009).Zinc is very important micronutrient for increasing grain yield in corn and sorghum, as well as onion and spinach. Also it has a positive interaction with K, increases of plant stress resistance to salinity, water stress, drought, cold, etc., and it is necessary for chlorophyll synthesis and carbohydrate formation (El-Hadidi and Mansour, 2008). Zinc has also a role in starch metabolism in plants. According to Brown *et al.,* (1993), formation of male and female reproductive organs and pollination process are disturbed in Zn deficiency, which may be attributed to the reduction of indol acetic acid (IAA) synthesis. Marschner (1995) declared that following Zn deficiency, reduction in RNA-polymerase activity and increase in RNA destruction can severely reduce the seed protein content.

The aim of the present investigation is to study the effect of organic manure, P-fertilizer and foliar spraying of Zn and their combinations on growth, yield and its components as well as grain quality of maize.

MATERIALS AND METHODS

Experimental site description and soil properties

Two field experiments were carried out during the summer seasons of 2013 and 2014 on maize plants (c.v. single hybrid 30K8) grown on a sandy loam soil at El-Kassasin Farm, Ismailia Governorate, Egypt, *(30º 33′ 31″ N-30° 56′ 7″ E, elev. 15.8 m),* to study the effects of organic manure, P-fertilizer and foliar spraying of Zn and their combinations on growth, yield and its components as well as grain quality of maize. Some physical and chemical properties of the investigated soil and the organic fertilizer estimated according to Page *et al.,* (1982) and presented in Tables (1&2).

Treatments and experimental design

The experiment included 12 treatments, which were the combination between two treatments of organic fertilizer (0 and 10 m^3FYM fed^{-1}.), three levels of P fertilizers (15, 30 and 45 kg P_2O_5 fed^{-1}) and two levels of zinc as foliar applications (0 and 100 mg Zn/L). The split-split plot system in a randomized block design with three replicates was used in both growing seasons. FYM treatments were arranged in the main plots, the three levels of P treatments were assigned to the sub plots, while the two zinc levels were assigned to sub-sub plots. The sub-sub plots area was 10.5m^2, containing 5 ridges of 3m long and 70cm a part. The grains were drilled at 30cm a part and thinned to one plant /hill before first irrigation. Phosphorus fertilizer was applied as single calcium superphosphate (15 % P_2O_5) in one dose before planting. Nitrogen fertilizer as ammonium sulphate (20.6 % N), was added at the rate of 120 Kg N fed^{-1}. in three equal doses before first, second and third irrigation. Potassium sulphate (48%K_2O) at the rate of 24kg K_2O fed^{-1}. was added in two equal doses, i.e.15 and 40 days after planting. The applied treatments of zinc were used as foliar spray twice, at 45 and 65 days after sowing with a concentration of 100 mg Zn/L (o.77g/L of Zn-EDTA, 13% Zn), using 400Lof water/fed. as spraying solution.

Table 1. physical and chemical properties of the experimental soil

Property	Value
Particle size distribution (%)	
Sand	67.30
Silt	22.20
Clay	10.50
Texture grade	Sandy loam
pH (1:2.5 soil water suspension)	7.64
ECe (dS/m, 1:5, soil: water extract.)	0.72
Soluble cations (meq/L)	
Ca++	2.96
Mg++	1.70
Na+	1.86
K+	0.55
Soluble anions (meq/L)	
CO_3^{--}	0.00
HCO_3^-	1.25
Cl^-	3.46
SO_4^{--}	2.36
Organic matter (%)	0.62
Available nutrient (mg/kg)	
N	40.0
P	8.00
K	173.5
DTPA-extractable (mg/kg)	
Fe	3.42
Mn	3.34
Zn	1.12
Cu	0.34

Table 2. Chemical analysis of the used farmyard manure.

C%	Total N %	C/N ratio	OM %	Total %		Available mg kg^{-1}		
				P	K	N	P	K
22.91	1.60	14.32	39.5	0.83	1.92	1106	1519	2018

At harvesting, the following characteristics were estimated:
Yield and Yield Components:

Plant height (cm), ear characters (i.e., ear length (cm), ear diameter (cm), ear weight (g), row number/ear and grain number /row); grain yield (kg/fed.), grain weight /ear (g), weight of 100 grain (g) and grain quality .

Chemical Constituents:

- Grain samples were taken for chemical analysis to determine the following chemical constituents:
- Nitrogen content was determined by Keldahl method as described by A.O.A.C (1985). Protein content in the grains was calculated by multiplying N% by 5.75 factors. Phosphorus was determined calorimetrically according to Chapman and Pratt, (1978). Potassium was determined by flam photometer according to Jackson (1973). Zinc content in grains was estimated using an atomic absorption spectrophotometer apparatus as described by Chapman and Pratt, (1978).
- Oil content (%) was determined by soxhelt apparatus using hexane as a solvent as described by A.O.A.C. (1990). Oil yield (kg/fed.) was estimated by multiplying grain yield (kg/fed.) by grain oil percentage.
- Total soluble sugars and total carbohydrate contents in maize grains were also determined according to Smith *et al.* (1956). Starch content was obtained by calculating the difference between total carbohydrate and total soluble sugar content. The obtained results were statistically analyzed according to Gomez and Gomez (1984) to define the statistical significance of L.S.D. at 0.05.

