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Synergetic Effect of N-K Fertilization on Growth, Yield and Nutrients Content of Corn Plants Grown on Sandy Soils Amended with Bentonite or Compost

Abd El-Rheem Kh. M.[1] Sahar M. Zaghloul[2] and Entsar M. Essa[2]

[1]Soils and Water Use Dept., [2]Plant nutrition Dept., Agricultural and Biological Research Division National Research Centre, Dokki, Giza, Egypt

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ABSTRACT

A field successive experiment was carried out employing sandy soil to clarify the role of compost, bentonite and varied levels of N and K fertilization on growth, yield and nutrients content of corn (Zea mays L., cv Giza 10) crop. The experiment was carried out to evaluate the effect of compost and bentonite as combined with different nitrogen and phosphorus fertilization combinations on corn plants. Each amendment was added to soil at a rate of 5 ton fed^{-1} in combination with three levels of N (100, 150 and 200 kg fed^{-1}) were combined with three levels of K_2O (40, 60 kg fed^{-1}) and one level of P_2O_5 (60 kg fed^{-1}).

Data obtained from the experiment indicate that highest growth and yield parameters under no amended condition obtained from combination of 200 kg N + 40 kgK_2Ofed^{-1}. While under compost and bentonite the highest growth and yield parameters obtained from combination 200 kg N + 60 kgK_2Ofed^{-1}.

Under no amended condition, 40 kgK_2Ofed^{-1} was found to be enough to increase N and Ca opposite to P, K and Mg when N fertilization increased. Increasing N fertilization level under any level of K fertilization increased N, P, K and Mg but decreased Ca content in plant under any amendment condition.

KEYWORDS: Sandy soil, Corn, Compost, Bentonite, N and K fertilization, Growth, Yield, Nutrient content.

INTRODUCTION

Corn is one of the most widely grown cereals in the world and has great significance as human food, animal feed and raw material. In most developing countries, about 50 to 55 percent of the total maize production is consumed as food. Maize has high production potential especially under irrigated condition when compared to any other cereal crop. The productivity of maize largely depends on its nutrient requirement and management particularly that of nitrogen, phosphorus and potassium **(Arun Kumar *et al*., 2007)**.

Bentonite is the main constituent of the water based drilling fluid due to high viscosity, good swelling and low filter loss **(Apaleke *et al., 2012*)**. Bentonite is asmectite clay mineral and largely composed of >80%montmorillonite clay mineral and a smaller amount of other clay minerals as kaolanite or non clay minerals as quartz. Montmorillonite is a type of natural mineral clay and has alayered structure. Na- bentonite is characterized by its ability to absorb large amounts of water and form viscous, thixotropic suspensions while Ca- bentonite, which has Ca^{+2}2as the dominant exchangeable cation, is characterized by its low water absorption and low swelling capabilities and its inability to stay suspended in water**(Luckham and Rossi, 1999).**

Compost is widely used in agriculture and horticulture, and it has been recently trialed for grapevine **(Korboulewsky *et al*., 2004 and Powell *et al*., 2007)**.The general benefits of compost addition are increasing soil water holding capacity **(Aggelides and Londra, 2000; Curtis and Claassen, 2005; Mylavarapu and Zinati, 2009)**, providing nutrients and organic matter, as well as improving soil physical properties, including soil structural stability **(Tejada *et al*., 2009)**, total porosity **(Jamroz and Drozd, 1999; Aggelides and Londra, 2000)**, aggregate formation **(Celik *et al*., 2004; Sodhi*et al*., 2009)** and hydraulic conductivity **(Curtis and Claassen, 2009)**. Therefore, compost application could be useful in vineyard management to increase water use efficiency and reduce irrigation requirements.

Nitrogen (N) is one of the critical nutrients for crop production and is generally applied in large quantities in form of fertilizer to soils **(Malhia *et al,* 2001; Murshedul *et al,* 2006; Singh *et al,* 2007; Kong *et al,* 2008)**. However, most plants only utilize less than one-half of fertilizer N applied, and the loss of fertilizer N was high **(Zhu, 2000; Zhu and Chen, 2002).**Nitrogen management in agro-ecosystems has been extensively studied due to

* **Corresponding Author:** Abd El-Rheem Kh. M., Soils and Water Use Dept., Agricultural and Biological Research Division National Research Centre, Dokki, Giza, Egypt. Khaled_abdelrheem@yahoo.com

its importance in improving crop yield and quality, and in mitigating the negative effects of fertilizer N losses such as nitrate contamination of groundwater, eutrophication of surface water, and greenhouse effect **(Hillin and Hudak, 2003; De Paz and Ramos, 2004; Alam *et al*, 2006; Dambreville *et al*, 2008)**.

