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Response of Potato (Solanum Tuberosum) to Foliar Application of Zinc And Manganese Which Fertilized by Organic Fertilizer.

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Abstract: *A field experiment was conducted during spring season of 2012 in the field of Horticulture department – Faculty of Agriculture – University of Baghdad –Abu Ghraib – Baghdad, Iraq to study effect of foliar application with Zinc and Manganese on mean weight of potato tuber, tuber yield per plant and total tuber yield, The experiment was a factorial in randomized complete block design with three replication. Treatments were foliar application: Control (no Zn or Mn applied), 60 ppm Zn, 30 ppm Mn and mixture (60 ppm Zn + 30 ppm Mn), Solutions were sprayed at three dates: vegetative growth stage, tuber initiation stage and tuber bulking stage. Plants were harvested after ripened and plant characteristic including weight of potato tuber, yield per plant and total tuber yield. Results showed that Zn and Mn application increased all plant parameters under study relating to yield components. Mixture solution application (Zn+ Mn) increased mean weight of potato tuber to 94.03 g tuber^{-1} which was 65 % higher compared to control, tuber yield per plant to 921.90 g Plant^{-1} which was 56 % higher compared to control and total tubers yield to 46.10 Mg ha^{-1} which 57% higher compared to control. The interaction (sprayed Zn+Mn× application date) was significant, Foliar application of Zn+Mn at vegetative growth stage increased mean weight of potato tuber, tuber yield per plant and total tubers yield which were 98.87 gm tuber^{-1}, 941.40 g Plant^{-1} and 47.07 Mg ha^{-1} respectively.*

Keywords: *Potato, Organic, Foliar application, Micronutrients.*

I. Introduction

Potatoes are the main food crops in the world, containing high protein, starch, vitamins and nutrients (AL- Farhan, 2001), Potatoes are useful crops that have nutritional value, economic, and they are high content of carbohydrates and a vital value because they contain a high containing of protein (Mohamad, 2000). Potato crop has a role in food security and must increase attention to feeding this crop and this in quality through the use of foliar application, that have proven successful in the plant for the needs of the necessary food nutrients and its impact on increasing winning both quantitatively and qualitatively, Matloob et al., (2000) gave a significant

increase in yield tuber and its components and attributes of quality when he used potassium fertilization and sprayed Boron on potato plant Desiree class.

Iraq comes in the fourth place after Egypt, Algeria and morocco in cultivation of potatoes, Increased attention to cultivated potatoes during the last two decades and reached the cultivated area in 2009 to 33.000 ha and the production of 348.800 ton and at average of 10.6 ton.ha-1 (Central Statistical Organization, 2009). Symptoms of micronutrient deficiencies clearly appear on cultivated plants in the Iraq soil because most of these soils are gypsum and also calcareous so pH is high more than 7.6 and ratio of calcium carbonate in more than of 25% and with low content of organic matter, all these factors lead to a shortage of readiness of micronutrients Despite the presence in the soil quantities outweigh the need for the plant (Saleh, 2010), The most vegetable crops grown in these conditions suffer from micronutrient deficiencies and there are a clear respons to spray nutrients (AL-Mohammadi, 2005).

Kohraee et, al (2011) explained that micronutrients are essential materials for growth and used in small quantities compared to the major nutrients N, P, K and they play an important rol in cells division and the development of Almrstimih tissue, metabolism, respiration increased maturity speed. Alloway (2004) pointed that the use of fertilizers containing Zinc element lead to increasing the quantity and improving the quality of potato tubers when Zinc activates enzymes and the representation of carbohydrates and proteins manufacturing. Manganese enters as a major component in the synthesis of enzymes affecting the photosynthesis process and in redox reaction and other reaction, deficiency leads to a lack of efficiency of the process of photosynthesis (Heckman.2000). This study was planned to study the response of potato to foliar application with Zn and Mn at three stage of plant growth at soil fertilized with organic fertilizers.

II. Materlals And Methods

The study was conducted in Department of Horticulture field, college of Agriculture, Abu – Ghraib – University of Baghdad - Iraq in spring season 2012 on clay loam soil, Soil samples were taken from depth of (0-30) cm, sample of soil were analyzed before sawing (Table 1), Randomized complete block design was used

with three replication, to study response of potato to zinc and manganese sprayed at deferent stage of potato growth which were vegetative growth (F_1), tuber initiation (F_2) and of tuber bulking (F_3). Four factor of spraying the first one is control spraying water only (T_o), spraying 60 mgZnL^{-1}(T_1), spraying 30 mgMnL^{-1}(T_2) and spraying mixture Zn+ Mn (60+30) mgL^{-1}(T_3). Field was divided into three block, each block was divided to 12 experimental plots. The area of each experimental plot was 6.75 m^2 (3 ridges, 0.75 m width and 3 m in length), Left a distance 1 m between experimental plots and between blocks

