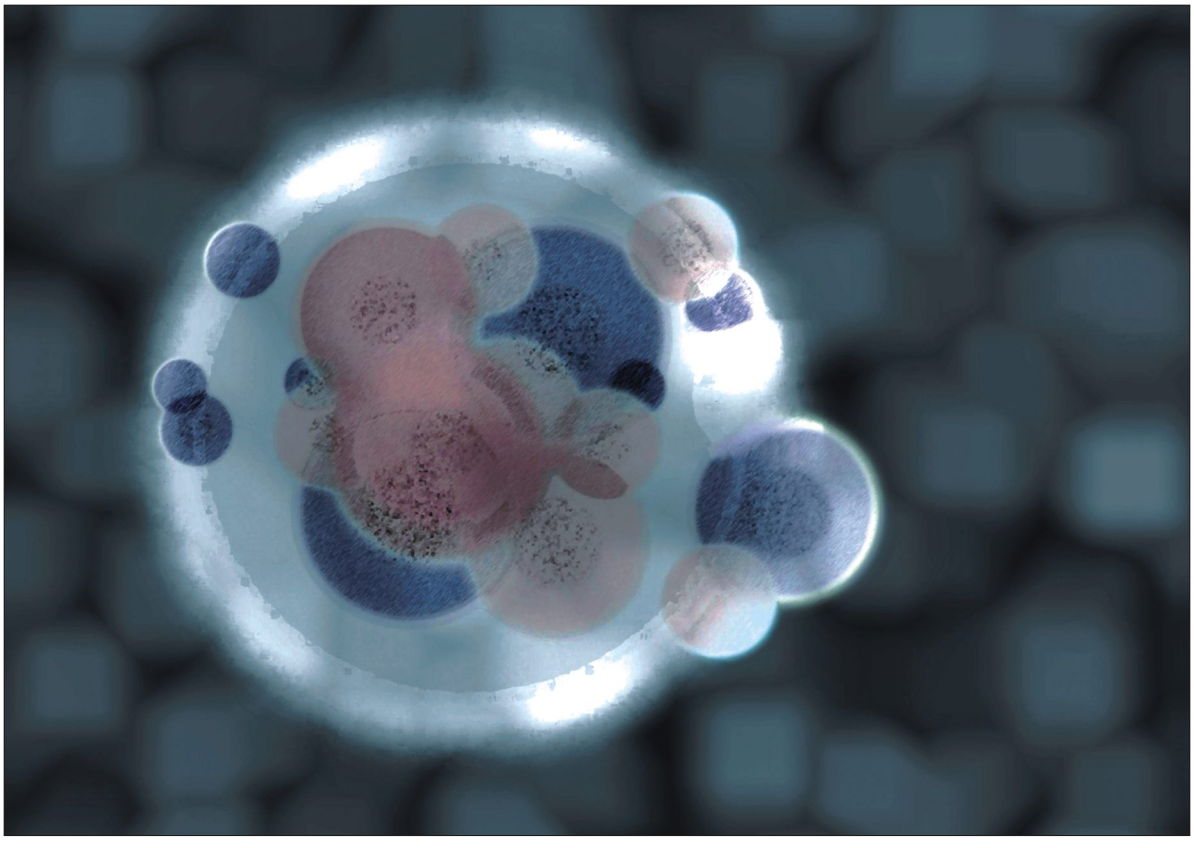

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Use of Industrial Waste and By-products as a P Source for Improving Crop Production. III: Effect of Applied and Residual Phosphorus from Two Sources on Three Crop Species

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Abstract: Effect of applied and residual P from two sources,di calcium phosphate (DCP) and single super phosphate (SSP), were evaluated by growing wheat, brassica and berseem crops in a pot experiment. The criteria used were plant yield and P uptake. Both of the P sources for grain and straw yield of brassica, residual as well as applied P did not improve the yield. However, grain yield of wheat, fodder yield of berseem and total P uptake by these crops were found to improve significantly due to residual and applied P as DCP compared to SSP. A heavy P application from DCP showed positive residual effect and resulted in increased yield and P uptake by wheat and berseem. These results, therefore, strongly advocate the suitability of DCP as a P fertilizer source.

