

Original Research Article

ASSESSING EFFICIENCY AND ECONOMICS OF PHOSPHORIC ACID AND HUMIC ACID IN ALKALINE CALCAREOUS SOILS FOR WHEAT PRODUCTION

Abstract

Phosphorus (P) is an essential nutrient needed for plant growth and root development. It has a specific role in root development and grain production. It is considered that application of humic acid (HA) improves the plant growth and enhances stress tolerance. So to feed ever increasing population of the world it is imperative to increase cereal grain yield through chemical and organic fertilizer. The decrease in amount of arable land and hiking prices of chemical fertilizers are a huge challenge for farmers. The prices of phosphatic fertilizers, especially the DAP urge the need to explore the cheaper sources of P. Therefore a three year field study was conducted to compare the efficiency and economics of phosphoric acid (PA) with two other traditional sources of P (SSP and DAP) for optimum wheat grain production. Six treatments applied were Viz. Control, RD of P from SSP, RD of P from DAP, RD of P from PA, RD of P from SSP + HA, RD of P from DAP + HA. These P fertilizers were applied at the recommended rates for wheat (90 kg/ha) from SSP, DAP and phosphoric acid. HA was also applied at the rate of 15 kg/ha. PA was applied at the time of first irrigation of the wheat crop. The experiment was conducted at Soil Chemistry Section, ISC&ES, Faisalabad, using RCBD with three repeats. Basic soil analysis showed that the field was free from salinity and sodicity hazards. The organic matter status was very low while available P was in the range of low to marginal and extractable K was adequate. The results showed that the maximum grain yield (4.98 t/ha) was obtained from the treatment where recommended dose of P was applied through DAP. The economic analysis showed that the Cost Benefit Ratio (CBR) of DAP (3.0) proved it as most profitable P fertilizer with the maximum benefit return. Further the fertigation of PA did not proved better in terms of CBR while the application of HA significantly lowered the CBR than alone SSP or DAP application.

Keywords: Phosphorus, economics, humic acid, alkaline, calcareous.

Introduction

Wheat is the most important cereal food grain in the world and a staple food of the subcontinent (Tunio, 2006; Malik, 2006). Among the cereals after rice wheat is next in area of production and yield (Jagshoran *et al.* 2004). Around the world, wheat is grown across a wide range of environments and it has the broadest adaptations of growth among all the cereal crops. It has good quantity of protein and gluten contents and contributes more calories and proteins to the world's human diet than any other cereals. Pakistan is one of the important wheat producing countries in the world. Fertilizer is the most important input which contributes significantly towards final grain yield of wheat and to exploit the inherited potential of a cultivar. P is an essential nutrient for plant growth and development. Plants require adequate P from the very early stages of growth for optimum crop production (Grant *et al.* 2005). It is generally agreed that higher P supply is a prerequisite for high yield potential of modern wheat cultivars (Clark, 1990). P fertilizers are used worldwide to sustain and improve crop yields, which are required to meet the needs of both a growing world population and annual depletion of soil nutrients. Pakistani soils are alkaline and calcareous in nature. Therefore P availability to crops is very low. To maintain the P availability to crops, it is necessary to apply adequate quantities of phosphatic fertilizers into the soil (NDFC, 2003).

Despite of being grown on larger area, average yield at farmers' fields is still far below than the potential (Mann *et al.* 2004). Although with favorable climatic conditions and irrigation water availability, wheat suffers from under production in terms of yield per hectare in Pakistan (Sarwar *et al.* 2010). The reason for this low yield is less use of chemical fertilizers especially P. The consistently increasing prices of P fertilizers especially DAP and their less availability in market at the right time of application mostly accounts for low fertilizer usage (Shahbaz *et al.* 2006). Alam *et al.* 2005 also reported that elevated P fertilizer prices and their scarcity at the right time of application to crop mostly accounts for low fertilizer usage. In Pakistan small land holding farmers are unable to purchase these very expensive chemical fertilizers. Besides this the high priced phosphatic fertilizers, especially the DAP compel the researchers to explore the cheaper sources of P. PA was considered a cheaper source of P as compared to DAP. So keeping in view the important role of this key element in wheat growth and grain yield a three year field study was conducted to compare the efficiency and economics of phosphoric acid (PA) with two traditional fertilizers (SSP and DAP) and organic fertilizer humic acid (HA) along with SSP and DAP for wheat cropping.

