J. Agric. Sci. Mansoura Univ., 34 (5): 5753 - 5762, 2009

INFLUNCE OF SOIL AND FOLIAR APPLICATION OF SUPERPHOSPHATE AND POTASSIUM SULFATE ON MAIZE YIELD AND ITS ATTRIBUTES

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ABSTRACT

Two field experiments were conducted at Mallawy Agricultural Research Station, Agric. Res. Center, El-Minia Governorate in summer seasons of 2006 and 2007 consecutively to study the effect of soil and foliar application of superphosphate and potassium sulfate on maize yield and its attributes and contents of N, P and K nutrients in ear leaf and kernels. Results indicated that foliar application of superphosphate at 10% concentration was significantly better than all other foliar applications involved in the current investigation in respect to kernel yield, ear length and ear diameter in the first season of (2006). Foliar application of potassium sulfate at 5% concentration was better than any other foliar application used in this investigation for producing kernel and ear yields in the second season of (2007). Foliar application of both superphosphate and potassium sulfate at 10% concentration gave the highest significant increase in N content in ear leaf and kernels in the second season of (2007).

Keywords: foliar application, superphosphate, maize, potassium sulfate, ear leaf, kernels.

INTRODUCTION

Maize (*Zea mays* L.) is one of the major summer cereal crops being grown in Egypt nationwide for man, livestock and industry. Maize plants respond very well to field experiments of genetic improvement. They are sensitive to soil fertility and all agricultural treatments. As a plant macronutrient element, phosphorus (P) is essential and an integral component of several plant cell important compounds such as sugar phosphates being involved in respiration, photosynthesis and phospholipids of plant membranes and nucleotides, which are used in plant energy metabolism and in molecules of DNA and RNA (Taiz and Zeiger, 1991). Phosphorus is not only necessary for biosynthesis of chlorophyll (Ambrose and Easy, 1977), but it is also a constituent of cell nucleus being vital for cell division and development of meristematic tissue (Russell, 1973). Phosphorus deficiency usually results in reducing the rate of leaf expansion and photosynthesis per unit leaf area (Rodriguez *et al.*, 1998).

Potassium (K) is essential for normal plant growth and development (Marschner *et al.*, 1986). Its deficiency can limit the accumulation of crop biomass because K increases photosynthetic rates of crop leaves, CO_2 assimilation and facilitates carbon movement (Sangakkara *et al.*, 2000). It greatly effects on carbohydrate partitioning by affecting either phloem export of photosynthates i.e. sucrose or growth rate of sink and/or source of organs (Cakmak *et al.*, 1994). Moreover, it plays a key role in translocation of photosynthates from sources to sinks. Meanwhile, Malakondaiah and Rajeswarao (1979) found that foliar application of phosphorus restored RNA and DNA levels in peanut in shoot apices and mature leaves, which were decreased by the effect of salinity. Rebafka *et al.* (1993) emphasized that

foliar application of P and soil application of triple superphosphate enhanced dry matter production, N and Mo uptake by groundnut. El-Fouly and Fawzi (1998) noted that by increasing the use of high-yielding maize cultivars the need for potash fertilizers arose. Maize could utilize over 50% of its need of potash within a short period of only 15 days, which by no means could be replenished by the soil K, in spite of the relatively high amounts of exchangeable K found in the soil. They added that using K fertilizers on maize in clay soil showed significant increase in yield and resulted in higher efficiency in absorbing available N and P from the soil that may minimize adverse effects in both drainage and shallow ground water used for villager's drinking water. Kaya *et al.*, (2001) concluded that foliar application of supplementary K and P resulted in increases in dry matter and chlorophyll concentrations for the three tomato cultivars grown in this experiment. Ling and Moshe (2002) found that vegetative growth parameters of sweet corn plants viz. root length, leaf area, fresh and dry weight and leaf contents of chlorophyll, N, P and K were increased in response to all forms of foliar fertilization of N, P and K. Mosali *et al.* (2006) suggested that low rate of foliar applied P might correct mid-season P deficiency in winter wheat and that might result in higher P use efficiency when compared to soil application. They also added that foliar P appeared to be more beneficial when yield levels were lower, likely due to moisture stress.