RESULTS AND DISCUSSION

Effect of the applied treatments on ear characters, yield of maize and grain quality

1. Effect of farmyard manure:

Results in Tables (3&4) showed that application of farmyard manure (FYM) influenced significantly yield and its components of maize compared to control. The treatment of FYM application significantly yielded higher values of 100-grain weight (42.03g), cob weight (312.67g), grain weight/ear (259.09g), grain yield (3850.33 kg fed^{-1}), protein yield(521.50 kg fed^{-1})and oil yield(296.92 kg fed^{-1}) than control treatment i.e. (36.24g), (272.40g), (231.14g),(3106.67 kg fed-^{1}), (331.67 kg fed-^{1})and (200.51 kg fed-^{1}) , respectively. The increase in growth of maize could be attributed to the enhanced nutrient use efficiency in the presence of organic fertilizer. Many research studies have shown that the composted organic materials release nutrients slowly and may reduce the leaching losses, particularly N (Umesha *et al*., 2014). All the studied characteristics were significantly affected by the application of farmyard manure. These increases may be attributed to high content of humus, macro and micronutrients, which might enhance the activity of photosynthesis and protein synthesis in the leaves. The plots received FYM treatment gave significantly higher N, P, K and Zn contents by maize grains (90.67, 18.67, 44.55 kg fed^{-1}and 226.48 g fed^{-1}, respectively).

This could be due to the increase N, P, K and micronutrient availability in the soil resulting in higher production of chlorophyll, dry matter and uptake of nutrients. The positive impacts of FYM on maize crop production and its mineral compositions are mainly due to improving the soil physical and chemical properties, preparing the suitable bed for germination and development of plant growth that reflect on resultant yield. Hassan and Mohey El-Din (2002) reported that the increasing of NPK content with FYM application, may be attributed to the mineralization of organic matter and slow releasing of minerals in an available form from organic manure, or may be due to the effect of several organic acids, produced during manure decomposition, which solublize the native P of the soil and partly due to the formation of a coating on $CaCO_3$ which did not allow to react with soil P, and thus P availability increased and consequently the content in plant is increased. All measured quality parameters under organic treatment were recorded the highest and significant values. Application of organic manure increased the protein, oil, total carbohydrate, total soluble sugars and starch content of maize grain over the control. The favorable effect of organic manure on enhancement of grain quality could be interpreted as the organic manure contains considerable amounts of macro and micronutrients which contribute to improve chemical constituents of grains and also the effect of organic acids produced during decomposition of soil minerals. Similar results were gained by Khalil *et al*., (2000), Ewais *et al*., (2004) and El-Shouny (2006).

Table 3. Effect of FYM on yield and yield components of maize plants (combined analysis of 2013 and 2014)

FYM m^3/fed	Yield and yield components								
	Plant Height (cm)	Ear Length (cm)	Ear Diameter (cm)	No of row/ ear	No of grain/ row	Cob weight (g)	Weight of 100 grain (g)	Grain weight /ear (g)	Grain yield Kg/fed
0	220.33	22.89	5.23	12.95	50.00	272.40	36.24	231.14	3106.67
10	256.00	24.57	5.54	13.73	58.00	312.67	42.03	259.09	3850.33
LSD at 5 %	7.67	0.96	0.10	0.24	3.52	4.72	0.80	14.27	11.26

Table 4. Effect of FYM on grain nutrient contents and quality of maize (combined analysis of 2013 and 2014)

FYM m^3/fed	Grain Nutrient contents (kg/fed)				Grain quality						
	N	P	K	Zn (g/fed)	Protein %	Protein Yield kg/fed	Oil %	Oil yield Kg/fed	Carbohydrate (mg/g DW)	TSS (mg/g DW)	starch (mg/g DW)
0	57.66	10.91	24.02	144.46	10.61	331.67	6.34	200.51	654.5	19.2	635.3
10	90.67	18.67	44.55	226.48	13.52	521.50	7.66	296.92	68 1.5	22.5	659.0
LSD at 5%	1.66	0.32	3.33	15.00	0.26	8.79	0.03	12.02	6.52	1.65	5.37

