

## RESPONSE OF POTATO PLANTS GROWN IN CLAY SOIL TO ANHYDROUS AMMONIA RATES AND FOLIAR APPLICATION OF ZN AND MN

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### ABSTRACT

Two Field experiments on potato (*Solanum tuberosum*, L. cv. Diamont) crop were carried out at El-Qanater Horticultural Research Station, Kalubiya, Governorate, Egypt located at lat. 30.11, long 31.60 and 14.00 m above the mean sea level during two successive seasons 2010 and 2011. The study concerned the use of different rates of anhydrous ammonia (100 and 120 kg N/fed.) with foliar application of zinc and manganese or both on potato crop in alluvial soil. Generally, in most cases,

The high anhydrous ammonia level (120 kg N/ fed.) was increased significantly dry matter of potato plant at 90 days from planting and nitrogen & phosphorus content as well as dry weight of tuber/ plant (g/plant), fresh & dry tuber yield/fed., N, P, K, Zn and Mn contents of tuber compared to low anhydrous ammonia level (100 kg N/ fed.) of both seasons.

Generally, the most parameters in this investigation were increased significantly when the treatment of foliar application with mixture of Zn and Mn was carried out in both seasons. In contrast, the lowest ones were recorded by the control treatment (without foliar spray) followed by sole foliar spray with Zn or Mn in two seasons.

Finally, the best significant values of most parameters were obtained by interaction between foliar application with mixture of Zn and Mn under the high anhydrous ammonia level (120 kg N/ fed.). Meanwhile, the lowest ones were observed when control treatment (without foliar spray) with the low anhydrous ammonia level (100 kg N/ fed.) was practiced of both seasons.

**Key words:** Potato, anhydrous ammonia, foliar application and yield productivity.

### INTRODUCTION

In Egypt, potato (*Solanum tuberosum*, L.) is one of the most important and favorite vegetable crops grown. Its economic importance arises from the fact that large amount of this crop is exported yearly. Potato is a staple food in the diet of the world's population and also being used as animal feed (**Dancs et al., 2008**). Although potato is considered as a starchy food, it is also included in the group of vegetables by its micronutrient content; **Robert et al. (2006)** suggested that expenditure of cooked potatoes (consumed with skin) may enhance antioxidant defense and improve the lipid metabolism, these effects could be interesting for prevention of cardiovascular diseases.

Nitrogen is the mineral nutrient most commonly deficient in agricultural soils (**Foth and Ellis, 1996**). As a result, farmers apply relatively high rates of N fertilizers. Soil-plant system inefficiencies prevent complete utilization of the N, leaving residual N in the soil, which is a waste of natural resources and cause for environmental concern. Plants absorb N in the inorganic forms of nitrate (NO<sub>3</sub><sup>-</sup>) and ammonium (NH<sub>4</sub><sup>+</sup>). Unfortunately, these forms can be lost

through conversion to nitrous oxide (N<sub>2</sub>O) (Ruser *et al.*, 1998 and Shoji, *et al.*, 2001). A long-lived gas that is a source of nitric oxide (NO), that is thought to contribute to ozone (O<sub>3</sub>) depletion in the stratosphere and increases in global temperatures (Isermann, 1994). In addition, the NO<sub>3</sub><sup>-</sup> form is mobile and is potentially leached below the rooting zone to groundwater (Mueller and Dennis, 1996). Nitrogen can also move laterally to surface water (Randall and Mulla, 2001). At high concentration in drinking water, nitrate poses a potential health risk to humans and livestock and is also one of the contributing factors for eutrophication and hypoxia in surface waters (Goolsby *et al.*, 2001, Rabalais *et al.*, 2002 and Munoz *et al.*, 2005). Nitrogen management is a high priority in potato cropping systems (Stark *et al.*, 2004, and Westermann, 2005). Characteristically, N is the most limiting nutrient in crop production and is higher in concentration than all other mineral nutrients in most plants (Foth and Ellis, 1996). In potatoes, N rivals only K in highest mineral concentration (Stark *et al.*, 2004, Munoz, *et al.*, 2005 and Westermann, 2005). Potatoes are especially sensitive to N deficiencies and excesses (Stark *et al.*, 2004). The necessity of N for growth has been demonstrated by several investigators, since nitrogen supply was desirable for vegetative growth, dry matter accumulation as well as nutrient uptake by potato plants (El- Ghamriny and Saeed, 2007). The increase in plant growth may be attributed to the beneficial effects of nitrogen on stimulating the meristematic activity for producing more tissues and organs, since it plays major roles in the synthesis of structural proteins and other several macro molecules, in addition to its vital contribution in several biochemical processes that related to plant growth (Marschner, 1995). Also, nitrogen may be contributed with the activation of cell division and cell elongation (Medani *et al.*, 2000).

