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PHOSPHORUS UPTAKE AND YIELD OF WHEAT AS INFLUENCED BY INTEGRATED USE OF PHOSPHATIC FERTILIZERS

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Integrated plant nutrition management (IPNM) approach was followed to study P use efficiency and determine its effect on crop productivity. Phosphorus was applied @ 40 mg kg^{-1} as mineral fertilizer (single super phosphate, SSP and di-ammonium phosphate, OAP) and as industrial by product (dicalcium phosphate, OCP and filter cake, FC) either alone or after integrating in 2:1 P ratio. Wheat (cv. Inqelab-91) was grown in pots and harvested at vegetative stage and at maturity to estimate P uptake and determine yield. Results showed that phosphorus uptake by plants at pre-booting stage, was higher for SSP compared to all other treatments except OAP. At maturity, however, grain and straw yield from OCP, OAP and SSP was equivalent but significantly higher than FC. Total P uptake from OCP was significantly higher than SSP and FC supplied treatments. Integrated use of fertilizer improved P fertilizer efficiency ranging from 4 to 37% over SSP and resulted in grain yield equivalent to that from OCP, OAP or SSP alone. Thus integrated use of fertilizers could possibly be more economical by replacing some of the expensive SSP with low cost by products.

Key words: Integrated fertilizer use, P efficiency, P sources, wheat

INTRODUCTION

The alkaline and calcareous soils of Pakistan are extensively deficient in nitrogen and phosphorus, hence application of fertilizer is considered imperative for increasing crop production (Memon, 1996). Fertilizer consumption in the country has therefore, increased considerably over the years. Nevertheless, the increase was disproportionate and N: P ratio remained always in favour of N fertilizers (Saleem,1992; Nisar 2000). The practice of low P input, not only effects crop yields adversely but leads to low fertilizer use efficiency as well (Saleem, 1992). The failure of small or low income farmer in applying fertilizers in recommended rates and in balanced proportion was attributed to constrains such as inadequate availability, shortages at proper time and higher prices etc. (Nisar, 2000; NFOC 2000). In such circumstances, farmers may be encouraged to utilize cheap and accessible organic wastes/industrial by-products, as a partial supplement of P. Adaptation of such practice may help improve the N:P ratio and subsequently add some organic matter to the soils. In an excellent review, Nisar (2000) has elaborated the benefits of adding farmyard manure (FYM) either alone or with NPK on crop yields. Other organic wastes such as filter press-mud (filter cake) or poultry dropping that contain P as well as several other nutrients may also be incorporated in soil that will help to improve soil physical and chemical properties (Ibrahim et al.,1992; Mian et al., 1990). Studies have shown that addition of crop residue or poultry waste either separately or in combination with mineral fertilizers, improved dry matter yield of maize and wheat (Badr-uz-Zaman et al., 1996; Mian et al., 1989). Dicalciurn phosphate (OCP), a by-product of a local gelatin industry containing high acetate soluble P, was found a good source of P fertilizer for a number of crop species (Alam et al., 2001; Latif et al., 1998). Biocompost, prepared from filter cake (FC) and stillage was found effective to reduce the need of mineral fertilizer for sugarcane (Nasir and Qureshi, 1999). These studies, therefore, indicate that adoption of such practices would reduce total input cost, sustain productivity, protect nutrient losses and check environmental pollution. This experiment was conducted to determine the effect of some industrial waste applied separately or after integration with mineral fertilizer on P fertilizer efficiency and yield of wheat.

MATERIALS AND METHODS

A greenhouse experiment was conducted on a silt loam soil (Lyallpur Series, Typic Ustochrept) which had: pH 7.9, organic matter 0.56%, calcium carbonate equivalent 3.4% and $NaHCO_3$-extractable P 9.9 mgkg-1. Bulk soil samples collected from surface 0-15 cm depth were air-dried, ground, passed through 2mm sieve and mixed thoroughly. Five kg soil was weighed in plastic pots lined with polyethylene and 40 mg P kg-1 soil was applied separately as organic or inorganic sources or after integration in 2:1 P ratio. The Nand P contents of waste materials used in the study are given in Table 1. The treatments were imposed in triplicate according to completely randomized design. Basal N @ 90 mg kg^{-1} was equalized in each treatment by adding varying amounts of urea to respective pots. The soil moisture in pots was maintained at 50% of maximum water holding capacity. Ten seeds of wheat (cv. Inqelab-91) were sown and after germination 7 seedlings per pot were maintained. At 3 leaf stage, a second dose of N @ 100 mg k~-1 and at booting stage, final dose of N @ 50 mg kg- as urea solution was applied to all treatments including control Three plants were harvested at prebooting stage, while 4 plants were harvested at maturity. At final harvest data on plant height, number of tillers per plant and thousand-grain weight were recorded and the harvest index was calculated after taking the dry weights of straw and grain. Phosphorus in dry matter or grain was determined by metavanadate yellow color method after wet digestion (Jackson, 1958). Phosphorus fertilizer efficiency (PFE) was calculated as:

