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PHOSPHORUS, ZINC AND MANGANESE FERTILIZATION IMPACTS ON GROWTH, YIELD AND CHEMICAL COMPOSITION OF MAIZE PLANT (*Zea mays L*).

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ABSTRACT: ***Two field experiments were carried out at Kafr EL_ Zayiat Center, Gharbia Governorate during two successive seasons 2008-2009. This study aimed to evaluate the effect of applied phosphorus fertilizer at three rates (0.0, 15 and 30 kg P2 O5 / fed.), also zinc and manganese at a rates of 0.3 and 0.15 g/l, respectively as well as combined treatments also between mineral phosphorus fertilizer levels and zinc and manganese on growth, yield and chemical composition of maize variety single hybrid 10. The tested micronutrients were in the form of EDTA i.e. Zn- EDTA (14% Zn) and Mn-EDTA (12% Mn), their solution were sprayed on the plants two times at volume of 400 l/fed., firstly sprayed at 35 and secondly at 50 days from sowing. The obtained data showed that, phosphorus fertilizer at a rate of 15 kg P2O5 /fed. had a pronouncing effect more than other different phosphorus rates in increasing significantly dry weights of shoots and roots, also significant increases in chlorophyll a, b and carotenoids in leaves of maize plant after 60 days from sowing for two the growing seasons. Significant increases in yield and yield components, since the percentage of increases in grains yield reached 39.96 and 39.92% for the first and the second seasons, at a respective order as comparing to the control treatment. Corresponding increases significantly in macronutrients (nitrogen, phosphorus and potassium) and micronutrients (zinc, manganese and ferrous) concentrations and uptake, likewise crude protein, protein yield and total carbohydrates in grains of single hybrid 10 maize variety.***

Data indicated that, application of zinc and manganese as foliar fertilization in association with different rates of phosphorus fertilizer gained more increases significantly in all studied parameters, a much greater extent more the phosphorus fertilization used alone. The combined treatment of 15 kg P2O5 /fed. + zinc + manganese could be an effective fertilization practice for the highest significant increases not only growth, yield and its attributes but also on nutrients concentrations and uptake, crude protein and total carbohydrates in grains of single hybrid 10 maize cultivar for the two growing seasons.

Key words: ***Maize plant, Phosphorus, Zinc and Manganese fertilizations.***

INTRODUCTION

Maize (*Zea mays L.*) is one of the most important cereal crops grown principally during the summer season in lower and Upper Egypt. Maize grains are widely used for human and animal feeding. Recently, efforts have been devoted to increase the productivity of maize per unit area through the addition of macro- and micronutrients.

Phosphorus is very important to plants as a constituent of nucleic acid, phospholipids and ATP. Also phosphorus activates amino acids to synthesis protein (Devlin and Witham, 1972). Shaban and Attia (2009) reported that, application calcium super phosphate at a rate of 100 kg/fed. increased weight of grains/ear, weight of 100-grains, grains and straw yield, N, P, K, Fe, Mn, Zn and protein concentrations in grains of maize crop.

As for zinc and its effect on maize plants, Gebraiel *et al.* (2005) showed that, zinc application increased significantly growth characters *viz* plant growth, stem diameter and dry weights of plants as well as N,K and Zn uptake after 75 days from sowing. Yield attributes *viz,* ear length, ear diameter, number of kernels/ rows, 100- kernel weights, shelling %, grains and straw yield, likewise protein and carbohydrates % in grains of maize.

Manganese may become deficient in acid or alkaline soils because it is converted to unavailable forms. Available manganese is the active which is sufficient to support normal plant growth. This element is considered as one of the micro-nutrients, which are optional in traces for plant growth. Manganese absorption is mainly as Mn^{+2} and translocation predominantly as the free divalent cation in xylem from roots to shoots (Marschner 1995). Kandeel and El-Maddah (1998) showed that, the effect of Mn-addition on plant growth, led to significantly increase dry matter of maize plant (leaves and stems), Mn-concentration and uptake in leaves as well as grain yield. El-Sayed (1998) found that, foliar spraying of Zn and Mn solution increased significantly grain yield, protein yield, shelling %, weight of 100 grains, N, P, K, Zn and Mn concentrations and uptake in leaves and grains of maize plant.

The aim of this investigation is to study the effect of phosphorus at different levels, zinc and manganese either singly or together on shoots and roots dry weights, chlorophyll a, b and carotenoids in leaves after 60 days from sowing. Also, on yield and yield components, macro- and micronutrients concentrations and uptake, crude protein and total carbohydrates in grains of maize plant.

MATERIALS AND METHODS

Two field experiments were conducted in two successive summar seasons (2008 and 2009) at Kafr El-Zayiat Center, Gharbia Governorate to study the effect of phosphorus, zinc and manganese- EDTA fertilizers added either solely or in association on maize genotype single hybrid 10 on its growth, yield and its components and chemical compositions of grains. Representive surface soil samples (0-30 cm) were taken before performance of the experiment, where the mechanical and chemical characteristics were determined using the standard methods according to Black (1965) Page *et al.,* (1982) and Page *et al*.(1982). The obtained data were recorded in Table (1).

Table (1): Mechanical and chemical properties of the studied soil.