Table 1: Some physical and chemical properties of soil of field experiment

Property		Value	Unit	Ref
pH (1:1)		7.59		Richards,1954
Ec (1:1)		3.15	dSm^{-1}	
Gypsum		5.24	gKg^{-1} soil	
CEC		26.80	C mol$_+$ Kg^{-1} soil	FA0, 2007
Carbonate minerals		182.50	gKg^{-1} soil	
SOM		18.20		Page *et al*., 1982
Soluble cation	Ca^{+2}	8.40	C mol$_+$ Kg^{-1} soil	
	Mg^{+2}	5.13		
	K^{+1}	0.55		
	Na^{+1}	3.95		
Available Nutrient Element	N	36.00	mg.Kg^{-1} soil	
	P	11.35		
	K	161.64		
	Zn	1.73		
	Mn	2.19		
Bulk density		1.36	g cm^{-3}	Black, 1965
Partical Size	sand	171.50	g.Kg^{-1} soil	
	silt	512.64		
	clay	315.86		
Texture		Silt clay loam		

50 T. ha $^{-1}$of (compost of mixture equal amount of waste cows, sheep and poultry) after decomposition to all experimental unite specification set out in table 2 (AL. Fadhly, 2011). Compost add to each ridges after making slit in the top of ridges with 30 cm depth 20 cm width and covered with soil. Tubers burren class in 18 January 2012 were sown in top of rides deeply at 10-12 cm depth, the distance between tubers was 25 cm (Muharem and Abdul, 1987). Sources of Zn and Mn were $ZnSo_4.7H_20$ and $MnSo_4$ respectively. Treatment of F_1 sprayed in 9 April 2012, F_2 sprayed in 20 April and sprayed the F_3 in 1 May 2012., Irrigation of all experimental units was done as they needed, So weeds were cut. Tubers were harvested on 26 May 2012 at plants maturity. Five plants from each experimental unite were cut to calculate:

1. Mean weight of potato tubers (g tuber^{-1})
2. Tuber yield per plant (g plant^{-1})
3. Total tubers yield (Mg ha^{-1}) which calculated as follow:

Table 2: chemical analyses of organic manures used

Parameter	Value	Unite
pH (1:5)	6.5	-
Ec (1:5)	30.37	ds m^{-1}
C/N ratio	16.33	-
Organic C	325	gkg^{-1}
Organic	19.90	
Organic	11.99	
Organic	17.46	
Zn	220.16	ppm
Mn	174.34	
Ca	22.00	Meq/L
Mg	11.00	
Organic matter	50.32	%
Humic	1.42	
Volvic	0.188	
Human	6.98	

Total yield = (tuber of experiment / area of experiment) × 10000
Results were tested statistically for all experimental date according to SAS system (SAS, 2001) and comparison among the average was calculated using the LSD test at significance level of 0.05.

III. Results And Discussion

Table 3. Significant effect of separate and combined Zn, Mn and (Zn+ Mn) was noted when spraying at, date of application and their interaction on mean weight of potato tuber increased from 57.06 g tuber^{-1} in control treatment T_0 to 94.03 g tuber^{-1} in Zn + Mn application treatment T_3, Increasing of mean weight of potato tuber at percent T_1 (Zn application), T_2 (Mn application), T_3 (Zn + Mn application) are 36.44 %, 53.70 % and 64.80 % respectively compared to control treatment T_0. dates of application had a significant effect on mean weight of potato tuber, F_3 treatment of tuber bulking stage gave the highest value which was 81.60 g tuber^{-1}

Interaction of both nutrients application and stage of spraying significantly increasing mean weight potato tuber, T_3F_1 treatment (Zn + Mn) application at vegetative gave the highest mean weigh of potato tuber which was 98.87 g tuber^{-1} revealing an increase of 104.19 % compared to the lowest mean weigh of potato tuber 48.42 g tuber^{-1} of T_0F_2 interaction treatment (nutrient free water treatment) on tuber initiation stage.