Micronutrients are required by plants in minute quantities, although these are very effective in regulating plant growth as they form a part of the enzyme system and thus regulate plant life. Pathak *et al.*, (2011) and Soleymani and Shahrajabian, (2012) found that, Fe, Zn and Mn had positive effect on yield and quality of forage sorghum. The highest values of plant height, fresh forage yield, dry leaf and stem yield, total dry yield and dry leaf weight/dry stem weight was obtained by Zn+Fe+Mn application. In higher pH soil as that in Egyptian soils, it is known that micronutrients as well as some macronutrients may be limiting. Foliar products containing multi-nutrients may correct these deficiencies giving increases in growth and development. Foliar applications are often the most effective economical way to correct plant mineral deficiency (Kannan, 1986), especially when sink competition for carbohydrates between plant organs take place and nutrient uptake from the soil is restricted (Marschner, 1986). Zn and Mn elements have main role in synthesis of proteins, enzyme activating, oxidation and revival reactions and metabolism of carbohydrates. By utilizing of fertilizers contain above elements, performance on quality of crops is increasing and with shortage of this elements due to decline in plant photosynthesis and destroy RNA, amount of solution carbohydrates and synthesis of protein decreased and then performance and quality of crop will be decreased. Kelling and Speth (2001) reported that utilization of elements like Zn and Mn together from resource sulfate Zn and Mn increased efficiency and quality of potato crop. Mohamadi (2000) found that application of Zn along with Mn from foliar application caused increase in efficiency and quality of potato crop.

The present investigation was carried out to assess the efficacy of applying N fertilizer in the form of anhydrous ammonia associated with zinc and manganese as foliar application on potato yield and its components as well as its nutrients contents.

**MATERIALS AND METHODS**

Field experiments was carried out at El-Qanater Horticultural Research Station, Kalubiya, Governorate (located at lat. 30.11, long 31.60 and 14.00 m above the mean sea level) representing clay loam soil during the seasons 2010 & 2011 to study the effect of ammonia gases levels with foliar spray by zinc or manganese or both on yield, its components as well as macro and micronutrients content in leaves at 90 days from planting and tuber at harvesting of potato crop.

Some physical and chemical properties of the tested soil which were measured and determined before planting according to **Black (1982) and Ryan et al., (1996)** were accessible in Tables 1 and 2.

Experiments were arranged in a split plot design with four replicates. The plot area was 21 m<sup>2</sup> (4.2x5) planted in ridges, 70 cm part, and 25 cm between plants in which the main treatments were devoted as anhydrous ammonia (82% N) at the rates 100 and 120 kg N/fed. The fertilizer was injection in the soil before cultivation about 8 days. While, the sub-ones included foliar applications of zinc or manganese or both. Micronutrients as an EDTA form were sprayed at a concentration of 0.06% twice, at 10 and 20 days after flowering.

A basal application of Phosphorus fertilizer was added at the rate of 75 kg P<sub>2</sub>O<sub>5</sub>/fed., as triple superphosphate (37% P<sub>2</sub>O<sub>5</sub>) according to recommended dose by Ministry of Agriculture and Land Reclamation (Egypt). Meanwhile, K fertilizer was applied at the rate of 96 kg K<sub>2</sub>O as potassium sulphate. Phosphorus and Potassium fertilizers were applied with preparation of soil for cultivation.

**Table (1) Physico - chemical properties of the soil**

Seasons	Particle size distribution (%)				EC <sub>e</sub> (dSm <sup>-1</sup> )	pH (1:2.5)	CaCO <sub>3</sub> %	OM
	Clay	Silt	Sand	Texture				
2010	31.4	33.5	35.1	CL	1.0	7.75	3.75	1.80
2011	32.6	34.5	32.9	CL	1.10	7.80	3.60	1.65

**Table (2) Ionic properties of the soil**

Seasons	HCO <sub>3</sub> <sup>-</sup>	SO <sub>4</sub> <sup>2-</sup>	Cl <sup>-</sup>	Na <sup>+</sup>	K <sup>+</sup>	Ca <sup>2+</sup>	Mg <sup>2+</sup>	N	P	K
	M mole L <sup>-1</sup>									
2010	3.65	2.56	4.00	4.20	0.31	2.97	2.73	38.50	9.12	193.30
2011	3.75	2.78	4.20	4.42	0.49	2.94	2.88	37.00	10.15	190.40

N, P and K: Available.

