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Interactions between N and P Fertilization and its Effect on Corn Plants Grown on Sandy Soils under Different Natural Soil Amendments

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ABSTRACT

A field successive experiment was carried out employing sandy soil to clarify the role of natural soil amendments and different levels of N, P 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 P_2O_5 (40, 60 and 80 kg fed^{-1}) and one level of K_2O (60 kg fed^{-1}).

Data obtained from the experiment indicated that increasing N and P fertilization increased growth and yield parameters were higher in compost compared to bentonite or no amendment application condition. Generally, interactions among N and P fertilization were found to affect significantly growth, yield and nutritional status of corn plants. Increasing N fertilization level increased nutrient content under compost and bentonite condition. However, increasing P fertilization level decreased N opposite to Ca and Mg contents; those of P and K content were less affected to increasing P fertilization.

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

INTRODUCTION

The huge increase in the human population in Egypt in last decades led to cultivating very poor soil as the sandy ones for food production. Cultivating grain crops such as corn and wheat are a must for secure bread production. Soil productivity newly reclaimed is weak; this may be due to the nature of the soil being sandy soil as well as imbalance of used fertilizers under such conditions.

Because bentonite is natural deposit widespread in different locations in Egypt with different physical and chemical properties, it could be subsequently used as soil amendment, **Abd El-Dayem *et al.*, (2012)** used bentoniteas soil conditioner for sandy soils and found that application of bentonite at the rate of 5% improved the physical and chemical properties of sandy soil and provided growing plants with nutrients.

Also, the recycling (composting) of organic wastes such as organic crop residues, animals wastes, garbage and human wastes in agriculture may have a role in correcting the imbalanced consumption of chemical fertilizers in such condition. **Awad (1994)** pointed out that the importance of organic matter to Egyptian agriculture comes directly next to water importance. In the same time, organic amendments are usually added to soils to improve their physical, chemical and biological properties and / or provide plants with nutrients.

Mukhtar *et al.*, (2011) found that increasing N and P application significantly increased plant height and spike length, straw, biological and grain of barley grown in sandy soil were significantly increased with increasing N fertilizer. **El-Nagar *et al.*, (1989)** reported that plant height and number of green leaves and their fresh weigh were increased significantly when both P and N were applied, as compared to control treatment. This trend was very clear when P was applied at the rate of 33 kg P_2O_5 fed^{-1}with any rate of N fertilizers whereas the highest increase in plant height was recorded by plants received 60kg N fed^{-1}. They added that grain yield increased significantly when both N and P were applied. **Saleque *et al.*, (2001)** reported that the grain N content generally decreased steeply as the soil available P level increased. The decrease in straw and grain N content of rice with an increase in soil P level may be attributed to the dilution effect as the yield in P deficient plots was about less than a half of that obtained in relatively high-P plots.

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

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 corncultivation.

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
$CaCO_3$ %	2.50	Na^+	1.54
Organic matter%	0.02	K^+	0.52
Available N (mg kg^{-1})	51.2	CO_3^{--}	Nd
Available P (mg kg^{-1})	1.75	HCO_3^-	1.10
Available K (mg kg^{-1})	**2.10**	Cl^-	0.96
		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 at a rated 5 ton $fed^{-1}$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 and3).In each plot, three nitrogen levels (100, 150 and 200 kg $Nfed^{-1}$) 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

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

nd: not detected

(20.6 %) combining with three phosphorus levels (40, 60 and 80 kg$P_2O_5fed^{-1}$) in the form of superphosphate (15% P_2O_5) and one potassium level 60 kg K_2Ofed^{-1} in the form of potassium sulfate. 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 P addition increased growth and yield parameters. This action was significantly accelerated under heavy P application. Such pattern revealed some sort of synergism phenomenon between P application and N utilization for corn crop production. Such synergism phenomenon continued to be acting for increasing N level on P utilization in corn crop. Where increasing P fertilization level from 40 to 80 kg P_2O_5 fed^{-1} didn't increase straw or grain yield significantly unless heavy N fertilization level (200 kg N fed^{-1}) was applied. **Mukhtar *et al.*, (2011)** found that maximum grain yield per hectare was achieved at the level of 400 kg N + 200 kg P_2O_5ha^{-1}. **Shah *et al.*, (1992)** found that increasing application levels of N with P significantly increased grain and straw yields. Similar increases in growth and yield of corn plant induced by N P fertilization were reported by **El-Far (1996)** and **Hegazy *et al.*, (1996)**.

Under compost as well as bentonite application, although the synergetic interaction between N and P continued to act, its value was with a lesser extent. The superior values for yields of straw or grain as well as growth were generally obtained when 200 kg N fed^{-1} was added as combined 80 kg P_2O_5 fed^{-1} under all amendment conditions.