Potassium (K) is an essential macronutrient for plants involved in many physiological processes. It is important for crop yield as well as for the quality of edible parts of crops, as it is also required in human nutrition. Although K is not assimilated into organic matter, K deficiency has a strong impact on plant metabolism. Plant responses to low K involve changes in the concentrations of many metabolites as well as alteration in the transcriptional levels of many genes and in the activity of many enzymes (**Armengaud *et al.*, 2009**).

The objective of this work was study the interaction between N and K fertilizers on growth, yield and nutrients content of corn (Zea mays L., cv Giza 10) crop under compost and bentonite.

MATERIALS AND METHODS

A field trial was successively conducted on a loamy sand soil at Ismailia Agricultural Research Station cultivated with corn (Zea mays L., cv Giza 10) at summer 2012. Some physical and chemical properties of the cultivated soil were evaluated in samples taken before corn planting according to standard procedures reported by **Cotteine (1980)** to be presented in (Table, 1).

Table (1): Some physical and chemical properties of soil before corn cultivation.

Soil property	Value	Soil property	Value
		pH (1:2.5 soil suspension)	**8.0**
Sand	84.1	EC (dS m^{-1}), soil paste extract	**1.20**
Silt	5.70	**Soluble ions (mmol L^{-1})**	
Clay	10.2	Ca^{++}	**6.12**
Texture	Loamy sand	Mg^{++}	**4.60**
		Na^{+}	**1.54**
$CaCO_3$ %	2.50	K^{+}	**0.52**
Organic matter%	0.02	CO_3^{--}	**Nd**
Available N (mg kg^{-1})	51.2	HCO_3^{-}	**1.10**
Available P (mg kg^{-1})	1.75	Cl^{-}	**0.96**
Available K (mg kg^{-1})	**2.10**	SO_4^{--}	**9.60**

nd: not detected

Interaction effects of different rates on nitrogen and phosphorus fertilizers on growth, yield components and nutrients content of the cultivated plants under different soil amendment conditions including compost and bentonite was tested. The experiment was carried out in a split plot design, with three replicates for each experimental unite. Soil amendments were added by thoroughly mixing with the surface soil layer only before corn cultivation in a 5 ton fed^{-1} rate for compost or bentonite with no addition plot standing up to represent no amendment condition. Some chemical properties of the used amendments were shown in (Table, 2) and (Table, 3). In each plot, three nitrogen levels (100, 150 and 200 kg N fed^{-1}) in the form of $NH_4(SO_4)_2$

Table (2): some chemical properties of used compost.

CEC Meq/ 100g	pH 1:2.5	O.C %	C/N ratio	EC dS/m	Anions meq/1				Cationmeq/1			
					Cl^{-}	$CO_3^{=}$	HCO_3^{-}	$SO_4^{=}$	Na^{+}	K^{+}	Ca^{++}	Mg^{++}
95.0	6.54	24	17.0	8.6	5.63	nd	3.26	98.5	70.2	24.8	8.33	3.1

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Table (3): Some chemical properties of used bentonite.

CEC Meq/ 100g	$CaCO_3$ %	pH 1:2.5	EC dS/m	Anions meq/1				Cationmeq/1			
				Cl^{-}	$CO_3^{=}$	HCO_3^{-}	$SO_4^{=}$	Na^{+}	K^{+}	Ca^{++}	Mg^{++}
44	2.90	7.8	4.74	1.88	nd	0.43	57.0	24.5	1.10	20.7	13.0

(20.6 %) combining with two potassium levels (40 and 60kg K_2Ofed^{-1}) in the form of potassium sulfate (50 % K_2O) and one phosphorus level(60 kg K_2Ofed^{-1}) in the form of superphosphate (15% P_2O_5). Plant samples were dried at 65C° for 48 hrs., ground and wet digested using H_2SO_4: H_2O_2 method **(Cottenie, 1980)**. The digests samples were then subjected to measurement of N using Micro-Kjeldahle method; P was assayed using molybdenum blue method and determined by spectrophotometer **(Chapman and Pratt, 1961)**; K was determined by Flame Photometer, while Ca and Mg were determined using atomic absorption spectrophotometer.