2. Effect of phosphatic fertilization:

Application of phosphorus fertilizer at different levels affected on yield attributes, grains yield/fed. as well as some grain mineral contents and grain quality (Tables 5and 6). All the studied characteristics increased steadily with the increase of P- fertilizer. The highest values were attained from the plots received rate (30kg P_2O_5/fed) compared with those attained with the others. Application of 30kg P_2O_5/fed significantly increased 100-grain weight (43.50g), cob weight (306.08g), grain weight/ear (255.44g), grain yield (3769.25kg fed^{-1}), protein yield(478kg fed^{-1})and oil yield(310.42kg fed^{-1}) over the other rates. These increases by using P may be due to the effect of phosphorus on some vital enzymatic reactions that depends mainly on phosphorlization. Meanwhile, phosphorus is a constituent of cell nucleus and is essential for cell division and development of meristematic tissues (Mengel and Kirkby, 1987).Promoting effect of phosphorus on grain protein and oil content may be due to the role of phosphorus in protein formation through providing the energy required for the synthesis of protein. Also, the increase in oil content with phosphorus application could be due to the fact that phosphorus helps in synthesis of fatty acids and their estererification by accelerating biochemical reactions in glyoxalate cycle (Dwivedi and Bapat, 1998). These results are in agreement with Nassar *et al*., (2005).Total carbohydrate, total soluble sugars and starch content of maize grain showed also the same previous trend. The highest values were recorded by application of 30kg P_2O_5/fed which were 711.3, 24.4 and 687.4 whereas the lowest values were recorded by 15kg P_2O_5/fed which were 650.8, 19.8 and 631.1 (mg/g DW) respectively. Phosphorus has stimulative effect and this may be due to its fundamental role in increasing the efficiency of plants to photosynthetic metabolic (Marschner, 1998), activating large number of enzymatic reactions depending on phosphorylation (Mohammed, 1998 and Nassar *et* a*l*. 2005) and increasing the plant meristematic tissues which take much of P in the early stages.

Table 5. Effect of P- fertilizer rates on yield and yield component of maize plants (combined analysis of 2013 and 2014)

P_2O_5 Kg/fed	Yield and yield components								
	Plant Height (cm)	Ear Length (cm)	Ear Diameter (cm)	No of row/ ear	No of grain/ row	Cob weight (g)	Weight of 100 grain (g)	Grain weight /ear (g)	Grain yield Kg/fed
15	224.75	22.48	5.13	12.59	47.92	278.48	34.50	231.35	3187.00
30	250.75	24.97	5.64	13.92	59.42	306.08	43.50	255.44	3769.25
45	239.00	23.74	5.40	13.34	54.59	293.05	39.40	246.06	3479.25
LSD at 5 %	4.39	0.53	0.10	0.85	3.97	4.66	0.67	6.00	20.44

Table 6. Effect of P- fertilizer rates on grain nutrient contents and quality of maize (combined analysis of 2013 and 2014)

P_2O_5 Kg/fed	Nutrient contents (kg/fed)				Grain quality						
	N	P	K	Zn (g/fed)	Protein %	Protein Yield kg/fed	Oil %	Oil yield Kg/fed	Carbohydrate (mg/g DW)	TSS (mg/ g DW)	starch (mg/ g DW)
15	63.78	7.93	26.67	155.28	11.29	366.75	5.43	176.55	65 0.8	19.8	631.1
30	84.32	20.28	41.53	218.45	12.74	478.00	8.19	310.42	711.3	24.4	687.4
45	74.42	16.16	34.64	182.70	12.17	428.25	7.38	259.19	685.3	22.0	663.3
LSD at 5 %	0.97	0.25	1.79	3.54	0.34	13.04	0.02	6.64	4.64	0.85	4.68

3. Effect of zinc fertilization:

Zinc as a foliar spray application treatment significantly promoted vegetative growth as indicated by increased plant growth parameters such as plant height, 100-grain weight, grain weight/ear, maize grain yield/fed. as well as some grain mineral contents and grain quality (protein, oil, total carbohydrate, total soluble sugars (TSS) and starch) (Tables 7and 8). Zinc application as foliar gave the highest values of100-grain weight, grain weight/ear and grain yield/fed. This result may be due to the role of Zn as a co-factor in the enzymatic reactions of the anabolic pathways in plant growth, activation of photosynthetic enzymes, chlorophyll formation and improvement of plant growth (Movahhedy-Dehnavy *et al*., 2009).It's evident from such data that foliar application of zinc significantly increased N, P and K content of maize grain compared with control. These increases in elemental constituents of maize grain may be due to the effect of zinc on stimulating biological activities, i.e., enzyme activity, chlorophyll synthesis, rate of translocation of photosynthetic products and increased nutrient uptake through roots after foliar fertilization (Marschner and Cakmak, 1989 and Grzebisz *et al*., 2008). Also, foliar application of Zn significantly improved total carbohydrate, total soluble sugars and starch contents of maize and doubled the grain Zn content of maize. Marschner (1995) declared that Zn is essentially necessary for protein synthesis and following Zn deficiency induced reduction in RNA-polymerase activity and increase in RNA destruction and this can severely reduce grain protein content. Zinc plays an important role in many biochemical reactions within the plants. Plants such as maize, sorghum and sugarcane show reduced photosynthetic carbon metabolism due to zinc deficiency. Zinc modifies and/or regulates the activity of carbonic anhydrase, an enzyme that regulates the conversion of carbon dioxide to reactive bicarbonate species for fixation to carbohydrates in these plants. Zinc is also a part of several other enzymes such as superoxide dismutase and catalase, which prevents oxidative stress in plant cells. Also, the content of carbohydrates tended to increase by adding Zn. In this respect, Jyung *et al.*, (1975) provided the evidence for a close relationship between zinc nutrition and starch formation. They found that under zinc deficient conditions, the starch synthetase activity and the starch content were decreased by 64% and 94% of their normal levels, respectively .They also showed that in the plants grow in the field under low zinc supply, the starch synthetase activity was reduced by 80% of that in plants grown under an adequate supply.

