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Growth and Chemical Composition of Corn in Three Calcareous Sandy Soils of Iran as Affected by Applied Phosphorus and Manure

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ABSTRACT

Phosphorus (P) fertilizer recommendations for calcareous-sandy soils low in organic matter need further investigation. Therefore, the objectives of this study were to evaluate the effects of P and manure on corn (*Zea mays* L.) growth and chemical compositions and P recommendations for calcareous sandy soils with low organic matter under greenhouse conditions. Treatments consisted of a factorial arrangement of P levels (0, 25, 50, and 100 mg kg^{-1} soil as KH_2PO_4), manure rates (0, 10, 20 and 30 g dried sheep manure per kg soil) and three soils (Soil 1, sandy loam, initial P 10.8 mg kg^{-1} ; Soil 2, sandy loam, initial P 7.6 mg kg^{-1} ; and Soil 3, loamy sand, initial P 5.5 mg kg^{-1}) in a completely randomized design with four replications. Results showed that P application in Soil 1 decreased corn dry matter. However, application of 25 or 50 mg P kg $^{-1}$ soil increased corn yield significantly in Soils 2 and 3, respectively. Maximum corn yield was obtained when 30 g kg $^{-1}$ manure was added to sandy loam soils and 20 g kg^{-1} to loamy sand soil. Application of P and manure significantly increased plant P concentration and uptake in all three soils. Zinc concentration in plants treated with Phosphorus was higher than in the control in soils 1 and 2. Such a trend was not observed in soil 3, but manure application increased it. Iron concentration in plants treated with P increased in soils 1 and 2 but was decreased in soil 3; however, manure application increased it in all soils. Plant Mn concentration and uptake responses to P and manure application was not consistent. Applied P, in general, increased plant Mn Concentration in soils 1 and 2, but had no effect on plants in Soil 3. Manure effect on plant Mn concentration was not consistent. It seems that addition of manure to sandy soils can improve soil productivity and increase corn yield. Due to the low P buffering capacity of sandy soils, application of high rates of P can increase P concentration to an undesirable level in soil solution. This may depress plant growth and also availability of some micronutrients like Fe and Zn to corn plants. Therefore, P fertilizer recommendations for sandy soils should be based on the soil test P level. Manure application is recommended for sandy soils, due to its positive effects on nutrient uptake and plant growth. Prior to any phosphorus fertilizer recommendations for sandy soils the results of this experiment should be verified under field conditions and measuring P concentration in soil solution at different stages of plant growth is highly recommended.

Keywords: Calcareous, Corn, Manure, Phosphorus, Sandy.

INTRODUCTION

Nutrient availability, including phosphorus (P), in soil is essential to plant growth. Different factors including soil pH, $CaCO_3$ and organic matter content, affect P availability and uptake by corn plants in calcareous soils (Fohse *et al*., 1991; Karimian, 1995; Yrakan and Christenson, 1990). Uptake of P by plants decreased as soil pH increased (Gupta *et al*., 1985; Verma and Achroo, 1984). Another factor decreasing soil P availability in

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calcareous and sodic soils is a high level of $CaCO_3$ and Ca^{+2} activity, which forms insoluble phosphates when in reaction with P.

Addition of organic matter slowly increases soil P availability (Dhillon and Dev, 1986) due to the slow release of organic matter-associated P. However, a continuous heavy application of manure may saturate the soil's capacity to retain manure-P and result in groundwater contamination with excessive P (James *et al*., 1996). Over-application of P fertilizers may decrease micronutrients (e.g., Zn, Fe and Mn) uptake and assimilation; and therefore has an undesirable effect on plant growth (Pasicha *et al*., 1986). However, due to surface adsorption and precipitation processes, not all of the applied fertilizer is available to plants (Afif, *et al*., 1993). Neither P fertilizer rates nor critical soil-test P concentration are commonly adjusted for the $CaCO_3$ content (Westerman, 1992). Application of organic matter can improve soil physical conditions and also nutrient availability including P and micronutrients (Sharma and Saxena, 1985).

The objectives of this study were to evaluate i) the effect of P and manure applications on corn growth and composition under greenhouse conditions ii) P recommendations for calcareous-sandy soils with low organic matter content.