RESULTS AND DISCUSSION

Regarding the response of growth and yield, obtained data (Table, 4) indicated that increasing N level under low K application increased significantly growth and yield parameters. As K application level increased, the activation action of N was found to be promoted.

Table (4): Interaction effect between N and K fertilization levels on growth and yield of corn plants cultivated in sandy soil under used amendments.

Treatment		Growth					yield	
		No.of leaf	length (cm)	Shoot	Root (g / plant)	Ear leaf	Straw	Grain (ton/fed)
kg/fed								
N	K_2O							
					No amendment			
100	40	13.6 b	163.9 d	49.9 f	7.08 f	1.61 d	4.23 d	1.62 e
100	60	13.7 ab	159.7 e	59.5 e	7.80 e	1.68 d	5.06 bc	1.73 d
150	40	14.1 a	171.2 c	99.7 c	13.0 c	1.98 c	499 c	2.05 c
150	60	12.9 c	183.2 b	75.7 d	11.2 d	2.13 b	5.25 b	2.07 c
200	40	13.9 ab	206.1 a	107.5 b	16.3 b	2.40 a	7.73 a	2.32 b
200	60	13.1 c	206.1 a	128.1 a	19.8 a	2.52 a	7.88 a	2.43 a
Total mean		13.6	181.7	86.7	12.5	2.1	5.85	2.04
					Compost			
100	40	13.3 b	181.6 e	74.5 f	15.2 d	1.97 d	6.81 c	2.42 d
100	60	13.3 b	183.6 d	81.1 e	15.4 d	1.96 d	7.15 b	2.44 cd
150	40	13.7 b	184.2 d	83.9 d	17.4 c	2.09 c	7.07 bc	2.52 c
150	60	14.0 a	190.3 c	94.7 c	18.3 b	2.12 bc	7.19 b	2.67 b
200	40	13.6 b	196.0 b	104.6 b	18.3 b	2.21 ab	8.10 a	2.84 a
200	60	13.6 b	205.2 a	118.9 a	19.7 a	2.26 a	8.23 a	2.87 a
Total mean		13.6	190.1	92.9	17.4	2.1	7.42	2.63
					Bentonite			
100	40	13.3 bc	178.3 e	95.8 c	12.2 f	1.71 d	5.37 e	2.15 d
100	60	14.0 a	189.2 d	96.0 c	17.0 e	1.90 c	5.46 d	2.17 d
150	40	13.1 bc	207.7 c	96.1c	22.6 c	2.03 b	6.21 c	2.48 c
150	60	13.4 bc	211.1 b	97.3 c	17.6 d	2.08 b	6.28 c	2.51 c
200	40	13.0 c	211.8 b	102.1 b	23.7 b	2.14 a	6.76 b	2.70 b
200	60	13.6 ab	216.3 a	136.3 a	30.4 a	2.18 a	6.85 a	2.74 a
Total mean		13.4	202.4	103.9	20.6	2.01	6.16	2.46

Values having the same letter (s) within a column aren't significantly different under 95% confidence.

Such pattern revealed a synergism phenomenon between K application and N stimulation for growth and yield of corn. Such synergism continued to be acting for increasing N level on K utilization in corn growth and yield. **Mackenzie *et al*., (1988)** stated that greater K application, in conjunction with more of N, stimulated dry matter production and yield of corn. Under local conditions, **El-Bana and Gomaa (2000)** reported that corn grain yield responded to only 175 kg N when 25 or 50 kg K_2O/fed was applied. In contrast, when 75 kg K_2O/fed was applied, the response was only to 150 kg N/fed. It seemed that under 50 kg N and 75 kg K_2O/fed, more equilibrium was attend. On the other hand, under 150 kg N, the response was only to the highest K level (75 kg/fed) indicating the same interaction approach.