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

Treatment		Growth					Yield	
		No. of leaf	Length (cm)	Shoot	Root	Ear leaf	Straw	Grain
				(g / plant)			(ton/fed)	
kg/fed								
N	P_2O_5							
		No amendment						
100	**40**	13.3 b	154.7 g	41.9 i	6.42 f	1.90 c	4.50 f	1.61 g
100	**60**	14.0 a	167.0 e	56.5 h	7.50 e	1.58 e	4.60 f	1.64 g
100	**80**	13.5 ab	163.7 f	65.7 g	17.5 c	1.75 d	4.83 ef	1.78 f
150	**40**	13.7 ab	163.8 f	70.6 f	8.95 d	1.67 de	4.99 de	2.03 e
150	**60**	13.3 b	183.8 d	80.6 e	6.96 ef	1.68 de	5.08 de	2.05 e
150	**80**	13.5 ab	184.0 d	112.0 c	17.6 c	2.52 b	5.30 d	2.10 d
200	**40**	13.7 ab	190.8 d	96.7 d	9.35 d	2.62 b	7.30 c	2.19 c
200	**60**	13.3 b	207.5 b	119.8 b	18.9 b	1.97 c	7.65 b	2.36 b
200	**80**	13.5 ab	220.0 a	136.9 a	19.5 a	2.80 a	8.47 a	2.59 a
Total mean		13,6	181,7	86,7	12,5	2,1	5,85	2,04
		Compost						
100	**40**	13.0 d	179.8 g	80.4 f	14.9 e	2.05 cd	6.67 e	2.37 e
100	**60**	14.5 a	201.7 c	83.2 e	20.6 b	2.30 b	6.87 e	2.42 de
100	**80**	12.5 e	176.3 h	69.8 g	13.4 f	1.77 e	7.40 c	2.51 d
150	**40**	13.5 c	205.9 b	106.5 c	13.9 f	2.08 c	6.94 de	2.49 d
150	**60**	14.0 b	186.8 e	82.3 d	17.0 d	1.95 d	7.27 c	2.63 c
150	**80**	14.0 b	171.0 i	71.5 g	19.6 c	2.05 cd	7.18 cd	2.67 c
200	**40**	13.0 d	197.8 d	88.6 d	16.9 d	1.83 e	7.96 b	2.79 b
200	**60**	14.3 a	182.8 f	122.7 b	17.6 d	2.45 a	8.09 b	2.86 ab
200	**80**	13.3 c	208.9 a	127.6 a	22.5 a	2.42 a	8.45 a	2.91 a
Total mean		13,6	190,1	92,9	17,4	2,1	7,42	2,63
		Bentonite						
100	**40**	13.8 a	183.7 g	96.2 e	15.1 g	1.75 e	5.22 h	2.09 h
100	**60**	13.5 abc	188.4 f	87.5 f	10.7 h	1.82 de	5.41 g	2.13 g
100	**80**	13.7 ab	177.1 h	72.9 g	10.8 h	1.90 cd	5.62 f	2.25 f
150	**40**	13.2 cde	197.8 e	96.0 e	18.8 f	2.15 b	6.03 e	2.41 e
150	**60**	13.0 de	218.0 c	76.2 g	22.1 e	2.18 b	6.26 d	2.50 d
150	**80**	13.7 ab	184.8 g	107.6 d	22.8 d	1.93 c	6.44 c	2.58 c
200	**40**	12.8 e	203.1 d	109.6 c	24.9 c	1.82 de	6.69 b	2.68 b
200	**60**	13.7 ab	219.8 b	125.1 b	25.6 b	2.12 b	6.79 b	2.72 b
200	**80**	13.3 bcd	249.1 a	164.5 a	34.5 a	2.32 a	6.94 a	2.77 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.

As the interactions between N and P fertilization under no amendment condition was concerned, obtained results (Table, 5) indicated that increasing N fertilization didn't significantly affect N content under low P fertilization levels combined with high dose of N application seemed to be significantly hazardous for N content. Opposite to that, high N fertilization level increased significantly N content only under moderate and high doses of P application. Such finding strongly revealed some sort of nutrient synergism for enough P application to allow plants get up and incorporate more N. In order words, enough P fertilization seemed to be a must for plants to incorporate more N and consequently increase N fertilization efficiency. In fact, such synergetic nature obtained for P fertilization in N incorporation by plants has been repeatedly reported by several authors **(Sumner and Farina, 1986 and Hegazy *et al.*, 1996)**.

On the other hand, increasing P fertilization level decreased significantly N incorporation by plants under low and medium N fertilization level. Under high N application level, however, increasing P fertilization enhanced significantly N incorporation by corn plants. Such findings clearly revealed that the synergetic nature of P on N incorporation requires high N fertilization to be acting. From obtained interaction between N and P on N content, it could be concluded that the nature of action dose not only depend on the level of a nutrient but also on the other one to drive the desired action.