In the light of the abovementioned facts, the current investigation depends on using foliar application of water soluble extract of super phosphate and potassium sulfate on maize plants during vegetative growth period on purpose to evaluate the effect of this technique on maize yield and its attributes as well as N,P and K contents of kernels and to highlight the differences between foliar and soil application of P and K towards maize plant parameters under investigation.

MATERIALS AND METHODS

Two field experiments were conducted at Mallawy Agricultural Research Station, Agric. Res. Center, El-Minia Governorate, Southward Egypt, in summer seasons of 2006-2007, consecutively to examine the effect of soil and foliar application of superphosphate and potassium sulfate on yield and its attributes of maize plants Three Way Cross (TWC) 310 cv. Representative soil samples were collected from the experimental field before planting in both years to study some physical and chemical properties in accordance with Chapman and Pratt (1961). The obtained results are shown in Table (1).

The experiment in each season examined 8 treatments as detailed below:

1- Soil application of 120 kg N/fed only (control).
2- Soil application of 15 kg P_2O_5/fed. + 24 kg K_2O/fed + 120 kg N/fed.
3- Foliar application of superphosphate (SP) at 5% concentration + soil application of 120 kg N/fed.
4- Foliar application of (SP)at 10% concentration+soil application of 120 kg N/fed.
5- Foliar application of potassium sulfate at 5% concentration + soil application of 120 kg N/fed.

6- Foliar application of potassium sulfate (PS) at 10% concentration + soil application of 120 kg N/fed.
7- Foliar application of both (SP) and (PS) at 5% concentration + soil application of 120 kg N/fed.
8- Foliar application of both (SP) and (PS) at 10% concentration + soil application of 120 kg N/fed.

Table (1): Some physical and chemical properties of the experimental soil

Soil properties	Values	
	2006	2007
Particle size distribution (%)		
Sand	8.10	8.35
Silt	52.95	52.25
Clay	38.95	39.40
Textural class	**Silt clay loam**	
Soil chemical properties		
pH (1: 2.5 soil suspension)	8.10	8.00
$CaCO_3$ %	1.68	1.50
Organic matter %	1.15	1.00
E.C (dS/m soil paste extract)	1.66	1.64
Available macronutrients (mg/kg)		
N	18.65	18.45
P	7.45	7.35
K	175.00	168.00
Soluble cations		
Ca^{2+}	9.10	8.85
Mg^{2+}	2.35	2.52
Na^{+}	4.20	4.10
K^{+}	0.25	0.22
Soluble anions (meq/L)		
CO_3^{2-}	-	-
HCO_3^{-}	3.45	3.25
Cl^{-}	4.65	4.35
SO_4^{2-}	7.80	8.09

The experimental treatments were arranged in a completely randomized design with four replicates, where maize grains) kindly supplied with Field Crops Research Institute, Agric. Res. Center, Giza, Egypt) were planted by hand in experimental plots of 6 m^2 in summer of 2006 and 2007. The experimental field in both years has been grown previously with wheat and it was under furrow irrigation system. Nitrogen fertilizer in the form of ammonium sulfate (20.5% N) was broadcasted at the rate of 120 kg N/fed in two equal doses; after thinning (21days from planting) and before the first irrigation (18 days later) to all experimental plots. Phosphorus and potassium as soil application were in the form of ordinary superphosphate (15.5% P_2O_5) and potassium sulfate (48% k_2O). Phosphorus was incorporated into soil at a rate of 15 kg P_2O_5/fed after slicing experimental plots and while preparing seedbed. Potassium sulfate was side dressed at the rate of 24 kg K_2O/fed in two equal split doses; after thinning and before the first irrigation in the same time of applying N fertilizer.

Foliar solutions of (SP) and (PS) at 5% and 10% concentration were prepared separately by dissolving 10 kg and 20 kg of each fertilizer in 200 L

of irrigation water and then the precipitate was removed from the container. Each foliar solution and the mixture of both were sprayed on maize plant foliage 30, 45 and 60 days after planting. Other routine agricultural practices were followed as instructed by agricultural extension.