Table 7. Effect of foliar spraying of Zn on yield and yield component of maize plants (combined analysis of 2013 and 2014)

Zn foliar application	Yield and yield components								
	Plant Height (cm)	Ear Length (cm)	Ear Diameter (cm)	No of row/ ear	No of grain/ row	Cob weight (g)	Weight of 100 grain (g)	Grain weight /ear (g)	Grain yield Kg/fed
-Zn	235. 00	23.56	5.34	13.11	52.44	287.65	38.30	241.32	3411.17
+Zn	241. 33	23.90	5.44	13.45	55.50	297.42	39.97	247.24	3545.83
LSD at 5 %	3. 38	N.S	0.03	0.39	2.48	N.S	0.44	5.51	15.73

Table 8. Effect o f foliar spraying of Zn on grain nutrient contents and quality of maize (combined analysis of 2013 and 2014)

Zn foliar application	Nutrient contents (kg/fed)				Grain quality						
	N	P	K	Zn (g/fed)	Protein %	Protein Yield kg/fed	Oil %	Oil yield Kg/fed	Carbohydrate (mg/g DW)	TSS (mg/g DW)	starch (mg/g DW)
-ZN	72.02	14.07	32.87	165.49	11.93	414.17	6.80	236.82	677.8	21.o	656.9
+Zn	76.32	15.50	35.69	205.45	12.19	434.50	7.20	260.62	687.0	23.1	664.3
LSD at 5 %	0.64	0.18	1.04	3.91	0.17	6.72	0.02	3.04	6.64	0.95	5.86

4. Interaction effect between FYM and P-fertilizers:

Data in Tables (9 a and10a) indicated that the all examined parameters except ear length, ear diameter; raw number/ear, grain number/raw and total soluble sugars responded significantly to FYM with P-fertilizer. The treatment of FYM + 30 P_2O_5/fed. application recorded significant the higher values of100-grain weight (47.45g), cob weight (323.63g), grain weight/ear (267g), grain yield (4095kg fed^{-1}), protein yield(580.50kg fed^{-1})and oil yield(357.69 kg fed^{-1}) than the rest of the applied treatments. The use of organic manure in combination with 30 P_2O_5/fed. application recorded the highest values of N, P and K contents by maize grains (94.27, 15.15 and 43.49 kg fed^{-1} significantly) as compared to those other treatments recorded .The increases in nutrients absorption could be due to that organic manure may play a favorable role in increasing nutrients availability in most soils, through the processes of chelating, biochemical processes and production of several organic acids during decomposition of organic manure as shown by Abd-Alla *et al.,* (2001) and Rizk (2002). The promoting impact of P on the maize yield and its mineral composition may be due to the fundamental role of P in all important nucleoproteins and a large number of enzymatic reactions that depend on phosphorylation (Nassar and Ismail, 1999). The current results may be due to the beneficial effect of organic manure combined with P-fertilizer on metabolic processes and growth, which in turn reflected positively on chemical content of maize grains. The use of organic fertilizers not only supplies sufficient nutrients to the plants but also improves soil physical and chemical properties. So, the continuous addition of organic manure with or without mineral fertilizer will help to maintain the soil organic matter at a reasonable level. Similar results were also gained by El-Zawity *et al.,* (2002) and Ewais *et al*., (2004).

Table 9 a. Yield and yield component of maize plants as affected by FYM X P- fertilization rates interactions

FYM m^3/fed	P_2O_5 Kg/fed	Yield and yield components								
		Plant Height (cm)	Ear Length (cm)	Ear Diameter (cm)	No of row/ ear	No of grain/ row	Cob weight (g)	Weight of 100 grain (g)	Grain weight/ ear (g)	Grain yield Kg/fed
0	15	202.5	21.42	4.92	12.34	43.83	254.35	32.70	215.93	2730.00
	30	236.5	24.42	5.55	13.67	55.50	288.51	39.55	243.88	3443.50
	45	222.0	22.83	5.24	12.84	50.67	274.33	36.45	233.63	3146.50
10	15	247.0	23.53	5.34	12.84	52.00	302.61	36.30	251.78	3644.00
	30	265.0	25.53	5.72	14.50	63.50	323.63	47.45	267.00	4095.00
	45	256.0	24.65	5.56	13.84	58.50	311.76	42.35	258.48	3812.00
LSD at 5%		6.21	N.S	N.S	N.S	N.S	0.81	0.95	8.48	28.90

Table 10 a. Grain nutrient contents and quality of maize as affected by FYM X P-fertilization interactions

