Effect of Manure and Soil-Carbonates on the Availability and Uptake of Superphosphate-Phosphorus by Wheat Plants Under Greenhouse Conditions

ABDULLAH S. GIBALI AND RAHMATULLAH[1]

ABSTRACT

A greenhouse experiment was conducted on medium textured, calcareous surface soil (Typic calciorthids) collected from the Agricultural Farms of the Al-Fateh University, Tripoli. The study consisted of two parts.

In one experiment 2 mm sieved and unsieved soil samples were treated with 100 ppm P as superphosphate and manure separately and in combination. The amount of manure applied was double that the amount of superphosphate fertilizer needed for 100 ppm P. In the second experiment the same levels of P and manure were applied separately and in combination to the sieved soil treated with 5% of $\ll 1$ mm and $\leq 6 \geq 1$ mm size fractions of soil-carbonates collected by soil sieving. Sidi Misri variety of wheat (*Triticum aestivum* L.) was grown to study the effect of treatments on plant uptake of P. Soil samples from all treated pots were analysed for $NaHCO_3$ extractable P to observe the effect on P availability.

Results indicated a strong effect of soil sieving on $NaHCO_3$-P in soil and uptake of P by plants in all treatments. The use of 5 mm sieved soils for greenhouse experiments is suggested for studies where results are to be extrapolated for immediate field applications, especially when interactions of a soil-added chemical element/compound with soil components are vital in controlling its availability for plant uptake. Addition of manure with P increased its availability and uptake by plants. Availability and uptake of applied P was inversely related to soil-carbonate particle size which could be enhanced by adding manure.

INTRODUCTION

Most of the soluble phosphorus added to soils as a fertilizer is generally rendered unavailable for plant uptake resulting in low recovery values. The capacity of soil to fix P depends upon various physico-chemical properties of the soil. Most of the Libyan soils are light to medium textured having less than one percent of organic matter. They contain high amounts of amorphous materials/sesquioxides. A great majority of them

[1] *Department of Soil and Water Sciences, Faculty of Agriculture University of Al-Fateh, Tripoli, (S.P.L.A.J).*

are alkaline calcareous containing as high as 60% of free $CaCO_3$. High free lime generally exists in these soils in the form of lime concretions of different sizes ranging from submicroscopic to as big as a few centimeters in diameter. Lime contents and specific surface area of calcium carbonates strongly influence P fixation in soils (1). The effect of different size fractions of soil-carbonates on plant uptake of P has rarely been reported. Other than the effects of pH of P solubility, most of the aforementioned soil properties are quite favorable for P fixation. However, the addition of organic matter to mineral soils, other than its favorable effects on soil physical and chemical properties, has also been observed to suppress the fixation of P both under acidic and alkaline soil conditions (2, 4, 9, 14, 15). Most of these investigators have used decomposed farmyard manure, while no standard practice exists in the Jamahiriya for composting farm wastes. The present investigation therefore, involving undecomposed dairy manure was initiated to study its effect on the availability and uptake of native and applied superphosphate-phosphorus to sieved and unsieved soils, and to sieved soil treated with different size-fractions of soil-carbonates.

MATERIALS AND METHODS

A bulk surface sample of a medium textured alkaline calcareous soil (Typic calciorthids) used in this study was collected from the Agricultural Experiment Stations of the Al-Fateh University, Tripoli, Libya. The soil was air dried, ground and passed through a 2 mm sieve. Various physico-chemical properties of the soil used are reported in Table 1. They were estimated according to the standard procedures described in USDA Handbook 60 (7).

The following two separate sets of treatments were imposed in triplicate to 3 kg soil placed in polyethlene lined earthen pots according to randomized complete block design (10).

Set A: This part of the experiment was designed to study the effect of manure on the availability and uptake of native and applied P (as ordinary superphosphate) by wheat plants grown in sieved and unsieved soil. Both sieved and unsieved potted soil samples received 100 ppm P as ordinary superphosphate and undecomposed dairy manure (0.26% P) at a rate so as to give 1:2 superphosphate: manure ratio. They were applied either separately or in combination. Dairy manure was either mixed with superphosphate 24 hours before application or applied to soil unmixed with superphosphate. Undecomposed dairy manure used in this investigation was also dried under the sun and sieved for uniformity.