Potato (Diamant, cv.) were planted on 3<sup>th</sup> and 6<sup>th</sup> of February 2010 & 2011, respectively and harvested at 27<sup>st</sup> and 30<sup>rd</sup> of May 2010 & 2011, respectively. Dry weight of above - ground plant parts /plant (g/plant) were measured in five plants at 90 days from planting. Dry weight of tuber/ plant (g/plant) was estimated at harvesting in five plants taken randomly from each treatment. Tuber fresh and dry (ton/ fed.) were also measured and recorded.

Plant samples after harvesting, dried at 70°C; ground, digested and assigned for analyzing N, P, K, Zn and Mn. Nitrogen was determined using modified Kjeldahl method, phosphorous was determined colourimetrically

according to the procedure outlined by **Ryan *et al.*, (1996)**. Potassium was determined using the flame spectrophotometry method (**Black, 1982**). Zn and Mn were determined by using Atomic absorption.

The results were statistically analyzed using Mstat computer package to calculate F ratio according to **Snedecor and Cochran (1980)**. Least significant differences method (L.S.D) was used to differentiate means at the 0.05 level (**Waller and Duncan, 1969**).

## RESULTS AND DISCUSSION

### 1. Dry matter as well as N and P content at 90 days from planting.

Data presented in Table (3) show that the high anhydrous ammonia level (120 kg N/ fed.) increased significantly dry matter leaves of potato at 90 days from planting as well as nitrogen and phosphorus content compared to low anhydrous ammonia level (100 kg N/ fed.) of both seasons. This can be attributed to increased vegetative growth of the potato plant by increasing nitrogen fertilizer rates. The current result is in consistent with the work of many researchers (**Mahmoodabad *et al.*, 2010**) who had reported that an increase in nitrogen application increases dry matter. Also, nitrogen fertilizer plays an important role in canopy development especially on the shoot dry matter (**Najm *et al.*, 2010**)

**Table (3) Effect of foliar application of zinc and manganese or both under anhydrous ammonia rates on dry matter, N and P uptake of potato leaves at 90 days from planting in both seasons**

Treatments	Dry matter (g)/ plant			N uptake(g)/ plant			P uptake(g)/ plant		
	N <sub>1</sub>	N <sub>2</sub>	Mean	N <sub>1</sub>	N <sub>2</sub>	Mean	N <sub>1</sub>	N <sub>2</sub>	Mean
2010									
Control	37.60	45.70	41.65	1.620	1.723	1.672	0.132	0.150	0.141
Zinc	39.50	48.63	44.07	1.780	1.880	1.830	0.099	0.112	0.106
Manganese	42.63	51.60	47.12	1.983	2.130	2.057	0.158	0.178	0.168
Zn +Mn	44.03	65.90	54.97	2.033	2.350	2.192	0.162	0.196	0.179
Mean	40.94	52.96*		1.854	2.021 *		0.138	0.159*	
LSD at 5 %									
Micronutrients	1.077			0.08895			0.001258		
Interaction	1.523			0.1258			0.001779		
2011									
Control	21.12	33.60	27.36	0.784	1.344	1.064	0.053	0.091	0.072
Zinc	25.93	34.57	30.25	1.006	1.449	1.227	0.074	0.097	0.085
Manganese	29.70	38.20	33.95	1.188	1.722	1.455	0.077	0.099	0.088
Zn +Mn	31.41	41.30	36.35	1.415	1.944	1.680	0.088	0.124	0.106
Mean	27.04	36.92*		1.098	1.615*		0.073	0.103*	
LSD at 5 %									
Micronutrients	0.1591			0.03978			0.001258		
Interaction	0.2250			0.05626			0.001779		