[P uptake (fertilized) - P uptake (control)]/amount of P applied.

Physiological-nutrient efficiency (PNE) was calculated by formula:

(Yf-Yc)/(Uf-Uc),

where Y and U represent grain yield and P uptake at fertilized (f) and control (c) treatment, respectively.

Table 1. Total nitrogen and phosphorus content in industrial waste/by-products.

Waste Products	%N	%P
Filter cake	3.65	1.25
Poultry waste	2.85	1.59
Oicalcium phosphate	-	17.9

RESULTS AND DISCUSSIONS

Dry matter yield and P uptake

The dry matter yield (OMY) and P uptake by wheat harvested at prebooting stage increased significantly over control due to P application (Table 2). At this stage of growth, the OMY produced due to application of SSP was significantly higher than that of OCP, indicating the superiority of water soluble source over the acetate soluble source. Application of P fertilizers increased P concentration in plants significantly depending on the source of application. Where P was applied from mineral sources (SSP or OAP), the concentration of P in plants was statistically similar but relatively higher than other treatments. Application of P as OCP (an inorganic and low water soluble source) or supplementing OCP with 1/3 P from mineral sources, though improved P concentration but P uptake remained significantly lower than that of SSP. Similarly application of P from organic source (FC) only or supplementing FC with 1/3 P from inorganic sources (SSP, OAP or OCP) resulted in reduced P concentration and decreased P uptake as compared to mineral sources. This indicates that P sources when applied alone or after integration, differed in their efficiency to supply P to plants at early stages of growth. The water-soluble sources (SSP or OAP), compared to organic (FC) or acetate soluble source (OCP), appeared more effective for early P acquisition and utilization by wheat plants. Obviously, P release from organic sources would require some time for decomposition by microbial biomass (Ghosal, 1975; Mian et al., 1990; Reddy et al., 1996). However, if we calculate physiological nutrient efficiency (PNE) even at this stage of growth, it would appear that plants supplied with integrated fertilizers had equivalent or a better PNE than those supplied with mineral fertilizers only. It, therefore, appeared more likely that the plants while approaching reproductive stage would benefit from this improved P nutrition.

Table 2. Effect of P application on dry matter yield, P concentration, P uptake and physiological nutrient efficiency in wheat at pre booting stage.

Treatments		OMY	P concentration	P uptake	PNE
Source	Rate (mg kg-1)	(g pot")	(mg kg-1)	(mg pot")	(g rng')
Control	-	3.66 c	1978 d	7.34 e	-
SSP	40	9.07 a	2942 ab	26.63 a	0.28 bc
OAP	40	8.16 ab	3188 a	25.92 ab	0.24 c
OCP	40	6.72 b	2840 ab	19.24 cd	0.26 c
FC	40	7.13 ab	2275 cd	16.14 d	0.41 a
FC+SSP	27+13	7.07 ab	2369 cd	16.73 d	0.36 abc
FC+OAP	27+13	8.54 ab	2369 cd	20.10 cd	0.38 ab
FC+OCP	27+13	7.30 ab	2246 cd	16,41 d	0,40 a
OCP+SSP	27+13	8.52 ab	2565 bc	21.82 bc	0.33 abc
OCP+OAP	27+13	7.79 ab	2853 ab	21.90 bc	0.28 be

Figures with similar letters in a column do not differ significantly at P<0.05 as determined by OMR test.

Yield and Yield Components

At maturity the *effect* of integrated P use pecams more evident on some of the yield components studied (Table 3). Integrated use of fertilizer, in general, improved plant height, thousand-grain weight (TGW) and the harvest index (HI) over control. The number of tillers per plant, however, could not improve significantly over control due to initial high P content of improving the wheat yield. Ibrahim et al. (1992) also reported that P from FC was less effective than TSP for improving the fodder yield of maize and the grain yield of subsequent wheat. However, from the results

Table 3. Effect of P application on yield and yield components of wheat at maturity.