FYM m^3/fed	P_2O_5 Kg/fed	Nutrient contents (kg/fed)				Grain quality						
		N	P	K	Zn (g/fed)	Protein %	Protein Yield kg/fed	Oil %	Oil yield Kg/fed	Carbohydrate (mg/g DW)	TSS (mg/g DW)	starch (mg/g DW)
0	15	46.74	5.81	18.17	119.05	9.85	269.11	4.65	127.05	64 0.5	18.3	622.3
	30	66.27	9.46	26.61	163.42	11.69	381.64	7.64	249.44	699.0	22.3	676.8
	45	58.24	7.74	23.21	141.15	11.06	335.49	6.71	203.59	668.5	20.2	648.4
10	15	72.85	9.73	30.65	180.91	12.17	418.63	6.20	213.58	661.0	21.2	639.8
	30	94.27	15.15	43.49	254.01	13.78	542.00	8.73	343.56	723.5	26.5	698.0
	45	83.00	12.62	37.03	223.41	12.81	476.74	8.05	299.62	702.0	23.8	678.3
LSD at 5%		1.37	0.35	2.19	12.96	0.25	7.90	3.31	1.17	6.56	N.S	6.62

5. Interaction effect between FYM and foliar spraying with Zn fertilizer:

Data in Tables (9 b and10b) indicated that the examined parameters i.e., ear diameter, 100-grain weight, grain yield, N, P, K, Zn contents of grain, protein and oil%, protein and oil yield significantly responded to foliar application of Zn in combination with organic manure. The highest100-grain weight (43.13 g), grain yield (3920.33 kg/fed), protein yield (534.67 kg/fed) and oil yield (311.31 kg/fed.) were realized by application of FYM at the rate of 10 m^3/fed. along with foliar spraying with Zn used, while the lowest values of grain yield and yield components were recorded under control treatment .Application of organic manure in combination with foliar application of Zn recorded significantly higher protein content, protein yield, oil content and oil yield. These results could be attributed to the effective role of Zn in controlling various enzymes activities and photosynthetic pigments formation, consequently affecting plant growth. The better efficiency of organic manure might be due to the fact that the organic manure activates many species of living organisms which release phytohormones and may stimulate the plant growth and absorption of nutrients.

Table 9 b. Yield and yield component of maize plants as affected by FYM X foliar spraying of Zn interaction

FYM m^3/fed	Zn foliar application	Yield and yield components								
		Plant Height (cm)	Ear Length (cm)	Ear Diameter (cm)	No of row/ ear	No of grain/ row	Cob weight (g)	Weight of 100 grain (g)	Grain weight /ear (g)	Grain yield Kg/fed
0	-Zn	216.67	22.73	5.18	12.67	48.44	265.96	35.67	225.70	3042.00
	+Zn	224.00	23.04	5.28	13.22	51.65	278.83	36.80	236.58	3171.33
10	-Zn	253.33	24.39	5.49	13.56	56.44	309.33	40.93	256.93	3780.33
	+Zn	258.67	24.75	5.59	13.89	59.56	316.00	43.13	261.23	3920.33
LSD at 5 %		N.S	N.S	0.05	N.S	N.S	N.S	0.62	N.S	22.25

Table 10 b. Grain nutrient contents and quality of maize as affected by FYM X foliar spraying of Zn interaction

FYM m^3/ fed	Zn foliar application	Nutrient contents (kg/fed)				Grain quality						
		N	P	K	Zn (g/fed)	Protein %	Protein Yield kg/fed	Oil %	Oil yield Kg/fed	Carbohydrate (mg/ g DW)	TSS (mg/ g DW)	starch (mg/ g DW)
0	-Zn	55.65	10.35	23.07	127.35	10.45	320.00	6.16	191.09	664.0	19.1	644.9
	+Zn	59.67	11.47	24.96	161.57	10.77	343.33	6.51	209.92	674.7	21.3	653.3
10	-Zn	88.37	17.79	42.67	203.63	13.42	508.33	7.43	282.53	691.7	22.8	668.9
	+Zn	92.97	19.54	46.41	249.33	13.61	534.67	7.89	297.31	699.3	24.8	675.2
LSD at 5 %		0.91	0.25	1.47	5.53	0.24	9.51	2.39	4.30	N.S	N.S	N.S

6. Interaction effect between P-fertilizers and foliar spraying with Zn fertilizer:

The effects of interaction between phosphorous and foliar spraying with Zn are presented in Tables (9 c and10c).The interaction showed that components except100-grain weight were not significantly affected by this interaction, however, grain yield/fed. was significantly affected and application of 30 kg P_2O_5/fed along with Zn fertilization recorded the highest values. Generally, the highest values of interaction effect were recorded with plots received 30 kg P_2O_5/fed with100 ppm Zn (Zn-EDTA) whereas, the lowest values were obtained under control treatment.

7. Interaction effect among FYM, P-fertilizers and foliar spraying with Zn fertilizer:

Concerning the interaction among FYM, P-rate and foliar application of Zn on ear characters of maize, data in Table (11) and fig. (1) revealed that the maximum ear characters were obtained when maize plants were fertilized with10 m^3FYM/fed+ 30 kg P_2O_5/fed. and foliar sprayed with Zn compared to untreated ones. Data in Table (12) and fig. (2-3) showed that FYM along with P-rate and foliar application of Zn led to significant increases in N, P, K, Zn contents, protein and oil%, protein and oil yield.This could be due to the more vegetative growth and root growth, which release hydrogen ions, phenolic compounds and organic acids as well as acidification effect of manure applied that helped in increasing nutrients availability and uptake of N, P and K by maize plants. Also, the effect of Zn on all studied parameters of maize plants can be discussed on the basis of its effective role on plant growth and enzymatic functions and consequently increased the absorbing efficiency of plant. Foliar application of Zn is readily absorbed by the leaves and not lost through fixation. Such favorable effects on yield and yield components could be attributed to the stimulation effect of organic fertilizer (Farmyard manure [FYM]) +30 kg P_2O_5/fed. and foliar sprayed with Zn on content of macronutrients, which might enhance the activity of photosynthesis and protein synthesis in the grains and nitrogen metabolism, which in turn reflected positively on maize yield attributes.