N1= 100 kg N/fed as anhydrous ammonia

N2= 120 kg N/fed as anhydrous ammonia

Regarding the effect of sole foliar application by Zn and Mn or both on dry matter, N and P uptake of potato leaves at 90 days from planting, data tabulated in Table (3) reveal that the treatments of foliar spray by Zn and Mn as a mixed gave a highest significant values for all such parameters in both seasons. Meanwhile, the lowest ones were obtained with control treatment (without foliar spray) followed by sole application of Zn as a foliar in both seasons. Increasing such parameters due to Zn & Mn application may be attributed to enhanced photosynthesis activity which increased production and accumulation of carbohydrates and favorable effect on vegetative growth and macronutrients content. The obtained results are in good agreement with those obtained by **Mona, Eleiwa et al. (2012)** who found that when foliar nutritional were used, the photosynthetic activity was stimulated, leading to enhancement of chemical constituents as crude protein, starch, carbohydrate, L-ascorbic acid and T.S.S in shoots which were afterwards translocated to the tubers. These effects may also due to the presence of micronutrients in the foliar compounds as Zn, Cu, Mn and B.

With respect to the interaction between nitrogen fertilizer rates and foliar application of micronutrients on dry matter, N and P uptake of potato leaves at 90 days from planting, data show that the highest mean values of such parameters were obtained by foliar application of Zn and Mn together with the high level of anhydrous ammonia in both seasons. On the other hand, the lowest ones were observed when the control treatment (without foliar spray) under the low level of anhydrous ammonia was practiced in both seasons.

#### **2. Potassium, Zinc and Manganese content at 90 days from planting.**

Results in Table (4) illustrate that the treatment of 120 kg N/ fed. gave the highest significant values of K, and Mn content at 90 days compared with 100 kg N/ fed. in both seasons. On the other hand, Zn content was affected significantly by anhydrous ammonia rates in second season only. Similar results were obtained by **Stark et al. (2004) and Westermann (2005)**.

For the effect of foliar application of zinc and manganese or both on K, Zn and Mn content of potato leaves at 90 days from planting, data reveal that, the same parameters were increased significantly by foliar spray with mixture Zn and Mn in both seasons. While, the lowest ones were recorded with control treatment (without foliar spray) followed by individual application of Zn in both seasons. These findings are in conformity with the observations of **Pathak et al. (2011) and Soleymani and Shahrajabian (2012)**.

Respecting the interacted factors under study, results show that the foliar spray of Zn and Mn together under the high nitrogen level gave the highest significant values of all parameters in Table (4) in two seasons. Conversely, the lowest ones were recorded by the control treatment (without foliar spray) under the low level of anhydrous ammonia in both seasons.

**Table (4) Effect of foliar application of zinc and manganese or both under anhydrous ammonia rates on K, Zn and Mn uptake of potato leaves at 90 days from planting in both seasons**

Treatments	K uptake(g)/ plant			Zn uptake(g)/ plant			Mn uptake(g)/ plant		
	N <sub>1</sub>	N <sub>2</sub>	Mean	N <sub>1</sub>	N <sub>2</sub>	Mean	N <sub>1</sub>	N <sub>2</sub>	Mean
2010									
Control	1.50	1.74	1.62	1.58	2.01	1.80	2.26	2.93	2.60
Zinc	1.66	1.93	1.80	1.90	2.47	2.19	2.45	3.24	2.85
Manganese	1.73	2.11	1.92	1.82	2.32	2.07	3.09	4.08	3.59
Zn +Mn	1.88	2.35	2.12	2.14	2.96	2.55	3.16	4.50	3.83
Mean	1.69	2.03*		1.86	2.44		2.74	3.69*	
LSD at 5 %									
Micronutrients	<b>0.056</b>			<b>0.040</b>			<b>0.040</b>		
Interaction	<b>0.080</b>			<b>0.056</b>			<b>0.056</b>		
2011									
Control	0.65	1.22	0.93	0.70	1.35	1.02	1.40	2.39	1.89
Zinc	0.86	1.31	1.09	0.98	1.59	1.28	1.75	2.52	2.14
Manganese	0.95	1.38	1.17	1.07	1.68	1.38	2.14	3.05	2.59
Zn +Mn	1.07	1.65	1.36	1.32	2.07	1.69	2.36	3.47	2.91
Mean	0.88	1.39*		1.02	1.67*		1.92	2.86*	
LSD at 5 %									
Micronutrients	<b>0.040</b>			<b>0.040</b>			<b>0.040</b>		
Interaction	<b>0.056</b>			<b>0.056</b>			<b>0.056</b>		