Key words: Brassica, berseem, P sources, residual P, wheat

Introduction

In intensive agriculture, crops are grown one after the other and fertilizers are applied at higher doses to maximize crop production. Repeated application of P fertilizer may result in "P built up" due to increase in phosphorus concentration in the soil solution, particularly when the amount of P added to soil as fertilizer exceeds removal by the crop (Tisdale *et al*., 1985; Memon, 1996). Positive effects of residual phosphorus on succeeding crops have been reported by (Hussain *et al*., 1992; Khan and Makhdum, 1990; Saeed *et al*., 1992). In a pot study two phosphatic fertilizers, DCP and SSP were repeatedly applied at 0, 22, 44, 88 and 176 mg kg^{-1} to three successive crops grown to various periods of time (Alam *et al*., 2001; Latif *et al*., 1998). Analyses of soil showed increase in available P content after each crop harvest, depending on source and rate of P applied. However, the cumulative mean available P, after three crop harvests, were found to be higher in DCP. Repeated applications of P upto 44 mg kg^{-1} rate resulted in equivalent available P (about 20 mg kg^{-1}) from both the sources, but higher application rates showed 2-3 times more P in DCP as compare to SSP supplied treatments. It was postulated that heavy P application as DCP may maintain relatively more available P in soil for a longer period of time and thus may have a greater residual effect than SSP. Fresh additions of P fertilizer from either source may also result in variable response by crops depending on their P requirements. By this experiment effect of applied and residual P from two sources, DCP and SSP, on yield and P uptake by three crop species, brassica, wheat and berseem was assessed.

Materials and Methods

To determine the effect of applied and residual P on crop growth, the treatments having 22 and 88mg P kg^{-1} from previous applications (Alam *et al*., 2001) were given 44 mg P kg^{-1} from the DCP and SSP, while the other treatments were kept as residual. Ten seeds of brassica (CV. Inmol), wheat (CV. Punjab-96) and berseem (CV. Local) were sown in each pot and after germination thinned to maintain 5 plants per pot. A basal dose of 25 mg N kg^{-1} as urea solution was applied to brassica after 4 weeks growth while 100 mg N kg^{-1} was applied to wheat, 3 weeks after sowing and again 100 mg N kg^{-1} was added after 8 weeks. Brassica and wheat were grown upto maturity for grain and straw yield (growth period 129 and 154 days respectively) while 4 cuttings of berseem were obtained for the estimation of fodder yield (growth period 147 days). Plant samples were dried in oven at 70°C for 3 days to record dry weight. The samples for wheat and berseem were then ground to fine powder in a wiley mill and 1g portions were digested in triacid mixture and analyzed for P concentration using Barton's reagent (Jackson, 1962). Data was analyzed statistically using MSTAT software. Duncan's multiple range test was used to compare the means.

Results and Discussion

Brassica: The effect of residual and applied P on straw and grain yield of brassica were not significantly different from control (Table 1). The two P sources, DCP and SSP were also not found to differ for the production of dry matter yield. Thus the native soil P was fairly adequate for growth and yield of brassica, indicating its low P requirement. The results agree with earlier report by Alam *et al*. (2001).

Wheat: Residual as well as applied P increased ($p < 0.05$) wheat straw and grain yield over control (Table 2). Application of 44 mg P kg^{-1} to residual P from a lower P rate (T_2) produced grain and straw yield equivalent to residual P from higher P rates (T_3 and T_5). Application of the same 44 mg P kg^{-1} at a relatively higher residual P (T_4) had beneficial effect for both straw and grain yield compared to control but resulted in similar yield as obtained by higher residual P (T_5). Thus heavy P application had more residual effect and persisted for a longer period of time than a normal or low P application rate.

Grain yield due to applied and residual P from DCP was higher ($p < 0.05$) than that from SSP, the difference in grain yield was only significant at the highest residual P rate (T_5), otherwise, the behavior of the two sources were almost similar for both straw and grain yield at each P rate. Similar results were earlier reported for applied DCP and SSP on wheat growth (Latif *et al*., 1998).

Application of 44 mg P kg^{-1} to lower (T_2) or higher (T_4) residual P treatments increased ($p < 0.05$) P concentration over control in grain while the increase in straw was significant only for the higher rate (T_4). The residual P from lower (T_3) and higher (T_5) rates also had a positive effect on P concentration in grain and resulted in significantly ($p < 0.05$) improved P concentration where the source was DCP. Total P uptake increased over control due to applied and residual P.