9--10

11---12

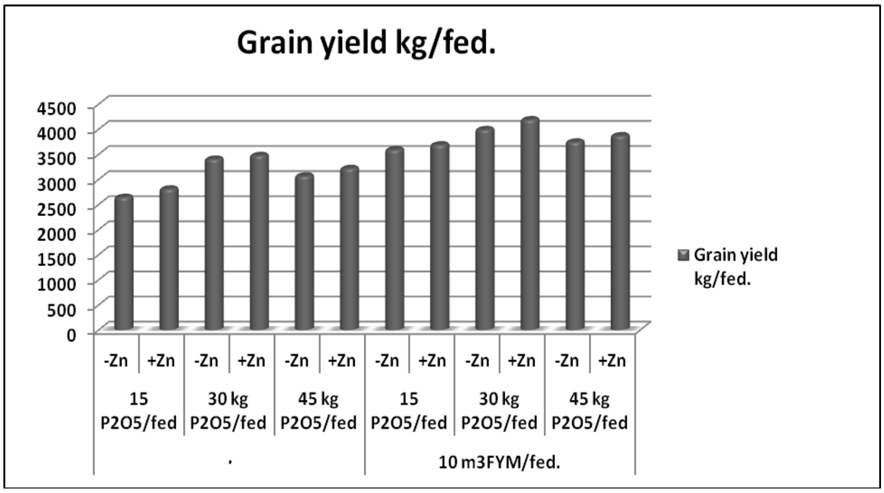

Fig. (1): Interaction effect among FYM, P-fertilizers and foliar spraying with Zn fertilizer on grain Yield

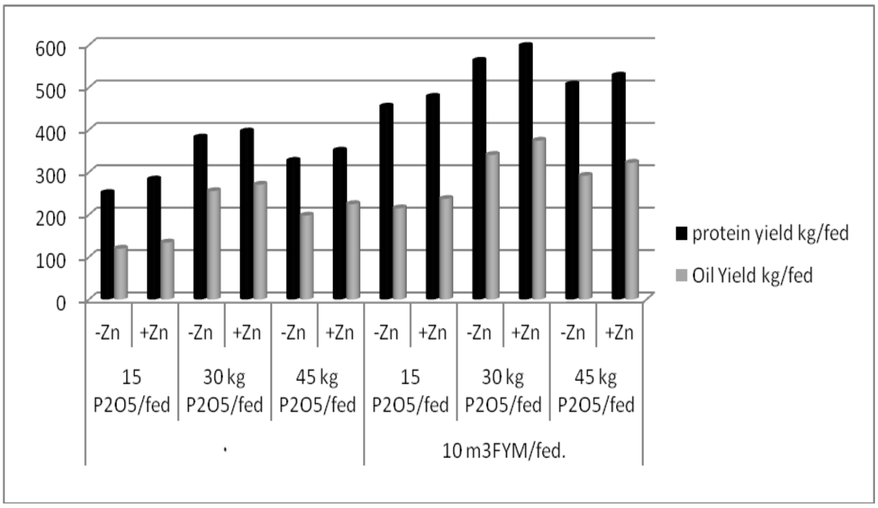

Fig. (2): Interaction effect among FYM, P-fertilizers and foliar spraying with Zn fertilizer on grain quality

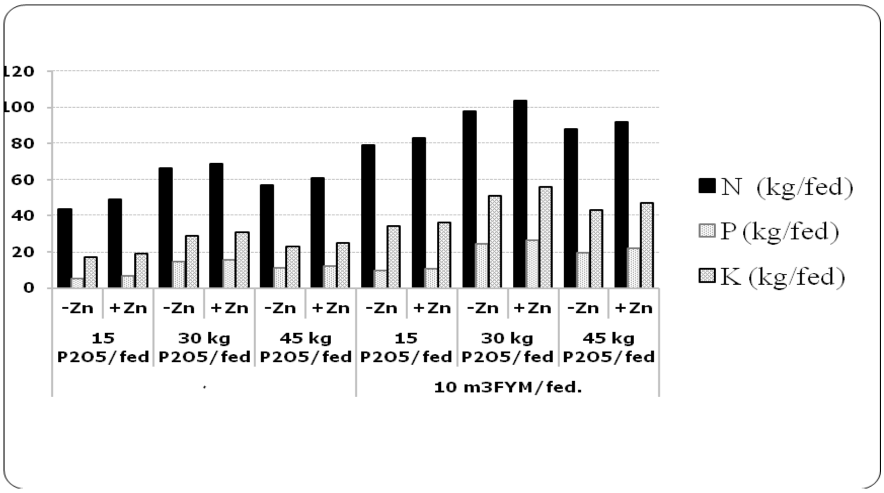

Fig.(3): Interaction effect among FYM, P-fertilizers and foliar spraying with Zn fertilizer on grain mineral contents