Source of P fertilizer applied*	Grain yield (g pot")	Straw yield (g pot)	No. of tillers (plant")	Plant height (cm)	1000 - grain wt.(g)	Harvest index (%)
Control	18.4 d	30.4 d	3.16 a	79.1 c	29.25 c	37.7 b
SSP	32.2 ab	43.4 abc	3.75 a	83.1 abc	41.45 b	42.61 a
OAP	35.1 a	46.7 a	4.08 a	83.1 abc	43.08 ab	42.99 a
OCP	35.1 a	47.2 a	3.92 a	81.6 bc	42.95 ab	42.65 a
FC	26.8 c	38.8 c	3.50 a	86.3 a	42.76 ab	40.89 a
FC+SSP	32.1 ab	43.7 abc	3.50 a	85.2 ab	42.56 ab	42.36 a
FC+OAP	29.1 bc	39.8 bc	3.58 a	84.6 ab	44.36 a	42.28 a
FC+OCP	30.9 abc	42.0 abc	3.50 a	86.5 a	45.03 a	42.36 a
OCP+SSP	32.8 ab	43.6 abc	4.08 a	82.5 abc	42.86 ab	42.93 a
OCP+OAP	34.2 a	45.1 ab	4.00 a	84.3 ab	43.96 ab	43.02 a

* P was applied @ 40 mg kg^{-1}

Table 4. Effect of integrated use of fertilizers on P uptake and phosphorus fertilizer efficiency by wheat.

Source of P fertilizer applied	P uptake, (mg pot')			P fertilizer efficiency (%)
	Grain	Straw	Grain+Straw	
Control	46.34 c	3.50 d	49.7 c	-
SSP	82.99 b	4.48 bcd	87.4 b	18.8 d
OAP	98.00 ab	4.98 a-d	103.0 ab	26.6 ab
OCP	104.00 a	6.41 ab	110.4 a	30.3 a
FC	88.40 ab	3.85 d	92.2 b	21.2 bed
FC+SSP	82.90 b	6.11 abc	89.0 b	19.6 cd
FC+OAP	83.31 b	4.25 cd	87.5 b	18.9 d
FC+OCP	90.62 ab	4.59 a-d	95.2 ab	22.7 bcd
OCP+SSP	95.50 ab	4.91 a-d	100.4 ab	25.3 a-d
OCP+OAP	94.78 ab	6.48 a	101.2 ab	25.7 abc

the soil. The differential effect of applied P on plant components improved grain and straw yield significantly over control. The grain yield was higher where P was applied alone from inorganic sources. Among the inorganic sources, the acetate soluble OCP and the water- soluble fertilizers, OAP and SSP resulted in equivalent grain yield. Integration of OCP with mineral sources (SSP or OAP) in 2:1 P ratio also produced grain yield as equivalent to mineral sources. In earlier studies also, OCP and SSP when applied at equivalent rates, produced similar grain or dry matter yield for a number of crop species (Alam et al., 2001; Latif et al., 1998). On the other hand, a relative decline in grain yield over SSP was observed where only FC was the P source. This indicates that use of FC as a sole source of P could not compete mineral fertilizer for

of the present study it is evident that where FC was supplemented with 1/3 P from a mineral source/by product, wheat grain yield improved to the level of SSP. This indicates the possibility of replacing some of the costly mineral fertilizers with low cost industrial waste materials.

Phosphorus Uptake and Efficiency

Efficiency of P uptake with respect to source is given in Table 4. It is evident that P uptake in straw as well as in grain, increased over control due to P application from either source or combination. Total P uptake was lowest where SSP or FC was applied alone while the P uptake was highest where only OCP was the P source. Integrated use of fertilizers significantly improved total P uptake over control but not over .mineral sources.

Nevertheless, P fertilizer efficiency (PFE) varied significantly depending on source and their integrated use. Among the sources, DCP recorded highest PFE followed by DAP, FC and SSP. Integrated use of fertilizers improved PFE ranging from 4 to 37% over SSP alone. Integration of mineral fertilizer with FC was less effective compared to their integration with DCP for improving the yield and P fertilizer efficiency. An appropriate balance between organic and mineral sources may improve P efficiency and may result in increased grain yield. Thus with proper management, the cost of fertilizer input may be reduced.

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