Set B: This part of the experiment was aimed to study the effect of manure on the availability and uptake of native and applied P as ordinary superphosphate to a sieved soil receiving 5% of soil carbonates fractioned into two different particle sizes. Soil carbonate concretions were collected from the soil used in this study. They were washed with tap water, air dried, and fractioned to two sizes, i.e., $S_1 \leq 1$ mm and $S_2 \leq 6 \geq 1$ mm. The 12 treatments were control, S_1, S_2, manure, P, $P+S_1$, $P+S_2$, manure $+S_1$, manure $+S_2$, P + manure, $P+S_1$ + manure and $P+S_2$ + manure. A basal dose of 200 ppm N was applied as urea to all pots. Pots were wetted and dried several times during three weeks of equilibration period before seeding. Before sowing, soil in each pot was again mixed thoroughly and a 100 g soil sample was taken from all pots for analysis of $NaNCO_3$-P (6, 13). Six seeds of Sidi Misri variety of wheat (*Triticum aestivum* L.) were planted, thinned to three plants per pot one month after sowing. The

Table 1. Some properties of the soil used in this study.

pH	E.C. (millimohs/cm)	Total N (%)	$NaHCO_3$-P (ppm)	Free lime (%)	DTPA extractable Fe	Mn	Cu	Zn
						ppm		
7.90	0.13	0.007	22.33	11.10	2.20	6.28	0.63	5.43

pots were maintained at a uniform moisture level (65% of the saturation percentage) throughout the experiment by using distilled water. The plants were harvested after two months. Plant samples were washed with distilled water, dried in an oven at 70° C to a constant weight. They were ashed by dry ashing procedure and P was determined by yellow Vandomolybdate colour method.

RESULTS AND DISCUSSION

The effect of applications of P and manure separately or in combination on $NaHCO_3$-P (available P) in soils, and P concentrations in wheat plants grown in sieved and unsieved soils are reported in Table 2. There were premixed and unmixed treatments of P and manure applications to the soil. But no difference among the two ways of applying P and manure was observed which agrees with Dalton *et al.* (2) and disagrees with other investigators (4, 9). Therefore, average values over these two treatments are reported.

The effect of various treatments on plant uptake of P was inconsistant in sieved and unsieved soils. Addition of manure alone resulted in lower concentrations of P in plants than control. Nevertheless, the addition of P alone or in combination with manure resulted in higher concentrations of P in plants compared to control or separate applications of manure. This inconsistant trend of P concentrations in plants could be attributed to undecomposed dairy manure used in this experiment.

Addition of P and manure separately and in combination, always increased $NaHCO_3$–P over control irrespective of the unsieved or sieved soil (4, 8, 9, 14, 15). The magnitude of effect of various treatments on $NaHCO_3$–P was greater in sieved soil where all those treatments gave appreciably higher amounts of available P than unsieved soil. The effect of soil sieving on P availability was more pronounced for treatments where P was applied alone and in combination with manure. Fixation of

Table 2. Effect of various treatments on soil and plant P in sieved and unsieved soils.

Treatment	Sieved soil		Unsieved soil	
	$NaHCO_3$-P (ppm)	Plant-P (%)	$NaHCO_3$-P (ppm)	Plant-P (%)
Check	22.33	0.32	20.40	0.36
Manure	31.27	0.27	25.93	0.34
P	96.90	0.50	50.40	0.56
Manure + P	97.53	0.61	66.47	0.44
Significance	**	**	**	**
L.S.D. 0.01	11.30	0.09	8.63	0.10
L.S.D. 0.05	7.46	0.06	5.70	0.07

applied P, as revealed by less $NaHCO_3$-P status for parallel treatments, was more in unsieved soil. The combined applications of P and manure, therefore, resulted in more relative increase in $NaHCO_3$-P in unsieved soil than sieved soil. Adding P and manure together resulted in 0.7% and 31.88% higher $NaHCO_3$-P in sieved and unsieved soils, respectively, as compared to separate application of P alone. This dominating role of soil sieving in nullifying the effect of manure in supressing fixation of applied P could be explained by the 333.95% and 147.06% increase in $NaHCO_3$-P in sieved and unsieved soil, respectively, for P application treatment compared to the control. Applications of manure therefore, increased the availability of native and applied P (2, 4, 9, 14) but it was obscured by soil sieving. This type of observation at least warrants a great caution in extrapolating greenhouse experimental results for immediate field applications.