Table 1: Effect of applied and resiudal P on grain and straw yield of brassica

Treatment		Grain yield (g pot^{-1})			Straw yield (g pot^{-1})		
No.	Status	DCP	SSP	Mean	DCP	SSP	Mean
T_1	Residual	1.21	1.43	1.32	12.2	11.4	11.8
T_2*	Applied + Residual	2.66	2.21	2.43	10.2	8.4	9.3
T_3	Residual	1.36	1.88	1.62	7.6	9.1	8.4
T_4*	Applied +Residual	1.69	1.95	1.82	8.1	8.6	8.3
T_5	Residual	2.85	1.80	2.32	12.0	9.0	10.5
Mean		1.95	1.85		10.0	9.3	

* Additional 44mgPkg^{-1} was applied as DCP or SSP to respective pots, Source rate and SxR interaction were all nonsignificant

Table 2: Effect of applied and residual P on grain and straw yield of wheat

Treatment		Grain yield (g pot^{-1})			Straw yield (g pot^{-1})		
No.	Status	DCP	SSP	Mean	DCP	SSP	Mean
T_1	R	4.48d	2.84d	3.66C	9.59c	9.74c	9.66C
T_2*	A+ R	21.62abc	22.17ab	21.89AB	39.57a	40.26a	39.82A
T_3	R	20.82bc	17.33c	19.07B	35.76ab	34.14b	34.95B
T_4*	A + R	23.77ab	22.37ab	23.07A	37.96ab	37.54ab	37.75AB
T_5	R	25.42a	19.60bc	22.51A	38.16ab	40.70a	39.43A
Mean		19.22A	16.86B		32.21A	32.43A	

Source x rate interaction was not significant for grain or straw yield, *R-residual; A-Applied P @ 44 mg kg^{-1}.

Table 3: Effect of applied and residual P on P concentration in grain and straw and total P uptake by wheat

Treatment		P source		
No.	Status	DCP	SSP	Mean
P conc. grain (mg kg^{-1})				
T_1	R	2283 d	2795 c	2539 C
T_2*	A + R	3506 b	2957 c	3232 B
T_3	R	3169 bc	3120 bc	3145 B
T_4*	A +R	4593 a	3494 b	4043 A
T_5	R	4604 a	3182 bc	3893 A
Mean		3631 A	3110 B	
P conc. straw (mg kg^{-1})				
T_1	R	125 bc	129 bc	127 B
T_2*	A + R	144 b	117 bc	131 B
T_3	R	101 c	115 bc	108 B
T_4*	A + R	241 a	123 bc	182 A
T_5	R	253 a	110 bc	182 A
Mean		173 A	119 B	
Total P uptake (mg pot^{-1})				
T_1	R	11.44 d	9.54 d	10.50 D
T_2*	A + R	79.77 b	70.14 bc	74.96 B
T_3	R	69.51 bc	57.95 c	63.73 C
T_4*	A + R	118.10 a	82.79 b	100.44 A
T_5	R	126.72 a	66.71 bc	96.71 A
Mean		81.11 A	57.43B	

Sources x rate interaction for P uptake was highly significant ($p<0.01$) as determined by DMR test. * R-residual, A-applied P @ 44 mg kg^{-1}

For P uptake DCP appeared significantly better than SSP. Source x rate interaction effect for total P uptake was also highly significant ($p<0.01$). Thus application of 44 mg P kg^{-1} as DCP at a lower (T_2) or higher (T_4) residual P resulted in equivalent or higher P concentration as well as P uptake compared to applied and residual higher P rate from SSP. This may be attributed to increased availability of P in soil from DCP compared to SSP at equivalent rates of applied and residual P. Akhtar and Alam (2001), reported increased availability of P in DCP compared to SSP from a clay loam soil incubated for 120 days (Table 3).

Berseem: The effect of applied and residual P on fresh and dry fodder yield of berseem is given in Table 4 and Fig. 1. Applied P increased fresh and dry fodder yield over control. Application of 44 mg P kg^{-1} to lower (T_2) or higher (T_4) residual P produced dry fodder yield equivalent to dry fodder yield from relatively high residual P (T_5). Residual P from a lower rate (T_3), however, could not increase the dry fodder yield over control. The DMY obtained from applied and residual P from DCP was significantly higher than that from SSP and this was particularly true for treatments T_4 and T_5 where the DMY was almost 2 times higher. In addition to increase in DMY, applied and residual P increased ($p<0.05$) P concentration in plants. Residual P had more pronounced effect compared to applied P (Table 5) and in this case again DCP proved better than

