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Effect of Farmyard Manure and Rate of Phosphatic Fertilizer on Phosphorus Availability and Yield of Corn

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Abstract

Farmyard manure (FYM) is a vital organic resource and their extensively used in soil management for sustainable agriculture. Field experiment was carried out during two successive growth seasons of 2014 and 2015 at the Experimental Farm of Department of Soils and Water, Faculty of Agricultural, AL-Azhar University, Assiut governorate to examine the effect of farmyard manure and level of applied phosphatic fertilizeron phosphorus availability and corn (*Zea mays*) yield. The experiment was designed as a randomized complete block design in split plots with four replications. Results showed that the farmyard manure treatments (0 and 30 m^3/fed.) were assigned to the main plots and levels of superphosphate (100, 200 and 300 kg /fed.) were in the sub-plots. The application of FYM to this soil increased significantly available phosphorus throughout two growth seasons. Also addition 30 m^3 FYM increased the grain yield of corn from 12.59 to 17.19 ardab/fed. in first season and from 12.22 to 19.61 ardab/fed in the second season. Application of 30 m^3 FYM combined with 200 kg/fed superphosphate resulted of increasing (GY) from 11.87 to 18.23 ardab/fed. at first season and from 11.82 to 21.43 ardab/fed. in second season.We Application of 200 kg superphosphate /fed combined with 30 m^3farmyard manure to the soil led to positive effect of this treatment on grain yield of corn.

Keywords: *Farmyard manure, phosphorus, corn, grain yield.*

Introduction

Phosphorus (P) is an essential macronutrient being required by plants in relatively large amounts. It primary role in plant is to store and transfer energy produced by photosynthesis for use in growth and reproductive processes. The availability of phosphorus in soils is affected by several factors such as soil pH, clay and sesquioxide content, and exchangeable Al^{3+} (White, 2006), content and decomposition of organic matter in the soil and activities of microorganisms (Brady and Weil, 1999), soil water conditions and soil temperature (Sanchez, 2007). The application of farmyard manure to the soils led to improving soil chemical, physical and biologic properties (Belay *et al*., 2001). Soil pH values fell by one degree as result of adding farmyard manuredue to the decomposition and mineralization of organic matter (Singh *et al*., 1980). The available P in soils is increased significantly due to application of FYM (Ayuba *et al*., 2005; Adeniyan *et al*., 2011). The addition of organic manure to the soil increased Olsen-P because of the decreased P adsorption and phosphate potential (Bahl and Toor, 2002).

Corn is an important crop worldwide for food, animal feed and bioenergy production (Bello *et al*., 2010; Randjelovic *et al*., 2011). It is an important food crop in Africa. corn crop provides over 30% of the dietary calories in East Africa (Salasya *et al*., 1998). The yield of corn was improved with FYM application (Kihanda, 1996). Moreover, Zhao *et al*. (2009) found that the additions of FYM combined with chemical fertilizer caused enhanced of corn yield. The objectives of this study to examine the effects of farmyard manure and rate of phosphatic fertilizer on phosphorous availability and yield of corn.

Materials and Methods

Field experiment

This study was carried out during two successive growth seasons of 2014 and 2015 at the agricultural Experimental Farm Department of Soils and Water, Faculty of Agricultural, AL-Azhar University, Assiut governorate to examine the effect of farmyard manure and phosphatic fertilizer on phosphorus availability and corn yield (*Zea mays*) yield. Some physical and chemical soil properties of the experimental soil and farmyard manure are given in Table (1). The experiment was designed as a randomized complete block in split plots with four replications. The farmyard manure treatments (0 and 30 m^3/fed.) were assigned to the main plots and levels of super phosphate, 15.5% P_2O_5 (100, 200 and 300 kg /fed.) were in the sub-plots. The experimental unit area was 11 m^2 (4 x 2.8 m) with three rows per plot was used. The additions of FYM and superphosphate fertilizer were done before planting. Corn grains were sown on May 5^{th} in the both growth seasons. Grains were sown in holes at space of 30 cm between each and 0.75m between rows. Nitrogen and potassium fertilizers were added according to the recommendations of the Ministry of Agriculture. The nitrogen fertilizer was added to the soil at level 120kg N /fed as Urea (46.5%) and was applied in two doses. The potassium fertilizer was applied to the soil in one dose at 50 kg K_2SO_4 (50%k_2o). Corn plants were harvested after 110 days from planting and estimated biological yield per plot (kg) as well as grain yield (kg/plot).Soil samples were taken from each plot after harvesting and prepared for analysis. Total P uptake by straw and grains was calculated using the following formulae:

$$\text{Puptake (kg/fed)} = \frac{\text{P contents (\%) in plant part (dry matter) x Yield (kg/fed)}}{100}$$