Soil properties	First season	Second season
Mechanical analysis		
Sand %	14.18	13.25
Silt %	30.71	30.92
Clay %	55.11	55.0
Textural class	Clayey	Clayey
Chemical analysis		
CaCO3	2.14	2.22
EC(dSm^{-1}) (1:5 soil : water extract)	0.44	0.45
pH (1:2.5 soil : water suspension)	7.65	7.67
Available N (mg/kg)	40.25	41.32
Available P (mg/kg)	11.22	12.46
Available K (mg/kg)	377.26	378.13
Available Zn (mg/kg)	0.85	0.89
Available Mn (mg/kg)	4.88	4.91
Available Fe (mg/kg)	6.33	6.69

Maize grains were sown on 25 and 27 of May in the first and second seasons, respectively in 30 cm- spaced hills at a rate of two grains / hill and plants were thinned after 25 days at one plant per hill using the experimental design of randomized complete block with four replicates. The experimental unites were 48 plots, where the area of each plot was
(3 x 3.5) = 10.5 m^2.

The studied treatments were as follow.

P0: without phosphorus fertilizer (control), P1: 15 kg P 2O5 /fed., P2: 30 kg P2O5 /fed., P0 + Zn, P1 + Zn, P2 + Zn, P0 +Mn, P1 + Mn, P2 + Mn, P0 +Zn + Mn, P1 +Zn +Mn, and P2 +Zn +Mn.

Phosphorus fertilize was added as calcium super phosphate (15% P2O5) at a rate of 15 and 30 kg P2O5 /fed. before sowing. All plots of two experiments were fertilized with nitrogen as ammonium nitrate (33.5 %) at a

rate of 120 kg N/fed. where its added into two split equal doses and side dressed by hand before the first and the second irrigation. Potassium as potassium sulphate (48 % K2O) was applied at a rate of 24 kg K2O /fed. before the first irrigation

The treatments of Zn and Mn were at o.3 and 0.15 g//l, respectively where its applied as foliar spray methods. Plants were sprayed after 35 and 50 days from sowing at the rate of 400 l/fed. in the form of EDTA compounds i.e. Zn-EDTA (14 % Zn) and Mn-EDTA (12 % Mn). The other field practices were followed in the usual manner for maize cultivation. Plants were grown till maturity and sampled twice. The area of each sample was 1m^2. The first sample was taken after 60 days from sowing. The second sample was at harvest. At the first sample, chlorophyll a, b and carotenoids content in the leaves were recorded using spectrophotometer methods recommended by Metzner *et al.* (1965). Also, dry weights of shoots and roots (g) were recorded. The harvest date was on 22 and 24 September for the first and second seasons, respectively. At harvest stage, agronomic traits were recorded, i.e., plant height (cm), weight of grains per ear (g), 100-grains weights (g) and grains yield (ardab/fed.) (ardab = 140 kg).

For chemical determination, plants were fine powdered, wet digestion for dry material was carried out according to Chapman and Pratt (1961). Nitrogen percent was determined in grains by microkjeldahl method as described by A. O. A. C. (1990). Crude protein percent was estimated in such organ by multiplying N % by 5.7 as described by A. O. A. C (1990). Phosphorus, potassium and total carbohydrates percent in grains were determined using the procedure described by A.O.A.C. (1990). The atomic absorption spectrophotometer was used to determine zinc, manganese and ferrous concentrations in prior organ according to the methods recommended by A.O.A.C. (1990). Least significant difference test was used for comparing treatments means as described by Barabara and Brain (1994).

RESULTS AND DISCUSSION

Dry Weights of Shoots and Roots.

Statistical analysis of data in Table (2) for dry weights showed that using any rate of phosphorus fertilizer significantly increases dry weights in term of dry matter accumulation either in shoots or roots and whole plants after 60 days from sowing. Phosphorus fertilizer at a rate of 15 kg P2O5 /fed. was the most effective one in this respect, where the percentage increase in shoots dry weights reached to 44.55 and 45.10 for the first and second seasons, at a respective order, surpassed the control treatment (without phosphorus fertilizer). The promotive effect of such nutrient might be due to the beneficial effect of phosphorus in energy transfer and utilization on the other metabolic processes, which reflect on increasing about growth (Zhang *et al.,* 1986). These results are in agreement with those obtained by Nawaz *et al.,* (2004).

Table (2): Effect of phosphorus, zinc and manganese fertilizers either individually or in combination on dry weights (g/plant) of maize plant for 2008 and 2009 seasons after 60 days from sowing

Treatments			2008			2009		
P (kgP_2O_5/fed.)	Zn (g/l)	Mn (g/l)	Dry weights (g/plant)			Dry weights (g/plant)		
			Shoots	Roots	Whole plant	Shoots	Roots	Whole plant
P0	0.0	0.0	173.77	13.20	186.97	174.11	13.43	187.54
P1			251.18	22.75	273.93	252.61	22.93	275.54
P2			224,93	18.24	243.17	226.18	18.51	244.69
P0	0.3	0.0	181.33	14.58	195.91	182.73	14.84	197.57
P1			291.40	28.25	319.65	293.84	29.16	323.00
P2			244.16	21.66	265.82	246.51	21.87	268.38
P0	0.0	0.15	179.37	14.18	193.55	180.19	14.43	194.62
P1			282.98	26.63	309.61	283.81	27.40	311.21
P2			238.76	20.71	259.47	240.61	21.06	261.67
P0	0.3	0.15	190.37	15.38	205.75	196.14	15.65	211.79
P1			302.24	30.88	333.12	307.48	31.18	338.66
P2			256.17	23.15	279.32	255.55	23.71	279.26
L.S.D. *	5%		8.22	1.46	12.36	8.88	1.97	13.01
	1%		12.13	2.16	18.24	13.11	2.91	19.21
C.V. **			11.33	12.41	13.61	12.44	13.55	13.75