MATERIALS AND METHODS

Soil samples from the surface layer (0-30 cm) of three soils in eastern Iran were collected, air-dried and passed through a 2-mm sieve. Soil samples 1, 2, and 3 were taken from the Amerifariab, Saidabadfariab and Jahadabad series, respectively and all were also classified into the family of coarse loamy, calcareous, mixed, thermic, Typic Torrifluvent (Soil and Water Research Ins, 1992). Some physical and chemical properties of the soil samples were determined (Table 1). Manure was used as an organic source. Selected chemical properties of the manure were determined by the same procedures as soil samples (Table 2). The experiment was a 4×4×3 factorial in a completely randomized design with four replications.

Treatments consisted of four P rates (0, 25, 50, and 100 mg kg^{-1} as KH_2PO_4), four manure rates (0, 10, 20 and 30 g kg^{-1}) and three soil types. Based on soil tests, 180 mg N kg^{-1} as CO $(NH_2)_2$ (1/2 before planting and 1/2 at 4-6 leaf stage), 5 mg Fe kg^{-1} as Fe EDDHA 10 mg Mn kg^{-1} as $MnSO_4.4H_2O$, and 5 mg Zn kg^{-1} as Zn $SO_4.7H_2O$ were uniformly added to all pots. Each pot contained 2 kg soil. Six corn seeds (var. Single Cross 704) were planted 2.5 cm deep in each pot. Plants were thinned to 3 per pot eight days after emergence. Shoots were harvested eight weeks after planting, rinsed with distilled water and dried at 65^oC, weighed and ground.

A portion of plant material was dry-ashed at 550 ^oC and used for determination of Fe, Mn, Zn, and Cu concentrations by atomic absorption and of P by using the yellow ammonium-molybdate method (Murphy and Riley, 1962). Nutrient uptake was calculated by multiplying the nutrient concentration by the dry matter weight. Statistical analysis, including F-test and Duncan multiple range test, were used to examine the effects of treatments on plant responses.

RESULTS AND DISCUSSION

The application of P decreased corn top dry matter in Soil 1 (Table 3), probably due to its high $NaHCO_3$-extractable P (10.8 mg P kg^{-1} soil). It seems that P critical level in sandy soils is lower compared to fine-textured soils, i.e., 18 mg kg^{-1} soil, which was reported by Karimian and Ghanbari (1990). But in Soils 2 and 3 with lower available P (7.6 and 5.5 mg P kg^{-1} soil respectively), soil corn dry matter increased significantly ($p \leq 0.05$) only at 25 mg P kg^{-1}. However, higher rates of P, either did not increase or at certain P levels decreased it (Table 3). These results are in agreement with the findings of Zia *et al*. (1988), who showed that corn dry matter increased when P was applied up to 92 mg kg^{-1} but de-

Table 1. Physical and chemical properties of soils.

Soil no	Sand	Silt	Clay	Organic Matter	CCE[a]	CEC[a]	pH (water)	Olsen P	Fe[a]	Zn[a]	Texture
		g kg^{-1}				Cmol$_c$ kg^{-1}			mg kg^{-1}		
1	714	235	51	3.5	164	5.8	8.2	10.8	2.7	0.34	SL[a]
2	734	226	40	3.6	194	3.8	8.4	7.6	2.7	0.54	SL
3	774	195	31	7.1	50	4.1	8.1	5.5	1.3	0.54	LS

[a] CCE = calcium carbonate equivalent; CEC = cation-exchange capacity; Fe, Zn = DTPA-extractable Fe and Zn; SL, LS=sandy loam, loamy sand.

creased at higher rates. Farah and Soliman (1987) reported that addition of 50, 100 or 200 mg P kg^{-1} to a calcareous soil with 5.5 mg available P kg^{-1} increased corn top dry matter yield. Maximum yield was obtained by a composite application of 90, 30 and 100 kg ha^{-1} of N, P, and K, respectively.

Application of P increased corn dry matter and P uptake (Belcher and Ragland, 1972). Karimian (1995) reported that P application to a calcareous soil significantly increased corn dry matter. P applied at the 25 mg kg^{-1} rate to Soil 1 increased plant P concentration and uptake significantly (Table 3). In Soils 2 and 3 both P concentration and uptake increased significantly at higher P rates, presumably due to lower initial P of Soils 2 and 3 (Table 1). Hagin *et al*., (1972), Schiquning *et al*., (1994), Sharma and Saxena (1985) and Karimian (1995) reported that P application increased both P concentration and uptake in corn plants.