Phosphorus use efficiency (PUE) on the basis of formulae as described by Fageria *et al*., (1997).

$$\text{PUE (\%)} = \frac{\text{[Total P uptake (kg/fed) in fertilized plot]-[Total P uptake (kg/fed) in control plot]}}{\text{P dose applied (kg/fed)}}$$

Chemical analysis

Available Phosphorus in soil was extracted by 0.5 M $NaHCO_3$ at pH 8.5 according to Olsen *et al.* (1954), and then it was determined calorimetrically using the chlorostanousphosphomolybdic acid method according to Jackson (1973). Available potassium was extracted using 1 M ammonium acetate at pH 7, and determined using the flame photometry method. Total nitrogen in soil was determined by microkjeldahl method (Jackson, 1973). The particle-size distribution analysis was conducted by pipette method and Organic matter was determined using the Walkley-Black method (Jackson, 1973). Soil pH measured in soil suspension by glass electrode. Electrical conductivity (EC) was measured in the soil extract using an electrical conductivity meter (Jackson, 1973). Calcium carbonate ($CaCO_3$) was estimated using a volumetric calcium carbonate calcimeter (Nelson, 1982). Phosphorous concentration in the digests was determined colorimetrically using the chlorostanousphosphomolybdic acid method according to Jackson (1973).

Table 1. Some physical and chemical analysis of the experimental soil and farmyard manure

Property	Value	
Particle size distribution		
Sand (%)	23	
Silt (%)	34	
Clay (%)	43	
Texture grade	Clay	
Total-N (%)	0.12	
Ava-P (mg kg^{-1})	9.1	
CH_3COONH_4-K ((mg kg^{-1}))	110.51	
OM (%)	0.94	
EC (dSm^{-1}) $_{(1:2.5)}$ extract	0.951	
pH $_{(1:2.5)}$ suspension	7.75	
$CaCO_3$(%)	1.25	
Farmyard Manure		
	2014	**2015**
N (%)	0.46	0.65
P (%)	0.3	0.18
K (%)	1.1	0.95
Organic matter (%)	22.16	28.24
C/N	27.9	25.2

Statistical analyses

Data obtained in this experiment were statistically analyzed by MSTAT program. Mean values were compared for each other using least significant difference (LSD) test at $P<0.05$(MSTAT, 1987).

Results and Discussion

1. Effects of Farmyard Manure

1.1. Soil pH and Available Phosphorus

The application of FYM to this soil decreased significantly soil pH during the two growth seasons (Tables 2). At first season, FYM added to the soil under study reduced soil pH from 7.67 to 7.57, while, in the second season the decrease in soil pH from 7.68 to 7.54. Many researchers found that the addition of FYM decreased soil pH (El-Ghamry *et al.*, 2004; Shaikh and Gachande, 2013). Available phosphorus (Olsen-P) was significantlyincreased due to FYM application throughout the two growth seasons. The addition of FYM (30 m^3/fed.) enhanced Olsen-P from 9.44 to 16.3 mg/kg at first season and from 11.1 to 20.4 mg/kg.This results similarly to (Singh *et al.*,1998). FYM additions in creased the availability of phosphorus in soil because the addition of P through FYM, and retardation of soil P fixation by organic anions formed during FYM decomposition (Ali *et al.*, 2009). Increase in available phosphorus was due to the addition of phosphorus through manure fertilizer in excess of removal of crop (Muneshwar *et al.*, 2008).

1.2. Biological yield and Grain yield of corn

Results of obtained showed that, the application of FYM caused significantly increase in biologicalyield (BY) and grain yield (GY) of maize during two growth seasons (Tables 2). Application of FYM to the soil under study led to an increase of (BY) from 9.94 to 11.68 ton/fed. and

9.56 to 12.13ton/fed at first and second seasons, respectively. Moreover, FYMadded to the soil raised the GY from 12.59 to 17.19 ardab/fed. at first season as well as from 12.22 to 19.61 ardab/fed in the second season.The application of FYM to soil significantly in creased the grain yield of maize plants according was also according by (Negassa *et al*., 2005). Increasing maize yields with increasing rates of farmyard manure was also according by (Kihanda, 1996).