***: Treatments, **: Coefficient of variation, P0: Without phosphorus fertilizer, P1: 15 kg P_2O_5 /fed. and P2: 30 kg P_2O_5 /fed.**

Supplementary of maize plants with zinc and manganese as foliar feeding gained non significant effect on those growth parameters. However, their combination with phosphorus fertilizer induced significant increases in such parameters and recorded high significant improvement by interaction with 15 kg P2O5 /fed., over the mineral phosphorus fertilizer added only. The increases percentage in roots dry weights amounted to 24.18 and 17.05 %, respectively for the first season. Also, data were 27.17 and 19.49 %, at a respective order for the second season. Concerning the effect of manganese on plant growth, Mn play essential roles in the plants. It can therefore replace Mg^{+2} in many reactions for example, in its roles as a bridge between ATP and enzyme complexes (e.g. in phosphokinases and phosphotransferases). (Clarkson and Hanson, 1980). Similar results were obtained by Kandeel and

EL_Maddah (1988). The influence of zinc application on dry matter accumulation might be mainly referred to the effect of zinc on tryptophan biosynthesis which in turn affects auxin biosynthesis (Singh and Nayyar, 1993). Grezebiez *et al.* (2008) came to the same results.

Data in Table (2) indicated that, foliar application of zinc + manganese enhanced the action of phosphorus fertilizer to achieve in high significant promotive effect in prior growth characters with a pronouncing response especially with plants received 15 kg P2O5 /fed. + zinc + manganese, since whole plants dry weight attained their maximum increases 20.33 and 21.72 % comparing to 15 P2O5 /fed. used alone and 73.93 and 76.60 % comparing to the control treatment for the first and second seasons, respectively. These results showed that increases in dry weights due to foliar spray with zinc and manganese is quite obvious as the soil under study was deficient where such nutrients enhanced some bioprocess and in turn on the dry weights of maize plant. Similar results were obtained by Sadek (2006).

Chlorophyll Content

Data in Table (3) indicated that soil application of phosphorus fertilizer at different rates significantly increased chlorophyll a, b, and carotenoids in maize leaves with superiority 15 kg P2O5 /fed., where the percentage increases in chlorophyll a reached 62.60 and 68.68% for the first and second seasons over the control treatment , at order state. In this respect, Wang and Ling (2010) indicated that chlorophyll content of wheat leaves was greater with NPK fertilizer than in the control treatment.

From that table, it could be noted that, the action of mineral phosphorus fertilizer was greatly improved by association with zinc as foliar fertilization. The significant increases in chlorophyll contents were obtained when the combined treatment of 15 kg P2O5 /fed. + Zn at a rate of 0.3g/l was added, since relative increases in chlorophyll b 27.17 % for the first season and 30.32 % for the second season, surpassed the 15 kg P2O5 added only. Similar results were found by Cakmak (2008) and Richmond (2009), they found that, zinc required for chlorophyll production.

Also, data in Table (3) indicated that, as manganese was added to plants grown with 15 kg P2O5 /fed. induced high increases significantly in studded parameters, where chlorophyll a+ b increases over 15 kg P2O5 /fed. attained its maximum 35.71 and 39.57 % for the first and second seasons in the order stated. In this connection, Sultana *et al.* (2001) stated that, external application of manganese increases chlorophyll, carotenoids, photosynthesis net assimilation and relative growth and yield.

Furthermore, with combination of zinc and manganese using foliar spray method and phosphorus fertilizer at 15 and 30 kg P2O5 /fed., more significant improvement in chlorophyll contents were produced throughout the two

growing seasons. The highest significant effect was gained under 15 kg P2O5 /fed. + Zn +Mn treatment, since the percentage increases in carotenoids rose by 60.71 and 65.95 % for the first and second seasons, at a respective order, comparing to that of the 15 kg P2O5 /fed. added individually. These results are in agreement with those recorded by Osman *et al.* (1993); who found that micronutrients mixture gave the highest content of photosynthetic pigments in corn plants leaves as compared with individual treatments.

Table (3): Effect of phosphorus, zinc and manganese fertilizers either individually or in combination on chlorophyll contents of maize leaves for 2008 and 2009 seasons after 60 days from sowing