Table 4: Effect of applied and residual P on dry fodder yield and total P uptake by berseem

Treatment		Grain yield (g pot^{-1})			Straw yield (g pot^{-1})		
No.	Status	DCP	SSP	Mean	DCP	SSP	Mean
T_1	R	8.64 c	6.40 c	6.52 C	15.78 c	15.13 c	15.46 C
T_2^*	A+R	11.34 b	9.79 bc	10.56 AB	36.40 b	32.47 b	34.43 B
T_3	R	9.78 bc	7.62bc	8.70 BC	37.86 b	24.17 bc	31.01 B
T_4^*	A+R	17.42 a	9.21 bc	13.31 A	63.75 a	33.03 b	48.40 A
T_5	R	16.84 a	8.85 bc	12.84 A	69.18 a	31.11 b	50.14 A
Mean		12.40 A	8.37 B		44.60 A	27.18 B	

*R-residual, A-applied P @ 44 mg kg^{-1}; source x rate interaction for DMY and P uptake was significantly different at $P<0.01$ as determined by DMR test respectively.

Table 5: Effect of applied and residual P on P concentration (mg kg^{-1}) in berseem

Treatment		2nd cutting			3rd cutting			4th cutting		
No.	Status	DCP	SSP	Mean	DCP	SSP	Mean	DCP	SSP	Mean
T1-	R	3270c	3208c	3239C	3272b	3452b	3262B	1891f	1680f	1785C
T2*-	A+R	3538c	3428c	3443C	3214b	3082b	3148B	3188d	3637bc	3413B
T3-	R	4433ab	3737bc	4084AB	4392a	3981a	4187A	3981ab	2725c	3353B
T4*-	A+R	3560c	3770bc	3665BC	4101a	3982a	4041A	3637bc	3492cd	3565AB
T5-	R	5038a	3585c	4311A	4444a	4114a	4279A	4021a	3466cd	3744A
Mean		3968A	3546B		3884A	3722A		3344A	3000B	

* R-residual, A-applied P at 44 mg kg^{-1}

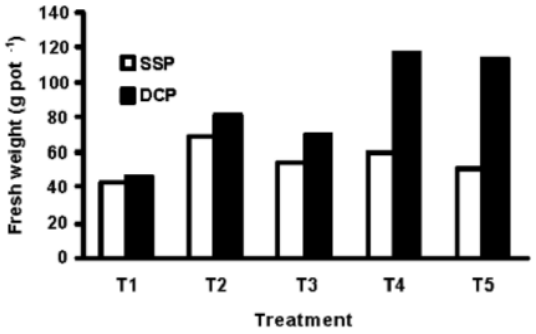

Fig. 1: Effect of applied and residual P on fresh fodder yield of berseem

SSP. The concentration of P decreased in plants with subsequent cuttings, that may be attributed to increased dry matter yield, because P uptake increased at each cuttings and total accumulative P uptake also increased over control. Application of 44 mg P kg^{-1} to residual P (T_2 and T_4) resulted in increased P uptake and was equivalent to P uptake of the next higher residual P (T_3 and T_5), respectively. Thus heavy P application showed a positive residual effect and resulted in increased P uptake and the dry matter yield of berseem.

Source x rate interaction was also significant for both DMY and P uptake. The dry matter yield and P uptake by berseem was significantly higher ($p<0.05$) in treatments receiving P as DCP compared to SSP. It may be observed that application of 44 mg P kg^{-1} as DCP on low residual P (T_2) produced DMY and P uptake equivalent to that recorded from applied and residual higher P from SSP. This indicates that where DCP was applied, the P content in soil was maintained consistently available for plant uptake, as compared to SSP, where it was largely fixed in the soil and was not available for crop.

Brassica, a low P responsive crop did not respond to higher residual P from previous application nor to the fresh P addition from the two P sources. However, wheat, a moderately responsive crop, showed significantly higher response of grain yield from residual DCP at the highest rate only while berseem, a high responsive crop to P, produced 2 times higher dry matter yield and P uptake in both applied and residual higher P compared to SSP. Thus we may conclude that DCP proved to compete favourably with SSP as a P fertilizer source. The increased availability of P in soil from DCP compared to SSP at equivalent rates of applied and residual P could make it a favorable choice for long term benefits.

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