Application of manure to soil as an organic source at 30 g kg^{-1} increased corn dry matter by 149 % compared to the control in Soil 1 (Table 3). In Soil 2, manure addition at 20 g kg^{-1} soil increased it by 167 %. However, manure had no effect on dry matter in Soil 3 (Table 3). Application of 142 Mg ha^{-1} poultry house litter to a clay soil and 72 Mg ha^{-1} to a sandy loam soil increased corn dry matter in both soils (Gianello and Ernani, 1983). Corn dry matter, N, P, and K concentrations increased when farmyard manure was added to soil. Manure application increased corn yield from 1.2 to 2.72 Mg ha^{-1}.

The highest corn dry mater in Soil 1 was obtained with 30 g manure kg^{-1} with no P applied, which shows that in sandy soils, with low buffering capacity, addition of P fertilizer should be based on soil test in order to avoid increasing the P concentration in soil solution to an undesirable level which may decrease plant dry matter (Table 3). Therefore, manure application to sandy soils low in organic matter contents (3.5, 3.6, and 7.1 g kg^{-1} in Soils 1, 2 and 3, respectively) seems preferable compared to fertilizer P. However, in Soil 3 with low available P, the maximum top dry-matter yield was obtained when P fertilizer was added at 50 mg kg^{-1} soil, however, there was no significant yield difference between P application and the application of manure at 10 g kg^{-1} soil (Table 3).

Due to a low organic matter content in all soils, plant response to manure application was expected. Also, Dahiya *et al*. (1987) demonstrated that farmyard manure application increased corn dry matter and P, N, and

Table 2. Selected chemical properties of manure.

EC[a] dS m^{-1}	pH	Olsen P mg kg^{-1}	Total (mg kg^{-1}) P	Fe	Mn	Zn	Cu	N g kg^{-1}	C:N ratio
6.1	7.5	241	8300	350	226	74	22	23.1	13.7

[a] EC= electrical conductivity of 1:5 manure water extract.

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Table 3. Corn top dry matter and P concentration.

Treatment		dry matter			P concentration		
Applied P	Applied manure	Soil 1	Soil 2	Soil 3	Soil 1	Soil 2	Soil 3
mg kg^{-1}	g kg^{-1}	g pot^{-1}			μ g g^{-1}		
0	0	6.7 de [a]	5.9 d	7.1 e	0.4 g	0.3 f	0.3 g
0	10	7.4 cde	11.2 bc	14.3 abc	0.7 fg	1.2 ef	1.2 def
0	20	8.7 bcd	13.8 ab	13.2 abcd	2.4 cdef	2.0 de	2.0 bc
0	30	12.3 a	13.8 ab	12.8 bcd	2.3 cdef	2.4 cd	2.4 bc
25	0	3.3 f	6.9 d	14.6 abc	1.3 efg	0.7 f	0.3 fg
25	10	5.2 ef	12.0 c	13.2 abcd	4.4 ab	3.0 bc	1.7 cde
25	20	7.5 cdef	14.0 ab	13.8 abcd	2.9 bcde	2.9 bcd	2.3 bc
25	30	10.1 b	14.0 ab	14.1 abc	3.2 bcd	3.1 abc	2.8 b
50	0	3.1 f	4.1 d	16.0 a	1.5 defg	1.1 ef	0.9 efg
50	10	4.1 f	10.0 c	14.2 abc	3.7 abc	3.4 ab	1.9 bcd
50	20	7.6 cd	13.5 ab	15.0 ab	3.0 bc	3.6 ab	2.5 bc
50	30	9.0 bc	13.0 ab	12.0 cd	3.5 abc	2.8 bcd	2.3 bc
100	0	3.5 f	4.1 d	13.8 abcd	6.8 fg	1.2 f	1.0 efg
100	10	3.8 f	9.6 c	13.7 abcd	4.3 ab	4.0 a	3.6 a
100	20	6.6 de	14.0 ab	13.3 abcd	5.0 a	3.5 ab	2.6 bc
100	30	10.0 b	14.7 a	11.2 d	4.2 ab	3.6 ab	2.6 bc

[a] Numbers in each column, for each soil, followed by the same letter are not significantly different by Duncan Multiple Range Test ($p<0.05$).

