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EFFECT OF NITROGEN CARRIERS ON SOIL pH AND THE AVAILABILITY OF NATIVE SOIL PHOSPHORUS

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In a laboratory study, in order to assess the effect on soil pH and available P; 50, 100, 200 and 400 ppm of N each as calcium ammonium nitrate, urea and ammonium sulphate were applied to texturally 3 different soils. The soils were incubated for 2 months after bringing the moisture content to 2/3rd of the field capacity. The data revealed that all the 3 fertilizers and their increasing levels caused a significant decrease in soil pH and a significant increase in available P. The magnitude of decrease in pH and of increase in available P by the fertilizers in the case of 3 soils was of the order: ammonium sulphate > urea > calcium ammonium nitrate.

It appears from the data that the N fertilizers tested are chemically well suited for application to alkaline calcareous soils of Pakistan and they promote favourable soil environment for plant growth.

INTRODUCTION

The amount of available soil phosphorus is controlled by the simultaneous effect of various factors including the nature and amount of clay colloids present, soil reaction and concentration of calcium and other insolubilizing ions. Plant availability of phosphorus in alkaline calcareous soil is directly proportional to hydrogen ion concentration. The addition of nitrogen fertilizers causes changes in soil reaction and leaves residues which consequently affect the availability of phosphorus.

Acid forming nitrogen fertilizers are reported to decrease soil pH (Robinson, 1956; Seeliger and French, 1971). Robertson *et al.* (1954), Ricly and Barber (1971) concluded that ammonium containing and/or ammonium releasing fertilizers increased available soil phosphorus attributable to the generation of H^+ ions during nitrification of the ammonium radical.

Urea, ammonium sulphate and calcium ammonium nitrate are the commonly used nitrogen fertilizers on alkaline calcareous soils of Pakistan and

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the present paper reports the effect of these fertilizers on pH and phosphorus availability of three soils varying in texture.

MATERIALS AND METHODS

It was a laboratory study in which 1 kg of each of the three texturally different soils (Table 1) was treated with 50, 100, 200 and 400 ppm of N as urea, ammonium sulphate and calcium ammonium nitrate. In all there were 13 fertilizer treatments including control applied to each of the three soils with three repeats. System of layout was completely randomized design. After treatment of soils with requisite amount of fertilizers, they were transferred to wide mouth plastic bottles and the moisture level in the bottles was brought to 2/3rd of the field capacity by the addition of distilled water. The bottles were plugged with cotton wool that permitted aeration of the soils without rapid drying. Samples were allowed to incubate for 60 days at a temperature of 25 ± 7°C. After the reaction period, the soils were taken out and analysed for pH and available phosphorus, respectively by Beckman pH meter using 1:2.5 soil:

Table 1. *Physico-chemical characteristics of the soils used.*

Soil characteristics	Soil 1	Soil 2	Soil 3
Sand %	90.96	68.96	57.96
Silt %	8.00	18.00	21.64
Clay %	1.04	13.04	20.40
Textural Class	Loamy sand	Sandy loam	Sandy clay loam
Saturation Percentage	20.00	30.00	35.00
$EC_e \times 10^3$	0.79	6.20	1.88
Soil pH	8.90	8.10	8.35
Organic Matter %	0.07	0.13	0.20
Available P (ppm)	6.00	10.00	13.00
Cation Exchange Capacity (me/100 g)	1.55	6.12	8.88
Exchangeable Cations (me/100 g)			
Na^+	0.23	3.12	1.00
K^+	0.18	0.36	0.96
$Ca^{2+} + Mg^{2+}$	1.13	2.64	6.91

water ratio (Jackson, 1960) and the method as described by Olson *et al.* (1954). The physico-chemical characteristics of the soils used (Table 1) were determined by methods as described in U.S.D.A. Handbook No. 60 (United States Salinity Laboratory Staff, 1954) except particle size distribution and organic matter which were determined by hydrometer and Walkley and Black's method, respectively as described by Moodie *et al.* (1959) and exchangeable Ca+Mg by the method outlined by Kelley (1951).

RESULTS AND DISCUSSION

Nitrogen Carriers and Soil pH

Fertilizer applications had a reducing effect on the pH of loamy sand, sandy loam and sandy clay loam soils (Table 2). The pH decreased progressively

Table 2. *Effect of nitrogen sources on the pH of 3 soils.*

Fertilizer source	*N level (ppm)*				Fertilizer Means
	50	100	200	400	
Loamy Sand					
Calcium ammonium nitrate	8.83	8.63	8.48	8.42	8.59 a
Urea	8.67	8.60	8.42	8.39	8.52 b
Ammonium sulphate	8.60	8.42	8.32	8.25	8.39 c
Level means	8.70 a	8.55 b	8.41 c	8.35 d	Control 8.80
Sandy Loam					
Calcium ammonium nitrate	8.39	8.28	8.22	8.19	8.27 a
Urea	8.29	8.25	8.20	8.10	8.21 b
Ammonium sulphate	8.21	8.20	8.09	8.90	8.10 c
Level means	8.29 a	8.24 b	8.17 c	8.06 d	Control 8.41
Sandy Clay Loam					
Calcium ammonium nitrate	8.31	8.20	8.14	8.10	8.18 a
Urea	8.20	8.00	7.90	7.80	7.97 a
Ammonium sulphate	8.10	7.82	7.50	7.10	7.63 b
Level means	8.20 a	8.00 ab	7.84 bc	7.67 c	Control 8.30