Materials and methods

The experiment was conducted at research area of soil chemistry section, ISC&ES, Faisalabad during the Rabi seasons of three years. The experiment was laid out in RCBD, having a plot sized 7.5 m x 5 m with three repeats. Wheat cultivar AARI 10, was sown using seed rate 100 kg/ha. The experiment comprised of T_1 = Control, T_2 = RD of P from SSP, T_3 =RD of P from DAP, T_4 =RD of P from PA, T_5 =RD of P from SSP + HA @ 15kg/ha, T_6 = RD of P from DAP + HA @ 15 kg/ha. All the treatments were applied before sowing of wheat except PA which was applied at first irrigation of crop through mixing in irrigation water. HA was also used along with SSP and DAP fertilizer. Nitrogen and potash were applied as Urea and SOP @ 120-50 kg/ha respectively. Whole P and K were applied at the time of sowing while half Nitrogen was applied at the time of sowing and remaining half at the time of first irrigation. Electrical conductivity of soil extract of pre sowing composite soil samples was measured by method of Mclean 1982, with a conductivity meter (model: Corning Conductivity meter 220) and the pH of soil samples were measured with the glass electrode pH meter method in a soil saturated paste (ORION Research 611). Organic matter contents of soil samples were estimated following the method of Ryan et al. 2001. Potassium in the extract was analyzed by flame photometry method (Rowell, 1994). Available P was determined by the Olsen P method (Rowell, 1994). Textural class was determined with particle size distribution hydrometer method (Bouyoucos, 1962). Plants from 1 m² were selected at random for recording plant height (cm), spike length, grains per spike and 1000 grain weight at harvest. An area of 9 m² was selected at random from each plot to collect plant biomass from which grain and straw yield was calculated in tones per hectare.

Chemical analysis of plant samples

After maturity, the harvested wheat grain and straw samples were used to analyze P. Plant samples were dried in an oven at 70 °C to obtain constant weight. Oven dried samples were ground in a Wiley Micro Mill, passed through 40 mesh screens, mixed well and stored in plastic bags. Grain and straw samples were analyzed to determine the amount of P, K, Zn, Cu, Mn and Fe contents. Plant samples were wet digested with tri acid mixture of HNO₃- H₂SO₄-HClO₄. P was measured by metavanadate yellow colour method (Jackson, 1979) with Spectrophotometer IRMECO model U-2020. Then from the standard curve, P contents (%) in grain and straw were

89 calculated. P uptake and PUE in wheat straw and grains was calculated according to formulae
90 given by Rehim *et al.* (2012) and Fageria *et al.* (1997).

91 $P \text{ uptake } \text{kg ha}^{-1} = P \text{ contents } (\%) \text{ in plant part (dry matter)} \times \text{Yield } (\text{kg ha}^{-1})/100$

92 $PUE (\%) = \{[\text{Total P uptake } (\text{kg ha}^{-1}) \text{ in fertilized plot}] - [\text{Total P uptake } (\text{kg ha}^{-1}) \text{ in control plot}]\}$
93 $/P \text{ dose applied } (\text{kg ha}^{-1})\}/100$

94 **Data analyses**

95 Statistical analysis of data in this experiment was performed using Analysis of Variance
96 (ANOVA) using the computerized system Statistix® for Windows version 8.1 (Analytical
97 Software ©). Difference among the treatment means were compared using least significant
98 difference at 5 % probably level (Steel and Torrie, 1997).

99 **Economic analysis**

100 A cost benefit analysis was conducted to estimate the economic feasibility of different P sources
101 and along with HA application to increase net economic returns of wheat production as described
102 by CIMMYT (1998).

103 **Physico-chemical properties of soil before the start of experiment**

104 **Table 1: Basic Soil Analysis**

Soil depth (cm)	pHs	Ece (dS m ⁻¹)	Av. P (ppm)	Av. K (ppm)	O.M (%)	Texture
0-15	7.95	2.85	7.98	160	0.69	Sandy clay loam
15-30	7.99	2.13	4.00	150	0.63	

105 Basic soil analysis showed that the field was free from salinity and sodicity hazards. The organic
106 matter status was very low while available P was in the range of low to marginal and extractable
107 K was adequate (Table 1).