Application of bentonite amendment proved to have some influences on the indicated interaction between N and P where increasing N fertilization increased significantly N content under low P fertilization level, but decreased it under high P fertilization level. Increasing P fertilization, however, increased and decreased significantly N content under low and high N fertilization level, respectively.

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

Treatment		**Nutrient content in the ear leaf, (%).**				
		N	**P**	**K**	**Ca**	**Mg**
kg/fed						
N	**P_2O_5**					
				Noamendment		
100	**40**	2.53 b	0.42 c	2.09 ab	0.60 e	0.41 cd
100	**60**	2.28 c	0.37 e	1.88 bcd	0.59 e	0.35 d
100	**80**	2.11 d	0.42 c	2.01 abc	0.81 b	0.62 a
150	**40**	2.49 b	0.48 a	2.12 a	0.60 e	0.40 cd
150	**60**	2.14 d	0.44 b	1.77 de	0.69 cd	0.41 cd
150	**80**	2.01 e	0.41 c	1.86 bcd	0.76 bc	0.36 d
200	**40**	2.33 c	0.34 f	1.60 e	0.89 a	0.44 c
200	**60**	2.65 a	0.35 ef	1.81 cde	0.65 de	0.54 ab
200	**80**	2.64 a	0.38 d	1.68 de	0.59 e	0.53 b
Total Mean		2,35	0,4	1,87	0,69	0,45
				Compost		
100	**40**	1.39 h	0.36 cd	2.97 bc	1.01 bc	0.56 a
100	**60**	1.81 f	0.34 d	2.62 c	0.54 f	0.41 c
100	**80**	2.03 d	0.39 bc	3.31 b	0.91 cd	0.34 d
150	**40**	1.74 g	0.51 a	3.02 bc	0.87 de	0.43 c
150	**60**	2.08 c	0.40 bc	3.25 b	0.77 e	0.50 b
150	**80**	2.14 b	0.40 bc	3.21 b	1.05 b	0.39 c
200	**40**	2.18 a	0.42 b	3.97 a	1.23 a	0.32 d
200	**60**	1.94 e	0.48 a	3.34 b	0.77 e	0.34 d
200	**80**	1.94 e	0.41 b	2.87 bc	1.14 a	0.41 c
Total Mean		1,92	0,41	3,17	0,92	0,41

				Bentonite		
100	**40**	1.68 e	0.38 e	1.78 a	0.49 e	0.44 bc
100	**60**	1.98 d	0.34 f	1.72 a	0.89 b	0.44 bc
100	**80**	2.20 c	0.39 de	1.73 a	0.72 c	0.28 e
150	**40**	2.23 c	0.40 cd	1.73 a	0.93 b	0.37 d
150	**60**	2.42 b	0.41 bc	1.78 a	0.58 d	0.47 b
150	**80**	2.01 d	0.44 a	1.76 a	0.47 e	0.43 c
200	**40**	2.62 a	0.41 b	1.78 a	0.59 d	0.38 d
200	**60**	2.27 c	0.43 a	1.76 a	0.45 e	0.44 bc
200	**80**	1.99 d	0.35 f	1.73 a	1.06 a	0.66 a
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.

Compost amendment played a role almost similar to that of bentonite with figures generally were lower than those obtained under bentonite conditions. The N content was generally higher in no amended plants than those amended ones; these results agree with those of **Kheder (1998)**. As P content in corn plants was regarded, increasing N fertilization level up to (150 kg $Nfed^{-1}$) increased incorporation under low P fertilization level (40 P_2O_5 kg fed^{-1}). High N fertilization level (200 kg N fed^{-1}) behaved an opposite trend. Under rich P fertilization (80 P_2O_5 kg fed^{-1}), increasing N fertilization level decreased significantly P content. Addition of bentonite or compost altered the indicated interaction for N on P incorporation while moderate and rich N fertilization led to great incorporation of P from all P fertilization levels.

Regarding N-P interaction on K content in corn plant, obtained results showed no clear interaction except under high N addition which decreased significantly K content may be due to dilution effect. Addition of bentonite and, to some extent, compost disappeared any interaction between N and P on K content in the cultivated plants.

Regarding the indicated N-P interaction in Ca and Mg content, it could be clearly concluded that increasing N fertilization increased and decreased Ca and Mg content under low and high P fertilization level, respectively. The opposite was true regarding P-N interaction where increasing P level increased and decreased ca and Mg content under low and high N level, respectively.

Addition of bentonite or compost amendments relatively altered the response of both Ca and Mg for N-P interaction. The response seemed to be dependent upon the handled concentration of both N and P fertilization.

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