Values for N application rates in horizontal rows and for fertilizer means in vertical columns followed by the same letter (s) are nonsignificant at the 5% probability level.

and significantly with a corresponding increase in N application levels in the case of loamy sand and sandy loam soils, whereas, in the case of sandy clay loam soil the levels of calcium ammonium nitrate and urea had nonsignificant effect on soil pH. The 50 and 100 ppm N from ammonium sulphate caused similar reduction in pH while 400 ppm N followed by 200 ppm N application rate gave the lowest pH values. The less pronounced effect of calcium ammonium nitrate and urea in lowering the pH of sandy clay loam soil may be explained due to high buffering capacity associated with high clay content of this soil.

With regard to the overall effect of fertilizers, it can be seen that ammonium sulphate had significantly the greatest retarding effect on the pH of the 3 soils studied. Urea in this respect had intermediate effect, whereas, calcium ammonium nitrate caused the minimum production of acidity. The decrease in pH by the application of ammonium containing and/or ammonium releasing fertilizers is reported by Dunton *et al.* (1954) and Pervez (1972). This decrease in pH is explained by the generation of H^+ ions via nitrification of NH_4^+ radical as under:

$$2NH_4^+ + 3O_2 \longrightarrow 2H_2O + 2NO_2^- + 4H^+$$

$$2NO_2^- + O_2 \longrightarrow 2NO_3^-$$

In the case of ammonium sulphate, the accompanying release of SO_4^{2-} ions causes production of H_2SO_4 to which is attributed greater decrease in pH.

Nitrogen Carriers and the Availability of Soil Phosphorus

A significant increase in the available P of loamy sand, sandy loam and sandy clay loam soil was recorded by the application of N increments of various nitrogen fertilizers (Table 3). The percent increase in available P over control by the application of calcium ammonium nitrate, urea and ammonium sulphate was 57.50, 72.16 and 78.83, respectively in the case of loamy sand; 27.0, 59.7 and 86.7 in the case of sandy loam and 14.84, 62.53 and 90.46 in the case of sandy clay loam soil revealing effectiveness of N carriers in the order of ammonium sulphate>urea>calcium ammonium nitrate for increasing P availability of the soils. General increase in P availability by the NH_4 containing or NH_4 releasing N fertilizers may be attributed to acidity produced by the nitrification of NH_4^+ ions. Other researchers have also reported similar results (Robertson *et al.*, 1954; Riely and Barber, 1971).

The lower availability of P by calcium ammonium nitrate may be explained due to part of its N being present in NO_3^- form and also to the P insolubilizing effect of Ca^{2+} which it contains, whereas, greater degree of P availability by the application of ammonium sulphate might be attributed partly to inactivation of soil calcium by the SO_4^{2-} ions and partly to greater acidity which it produces through nitrification (Table 2). It is evident from the data (Tables 2 and 3) that increase in acidity and available P by the application of fertilizers proceed side by side and appear to be positively correlated.

Table 3. *Effect of nitrogen sources on the availability of native soil phosphorus (ppm of P) in 3 soils.*

Fertilizer source	*N levels (ppm)*				Fertilizer means
	50	100	200	400	
	Loamy Sand				
Calcium ammonium nitrate	8.00	9.00	10.20	10.60	9.45c
Urea	9.00	10.33	10.67	11.33	10.33b
Ammonium sulphate	9.73	10.60	11.00	11.60	10.73a
Level means	8.91d	9.98c	10.62b	11.17a	
				Control	6.00
	Sandy Loam				
Calcium ammonium nitrate	11.13	12.00	13.67	14.00	12.70c
Urea	13.33	14.67	16.67	19.20	15.97b
Ammonium sulphate	15.00	16.00	19.67	14.00	18.67a
Level means	13.15d	14.22c	16.67b	19.07a	
				Control	10.00
	Sandy Clay Loam				
Calcium ammonium nitrate	13.56	14.67	15.40	16.13	14.93c
Urea	15.80	19.93	23.80	25.00	21.13b
Ammonium sulphate	19.93	23.93	25.40	29.80	24.76a
Level means	16.43d	19.51c	21.53b	23.64a	
				Control	13.00

Values for N application rates in horizontal rows and for fertilizer means in vertical columns followed by the same letter(s) are nonsignificant at the 5% probability level.

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