108 **Results and Discussion**

109 **Effect of P sources on growth parameters**

Three years pooled results showed that wheat growth parameters (Plant height, spike length, grains per spike, 1000 grain weight) were significantly affected by P sources and the highest results were obtained with the application of DAP (Table 2). Similar trend was found by Alam *et al.* (1999). Application of P fertilizer significantly increased the growth parameters over the control. Alam *et al.* (2003) has shown that the application of P fertilizer (SSP) to wheat crop has significantly increased the plant height, number of tillers plant⁻¹ over control. The differences among different P sources were statistically insignificant but maximum growth was observed where DAP fertilizer was applied followed by SSP. This is also reported by Majeed *et al.* (2014) that use of DAP resulted in more plant growth than other P sources. The results revealed that PA did not significantly improved the growth and yield of wheat rather DAP significantly improved the plant height, spike length, number of grains per spike, 1000 grain weight and grain yield of wheat as compared to control. These results are in line with the findings of (Iqtidar *et al.* 2006; Alvarez *et al.* 2004; Jamwal and Bhagat 2004). They reported that the increase in biological yield is due to the use of chemical fertilizers as compared to PA.

Table 2: Yield contributing parameters

Treatments	Plant Height (cm)	Spike Length (cm)	Grains/Spike	1000 Grain wt (g)
Control	85B	14B	42B	47C
RD of P from SSP	98A	16AB	48AB	54AB
RD of P from DAP	103A	16A	51A	57A
RD of P from Phosphoric Acid	99A	14B	46AB	53BC
RD of P from SSP+ Humic Acid	101A	16AB	48AB	55BC
RD of P from DAP+Humic Acid	98A	16AB	49AB	54BC
LSD	6.04	2.02	5.89	1.93

Means for each parameter sharing similar letters do not differ significantly at p = 0.05

Effect of P sources on grain yield

Year wise three year pooled grain yield data is presented in Fig 1. The pooled results showed that similar trend was observed in all the three years and all the P sources had a significant effect on grain yield over the control. Alam *et al.* (2003) also reported the increase in wheat grain yield due to application of P fertilizers. Data revealed that highest (40 % more as compared to control) grain yield (4.98 t/ha) was recorded where DAP was applied as P source followed by SSP (4.56

132 t/ha) and PA (4.25 t/ha). The increase in yield with DAP fertilizer is in line with findings of
 133 (Majeed *et al.* 2014; Jamwal and Bhagat 2004). DAP and SSP increased grain yield up to 17 and
 134 7 percent more as compared to PA respectively. Decline in yield was observed when DAP and
 135 SSP were applied along with HA. The reason for this decrease in yield is unknown but it may be
 136 due to complex formed between HA and P which made P less available to crop (Delfine *et al.*
 137 2005). This decrease in yield may also be due to more vegetative growth due to HA addition.

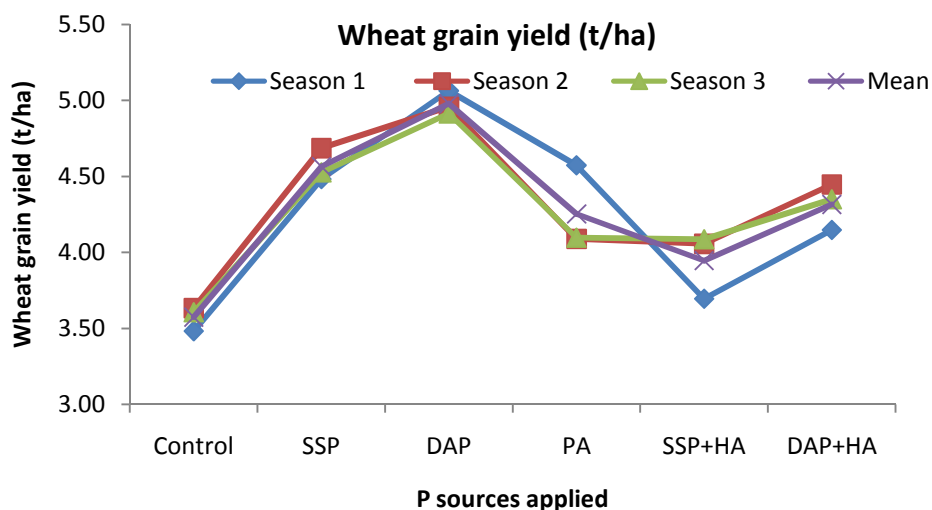


Fig 1 Grain yield of wheat crop (t/ha)