Treatments			2008				2009			
P (P_2O_5/fed)	Zn (g/l)	Mn (g/l)	Chl.a (ug/ml)	Chl.b (ug/ml)	Chla+b (ug/ml)	Carote Noids (ug/ml)	Chl.a (ug/ml)	Chl.b (ug/ml)	Chl.a+b (ug/ml)	Carote Noids (ug/ml)
P0			3.69	1.08	4.77	1.98	3.80	1.10	4.90	2.05
P1	0.0	0.0	6.00	1.84	7.84	3.08	6.41	1.88	8.29	3.26
P2			4.99	1.38	6.37	2.48	5.03	1.39	6.42	2.50
P0			3.90	1.15	5.05	2.13	4.02	1.17	5.19	2.22
P1	0.3	0.0	8.70	2.34	11.04	4.42	9.60	2.45	12.05	4.75
P2			5.78	1.60	7.38	2.94	5.87	1.62	9.51	2.99
P0			3.82	1.12	4.94	2.08	3.95	1.14	5.09	2.16
P1	0.0	0.15	8.39	2.25	10.64	4.30	9.23	2.34	11.57	4.60
P2			5.65	1.58	7.23	2.87	5.72	1.60	7.32	2.89
P0			3.94	1.18	5.12	2.17	4.11	1.22	5.33	2.28
P1	0.3	0.15	9.62	2.62	12.24	4.95	10.61	2.77	13.38	5.41
P2			5.85	1.65	7.50	2.99	5.93	1.66	7.59	3.01
L.S.D. *	5%		0.91	0.17	1.23	0.51	0.93	0.20	1.36	0.57
	1%		1.34	0.25	1.81	0.75	1.37	0.29	2.01	0.84
C.V. **			7.66	8.14	9.11	9.23	8.66	8.31	9.65	9.14

*: Treatments, **: Coefficient of variation, P0: Without phosphorus fertilizer, P1: 15 kg P_2O_5/fed. and P2: 30 kg P_2O_5/fed.

Yield and Yield Components.

Data in Tables (4&5) showed that application of phosphorus fertilizer at rate of 15 kg P2O5 /fed. increased significantly yield attributes, since relative increases in plant height reached by 47.47 and 49.61% for the first and second seasons, respectively as comparing with that of control (P0). The same trend was found for the grains yield. Such a response might be ascribed due to high available phosphorus in the soil (Table 1) and adequate supply of this nutrient induced higher production of photosynthesis and their translocation to sink, the increased leaf area and dry matter production and ultimately resulted into higher yield (Tamak *et al.,* 1997). These results are in conformity with those obtained by Yazadani *et al.* (2009).

Table (4): Effect of phosphorus, zinc and manganese fertilizers either individually or in combination on yield and yield components of maize plant for 2008 season.

Treatments			Plant heights (cm)	Grain weights /ear (g)	100-grains weights (g)	Grains yield (ardab/fed.)	Grains yield increase (%)
P (kgP_2O_5/fed.)	Zn (g/l)	Mn (g/l)					
P0	0.0	0.0	196.25	158.26	27.45	16.84	_
P1			289.41	221.50	38.97	23.57	39.96
P2			235.70	187.28	33.59	20.19	19.89
P0	0.3	0.0	209.75	170.03	28.89	18.05	7.19
P1			308.13	289.15	45.84	27.11	60.99
P2			264.21	212.79	37.25	21.85	29.75
P0	0.0	0.15	207.18	168.52	28.11	17.99	6.83
P1			299.57	281.45	44.99	26.35	56.47
P2			258.58	209.33	36.32	20.65	22.62
P0	0.3	0.15	213.75	173.77	29.49	18.80	11.64
P1			310.61	307.10	48.58	28.65	69.54
P2			273.52	214.64	37.77	23.50	39.55
L.S.D.	5%		4.85	2.82	1.25	1.16	
	1%		7.16	4.17	1.85	1.71	
C.V. **			10.16	11.33	10.22	12.44	

***: Treatments,**: Coefficient of variation, P0: Without phosphorus fertilizer, P1: 15 kg P_2O_5 /fed. and P2: 30 kg P_2O_5 /fed.**

Table (5): Effect of phosphorus, zinc and manganese fertilizers either individually or in combination on yield and yield components of maize plant for 2009 season.

Treatments			Plant height (cm)	Grain weights /ear (g)	100-graine weights (g)	Grains yield (ardab/fed.)	Grains yield increase (%)
P (kgP_2O_5/fed.)	Zn (g/l)	Mn (g/l)					
P0	0.0	0.0	197.69	160.04	27.66	17.01	_
P1			295.77	225.10	39.54	23.80	39.92
P2			238.89	189.01	34.45	20.55	20.81
P0	0.3	0.0	211.73	172.02	29.24	18.43	8.35
P1			312.91	294.33	47.10	27.68	62.73
P2			269.66	216.73	38.20	22.12	30.04
P0	0.0	0.15	209.18	170.10	28.42	18.34	7.82
P1			302.60	261.34	45.95	26.81	57.61
P2			262.02	210.59	37.68	20.86	22.63
P0	0.3	0.15	215.50	175.32	29.95	19.10	12.29
P1			315.74	324.50	50.20	28.94	70.14
P2			279.48	217.38	39.23	23.83	40.10
L.S.D. *		5%	5.04	2.95	1.29	1.46	
		1%	7.44	4.35	1.91	2.15	
C.V. **			11.22	11.71	11.27	12.55	

***: Treatments, **: Coefficient of variation , P0: Without phosphorus fertilizer, P1: 15 kg P_2O_5 /fed. and P2: 30 kg P_2O_5 /fed.**

From that Tables (4&5), it could be noted that, foliar nutrition with Zn-EDTA at a rate of 0.3g/l plus 15 kg P2O5 /fed. gained high significant increases in grains weights/ fed. by about 30.54% for the first season and 30.76% for the second season, over 15 kg P2O5/fed.applied solely. This was excepted since zinc plays a biovital role in regulating the auxin concentration in plant and nitrogen metabolism (Dewal and Pareek, 2004). Its function as catalyst or stimulator in most physiological and metabolic processes as a metal activator for some- enzymes resulting improvement in growth parameters which ultimately gave higher grain yield (Singh *et al.,* 2004). These results are in agreement with obtained results by Sudar *et al.* (2010).