After maize plants in the experimental field have tasseled by 50%, approximately after 54 days from planting, random samples of cob leaves were collected from each experimental plot to determine the content of N, P and K in line with A. O. A. C (1990). Moreover, after 120 days all experimental plots were harvested separately to evaluate morphological characteristics of maize cobs together with yield and its attributes and N, P and K contents of kernels. Data were tabulated and subjected to statistical analysis according to Steel and Torrie (1980).

RESULTS AND DISCUSSION

I. Effect of fertilizer treatments on maize yield and its attributes:

Data in Tables (2 & 3) noted that soil application of superphosphate and potassium sulfate at the rate of 100 kg/fed and 50 kg/fed, respectively, increased significantly kernel yield and all relevant attributes in both seasons with the exception of ear length in season of 2007. This positive effect may be attributed to the vital role of phosphorus in respiration, photosynthesis and phospholipids of plant membranes, nucleotides being used in plant energy metabolism and in molecules of DNA and RNA, biosynthesis of chlorophyll and cell nucleus are essential for cell division and the development of meristematic tissue. These findings are in full agreement with those of Russell (1973), Ambrose and Easy (1977) and Taiz and Zeiger (1991). Also, these findings are associated with the vital role of potassium, which contributed to the increase of photosynthetic rates, CO_2 assimilation and facilitates carbon movement (Sangakkara *et al*, 2000). Moreover, soil application of (SP) and (PS) with those rates brought about the highest significant percentage of increases in kernels and ear yields and the relevant attributes. Data in Table (2) showed that foliar application of (SP) at 10% concentration was significantly better than all other foliar applications involved in the current investigation in respect of kernel yield and ear length and ear diameter, whereas data in Table (3) clarified that foliar application of (PS) at 5% concentration was better than any other foliar application used in this investigation in producing kernel and ear yields but it was similar to foliar application of (SP) at 10% concentration in producing kernel and ear yields. This positive effect may be attributed to the improvement of vegetative growth parameters such as root length, leaf area, fresh and dry weight and leaf contents of chlorophyll, N, P and K as suggested by Ling and Moshe (2002) and Mosali *et al.*(2006).

II. Effect of fertilizer treatments on N, P and K contents in ear leaf and kernels:

Data in Tables (4&5) elucidated that soil application of (SP) and (PS) at the rate of 100 kg/fed and 50 kg/fed respectively; significantly increased N, P and k contents in ear leaf and kernels and resulted in the highest significant percentages of increase of such elements in ear leaf and kernels.

Table (2): Effect of soil and foliar application of superphosphate and potassium sulfate on maizee yield and its attributes in season 2006

No.	Treatments	kernel yield Ardab/fed	Percentage increase	Ear yield Ardab/fed	Percentage increase	Ear length (cm)	Percentage increase	Ear diameter (cm)	Percentage increase
1	Soil application of 120 kg N/fed (control)	22.55	0.00	26.00	0.00	18.80	0.00	4.50	0.00
2	Soil application of 120kg N\fed + 100 kg (SP)/fed + 50 kg (PS)/fed	26.08	15.64	29.60	13.85	20.40	8.50	4.75	5.56
3	Foliar application of (SP) at 5% concentration + soil application of 120 kg N/fed	23.78	5.45	27.30	5.00	20.20	7.45	4.60	2.22
4	Foliar application of (SP) at 10% concentration + soil application of 120 kg N/fed	24.30	7.76	27.20	4.62	19.70	4.78	4.75	5.56
5	Foliar application of (PS) at 5% concentration + soil application of 120 kg N/fed	24.30	7.76	28.00	7.69	19.80	5.30	4.55	1.10
6	Foliar application of (PS) at 10% concentration + soil application of 120 kg N/fed	25.18	11.66	28.60	10.00	19.00	1.06	4.40	-0.02
7	Foliar application of both (SP) and (PS) at 5% concentration + soil application of 120 kg N/fed	24.30	7.76	28.40	9.23	19.90	5.85	4.60	2.22
8	Foliar application of both (SP) and (PS) at 10% concentration + soil application of 120 kg N/fed	25.52	13.17	28.80	10.77	19.60	4.26	4.75	5.56
LSD at 0.05		1.37		0.89		1.40		0.22	