### 3. Tuber weight/ plant, fresh and dry tuber yield of potato/fed.

Data presented in Table (5) show the effect of micronutrients as foliar application and soil application of different N levels as anhydrous ammonia on tuber weight/ plant, fresh and dry tuber yield of potato/fed. grown in two seasons. Generally, the same trend almost of Tables (3&4) was obtained in Table (5). The high level of anhydrous ammonia (120 kg N/fed.) gave a highest significant value of tuber weight/ plant, fresh and dry tuber yield of potato compared to other one in both seasons. The increase of potato tuber yield may be due to the helpful effects of nitrogen on motivating the merestimatic activity for producing more tissues and organs, because it plays main roles in the synthesis of structural proteins and other several macro molecules. Also, the current result is in consistent with the work of **Zewide, et al. (2012)** who concluded that different nitrogen rates have sound and promising impact on growth and marketable tuber yield of potato.

Parameters in Table (5) were increased significantly when the treatment of foliar application with Zn and Mn together was used in both seasons. In contrast, the lowest ones were observed by the control treatment (without foliar spray) followed by sole foliar spray with Zn or Mn in two seasons. This effect means that foliar nutrition application by Zn and Mn led to an increase in plant yield through dry matter accumulation in the economic parts of potato tuber. Results agree with **El-Zeiny (2002)** who found that vegetative growth, data affected by foliar compounds which in turn increased carbohydrate, cell division and enlargement leading to more yield.

**Table (5) Effect of foliar application of zinc and manganese or both under anhydrous ammonia rates on tuber Weight/ plant, fresh and dry tuber yield of potato/fed. in both seasons**

Treatments	Tuber weight (g)/ plant			Tuber yield (t/fed.)			Tuber dry yield (t/fed.)		
	N <sub>1</sub>	N <sub>2</sub>	Mean	N <sub>1</sub>	N <sub>2</sub>	Mean	N <sub>1</sub>	N <sub>2</sub>	Mean
2010									
Control	542.4	611.9	577.2	9.319	10.11	9.72	1.76	1.96	1.86
Zinc	634.3	714.7	674.5	10.32	11.30	10.81	2.13	2.16	2.15
Manganese	667.2	754.0	710.6	11.10	11.72	11.41	2.20	2.30	2.25
Zn +Mn	704.8	772.3	738.6	11.70	12.31	12.01	2.24	2.41	2.33
Mean	637.18	713.23*		10.61	11.36*		2.08	2.21*	
LSD at 5 %									
Micronutrients	7.016			0.154			0.080		
Interaction	9.922			0.218			0.113		
2011									
Control	231.2	242.7	236.9	6.41	6.72	6.57	1.54	1.54	1.54
Zinc	257.8	324.3	291.0	6.80	7.54	7.17	1.61	1.77	1.69
Manganese	262.3	334.2	298.3	7.11	7.79	7.45	1.65	1.79	1.72
Zn +Mn	300.6	350.1	325.4	7.65	8.02	7.84	1.84	1.93	1.89
Mean	262.98	312.82*		6.99	7.52*		1.66	1.76*	
LSD at 5 %									
Micronutrients	19.27			0.126			0.113		
Interaction	27.25			0.178			0.159		

With regard to the interacted factors under this investigation, data show that the foliar application of Zn & Mn as mixture under the high level of nitrogen fertilizer gave the highest significant values of tuber weight/ plant, fresh and dry tuber yield of potato in two seasons. Whereas, the same trend was observed by sole foliar application of Mn under the high nitrogen rates on dry tuber yield of potato in two seasons, also, the individual foliar application of Zn or Mn with 120 kg N/fed., gave a high significant value of tuber weight/ plant in 2<sup>nd</sup> season only. Otherwise, the lowest significant values of all parameters in Table (5) were recorded by the control treatment (without foliar spray) under 120 kg N/fed., in both seasons. While, the control treatment or sole foliar spray by Zn under the high level of nitrogen gave the same trend of tuber weight/ plant and dry tuber yield of potato in 2<sup>nd</sup> season only. Potatoes require high amounts of fertilizer not only because of high nutrient demand, but also because they have a shallow, inefficient rooting system (**Munoz et al., 2005 and Pack et al., 2006**). Improvement in growth characters as a result of application of micronutrients might be due to the enhanced photosynthetic and other metabolic activity which leads to an increase in various plant metabolites responsible for cell division and elongation as opined by **Hatwar et al. (2003)**. The photosynthesis enhanced in presence of zinc and boron was also reported by **Rawat and Mathpal (1984)**. **Mallick and Muthukrishnan (1979)** explained that presence of zinc activates the synthesis of tryptophan, the precursor of IAA and it is responsible to stimulate plant growth.