Also, results in that Tables indicated that exogenous foliar application of Mn-EDTA at a rate of 0.15g/l together with 15 kg P2O5 /fed. yielded in high increases significantly in studied parameters, where the percentage increases in 100-grains weights was as much as 15 45 and 16.21% for the first and second seasons, at a respective order, over 15 kg P2O5 . The significant favorable effect of manganese fertilizer may be due to the physiological function and role of this nutrient on enzyme syuthetase and function on plant growth as well as yield and yield components (El-Hadidy *et al.,* 2000). Similar results were obtained by Amin *et al.* (1998).

Moreover, more positive effect was obtained when mixture of zinc and manganese-EDTA associated with mineral phosphorus fertilizer addition at all levels, responding significantly those parameters. The combined treatment of 15 kg P2O5 +Zn +Mn gave the highest significant increases not only yield components but also on grains yield by about 21.55 and 21.60% for the first and second seasons in the order state as comparing with 15 kg P2O5 /fed. treatment. The promoting effect of this treatment may be due to the fact that these nutrients play an active role in building new merestematic cells, cell elongation and increasing photosynthesis (El-Sayed, 1998).

Mineral Concentrations and Uptake.

Macronutrients Concentrations and Uptake.

Data in Tables (6&7) declared that, the increase dose of added phosphorus fertilizer from zero to 15 kg P2O5 /fed .induced significant increases in macronutrients concentrations (%) and uptake (kg/fed.) in grains of maize plant as comparing with the control treatment. This was true for the two growing seasons. However, 30kg P2O5 /fed. caused continuous significant increases in phosphorus concentration in the same organ which produced reduction in grains yield (Tables 4&5). This may be due to the fact that greater application of phosphorus fertilizer influences calcium uptake and translocation to the growing points in roots (Jakobsen, 1979), and if calcium ions are not constantly translocated to the growing points, its biological function will be restricted (Jakobsen,1993). Similar results were

obtained by Sobh *et al.* (2000). From these results, it could be noted that, 15 kg P2O5 /fed. is may be consider as economically recommended rate for maize production in the district soil. These results are in line with those obtained by Mohamed and Gebraiel (2001).

Further high significant increases in those concentrations and uptake were recorded when Zn or Mn –EDTA coupled with 15 kg P2O5 /fed. followed by combination with 30 kg P2O5 /fed, surpassed the phosphorus fertilizer at the same rate added only, throughout the period of two growing seasons. Where, nitrogen concentration increases reached to 13.58 and 10.49%, respectively for the first season and 14.55 and 12.12%, respectively for the second season. Corresponding significant increases in nitrogen uptake by about 30.64 and 23.51%, at a respective order for the first season. In case of the second season, data were 33.21 and 26.30%, in the order state. According to Mengel and Kirkby (1987), zinc is very closely involved in the nitrogen metabolism of plant. These results are in well accordance with the recent results obtained by Ziaeyan and Rajaie (2009). The positive role of manganese may be due to the fact that Mn play an important function in plant metabolism (Amberger, 1972).

Table (6): Effect of phosphorus, zinc and manganese fertilizers either individually or in combinations on macronutrients Concentrations (%) and uptake (kg/fed.) in grains of maize plant for 2008 season.

Treatments			N		P		K	
P (kgP_2O_5/fed.)	Zn (g/l)	Mn (g/l)	%	Uptake (kg/fed.)	%	Uptake (kg/fed.)	%	Uptake (kg/fed.)
P0			1.07	25.23	0.278	6.55	0.35	8.25
P1	0.0	0.0	1.62	53.46	0.430	14.19	0.51	16.83
P2			1.21	34.20	0.478	13.51	0.41	11.59
P0			1.13	28.56	0.292	7.38	0.38	9.60
P1	0.3	0.0	1.84	69.84	0.488	18.52	0.57	21.63
P2			1.34	40.99	0.517	15.82	0.46	14.07
P0			1.10	27.70	0.288	7.25	0.36	9.07
P1	0.0	0.15	1.79	66.03	0.475	17.52	0.55	20.29
P2			1.29	37.29	0.497	14.37	0.44	12.72
P0			1.16	30.53	0.299	7.87	0.39	10.26
P1	0.3	0.15	1.90	76.21	0.529	21.22	0.69	27.68
P2			1.40	46.06	0.534	17.57	0.47	15.46
L.S.D. *		5%	0.15	2.66	0.1	1.81	0.1	2.14
		1%	0.22	3.93	0.15	2.67	0.15	3.16
C.V. **			7.33	8.16	8.23	9.14	9.55	7.51

***: Treatments, **: Coefficient of variation, P0: Without phosphorus fertilizer, P1: 15 kg P_2O_5 /fed. and P2: 30 kg P_2O_5 /fed.**

Table (7): Effect of phosphorus, zinc and manganese fertilizers either individually or in combinations on macronutrients concentrations (%) and uptake (kg/fed.) in grains of maize plants for 2009 season