Table (3): Effect of soil and foliar application of superphosphate and potassium sulfate on maize yield and its attributes in season 2007

No.	Treatments	kernel yield Ardab/fed	Percentage increase	Ear yield Ardab/fed	Percentage increase	Ear length (cm)	Percentage increase	Ear diameter (cm)	Percentage increase
1	Soil application of 120 kgN/fed (control)	22.90	0.00	25.60	0.00	19.20	0.00	4.60	0.00
2	Soil application of 120 kg N/fed + 100 kg (SP)/fed + 50 kg (PS)/fed	26.05	13.76	29.60	15.63	20.20	5.21	4.90	6.52
3	Foliar application of (SP) at 5% concentration + soil application of 120 kg N/fed.	24.05	5.02	26.98	5.39	18.70	-2.60	4.55	-1.09
4	Foliar application of (SP) at 10% concentration + soil application of 120 kg N/fed.	23.95	4.59	27.60	7.81	19.90	3.65	4.75	3.26
5	Foliar application of (PS) at 5% concentration + soil application of 120 kg N/fed	24.65	7.64	26.46	3.36	19.20	0.00	4.50	-2.17
6	Foliar application of (PS) at 10% concentration + soil application of 120 kg N/fed.	25.18	9.96	28.60	11.72	21.20	10.42	4.75	3.26
7	Foliar application of both (SP) and (PS) at 5% concentration + soil application of 120 kg N/fed.	25.00	9.17	27.60	7.81	20.20	5.21	4.60	0.00
8	Foliar application of both (SP) and (PS) at 10% concentration + soil application of 120 kg N/fed.	25.35	10.70	28.80	12.50	19.50	1.56	4.85	5.43
LSD at 0.05		0.78		1.58		1.13		0.17	

Table(4): Effect of soil and foliar application of superphosphate and potassium sulfate on N, P and K contents in ear leaf and kernels in season 2006

No.	Treatments	Ear leaf						Kernels					
		N%	Percentage increase	P%	Percentage increase	K%	Percentage of increase %	N%	Percentage increase	P%	Percentage increase	K%	Percentage increase
1	Soil application of 120 kgN /fed (control)	2.93	0.00	0.26	0.00	2.18	0.00	2.07	0.00	0.18	0.00	0.58	0.00
2	Soil application of 120 kg N/fed + 100 kg (SP)/fed + 50 kg (PS)/fed	3.43	17.06	0.39	50.00	2.80	28.44	2.58	24.64	0.27	50.00	0.85	46.55
3	Foliar application of (SP) at 5% concentration + soil application of 120 kg N/fed,	3.15	7.51	0.31	19.23	2.18	0.00	2.16	4.35	0.22	22.22	0.51	-12.07
4	Foliar application of (SP) at 10% concentration + soil application of 120 kg N/fed,	3.28	11.95	0.33	26.92	2.13	-2.29	2.30	11.11	0.23	27.78	0.49	-15.52
5	Foliar application of (PS) at 5% concentration + soil application of 120 kg N/fed	3.05	4.10	0.27	3.85	2.48	13.76	2.27	9.66	0.20	11.11	0.60	3.45
6	Foliar application of (PS) at 10% concentration + soil application of 120 kg N/fed,	3.18	8.53	0.29	11.54	2.55	16.97	2.39	15.46	0.21	16.67	0.78	34.48
7	Foliar application of both (SP) and (PS) at 5% concentration + soil application of 120 kg N/fed.	3.18	8.53	0.32	23.08	2.38	9.17	2.20	6.28	0.23	27.78	0.58	0.00
8	Foliar application of both (SP) and (PS) at 10% concentration + soil application of 120 kg N/fed.	3.39	15.70	0.33	26.92	2.46	12.84	2.39	15.46	0.24	33.33	0.67	15.52
	LSD at 0.05	0.11		0.02		0.10		0.09		0.02		0.07	

Table (5): Effect of soil and foliar application of superphosphate and potassium sulfate on N, P and K contents in ear leaf and kernels in season 2007