CONCLUSION

From the aforementioned data, it could be concluded that raising phosphorus rate up to 30kg P_2O_5 /fed induced the greatest increases of maize yields and yield components as well as some grain mineral contents and grain quality. The application of Zn as foliar raised the mean values of the same parameters. Using organic manure plus P fertilizers gave a significant promotive effect on yield, yield components as well as some grain mineral contents and grain quality of maize. Organic manure enhances soil aggregation, aeration, water holding capacity and amended the root system by slow release flow of nutrients which in combination creates favorable condition for root respiration, nutrients absorption, root and shoot growth and yield quantity and quality. Organic manure increases the fertility and productivity of sandy soils.

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تأثير السماد العضوى والفوسفور والزنك على المحصول ومكوناته وجودة الحبوب فى الذرة

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أجريت تجربتان حقليتان على نباتات الذرة الشامية (صنف هجين فردى 30K8) بمزرعة القصاصين (أرض رملية طميية) بمحافظة الاسماعيلية خلال الموسمين الصيفيين 2013-2014 بهدف دراسة تأثير إضافة السماد العضوى وبعض الاسمدة المعدنية على إنتاجية محصول الذرة ومكوناته وجودة الحبوب .

اشتملت التجربة على اثنتى عشرة معاملة فى قطاعات منشقة مرتين كل منهم فى ثلاثة مكررات ، استخدم فيها السماد العضوى(صفر – $10m^3$للفدان) وسماد السوبر فوسفات بمعدلات 15-30-45 كجم فو$_2$ا$_5$ للفدان والرش بعنصر الزنك بتركيزات محاليل (صفر- 100 ملى جرام/لتر) - زنك اديتا (13 % زنك) .

وأوضحت النتائج ان:-

- استخدام التسميد العضوى أدى الى زيادة معنوية فى محصول الحبوب فى الذرة وكذلك زيادة المحتوى من العناصر الغذائية والجودة فى الحبوب .
- وأيضا أدت إضافة السماد الفوسفاتى إلى زيادة معنوية فى المحصول ومكوناته وتحققت أفضل النتائج مع إضافة 30 كجم فو$_2$ا$_5$ للفدان مثل (ارتفاع النبات 250.75 سم ووزن الكوز 306.08 جم ووزن 100 حبة 43.5 جم ووزن الحبوب/كوز 255.44 جم ومحصول الحبوب 3769.25 كجم/فدان ومحصول البروتين 478 كجم /فدان مقارنة بالمستويات الاخرى من الفوسفور).
- أظهرت نتائج الدراسة أن هناك إستجابة معنوية لمحصول الحبوب وكذلك المحتوى من العناصر الغذائية ومحتوى الحبوب من البروتين والزيت والكربوهيدرات الكلية والسكريات الذائبة الكلية والنشا عند الرش بعنصر الزنك.
- أدى استخدام التسميد العضوى مع إضافة السماد الفوسفاتى عند المستوى30 كجم فو$_2$ا$_5$ للفدان والرش بالزنك متحدة معا الى الحصول على أفضل النتائج.
- ومن ثم يمكن القول بأنه تحت ظروف هذه التجربة يمكن زيادة إنتاجية محصول الذرة مع جودة الحبوب وذلك بإضافة $10\ m^3$ للفدان من السماد العضوى و30 كجم فو$_2$ا$_5$ للفدان والرش بالزنك بتركيز 100 ملى جرام/لتر .

Table 9 c. Yield and yield component of maize plants as affected by P-fertilization rates X foliar spraying of Zn interaction

P_2O_5 Kg/fed	Zn foliar application	Yield and yield components								
		Plant Height (cm)	Ear Length (cm)	Ear diameter (cm)	No of row/ ear	No of grain/ row	Cob weight (g)	Weight of 100 grain (g)	Grain weight/ear (g)	Grain yield Kg/fed
15	-Zn	221.5	22.33	5.08	12.34	46.00	270.70	33.90	226.60	3121.0
	+Zn	228.0	22.62	5.17	12.84	49.83	286.25	35.10	236.10	3253.0
30	-Zn	248.0	24.83	5.59	13.83	58.33	301.59	42.90	253.53	3702.0
	+Zn	253.5	25.11	5.68	14.00	60.50	310.56	44.10	257.35	3836.5
45	-Zn	235.5	23.52	5.34	13.17	53.00	290.65	38.10	243.83	3410.5
	+Zn	242.5	23.96	5. 46	13.50	56.17	295.44	40.70	248.28	3548.0
LSD at 5%		N.S	N.S	N.S	N.S	N.S	N.S	0.75	N.S	27.25

Table 10 c. Grain nutrient contents and quality of maize as affected by P-fertilization rates X foliar spraying of Zn interaction