K concentrations in corn shoots. Furthermore, Asadikangarshahi (1997) reported that manure significantly increased corn dry matter in a calcareous soil. Plant P concentration and uptake increased in all three soils due to manure application. The highest plant P concentration and uptake in Soil 1 was obtained with 20 g kg^{-1} manure plus 100 mg P kg^{-1} and in Soils 2 and 3 with either 10 or 30 g kg^{-1} manure plus 100 mg P kg^{-1}, respectively.

Based on these findings, in sandy soils with low P buffering capacity and also a low amount of soil colloidal particles, the addition of P fertilizer, particularly in soils with high soil P available, can increase P concentration in the soil solution to an undesirable level. This may decrease micronutrient availability and uptake and thus reduce corn yield significantly. Whereas, manure application to sandy soils not only can increase micronutrients availability, but also increase organic colloids which can adsorb excess P in soil solution.

Zinc concentration in plants treated with Phosphorus was higher than the control in soils 1 and 2; however, such a trend was not observed in soil 3 probably due to physical and chemical differences (Table 4). Manure application increased Zn concentration in all three soils. The antagonistic effect of excess P on plant Zn concentration has been reported by a number of researchers. Karimian (1995) demonstrated that P applied to a calcareous soil decreased the Zn concentration in corn plants. Application of P decreased corn Zn concentration due to a dilution effect resultant from higher dry matter produced (Lonergan *et al*., 1997).

Plant Fe concentration increased in Soil 1 when P was applied at 25 mg kg^{-1} soil, but it was decreased at higher rates, probably due to a high P concentration in the soil solution (Table 4). In soil 2, P applied up to 50 mg kg^{-1} increased plant Fe concentration, but it decreased at higher rates. Iron concentration was decreased in plants treated with P in soil 3. These results are in agreement with the findings of George and Louchli (1985), who stated that P application decreased corn plant Fe concentration due to high P level in soil solution which decreased Fe uptake by plants, and therefore reduced leaf Fe concentration. Also, Kashirad *et al*. (1987) demon-

Table 4. Effects of P and manure on corn top dry matter Zn, Fe and Mn concentration (μ g g^{-1}).

Treatment		Zn concentration			Fe concentration			Mn concentration		
Applied P mg kg^{-1}	Applied Manure g kg^{-1}	Soil 1	Soil 2	Soil 3	Soil 1	Soil 2	Soil 3	Soil 1	Soil 2	Soil 3
0	0	21 fg	22 f	39 bcd	103 f	88 hi	116 efg	40 ef	69 c	27 ef
0	10	36 d	37 e	39 bcd	159 cde	142 def	159 b	51 de	49 de	33 def
0	20	70 b	53 bc	47 bc	169 ab	185 bc	124 e	67 bc	59 cde	20 f
0	30	92 a	73 a	50 b	203 a	200 b	232 a	32 f	66 cd	41 bcde
25	0	38 d	35 e	43 bc	190 ab	122 efg	89 gh	94 a	97 a	30 def
25	10	54 c	46 cde	50 b	213 a	147 def	168 bc	69 bc	89 ab	46 bcd
25	20	40 d	61 b	31 def	103 f	73 I	65 hi	40 ef	32 f	34 def
25	30	65 bc	47 cde	46 bc	185 abc	184 bc	192 b	43 ef	64 cd	56 b
50	0	33 de	59 b	35 cde	157 de	160 cd	51 i	69 bc	105 a	34 def
50	10	24 ef	18 f	21 fg	205 a	102 ghi	89 fgh	71 b	61 cde	54 bc
50	20	35 de	43 cde	25 efg	92 f	92 ghi	118 ef	64 ef	70 c	40 bcde
50	30	55 c	52 bcd	71 a	185 abc	174 bcd	188 bc	44 ef	42 ef	38 de
100	0	39 d	39 e	35 cde	171 bcd	87 hi	87 gh	52 cde	73 bc	39 cde
100	10	12 g	15 f	18 g	143 e	150 de	139 de	75 b	38 f	71 a
100	20	30 def	34 e	21 fg	190 ab	233 a	162 cd	65 bcd	43 ef	31 def
100	30	30 def	40 de	50 b	155 de	117 fgh	89 fgh	43 ef	49 def	41 bcde

+ Means in each column within the same nutrient concentration, either for P or manure rates, followed by the same letter are not significantly different by Duncan Multiple Range Test ($p<0.05$).

strated that P application decreased Fe concentration in cowpea (*Vigna sinensis* L.). They concluded that this reduction was due to the high P concentration in root medium.