### 3.4. Nitrogen, P uptake and starch of potato tuber

Results in Table (6) illustrate that when nitrogen fertilizer rate was increased from 100 to 120 kg N / fed., the values of N and P uptake as well as starch percent of potato tuber were increased significantly in both seasons. This is due to the fact that, increased concentration of nitrogen fertilizer can increase the nitrogen and phosphorus uptake as well as starch percent of potato tuber and this increase has a positive effect on dry matter accumulation.

Foliar spray of Zn + Mn as a mixture gave the highest values of N and P uptake in both seasons, while, starch percent was increased significantly by the same treatment in first one. Whereas, sole foliar application of Mn gave the highest significant value of starch % in second season. On the other hand, the lowest significant values of N and P uptake as well as starch of potato tuber were obtained by the control treatment (without foliar spray) in both seasons. P uptake was decreased significantly by adding sole foliar application of Zn in two seasons.

**Table (6) Effect of foliar application of zinc and manganese or both under anhydrous ammonia rates on N and P uptake as well as starch of potato tuber in both seasons**

Treatments	N uptake (kg/fed.)			P uptake (kg/fed.)			Starch %		
	N <sub>1</sub>	N <sub>2</sub>	Mean	N <sub>1</sub>	N <sub>2</sub>	Mean	N <sub>1</sub>	N <sub>2</sub>	Mean
2010									
Control	26.93	29.40	28.17	2.46	3.61	3.035	19.80	21.51	20.66
Zinc	35.91	34.34	35.13	1.93	3.72	2.825	21.60	22.15	21.88
Manganese	37.62	37.03	37.33	2.97	4.48	3.725	21.75	22.61	22.18
Zn +Mn	39.42	39.52	39.47	3.86	5.79	4.825	22.47	23.48	22.97
Mean	34.97	35.07*		2.80	4.40*		21.40	22.44*	
LSD at 5 %									
Micronutrients	<b>0.069</b>			<b>0.089</b>			<b>0.187</b>		
Interaction	<b>0.097</b>			<b>0.126</b>			<b>0.264</b>		
2011									
Control	25.75	29.85	27.80	2.14	3.02	2.58	18.70	19.90	19.30
Zinc	34.38	41.42	37.90	1.46	3.17	2.33	19.20	20.70	19.95
Manganese	35.76	45.11	40.44	2.62	3.99	3.31	20.80	21.90	21.35
Zn +Mn	41.92	52.11	47.02	3.11	5.06	4.09	20.10	21.00	20.55
Mean	34.45	42.12*		2.33	3.81*		19.70	20.88*	
LSD at 5 %									
Micronutrients	<b>0.31</b>			<b>0.097</b>			<b>0.159</b>		
Interaction	<b>0.43</b>			<b>0.138</b>			<b>0.225</b>		

Concerning the interacted factors under this study on N and P uptake as well as starch of potato tuber, data tabulated in Table (6) reveal that the best significant values of such parameters were observed when foliar spray mixture of Zn & Mn with the high nitrogen fertilizer rates was practiced in both seasons. With one exception, starch percentage of tuber yield was increased significantly by foliar application of Mn alone under 120 kg N/fed., in the 2<sup>nd</sup> one only. *Vis versa*, the control treatment (without foliar spray) beneath the low nitrogen level gave the lowest significant values of N uptake and starch %



of potato tuber in both seasons. In addition to the foliar application of Zn alone under 100 kg N/fed., was significantly decreased P uptake in both ones.

**3.5. K, Zn and Mn uptake of potato tuber**

Statistical analysis for results presented in Table (7) show that the high nitrogen fertilizer level was superior to the lowest one; the highest significant values of K, Zn and Mn uptake of potato tuber were recorded by 120 kg N/fed., while the lowest ones were obtained by 100 kg N/fed., in both seasons.

With reference to the effect of foliar application of zinc and manganese or both under anhydrous ammonia rates on K, Zn and Mn uptake of potato tuber, data reveal that the foliar spray of potato plants by mixture of Zn & Mn significantly increased such parameters in both seasons. Meanwhile, the control treatment (without foliar spray) gave the lowest significant ones in both seasons.