Treatments			N		P		K	
P (kgP_2O_5/fed.)	Zn (g/l)	Mn (g/l)	%	Uptake (kg/fed.)	%	Uptake (kg/fed.)	%	Uptake (kg/fed.)
P0			1.08	25.72	0.279	6.64	0.36	8.57
P1	0.0	0.0	1.65	54.98	0.441	14.69	0.52	17.33
P2			1.22	35.10	0.480	13.81	0.42	12.08
P0			1.14	29.41	0.295	7.61	0.39	10.06
P1	0.3	0.0	1.89	73.24	0.490	18.99	0.60	23.25
P2			1.35	41.81	0.520	16.10	0.47	14.55
P0			1.12	28.76	0.290	7.45	0.37	9.50
P1	0.0	0.15	1.85	69.44	0.480	18.02	0.57	21.39
P2			1.31	38.26	0.498	14.54	0.45	13.14
P0			1.17	31.29	0.301	8.05	0.40	10.70
P1	0.3	0.15	1.94	78.60	0.533	21.60	0.72	29.17
P2			1.42	47.37	0.540	18.02	0.49	16.35
L.S.D. *		5%	0.16	2.70	0.11	1.85	0.13	2.21
		1%	0.24	3.99	0.16	2.73	0.19	3.26
C.V. **			8.14	9.23	8.66	8.44	9.81	8.19

***: Treatments, ** Coefficient of variation, P0: Without phosphorus fertilizer, P1: 15 kg P_2O_5 /fed. and P2: 30 kg P_2O_5 /fed.**

From Tables (6&7), it could be noted that, foliar application mixture Zn+ Mn –EDTA +P could not bring any significant improvement in macronutrients concentrations and uptake with some exceptions. However, their associations with phosphorus fertilizer especially with 15 kg P2O5 /fed. produced the highest significant increases in studied parameters. Since the relative increases in potassium concentrations rose to 35.29 and 38.46% for the first and second season, respectively. Such increases were accompanied with corresponding significant increases in potassium uptake by about 64.47 and 68.32% for the first and second seasons, at a respective order. In this respect, Nassar (1997), stated that, the superiority effect of Zn+ Mn together may be due to that the suitable balance between these nutrients required to obtain the best growth and the highest values of nutrients concentrations and uptake. Ngouajio *et al.* (2007) reported that application of micronutrients enhanced a deeper and more extensive root system. This would allow plants to use water and nutrients from deeper soil, thus increase irrigation water use efficiency and nutrients use efficiency and reduce nitrogen leaching.

Micronutrients Concentrations (mg/kg) and Uptake (g/fed.).

Micronutrients data in Tables (8&9) declared that plants received phosphorus fertilizer at rates of 15 and 30 kg P2O5 /fed. increases significantly micronutrients concentrations and uptake in grains of maize

plant. The first rate was the most effective one in this respect for two the growing seasons. Wherein, percentage increases in zinc concentrations as well as significant increases in zinc uptake by 118.57 and 116.77 for the first and second seasons, at a respective order, over the control treatment. Similar results were obtained by Komljenovic *et al.* (2009), who postulated that phosphorus application increase growth, yield and thereby enhance the uptake of nutrients i.e. P, Zn, Fe, Mn and Cu.

Tables (8&9) showed that, foliar nutrition of Zn-EDTA along with phosphorus fertilizer was pronouncing in increasing significantly those elemental concentrations and uptake. The best effect appeared only at 15 kg P2O5/ fed. +Zn treatment, since the percentage increases in manganese concentration rose to 18.32 for the first season. Also, data were 18.89 for the second season as comparing with 15 kg P2O5/fed.added solely (P1).

More promotive effect in manganese concentration and uptake were induced when Mn-EDTA added as foliar spray method in presence of 15 kg P2O5 /fed., relative increase in manganese uptake amounted to 55.21 and 56.59 for the first and second seasons, in the order stated, surpassed mineral phosphorus fertilizer at prior rate used alone. Jiang and Ireland (2005) found that manganese content was significantly increased for all wheat cultivars treated with manganese fertilizer.

Table (8): Effect of phosphorus, zinc and manganese fertilizers either individually or in combination on micronutrients concentrations (mg/fed.) and uptake (g/fed.) in grains of maize plants for 2008 season.

Treatments			Zn		Mn		Fe	
P (kgP_2O_5/fed.)	Zn (g/l)	Mn (g/l)	mg/kg	Uptake (g/fed.)	mg/kg	Uptake (g/fed.)	mg/kg	Uptake (g/fed.)
P0			22.50	53.05	26.10	61.53	87.23	205.65
P1	0.0	0.0	35.14	115,95	42.36	139.78	141.66	467.45
P2			26.59	75.16	29.88	84.46	101.30	286.33
P0			24.52	61.96	28.16	71.16	92.15	232.86
P1	0.3	0.0	49.86	189.24	50.12	190.23	200.68	761.67
P2			31.49	96.33	33.93	103.79	111.90	342.30
P0			24.22	61.00	28.94	72.89	90.10	226.93
P1	0.0	0.15	46.93	173.12	58.81	216.95	194.73	718.36
P2			29.87	86.35	35.26	101.94	110.02	318.10
P0			25.10	66.06	29.63	77.99	97.92	257.73
P1	0.3	0.15	57.95	232.44	64.07	256.98	203.71	817.08
P2			32.50	106.93	36.85	121.24	115.75	380.82
L.S.D. *		5%	1.76	5.26	2.25	6.18	7.66	24.68
		1%	2.60	7.76	3.32	9.12	11.32	36.43
C.V. **			8.16	8.71	7.22	7.91	9.18	9.27