However, applied manure increased Fe concentration in the three soils studied (Table 4), Asadikangarshahi (1997) reported that organic matter application increased corn Fe, Zn, and Mn concentrations in a calcareous soil. Press *et al*. (1996) also demonstrated that organic by-product application increased soil Mg, Fe, Zn, and Mn availability. Manure decomposition and mineralization increases micronutrient availability due to the release of CO_2 and decreasing soil pH. The application of P in general increased corn Mn concentration but was decreased at high P rates in soils 1 and 2. Also, manure application increased Mn concentration in all soils (Table 4) although at some P rates it was decreased.

CONCLUSIONS

Application of P fertilizer to sandy soils with low P buffering capacity should be based on the soil test P level, in order to avoid causing high P concentration in soil solution which may depress plant growth and micronutrient availability. Addition of manure to sandy soils is recommended due to its positive effects on micronutrients availability and plant growth enhancement.

Prior to any phosphorus fertilizer recommendations for sandy soils the results of this experiment should be verified under field conditions and measuring P concentration in soil solution at different stages of plant growth is highly recommended.

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Table 5. The main effects of P and manure on corn top dry matter Zn, Fe and Mn uptake.

Treatment	Zn Soil 1	Zn Soil 2	Zn Soil 3	Fe Soil 1	Fe Soil 2	Fe Soil 3	Mn Soil 1	Mn Soil 2	Mn Soil 3
P rate mg kg^{-1}	μg pot^{-1}								
0	530a [a]	571a	506a	1502a	1850a	2152a	405a	668a	362b
25	290b	524a	502a	1092b	1464b	1782b	354a	675a	577a
50	309b	429b	567a	921b	1538b	1534b	331a	635a	578a
100	179c	353c	418b	1005b	1688ab	1785b	333a	430b	597a
Manure rate g kg^{-1}									
0	125c	190d	477b	622c	574c	1261c	246c	435b	424c
10	155c	320c	372c	910b	1401b	2050a	331b	518b	708a
20	362b	640b	486b	1089b	2246a	1715b	414a	687a	424c
30	665a	700a	677a	1897a	2319a	2227a	432a	767a	557b

[a] Means in each column within the same nutrient uptake, either for P or manure rates, followed by the same letter are not significantly different by Duncan multiple range test ($p<0.05$).

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REFERENCES

1. Afif, E., Matar, A., and J. Torrent. 1993. Availability of Phosphate Applied to Calcareous Soils of West Asia and North Africa. *Soil Sci. Soc. Am. J.*, **54:** 756-760
2. Asadikangarshahi, S. A. 1997. Effect of Organic Matter and Copper on the Growth and Chemical Composition of Corn and Rice. Msc. thesis. Shiraz University, Shiraz, Islamic Republic of Iran. (In Persian).
3. Belcher, C. R., and Ragland, J. L. 1972. Phosphorus Absorption by Sand-planted Corn (*Zea mays*. L.) From Surface-applied Phosphorus. *Agron. J.*, **64**: 454-456.
4. Dahiya, S. S., Antilands, R. S., and Arwasra, P. S. K. 1987. Effect of Farmyard Manure and Cadmium on Dry Matter Yield and Nutrient Uptake by Maize. *J. Indian Soc. Soil Sci.*, **32**: 275-78.
5. Dhillon, N.S., and Dev, G. 1986. Effect of Applied Farmyard Manure and Moisture Regimes on Transformations of Inorganic Phosphate. *J. Indian Soc. Soil. Sci*., **34**: 605-607.
6. Farah, M. A., and Soliman, M. F. 1987. Zinc-phosphorus Interaction in Wheat Plants. *Agrochemica*, **30**: 419-425.
7. Fohse, D., Classen, N., and Jungk, A. 1991. Phosphorus Efficiency of Plants. II. Significance of Root Radius, Root Hairs and Cation-anion Balance for Phosphorus Influx in Seven Plant Species. *Plant Soil*., **132**: 261-272.
8. Gianello, C., and Ernani, A. R. 1983. Dry Matter Yield of Maize and Change in Soil Chemistry as Influenced by Incorporation of Poultry House Ltter in Greenhouse Experiment. *Ciencia Solo*., **7**: 285-290.
9. George, C., and Louchli, A.1985. Phosphorus Efficiency and Phosphate-iron Interaction in Maize. *Agron. J.*, **77**: 399-403.
10. Gupta, A. P., Khan, S. S. and Tomar, N. K. 1985. Effect of Sodicity on the Utilization of Phosphatic Fertilizers by Wheat. *J. Indian Soc. Soil Sci*., **36:** 49-51.
11. James, D.W., Kotuby-Amacher, J., Anderson, G. L., and Huber, D. A. 1996. Phosphorus Mobility in Calcareous Soils Under Heavy Manuring. *J. Environ. Qual*., **25**: 770-775.
12. Hagin, J., Giskin, M. and Kafkafi, P.1972. Crop Response to Phosphate Fertilization and to Residual Phosphate Levels. III. Greenhouse Experiment. *Agron. J*., **64**: 593-597.
13. Kashirad, A., Bassiri, A., and Kheradmand, M. 1987. Response of Cowpeas to Applica-