**Table 7 Effect of foliar application of zinc and manganese or both under anhydrous ammonia rates on K, Zn and Mn uptake of potato tuber in both seasons**

Treatments	K uptake (kg/fed.)			Zn uptake (g/fed.)			Mn uptake (g/fed.)		
	N <sub>1</sub>	N <sub>2</sub>	Mean	N <sub>1</sub>	N <sub>2</sub>	Mean	N <sub>1</sub>	N <sub>2</sub>	Mean
2010									
Control	30.80	39.52	35.16	61.60	72.16	66.88	106.3	119.7	113.0
Zinc	40.25	44.25	42.25	77.89	93.81	85.85	115.9	141.5	128.7
Manganese	40.59	44.75	42.67	70.95	85.92	78.43	128.7	148.6	138.6
Zn +Mn	49.86	55.54	52.70	92.00	113.9	102.9	152.4	183.4	167.9
Mean	40.38	46.02*		75.61	91.44*		125.82	148.29*	
LSD at 5 %									
Micronutrients	<b>0.21</b>			<b>0.81</b>			<b>0.41</b>		
Interaction	<b>0.30</b>			<b>1.14</b>			<b>0.58</b>		
2011									
Control	26.30	34.60	30.45	59.75	72.13	65.94	104.6	112.6	108.6
Zinc	37.74	42.12	39.93	78.56	93.79	86.18	115.6	139.4	127.5
Manganese	36.78	41.16	38.97	69.47	84.12	76.80	119.3	141.7	130.5
Zn +Mn	43.55	50.95	47.25	91.14	112.66	101.90	152.4	184.6	168.5
Mean	36.09	42.21*		74.73	90.68*		122.98	144.58*	
LSD at 5 %									
Micronutrients	<b>0.3280</b>			<b>0.5141</b>			<b>0.4707</b>		
Interaction	<b>0.4639</b>			<b>0.7270</b>			<b>0.6656</b>		

Regarding the interaction effect between anhydrous ammonia fertilizer rates and foliar spray of zinc and manganese or both on K, Zn and Mn uptake of potato tuber; data in Table (7) show that the treatment of foliar application by mixture of Zn & Mn under the high nitrogen fertilizer level increased significantly the studied parameters in both seasons. On the other hand, the lowest ones were obtained when control (without foliar spray) under the low nitrogen level was applied in both seasons.

**4. Conclusion**

Potato is sensitive to nitrogen fertilizer, consequently has become an essential component of potato production. Also, increased yield due to micronutrients application may be attributed to enhancing photosynthesis activity, increasing production and accumulation of carbohydrates and favorable effect on vegetative growth and retention of potato tuber yield.

Therefore, it is recommended that potato cv. Diamant should be fertilized with (120 N kg/fed., and foliar application by mixture of Zn & Mn) to achieve the optimum quantity and quality of tuber yield.

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استجابة البطاطس لمعدلات التسميد بالامونيا الغازية و الرش بالزنك  
والمنجنيز في الأرض الطينية

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أقيمت تجربتان حقليتان بمزرعة محطة بحوث البساتين - القناطر الخيرية - القليوبية لموسمين متتاليين (٢٠١٠-٢٠١١) وذلك لدراسة تأثير استخدام الامونيا الغازية بمعدلي (١٠٠-١٢٠ كجم/ن/فدان ) و الرش بالزنك والمنجنيز على محصول البطاطس صنف الدايمونت في الارض الرسوبية.

وقد اوضحت النتائج ما يلي:

- اعطى مستوى الامونيا الغازية (١٢٠ كجم/ن/فدان) زيادة معنوية في المادة الجافة عند عمر ٩٠ يوم من الزراعة و كذا محتواها من النيتروجين و الفوسفور كما ادى ايضا الى زيادة في الوزن الرطب والجاف للدرنات ومحتواها من النيتروجين والفوسفور والبوتاسيوم والزنك والمنجنيز مقارنة بالمعدل ١٠٠ كجم/ن/ فدان في كلا الموسمين.
- عموما زادت اغلب الصفات في هذا البحث زيادة معنوية باستخدام معاملة الرش بمخلوط الزنك والمنجنيز مقارنة بمعاملة بدون رش.
- سجلت أفضل قيم معنوية لمعظم الصفات باستخدام المعدل ١٢٠ كجم ن /فدان و الرش بمخلوط الزنك والمنجنيز في حين سجلت اقل القيم عند استخدام معاملة الكنترول بدون رش مع ١٠٠ كجم ن /فدان من الامونيا الغازية في كلا الموسمين.