Effect of various size-fractions of soil-carbonates and applications of manure separately or in combination with P on the availability and uptake of native and applied P is reported in Table 3. Addition of ≤ 1 mm and $\leq 6 \geq 1$ mm size fractions of soil-carbonate slightly decreased and increased $NaHCO_3$ extractable P in soil, respectively but did not effect plant P concentrations. Separate applications of manure and P decreased and increased plant P concentrations but both of them have an enhancing effect on $NaHCO_3$ extractable P in soil. Adding the two size-fractions of soil-carbonates in combination with manure did not change the trend of $NaHCO_3$ extractable P (high fixation) in soil receiving 100 ppm P and 5% of ≤ 1 mm size-fraction of soil-carbonate unlike that of $\leq 6 \geq 1$ mm size-fraction treatment. This effect was also shown by plant uptake of P. These results support earlier observations of Abdel-Salam *et al.* (1) who have shown an inverse relation between P fixation and particle size of soil-carbonates. Nevertheless, when manure was applied with super-

Table 3. Effect of particle sizes of soil-carbonates and undecomposed dairy manure on the availability and uptake of native and applied superphosphate-phosphorus by plants.

Treatment	$NaHCO_3$-P (ppm)	Plant-P (%)
Check	22.33	0.32
S_1	21.60	0.33
S_2	25.67	0.33
Manure	31.27	0.27
P	96.90	0.50
S_1 + Manure	30.13	0.25
S_2 + Manure	34.67	0.31
S_1 + P	25.17	0.45
S_2 + P	99.80	0.62
P + Manure	97.53	0.61
S_1 + P + Manure	96.00	0.56
S_2 + P + Manure	86.73	0.53
Significance	**	**
L.S.D. 0.01	8.06	0.12
P = Ordinary superphosphate		
L.S.D. 0.05	5.75	0.08

$S_1 = \leq 1$ mm size fraction of soil-carbonates
$S_2 = \leq 6 \geq 1$ mm size fraction of soil-carbonates

phosphate to a soil receiving 5% of ≤ 1 mm size-fraction of soil-carbonates, $NaHCO_3$-P in soil was the same as when superphosphate was applied alone to a sieved soil not-receiving soil-carbonates. The effect of ≤ 6 ≥ 1 mm size-fraction was not clear. But the effect of manure in suppressing fixation of applied P was evident from P uptake by plants.

There were premixed and unmixed methods of manure application with superphosphate. However, no difference was observed between the two methods which agrees with Dalton *et al.* (2) and disagrees with other investigators (4, 8, 9). It may be due to the undecomposed dairy manure used in this experiment unlike to other investigations involving decomposed farmyard manure (2, 4, 8, 9, 15). The data presented in Tables 2 and 3 for P+manure treatment is, therefore, average over premixed and unmixed methods of manure applications with P supports the hypotheses of inactivating the soil fixating agents (8, 11), solubilizing effect of natural organic chelates (12), and microbial effects (5), rather than coating superphosphate particles as postulated by Sharif *et al.* (9).

This study suggests that a 5 mm sieved soil should be used in greenhouse experiments. It is important when interactions of an applied chemical with soil is vital in controlling its availability for plant uptake.

Additions of manure with P increase its avaialbility and uptake by plants. Availability and uptake of applied P is inversely related to soil-carbonate particle size which of course, could be enhanced by adding manure.

LITERATURE CITED

1. Abdel-Salam, M. A., S. A. Sabet and S. Hashish. 1964. Patterns of fixation of P^{32}-labelled phosphate by some soil minerals. Pl. and Soil. 20:241–250.
2. Dalton, J. D., G. C. Russel and D. H. Sieling. 1952. Effect of organic matter on phosphate availability. Soil Sci. 73:173–182.
3. El-Baruni, B. S. 1978. Phosphate status in some calcareous soils. Ph.D. Thesis in Agronomy, Colorado State University, Fort Collins, Colorado, U.S.A.
4. El-Baruni, B. and S. R. Olsen. 1979. Effect of manure on solubility of phosphorus in calcareous soils. Soil Sci. 128:219–225.
5. Gerretsen, F. C. 1948. Influence of microorganisms on the phosphate intake by the plant. P. and soil. 1:51–81.
6. Olsen, S. R., C. V. Cole, F. S. Watanabe and L. A. Dean. 1954. Estimation of available phosphorus in Soils by extraction with sodium bicarbonate. USDA Circular 939:1–19.
7. Richards, A. L. 1954. Diagnosis and improvement of saline and alkali soils. USDA Handbook No.60.
8. Sharif, M., F. M. Chaudhry and G. A. Lakho. 1974. Suppression of superphosphate-phosphorus fixation by farmyard manure: 2. Some studies on the mechanisms. Soil Sci. Pl. Nutr. 20:395–401.
9. Sharif, M., F. M. Chaudhry and A. Latif. 1974. Suppression of superphosphate-phosphorus fixation by farmyard manure. 1: Higher phosphorus uptake from superphosphate. Soil Sci. Pl. Nutr. 20:387–393.
10. Steel, R. G. D. and J. H. Torrie. 1960. Principles and Procedures of Statistics. McGraw-Hill, Inc., New York.