P_2O_5 Kg/fed	Zn foliar application	Nutrient contents (kg/fed)				Grain quality						
		N	P	K	Zn (g/fed)	Protein %	Protein Yield kg/fed	Oil %	Oil yield Kg/fed	Carbohydrate (mg/g DW)	TSS (mg/g DW)	starch (mg/g DW)
15	-Zn	61.39	7.35	25.68	141.04	11.07	353.00	5.26	167.45	646.5	18.7	627.8
	+Zn	66.16	8.50	27.66	169.51	11.50	380.50	5.60	185.64	655.0	20.8	634.3
30	-Zn	82.19	19.52	39.86	196.55	12.65	472.50	8.02	298.24	706.5	23.3	683.3
	+Zn	86.45	21.04	43.20	240.35	12.83	483.50	8.36	322.59	716.0	25.5	691.5
45	-Zn	72.47	15.34	33.08	158.89	12.08	417.00	7.11	244.76	680.5	20.9	659.6
	+Zn	76.36	16.97	36.20	206.50	12.25	439.50	7.65	273.62	690.0	23.0	667.0
LSD at 5%		1.11	0.31	1.80	6.77	0.30	11.64	2.93	5.27	N.S	N.S	N.S

Table 11. Interaction effect between FYM, P fertilization rates and spraying of Zn on Yield and components of maize plants (combined analysis of2013 and 2014)

FYM m^3/fed	P_2O_5 Kg/fed	Zn Foliar	Yield and yield components: Plant Height (cm)	Ear Length (cm)	Ear Diameter (cm)	No of row/ear	No of grain/row	Cob weight (g)	Weight of 100 grain (g)	Grain weight /ear (g)	Grain yield Kg/fed
0	15	-Zn	198	21.33	4.87	12.00	42.33	242.54	31.90	204.70	2647
		+Zn	207	21.50	4.96	12.67	45.33	266.15	33.50	227.15	2813
	30	-Zn	234	24.33	5.48	13.33	54.33	283.52	39.40	241.25	3407
		+Zn	239	24.50	5.61	14.00	56.67	293.50	39.70	246.50	3480
	45	-Zn	218	22.53	5.19	12.67	48.67	271.82	35.70	231.15	3072
		+Zn	226	23.12	5.28	13.00	52.67	276.84	37.20	236.10	3221
10	15	-Zn	245	23.33	5.29	12.67	49.67	298.86	35.90	248.50	3595
		+Zn	249	23.73	5.38	13.00	54.33	306.35	36.70	255.05	3693
	30	-Zn	262	25.33	5.69	14.33	62.33	319.65	46.40	265.80	3997
		+Zn	268	25.72	5.75	14.67	64.67	327.61	48.50	268.20	4193
	45	-Zn	253	24.50	5.48	13.67	57.33	309.48	40.50	256.50	3749
		+Zn	259	24.80	5.64	14.00	59.67	314.04	44.20	260.45	3875
LSD at 5%			N.S	N.S	N.S	N.S	N.S	N.S	1.07	N.S	38.54

Table 12 . Interaction effect between FYM, P fertilization rates and spraying of Zn on grain nutrient contents and quality of maize (combined analysis of 2013and2014)

FYM m^3/fed	P_2O_5 Kg/fed	Zn Foliar	Nutrient content (kg/fed)				Grain quality						
			N	P	K	Zn (g/fed)	Protein %	Protein Yield kg/fed	Oil %	Oil yield Kg/fed	Carbohydrate (mg/g DW)	TSS (mg/g DW)	starch (mg/g DW)
0	15	-Zn	43.68	5.21	17.21	105.88	9.49	251	4.53	119.91	635	17.5	617.5
		+Zn	49.23	6.50	19.13	132.21	10.06	283	4.77	134.18	646	19.0	627.0

	30	-Zn	66.44	14.65	28.96	153.30	11.21	382	7.50	255.53	695	21.0	674.0
		+Zn	68.90	15.66	30.62	191.40	11.39	396	7.78	270.74	703	23.5	679.5
	45	-Zn	56.83	11.18	23.04	122.88	10.64	327	6.44	197.84	662	18.8	643.2
		+Zn	60.88	12.24	25.12	161.10	10.87	351	6.98	224.83	675	21.5	653.5
10	15	-Zn	79.09	9.49	34.15	176.20	12.65	455	5.98	214.98	658	19.9	638.1
		+Zn	83.09	10.49	36.19	206.80	12.94	478	6.42	237.09	664	22.5	641.5
	30	-Zn	97.93	24.38	50.76	239.80	14.09	563	8.53	340.94	718	25.5	692.5
		+Zn	103.99	26.42	55.77	289.30	14.26	598	8.93	374.43	729	27.5	703.5
	45	-Zn	88.10	19.49	43.11	194.90	13.51	507	7.78	291.67	699	23.0	676.0
		+Zn	91.84	21.70	47.28	251.90	13.63	528	8.32	322.40	705	24.5	680.5
LSD at 5%			1.57	0.44	2.54	9.57	0.42	16.47	4.14	7.46	N.S	N.S	N.S