Table 2. Effect of farmyard manure on Olsen-P, pH, biological and grain yield of corn

FYM treatment	Season 2014				Season 2015			
	pH	Olsen-P (mg/kg)	BY (ton/fed)	GY (ardab/fed)	pH	Olsen-P (mg/kg)	BY (ton/fed)	GY (ardab/fed)
without	7.67	9.44	9.94	12.59	7.68	11.1	9.56	12.22
with 30m^3	7.57	15.62	11.68	17.19	7.54	20	12.13	19.61
Fvalue	*	*	*	**	*	*	*	**

1.3 Phosphorus concentrations in shoot and grain of corn

The results showed a significant increase in P concentration in shoot of corn plant due to addition of farmyard manure in the first and second growth seasons (Table 3). Applying 30 m^3/fed. Farmyard manure increased P concentration in shoot of corn from 808.01 to 1177.28 in the first season and from 905.3 to 1076.9 ppm in the second season. The increase P concentration in plant shoots, because of the addition of organic manure in the soil was attributed to the increased in P availability (Mohanty *et al.,* 2006). Significant increasesin P concentration (ppm) were observed in grain of corn plants duo to the additions of farmyard manure during to seasons. Adding FYM caused increase in P concentration (ppm) in grains of corn from2560.8 to 2874.8ppm and 2492.7 to 2974.8ppm in the first and second seasons, respectively.

1.4 Phosphorus Use Efficiency and Phosphorus Uptake of Corn

Phosphorus use efficiency (PUE) and P uptake by corn plants weresignificantly increased withthe application of FYM to thesoil under study (Table 3). Application of FYM raised P uptake by corn plants from 9.02 to 15.39 kg/fed.andfrom 11.95 to 19.51 kg/fed. in first and second seasons, respectively. Application of FYM improved the phosphorus use efficiency ofcorn from 22.2 to 85.3 % in first season and from 47.9 to 122.7% in the second season. Mohanty *et al*. (2006) found that the additions of FYM resulted in highest P use efficiency.

Table 3. Effect of farmyard manure on phosphorus content in shoot and grain as well as phosphorus uptake and use efficiency of corn

FYM treatment	Season 2014				Season 2015			
	P concentratin in shoot(ppm)	P concentration in grain(ppm	P uptake (Kg/fed)	PUE (%)	P concentration in shoot(ppm)	P concentration in grian(ppm)	P uptake (Kg/fed)	PUE (%)
without	808.01	2560.8	9.02	22.2	905.3	2492.7	11.95	47.9
With	1177.28	2874.8	15.35	85.3	1077	2974.8	19.51	123
F_{value}	*	*	**	**	*	*	**	**

2. Interaction between superphosphate and farmyard manure

2.1 Available phosphorus

Significant increases were observed the available phosphorus content in soil due the combined effect between superphosphate and farmyard manure applications (Table 4). The additions of superphosphate combined with farmyard manure led to enhancing the availability phosphorus from 7.68mg/kg at 100 kg superphosphate without FYM treatment to 18.6 at 200 kg superphosphate with 30 m^3 FYM treatment during first season, in the second season the available phosphorus was increased from 10.2 to 23.5mg/kg at 100 kg superphosphate without FYM and 300 kg superphosphate with 30 m^3 FYM treatments, respectively. (Tadesse *et al.*, 2013) reported that the highest concentrations of available phosphorus after harvest was observed with the combined application of 6 ton/fed FYM with 20 and 40 kg/fedP_2O_5.

Table 4. Grain yield and biological yield of corn as affected by farmyard manure and phosphatic fertilizer

FYM Levels	Superphosphate Levels (P_2O_5 kg /fed.)	Season 2014				Season 2015			
		pH	Olsen-P (Mg/kg)	BY (ton/fed)	GY (arda/fed)	pH	Olsen-P (mg/kg)	BY (ton/fed)	GY (arda/fed)
Without	100	7.7	7.68	9.084	11.9	7.69	10.2	10.2	11.8
	200	7.67	9.94	10.07	12.7	7.68	11.1	11.1	12.2
	300	7.64	10.7	10.68	13.2	7.67	12.27	12.3	12.6
With	100	7.59	13.8	11.53	15.9	7.58	16.2	17.8	19
	200	7.55	16.3	11.67	18.2	7.5	21.6	22.2	21.4
	300	7.58	18.6	11.77	17.4	7.54	23.5	20	18.5
$LSD_{0.05}$		NS	0.98	NS	NS	NS	2.09	NS	0.29

2.2. Biological yield and Grain yield of corn

Interaction between FYM and superphosphate levels is shown in Table (4). The application of FYM and phosphate fertilizer caused significant increase in BY and GY during two growth seasons. The combined application at 300kg superphosphate /fed resulted in improved of BY from 9.084 to 11.77 ton/fed at first season while, the addition of 30m^3 FYM and superphosphate at level 200 kg increase the By from 10.2 to 22.2 ton/fed . The grain yield was increased from 11.9 to 18.2ardab/fed. at the first season due the addition FYM combined 200 kg superphosphate/fedat first season. Moreover, the addition of FYM and 200 kg superphosphate cased increased GY from 11.8 to 21.4 at the second season. Zhang *et al.* (2009) reported that application of pig manure and P fertilizers significantly enhanced grain yields of corn. Many workers found that the farmyard manure combined with chemical fertilizer led to increaseof corn yield (Fan *et al.*, 2008; Zhao *et al.,* 2009).