tion of P and Fe in Calcareous Soils. *Agron. J*., **70**: 67-70.

14. Karimian, N. 1995. Effect of Nitrogen and Phosphorous on Zinc Nutrition of Corn in Calcareous Soil. *J. Plant Nutr*., **18**: 2261-2271.
15. Karimian, N., and Ghanbari, A. 1990. Evaluation of Different Extractants for Prediction of Plant Responses to Applied P Fertilizers in Highly Calcareous Soils. *Abst. 10th World Fert. Congr*. CIEC. p. 25.
16. Lonergan, J. F., Grove, T. S., Robson, A. D., and Snowball, K.1997. Phosphorus Toxicity as a Factor in Zinc-phosphorus Interaction in Plant. *Soil Sci. Soc. Am. J.*, **43**: 966-972.
17. Murphy, J., and Riley, J. P. 1962. A Modified Single Solution Method for the Determination of Phosphate in Natural Waters. *Anal. Chem. Acta*., **27**: 31-36.
18. Pasicha, V. S., Baddesha, H. S., and Aulakh, M. S. 1986. Rates of Growth of Corn in Four Different Soils as Influenced by Phosphorus. *Soil Sci*., 143-144.
19. Press, C. M., Mahaffee, W. F., Edwards, J. H. and Klocepper, J. W. 1996. Organic By-product Effect on Soils Chemical Properties and Microbial Communities. *Compost Sci. Utilization.*, **4**: 70-80.
20. Schiquning, P., Christensen, B. T. and Castensen, B. 1994. Physical and Chemical Properties of a Sandy Loam Receiving Animal Manure, Mineral Fertilizer or no Fertilizer for 90 Years. *Eur. J. Soil Sci*., **45**: 257-268.
21. Sharma, J. P., and Saxena, S. N. 1985. Utilization of Phosphorus by Maize as Influenced by Various Sources of Organic Matter and Applied Phosphorus. *J. Indian Soc. Soil Sci*., **33**: 561-567.
22. Soil and Water Research Institute. 1992. Land Evaluation and Suitability of the Jiroft Region (Kerman province). Agricultural and Natural Resources Research Organization.*Tech. Bul*. no.**857**.
23. Verma, K. S., and Achroo, A. K. 1984. Effect of Added Phosphate and Zinc on Their Availability, Uptake and Yield of Pearl Millet in the Presence of Calcium Carbonate and Farmyard Manure. *J. Indian Soc. Soil Sci*., **32**: 684-689.
24. Westermann, D. T. 1992. Lime Effects on Phosphorus Availability in a Calcareous Soil. *Soil Sci. Soc. Am. J*., **56**: 489-494.
25. Yrakan, O. A., and Christenson, D. R. 1990. Relating High Soil Test Phosphorus Concentration to Plant Uptake. *Soil Sci. Soc. Am. J*., **54**: 796-799.
26. Zia, M. S., Amin, R., Qayum, F. E. and Aslam, M. 1988. Plant Tissue Concentration and Uptake of Phosphorus by Maize as Affected by Level of P Fertilizer. *Pakistan J. Agric. Res.*, **9**: 335-338.