Table 3. Effects foliar application Zn, Mn and (Zn+ Mn) on mean weight of potato tuber (g tuber^{-1})

Treatment	Stage of application			mean
	F_1	F_2	F_3	
T_0	54.01	48.42	68.77	57.06
T_1	81.35	67.05	76.14	77.85
T_2	85.77	88.83	88.49	87.70
T_3	98.87	90.21	93.01	94.03
L. S. D F*T	2.66			L. S. D T
mean	80.00	75.88	81.60	1.53
L. S. D F	1.33			

Table 4. Shows the effect of Zn, Mn spraying separately and together, time of application, on tuber yield per plant, it is obverse to see the significant effect of spraying application with these nutrient, where the mean tuber yield per plant had increased from 588.80 g Plant^{-1} at T_0 (nutrient free water spraying application) up to 721.13 g Plant^{-1} in T_1 (Zn application), 751.53 g Plant^{-1} at T_2 (Mn application) and up to 921.40 g Plant^{-1} in T_3 (Zn + Mn application) while the increase of the mean tuber yield per plant T_3 56.49 % when compared to the mean tuber yield per plant of T_0, Time of spraying application have no significant effect on yield.

Interaction effect of these nutrient and dates of application was significantly effect in increasing mean tuber yield per plant, where the interaction treatment of sprayed Zn + Mn at vegetative growth stage T_3F_1 gave the highest mean tuber yield per plant of 941.40 g Plant^{-1}, revealing an increase of 63.72 % compared to the interaction treatment of nutrient free water application at tuber initiation stage of lowest yield 575.00 g Plant^{-1}.

Table 4. Effects foliar application Zn, Mn and (Zn+ Mn) on tuber yield per plant (g plant^{-1})

Treatment	Stage of application			mean
	F_1	F_2	F_3	
T_0	587.40	575.00	604.00	588.80
T_1	730.20	706.60	726.60	721.13
T_2	734.60	760.40	751.53	751.53
T_3	941.40	900.00	924.40	921.40
L. S. D F*T	94.28			L. S. D T
mean	748.40	735.50	753.65	54.43
L. S. D F	47.14			

Table 5. Shows the significant effect of combined and separate application of both nutrients, dates of application and their interaction on total tuber yield of potato plants, T_3 (Zn + Mn) gave the highest total tuber yield was 46.10 Mg ha^{-1} which increases at percent of 56.54 % compared to the control treatment T_0, there is no significant differences in total tuber yield between T_1 and T_2.

Also results of table 5 showed no significant effect of dates spraying on total tuber yield of potato, also table shows the significant effect of interaction of both nutrients application and date of spraying, where the highest total tuber of yield found in T_3F_1 treatment (sprayed Zn + Mn at the vegetative growth stage) which was 47.07 Mg ha^{-1} increased at percent of 63.72% compared to total tuber yield of T_0T_2 which gave the lowest total tuber yield of potato plants 28.75 Mg ha^{-1}.

Table 5. Effects foliar application Zn, Mn and (Zn+ Mn) on total tuber yield (Mg ha^{-1})

Treatment	Stage of application			mean
	F_1	F_2	F_3	
T_0	29.37	28.75	30.22	29.45
T_1	36.51	35.33	36.33	36.06
T_2	36.73	38.02	37.98	37.58
T_3	47.07	45.00	46.22	46.10
L. S. D F*T	**2.96**			**L. S. D T**
mean	37.69	36.77	37.42	**1.71**
L. S. D F	**1.48**			

Due to metabolic role of Zn in synthesis of proteins, enzyme activation and metabolism of carbohydrate, Utilization of fertilizers containing this element increase qualitative and quantitative performance of potato tubers, Due to shortage of Zn, performance and quality of potato will be decreased (Alloway, 2004). Potarzycki and Grzebisz (2009) reported that Zinc exerts a great influence on basic plant life processes, such as (1) nitrogen metabolism, uptake of nitrogen and protein quality; (2) photosynthesis – chlorophyll synthesis, carbon anhydrate activity. Crops yield increases with manganese foliar applications due to increasing photosynthesis efficiency and synthesis of carbohydrates such as starch. Manganese has an important metabolic role in nitrate – reducing enzyme activity and activation of enzyme involved in carbohydrate metabolism thus its deficiencies decrease photosynthesis and thereby reducing crops yield and quality (Malakouti and Tehrani, 1999; Diedrick, 2010). Utilization of elements Zn and Mn together from source sulfate Zn and Mn increased efficiency and quality of potato crop (Kelling and Speth, 2001). Mohamadi (2000) found that application of Zn along with Mn as foliar application caused increasing in efficiency and quality of potato crop.

III. Conclusion

Results of this study revealed that spraying (Zn + Mn) on potato plants significantly increased mean weight of tuber, mean tuber yield per plant and total tuber yield. Application of (Zn + Mn) mixture during vegetative growth stage caused to enhance mean weight of tuber, mean tuber yield per plant and total tuber yield, Also result showed interaction between sprayed mixture (Zn + Mn) and date of application.

Production of potato tuber yield can be improved by application of (Zn + Mn) mixture during vegetative growth stage.

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