11. Struthers, P. H. and D. H. Sieling. 1950. Effect of organic anions on phosphate precipitation by iron and aluminium as influenced by pH. Soil Sci. 69:205–213.
12. Waksman, S. A. and H. W. Reuszer. 1932. Origin of the uronic acids in humus of soil, peat and composts. Soil Sci. 33:135–151.
13. Watanabe, F. S. and S. R. Olsen. 1965. Test of an ascorbic acid method for determining phosphorus in water and $NaHCO_3$ extracts from the soil. Soil Sci. Soc. Am. Proc. 29:677–678.
14. Widdowson, F. V. and A. Penny. 1968. Results of an experiment at Rothamsted testing FYM and N, P and K fertilizers on five arable crops and permanent grass. J. Agric. Sci. 70:53–58.
15. Williams, R. J. B., G. W. Cooke and F. V. Widdowson. 1963. Results of an experiment at Rothamsted testing FYM and N, P and K fertilizers on five arable crops. J. Agric. Sci. 60:353–357.

أثر كربونات الكالسيوم والأسمدة العضوية على تيسر الفوسفور وإمتصاصة بواسطة نبات القمح

د . عبد الله ساسي الجبالي ورحمة الله

المستخلـص

في هذه الدراسة إستخدمت الطبقة السطحية الجيرية ذات القوام المتوسط والمأخوذة من محطة التجارب بكلية الزراعة ، جامعة الفاتح وقد شملت الدراسة جزئين .

الجزء الأول إستخدمت عنيات تربة منخولة بمنخل ٢ مم واخرى غير منخولة وقد أضيف اليهم ١٠٠ جزء في المليون فوسفور في صورة سوبر فوسفات ومادة عضوية في معاملات منفصلة وأخرى متحدة ، وكانت كمية السماد العضوى ضعف كمية سماد السوبرفوسفات المطلوبة لإضافة ١٠٠ جزء في المليون فوسفور .

اما الجزء الثاني فقد شمل نفس المستويات للفوسفور والسماد العضوي في معاملات منفصلة وأخرى متحدة وذلك للتربة المنخولة والتي عوملت بـ ٥٪ من كربونات الكالسيوم ذات الحجوم $\geq$ ١ مم $\geq$ ٦ $\geq$ ١ مم وقد تم الحصول على هذه الأحجام بنخل التربة بمناخل مناسبة . هذا وقد استخدم القمح صنف سيدي المصري لدراسة تأثير المعاملات السابقة على إمتصاصة للفوسفور ، وجمعت عينات تربة من كل أصيص وأستخلص الفوسفور بواسطة بيكربونات الصوديوم وذلك لدراسة مدى تأثير المعاملات السابقة على تيسر الفوسفور للتربة .

وقد أشارت النتائج إلى وجود تأثير واضح للتربة المنخولة على تيسر الفوسفور وإمتصاصة بواسطة القمح وذلك لجميع المعاملات ، وأقترح إستخدام التربة المنخولة بواسطة منخل ٥ مم في تجارب الصوبات والتي تجعلها إلى ظروف التجارب الحقلية . ولقد كان لإضافة الأسمدة العضوية مع الفوسفور زيادة واضحة على تيسر وامتصاص الفوسفور بواسطة القمح . كما كان تيسر وامتصاص الفوسفور المضاف ذات علاقة عكسية مع حجوم حبيبات كربونات الكالسيوم والذي يمكن زيادته بإضافة سماد عضوي للتربة .