No.	Treatments	Ear leaf						Kernels					
		N%	Percentage increase	P%	Percentage increase	K%	Percentage of increase %	N%	Percentage increase	P%	Percentage increase	K%	Percentage increase
1	Soil application of 120 kgN /fed (control)	2.88	0.00	0.25	0.00	2.39	0.00	2.18	0.00	0.19	0.00	0.49	0.00
2	Soil application of 120 kg N/fed + 100 kg (SP)/fed + 50 kg (PS)/fed	3.43	19.10	0.39	56.00	2.87	20.10	2.34	7.34	0.29	52.63	0.82	67.35
3	Foliar application of (SP) at 5% concentration + soil application of 120 kg N/fed,	2.93	1.74	0.27	8.00	2.23	-6.69	2.21	1.38	0.21	10.53	0.48	-2.04
4	Foliar application of (SP) at 10% concentration + soil application of 120 kg N/fed,	2.95	2.43	0.30	20.30	2.03	-15.10	2.20	0.92	0.22	15.79	0.47	-4.08
5	Foliar application of (PS) at 5% concentration + soil application of 120 kg N/fed	2.96	2.78	0.26	4.00	2.28	-4.60	2.18	0.00	0.21	10.53	0.60	22.49
6	Foliar application of (PS) at 10% concentration + soil application of 120 kg N/fed,	3.00	4.17	0.27	8.00	2.61	9.21	2.33	6.88	0.22	15.79	0.67	36.73
7	Foliar application of both (SP) and (PS) at 5% concentration + soil application of 120 kg N/fed.	2.66	-7.64	0.28	12.00	2.20	-7.95	2.30	5.50	0.22	15.79	0.58	18.37
8	Foliar application of both (SP) and (PS) at 10% concentration + soil application of 120 kg N/fed.	3.18	10.42	0.31	24.00	2.33	-2.51	2.45	12.39	0.24	26.32	0.66	34.69
LSD at 0.05		0.34		0.03		0.15		0.12		0.03		0.07	

Such results may be attributed to the increase in dry matter similarly as suggested by Rebafka *et al.* (1993). In season of 2006 as shown in Table (4) foliar application of (PS) at 10% concentration significantly surpassed all other foliar applications in increasing K content in ear leaf and N and K contents in seeds. These results were similar to those achieved by Mosali *et al.* (2006). In season 2007, data in Table (5) showed that foliar application of both (SP) and (PS) at 10% concentration resulted in the highest significant increase in N content in ear leaf and kernels.

In the light of the current research soil sample analyses, treatments and results achieved it could be recommended that foliar application of (SP) at 10% and (PS) at 5% concentration brings about significant maize kernel and ear yields under soil application of 120 kg N/fed.

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تأثير الإضافة الأرضية الورقية للسوبرفوسفات وسلفات البوتاسيوم على محصول الذرة الشامية ومكوناته

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أقيمت تجربتين حقليتين بمحطة البحوث الزراعية بملاوي – محافظة المنيا التابعة لمركز البحوث الزراعية في الموسمين الصيفيين ٢٠٠٦ و٢٠٠٧ على التوالي لدراسة تأثير الإضافة الأرضية والرش الورقي لسماد السوبر فوسفات أو سماد سلفات البوتاسيوم أو كلاهما معا على محصول الذرة الشامية وصفاته ومحتوى ورقة الكوز والحبوب من العناصر الغذائية (النيتروجين والفوسفور والبوتاسيوم) وقد أشارت النتائج المتحصل عليها إلى أن الرش الورقي للسوبر فوسفات بتركيز ١٠% كان أفضل معنويا من تركيزات الرش الأخري المستخدمة في هذا البحث فيما يتعلق بمحصول الحبوب وطول الكوز وقطر الكوز في الموسم الأول (٢٠٠٦). الرش الورقي لسلفات البوتاسيوم بتركيز ٥% كان أفضل من أي رش ورقي أخر استخدم في هذا البحث فيما يتعلق بمحصول الحبوب ومحصول الكيزان في الموسم الثاني (٢٠٠٧). الرش الورقي للسوبر فوسفات وسلفات البوتاسيوم كل منهما بتركيز ١٠% معا قد أعطى أعلى زيادة معنوية لمحتوى ورقة الكوز ومحتوى الحبوب من عنصر النيتروجين في الموسم الثاني (٢٠٠٧).