***: Treatments, **: Coefficient of variation, P0: Without phosphorus fertilizer, P1: 15 kg P_2O_5 /fed. and P2: 30 kg P_2O_5 /fed.**

Table (9): Effect of phosphorus, zinc and manganese fertilizers either individually or in combinations on micronutrients concentrations (mg/fed.) and uptake (g/fed.) in grains of maize plants for 2009 season

Treatments			Zn		Mn		Fe	
P (kgP_2O_5/fed.)	Zn (g/l)	Mn (g/l)	mg/kg	Uptake (g/.fed.)	mg/kg	Uptake (g/fed.)	mg/kg	Uptake (g/fed.)
P0	0.0	0.0	22.88	54.49	26.64	63.44	88.79	211.44
P1			35.45	118.12	42.66	142.14	142.95	476.31
P2			26.90	77.39	30.52	87.81	103.40	297.48
P0	0.3	0.0	24.96	64.40	28.73	74.13	94.50	243.83
P1			50.38	195.23	50.72	196.55	203.46	788.45
P2			32.25	99.87	34.74	107.58	114.53	354.68
P0	0.0	0.15	24.71	63.45	29.63	76.08	92.10	236.48
P1			47.42	177.99	59.30	222.58	197.10	739.80
P2			30.36	88.66	36.10	105.43	111.48	325.57
P0	0.3	0.15	25.67	68.64	30.31	81.05	99.43	265.88
P1			58.53	237.14	64.84	262.71	206.95	838.48
P2			33.10	110.43	37.88	126.38	117.93	393.44
L.S.D. *		5%	1.80	6.51	2.71	6.25	8.71	25.44
		1%	2.66	9.61	4.00	9.23	12.86	37.55
C.V. **			9.13	9.24	8.44	9.37	9.66	9.81

***: Treatments, **: Coefficient of variation, P0: Without phosphorus fertilizer, P1: 15 kg P_2O_5 /fed. and P2: 30 kg P_2O_5 /fed.**

Furthermore, the highest significant improvement in Zn, Mn and Fe concentrations and uptake were produced when mixture of zinc and manganese-EDTA associated with 15 kg P2O5 /fed. and surpassed the other combination treatments, since the percentage increases in ferrous concentrations and uptake rose to 43.80 and 74.80, respectively for the first season, also data were 44.77 and 76.04,at a respective order for the second season. These calculations based on treatment of soil with 15 kg P_2O_5/fed. These results are in agreement with those obtained by Salem and Mohamed (2000).

Crude Protein Percent and Protein yield.

Data recorded in Table (10) emphasized that, treated soil with mineral phosphorus fertilizer at a rate of 15 P2O5 /fed. significantly improved crude protein percent and protein yield as comparing with the control treatment throughout the two growing seasons. Where the percentage increases in crude protein percent reached to 51.31 and 52.76 for the first and second seasons, respectively. These results are in agreement with those found by Kovacevic *et al.* (2008), they found that, the plant absorb enough of

phosphorus fertilizer lead to normal growth and was reflect on grain yield and protein content.

Examining interaction data between zinc and manganese and phosphorus fertilizer recorded in Table (10), it could be noted that implying zinc and manganese –EDTA in presence of mineral phosphorus fertilizer at different rates produced more significant increases in those parameters, over phosphorus fertilizer applied singly. The highest significant increases were appreciable at 15 kg P2O5 /fed. + Zn+ Mn, since the percentage increases in protein yield being 42.62 and 42.92 for the first and second seasons, in the order stated. In this respect, Marschner (1995) declared that Zn is essentially necessary for protein synthesis.

Table (10): Effect of phosphorus, zinc and manganese fertilizers either individually or in combinations on crude protein percent, protein yield and total carbohydrates percent in grains of maize plant for 2008 and 2009 seasons

Treatments			2008			2009		
Zn (g/l)	Mn (g/l)	Phosphorus Fertilizer levels	Crude protein %	Protein Yield (kg/fed.)	Total carbohydrates %	Crude protein %	Protein Yield (kg/fed.)	Total Carbohydrates %
0.0	0.0	P0	6.10	143.81	47.60	6.16	146.69	48.36
		P1	9.23	304.57	71.61	9.41	313.54	72.95
		P2	6.90	195.04	55.93	6.95	199.95	56.67
0.3	0.0	P0	6.44	161.74	48.60	6.50	167.71	50.13
		P1	10.49	398.14	75.34	10.77	417.36	77.45
		P2	7.64	233.71	57.36	7.70	238.45	58.44
0.0	0.15	P0	6.27	157.92	48.34	6.38	163.81	49.62
		P1	10.20	376.28	74.93	10.55	395.98	76.46
		P2	7.35	212.49	57.16	7.47	218.15	57.96
0.3	0.15	P0	6.61	173.98	48.86	6.67	178.36	51.07
		P1	10.83	434.39	79.48	11.06	448.11	81.20
		P2	7.98	262.54	58.25	8.10	270.23	59.75
L.S.D. *		5%	0.7	10.33	2.16	0.98	12.14	2.25
		1%	1.03	15.25	3.19	1.15	17.92	3.32
C.V. **			8.16	8.31	7.69	8.55	9.11	8.35

*: Treatments, **: Coefficient of variation, P0: Without phosphorus fertilizer, P1: 15 kg P_2O_5 /fed. and P2: 30 kg P_2O_5 /fed.