Under condition of compost as well as bentonite application, the synergetic interaction continued to act between N and K but with a lesser extent. The best growth and superior yield for either straw or grain were generally obtained when high level of N rate (200 kg/fed) combined the second level of K rate (60 kg/fed) under all amendment conditions.

As the response of nutrient content was concerned, obtained data (Table, 5)indicated that increasing N application level increased N content under low and high K fertilization levels. Increasing K fertilization level increased N content of corn plants only under low N fertilization level. Under medium and high N application levels, however, increasing K fertilization decreased N content. Under amendment conditions, the synergetic nature of K on N continued to act where increasing N fertilization increased N content under low and high K application levels. Also, the synergetic nature of N on K continued to be acting where increasing K fertilization increased N content under all N fertilization levels.

Table (5): Interaction effect between N and K fertilization levels on nutrient content of corn plants cultivated in sandy soil under used amendments.

Treatment		Nutrient content in the ear leaf , (%).				
		N	P	K	Ca	Mg
kg/fed						
N	K_2O					
		No amendment				
100	40	2.29 cd	0.37 d	1.98 a	0.71 bc	0.46 ab
100	60	2.33 c	0.44 b	2.01 a	0.62 de	0.46 ab
150	40	2.24 de	0.46 a	2.02 a	0.57 e	0.38 c
150	60	2.19 e	0.43 b	1.82 b	0.80 a	0.40 bc
200	40	2.59 a	0.34 e	1.51 c	0.77 ab	0.52 a
200	60	2.49 b	0.38 c	1.89 ab	0.65 cd	0.49 a
Total Mean		2.35	0.4	1.87	0.69	0.45
		Compost				
100	40	1.55 e	0.34f	2.43 c	0.90 c	0.42 bc
100	60	1.94 c	0.39 e	3.50 a	0.75 d	0.45 ab
150	40	1.77 d	0.45 b	2.87 b	1.03 b	0.40 c
150	60	2.20 a	0.43 c	3.44 a	0.76 d	0.48 a
200	40	1.93 c	0.46 a	3.00 b	1.20 a	0.40 c
200	60	2.12 b	0.41 d	3.78 a	0.90 c	0.31 d
Total Mean		1.92	0.41	3.17	0.92	0.41
		Bentonite				
100	40	1.80 e	0.37 d	1.72 bc	0.74 a	0.36 d
100	60	2.11 d	0.37 d	1.76 b	0.66 b	0.42 bc
150	40	2.21 c	0.42 a	1.67 c	0.66 b	0.45 b
150	60	2.23 c	0.41 ab	1.84 a	0.66 b	0.40 cd
200	40	2.27 b	0.40 bc	1.75 b	0.65 b	0.55 a
200	60	2.32 a	0.39 c	1.76 b	0.75 a	0.43 bc
Total Mean		2.16	0.39	1.75	0.69	0.44
Values having the same letter (s) within a column aren't significantly different under 95% confidence.						

Regarding response of P content, increasing N fertilization level had negative effect on P content under low and high K levels. Increasing K application level increased significantly P content with low and high N fertilization levels. Under medium N fertilization level, however, increasing K fertilization decreased significantly P incorporation by corn plants.

Under amended conditions, increasing N fertilization relatively increased P content in plants under both levels of K application. Also increasing K fertilization decreased significantly P content under moderate (150 kg N/fed) and high levels of N application (200 kg N/fed). However, increasing K fertilization level increased only P content with low N fertilization level (100 kg N/fed) under compost condition.

Regarding K content, increasing N fertilization level decreased significantly K content under both K fertilization levels. Increasing K fertilization level, however, was not able to increase K content under low N fertilization level (100 kg N/fed). Increasing N level altered the response of K content to increasing K level as N_2 (150 kg N/fed) was negative while N_3 (200 kg N/fed) was positive. Under amended conditions the synergetic effect seemed to be more obvious.

Regarding Ca content, increasing N fertilization level increased significantly Ca content in plants under low K fertilization, but under high K one, increasing N fertilization up to medium level increased Ca content to be then decreased under no amended condition.

Under amendment condition, increasing N fertilization level decreased Ca content in plants under low opposite to heavy K fertilization level. Generally Mg content behaved relatively different pattern if compared with that of Ca.

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