تاثیر فسفر و کود حیوانی بر رشد و ترکیب شیمیایی ذرت در سه خاک آهکی- شنی ایران

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چکیده

توصیه کود شیمیایی فسفری برای خاک های شنی آهکی با میزان ماده آلی کم به تحقیقات بیشتری نیاز دارد. بنابراین، هدف‌های این مطالعه ارزیابی تاثیر فسفر و کود حیوانی بر رشد و ترکیب شیمیایی ذرت (*Zea mays* L.) و توصیه کود فسفری برای خاک های شنی آهکی با میزان ماده آلی کم در شرایط گلخانه بود. تیمارها شامل چهار سطح فسفر(۰، ۲۵، ۵۰ و ۱۰۰ میلی گرم فسفر در کیلوگرم خاک بصورت

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KH_2PO_4)، چهار سطح کود حیوانی (۰، ۱۰، ۲۰ و ۳۰ گرم کود خشک گوسفندی در کیلوگرم خاک) و سه خاک (خاک ۱، لوم شنی با ۱۰/۸ میلی گرم فسفر اولیه در کیلوگرم؛ خاک ۲، لوم شنی، با ۷/٦ میلی‌گرم فسفر اولیه در کیلوگرم و خاک ۳، با ۵/۵ میلی‌گرم فسفر اولیه در کیلوگرم) بصورت فاکتوریل در قالب طرح کاملاً تصادفی با چهار تکرار بود. نتایج نشان داد که افزودن فسفر در خاک ۱ وزن ماده خشک ذرت را کاهش داد. هر چند که کاربرد ۲۵ یا ۵۰ میلی‌گرم فسفر در کیلوگرم به ترتیب در خاک‌های ۲ و ۳ وزن خشک ذرت را بصورت معنی داری افزایش داد. حداکثر وزن ماده خشک با اضافه نمودن ۳۰ گرم کود حیوانی در کیلوگرم خاک های لوم شنی یا ۲۰ گرم در کیلو گرم خاک شنی لوم به دست آمد. مصرف فسفر و ماده آلی غلظت و جذب کل فسفر گیاه را بطور معنی داری در سه خاک مورد مطالعه افزایش داد. غلظت روی در گیاهانی که با فسفر تیمار شده بودند در خاک‌های ۱ و ۲ نسبت به شاهد بیشتر بود گرچه چنین روندی در خاک ۳ مشاهده نگردید اما افزودن کود حیوانی آن را در هر سه خاک افزایش داد. غلظت آهن در گیاهان تیمار شده با فسفر در خاک‌های ۱ و ۲ افزایش اما در خاک ۳ کاهش یافت گرچه افزودن کود حیوانی آن را در تمام خاک‌ها افزایش داد. پاسخ غلظت و جذب کل منگنز با مصرف فسفر و کود حیوانی روند مشخصی را نشان نداد. بطور کلی، مصرف فسفر غلظت منگنز را در گیاه در خاک های ۱ و ۲ افزایش داد اما بر گیاهان در خاک ۳ تاثیری نداشت. . تأثیر کود حیوانی بر غلظت منگنز گیاه روند مشخصی را نشان نداد. بنظر می رسد که اضافه نمودن کود حیوانی به خاک‌های شنی می‌تواند سبب افزایش عملکرد ذرت و بارآوری خاک شود. به دلیل کمی ظرفیت بافری فسفر در خاک های شنی، کاربرد سطوح بالای فسفر می‌تواند غلظت فسفر را در محلول خاک تا سطح نامطلوبی افزایش دهد. امکان دارد این افزایش سبب کاهش رشد گیاه و قابل دسترس بودن برخی عناصر کم مصرف نظیر آهن و روی برای گیاه ذرت شود. بنابراین توصیه کودهای فسفری برای خاک‌های شنی بایستی بر اساس نتایج آزمون خاک باشد. کاربرد کود حیوانی در خاک‌های شنی به دلیل تاثیر مثبت آن بر جذب عناصر غذایی و رشد گیاه توصیه می شود. قبل از هر گونه توصیه کود فسفری برای خاک‌های شنی نتایج این آزمایش باید در شرایط مزرعه تأیید گردد. علاوه بر آن اندازه‌گیری فسفر موجود در محلول خاک در مراحل مختلف رشد گیاه نیز قویاً توصیه می‌شود.

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