Total Carbohydrates.

It is quite clear from total carbohydrates data in Table (10) that increasing phosphorus fertilizer rates from zero to 30 kg P2O5 /fed. gave significant increases in total carbohydrates (%). The high positive response was

obtained by 15 kg P2O5 /fed. This was true for the two growing seasons, where the percentage increases were 50.44 and 50.85 for the first and second season, respectively, over the control treatment. Tabulated results are in a quite good agreement with those obtained by Djuro *et al.* (2006).

As for micronutrients, data at Table (10) reveal that activity of phosphorus fertilizer was greatly increased when combined with zinc and manganese, especially with 15 kg P2O5 /fed., where the percentage increases in studied parameter reached to 5.21 and 4.64, respectively for the first season, likewise 6.17 and 4.81, respectively for the second season as comparing with 15 kg P2O5 /fed. used alone. This is obvious inside the plant, where Zn application effect on chlorophyll concentrations and/ or activities of carboxlating and dehydrogenase enzymes of CO2 fixation (Katyal and Randhawa, 1983). Manganese application is very important for activities number of enzymes involved in carbohydrates metabolism (Anderson and Pylloties, 1969).

Furthermore, high promoting effect gained by spraying maize plant with mixture of Zn and Mn-EDTA solution in presence of phosphorus fertilizer. The highest significant increases in total carbohydrates were recorded for plant treated with combined treatment of 15 P2O5 /fed. +Zn +Mn, wherein the percentage increases reached to 10.99 and 11.31 for the first and second seasons, respectively, over 15 P2O5 /fed added alone and over the control treatment by about 66.97 for the first season and 67.91 for the second season. Suggestion of the possibility of the promoting effect of these nutrients on biosynthesis and metabolism of carbohydrates through their roles in activation of the enzymes catalyzing these processes or by facilitating its translocations to the plant from source to sink Mohamed (2004).

CONCLUSION

This study emphasized the great importance of the appropriate role of mineral phosphorus fertilizer especially at 15 kg P2O5 /fed. in enhancing growth yield and promotes the uptake of macro- and micronutrients by maize plant under the condition of such soil. It is of a great significance to point out that foliar spraying Zn+ Mn in presence of phosphorus fertilizer at prior rate achieve balancing between each other may affect the biochemical compounds translocation inside plant till gaining the economic parts i.e. crude protein and total carbohydrates with preferable quality.

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تأثير التسميد الفوسفاتي والزنك والمنجنيزعلي النمو والمحصول والتركيب الكيماوي لنبات الذرة الشامية

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الملخص العربي

أقيمت تجربتان حقليتان في مركز كفر الزيات– محافظة الغربية خلال موسمي ٢٠٠٨ و ٢٠٠٩ بهدف تقييم إضافة ثلاث مستويات من السماد المعدني الفوسفاتي (صفر ، ١٥ و٣٠ كيلو جرام فو٢ أ٥ / فدان) وكذلك إضافة الزنك والمنجنيز في صورة مخلبية بمعدل ٣، ، ١٥، جرام /لتر علي التوالي في شكل محلول مغذي بحجم ٤٠٠ لتر / فدان عن طريق الرش علي النباتات مرتين الرشة الأولي بعد ٣٥ والرشة الثانية بعد ٥٠ يوم من تاريخ الزراعة. أيضا أستخدمت معاملات الدمج بين مستويات التسميد الفوسفاتي والعناصر الصغري علي نمو ومحصول والتركيب الكيماوي في نبات الذرة صنف هجين فردي ١٠ ويمكن تلخيص النتائج كالتالي. إضافة التسميد الفوسفاتي بمعدل ١٥ كيلو جرام فو٢ أ٥ / فدان كان الأفضل في إحداث إستجابة معنوية في الأوزان الجافة للمجموع الخضري والجذور. أفضل إستجابة معنوية في محتوي الأوراق من الكلوروفيل أ وب والكاروتينات في كل من موسمي الزراعة وذلك بعد ٦٠ يوم من تاريخ الزراعة. زيادة إحصائية لمحصول الذرة ومفرداتة حيث وصلت الزيادة النسبية لمحصول الحبوب 39.96 و 39.92 في كل من الموسم الأول والثاني غلي التوالي مقارنة بالكنترول. زيادة معنوية في محتوي الحبوب من العناصر الكبري (نيتروجين– فوسفور– بوتاسيوم) ةالعناصر الصغري (زنك– حديد– منجنيز) بلإضافة إلي البروتين الخام والكربوهيدرات الكلية في الحبوب في كل من موسمي الزراعة. سجلت النتائج أيضا أنه نتيجة إضافة الزنك والمنجنيز مع التسميد الفوسفاتي كان له تأثيرا فعالا في إظهار النتأئج المرجوه في كل التقديرات السابقة التي اجريت في هذة الدراسة وكانت معاملة الدمج المكونة من ١٥ كجم فو٢ أ٥ / فدان + ٣،

جرام/لتر زنك + ١٥، جرام /لتر منجنيز هي المثلي في معاملات الدمج حيث أحدثت أعلي زيادة معنوية ليس في المحصول ومكوناته فقط ولكن أيضا في تركيز العناصر المغذية والبروتين الخام بالإضافة الي الكربوهيدرات الكلية في حبوب الذرة صنف هجين فردي ١٠ في كلا موسمي الزراعة.