2.3 Phosphorus concentration in shoot and grain of corn

The concentration of phosphorus in shoot and grain of cornplants were in creased significantly due the additions of FYM with super phosphate (Table 5). Throughout the first season, P concentration in shoot was increased from 718.1 to 1308 ppm at due addition 100 kg superphosphate without FYM. 300 kg superphosphate with 30 m^3 FYM increased from850 to 1195 ppm at same treatments during second season. The content of phosphorus in corn grains was significant increased with additions of FYM with superphosphate during the two growth seasons. The highest values of phosphorus concentration in grain are observed due to the addition of 200 kg super phosphate with FYM in two seasons.

2.4. Phosphorus use efficiency and phosphorus uptake of corn

The additions of FYM and superphosphate to the soil under study caused non significant increase of the total phosphorus uptake by corn. The phosphorus use efficiency (PUE) was increased significantly due to combined effect of FYM and superphosphate fertilizer in the second season, while at the first season this effect was non significant on (PUE) (Table 5). The combined application at 100kg superphosphate with 30m^3 FYM resulted in increasing PUE from 132.1 and 213.9 % at first and second season, respectively. The applications of phosphate fertilizers and farmyard manure led to improve nutrient P use efficiency (Adembaa *et al*., 2015).

Table 5. Effect of interaction between farmyard manure and superphosphate on phosphorus concentration in shoot and grain as well as P uptake and phosphorus use efficiency of corn

FYM Levels	Superphosphate Levels	Season 2014				Season 2015			
		P concentration in shoot(ppm)	P concentration in grain(ppm)	UP	PUE	P concentration in shoot(ppm)	P concentration in grain(ppm)	UP	PUE
Without	100	718.1	2600	9.22	33.6	850	2540	11.49	74
	200	820.3	2802.5	8.96	17.7	852.5	2700.7	11.91	40.2
	300	885.7	2280	8.88	15.3	1013.3	2237.3	12.46	29.6
With 3m^3	100	1409.4	2702.2	16.88	132.1	1322.5	2802	20.66	213.9
	200	813.6	3529	15.2	80.8	712.5	3629.6	18.12	89.6
	300	1308	2392.5	13.78	42.9	1195	2492.5	19.77	66.8
$LSD_{0.05}$		359.7	188.7	NS	NS	171.8	187.7	NS	23.06

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تأثير السماد البلدي ومعدلات التسميد الفوسفاتى على تيسر الفوسفور ومحصول الذرة الشامية

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الملخص

اجريت التجربة الحقلية فى مزرعة كلية الزراعة جامعة الازهر، اسيوط خلال موسمي النمو ٢٠١٤،٢٠١٥. لدراسة تأثير السماد البلدي على صلاحية الفوسفور ومحصول الذرة الشامية . صممت هذه التجربة في قطاعات كاملة العشوائية فى قطع منشقة مع وجود أربع مكررات. معاملات السماد البلدي (صفر،٣٠م^{3}/الفدان) وضعت في القطاعات الرئيسية ومستويات السوبر فوسفات (١٠٠،٢٠٠،٣٠٠كجم/فدان) وضعت في القطع الفرعية. النتائج المتحصل عليها من هذه التجربة: أدت اضافة السماد البلدي الى زيادة معنوية فعلا من الفوسفور الميسر ومحصول الحبوب خلال موسمي الزراعة. اضافة السماد الفوسفاتى فى وجود السماد البلدي أدى الى زيادة معنوية في محصول الحبوب خلال موسمي النمو. حيث ننصح بإضافة ٢٠٠ كجم سوبر فوسفات فى وجود ٣٠ م^{3} من السماد البلدي لأنها أدت الى زيادة محصول الحبوب للذرة الشامية من١١,٨ الى ١٨,٢اردب/الفدان خلال الموسم الاول ، أما فى الموسم الثانى فأدت الى زيادة المحصول من ١١,٢الى ٢١,٤أردب/الفدان.

***الكلمات الداله:** السماد البلدى، الفوسفور، الذرة الشاميه ، الحبوب.*