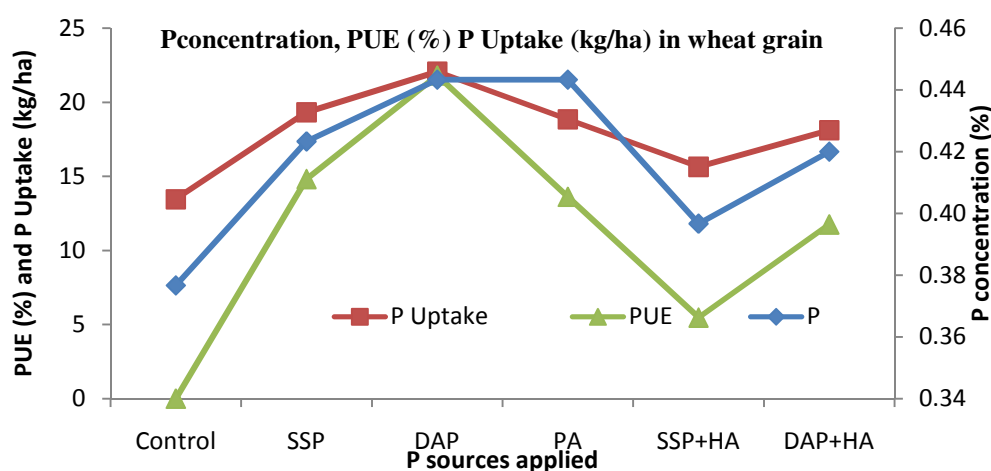


Fig 2. P concentration and PUE (%) and P uptake (kg/ha) in grain

142 Three years averaged pooled data showed that with the use of fertilizers there was an increases in
 143 P concentration and PUE and P uptake in wheat grain (Alam *et al.* 2003). Data revealed highest

P concentration, PUE and P uptake (0.44 %, 22 %, 22 kg/ha) where DAP was applied as P source over the other treatments (Fig 2). Majeed *et al* (2014) also reported the increase in PUE with the use of DAP fertilizer. The reason behind is that DAP fertilizer is the best P source in alkaline calcareous soils. This is also reported by Rahamatullah *et al.* (2007) that application of DAP resulted in highest concentration of P in grain. There is lesser P fixation due to acidic localized reaction of DAP and more availability to plant, lesser chances of P fixation and Precipitation (Memon *et al.* 2011). In contrast where SSP and PA were applied, P concentration, PUE and P uptake were recorded comparatively lower than DAP but higher than no fertilizer and SSP + HA and DAP + HA. The results showed that percent increase in P uptake and PUE with the use of DAP as compared to PA fertilizer is 16 and 56 respectively in wheat grain.

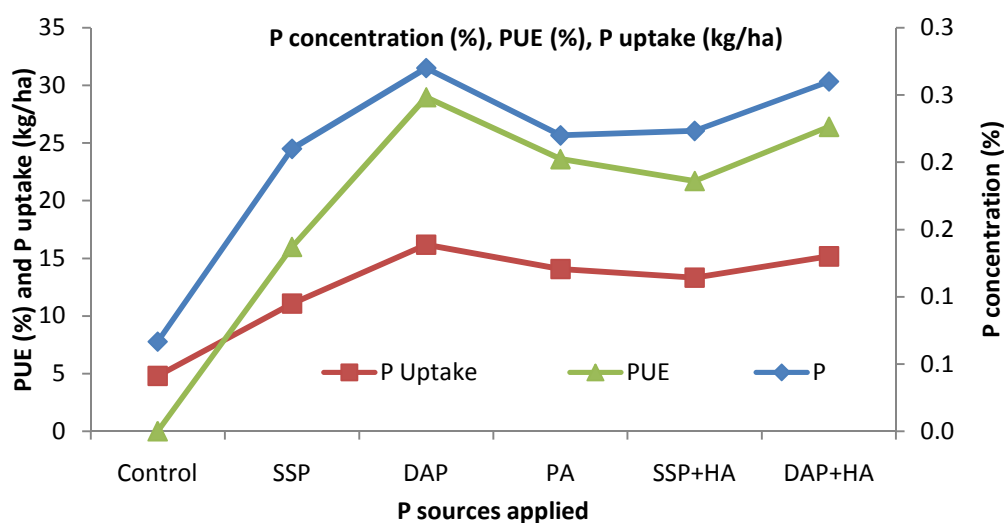


Fig 3. P concentration and PUE (%) and P uptake (kg/ha) in straw

Application of Phosphorus fertilizers had a significant effect on concentration of P, PUE and P uptake in wheat straw. It was observed that P concentration and P uptake were lowest (0.1 %, 5 kg/ha) in control where no fertilizer was applied as compared to fertilizers applied. Highest P uptake, P and PUE (16 kg/ha, 0.3 %, 29%) were recorded where DAP was applied as compared to SSP (11 kg/ha, 0.2 %, 16 %) and PA (14 kg/ha, 0.2 %, 24 %). These results are also in line with Majeed *et al.* (2014). Shah *et al.* (2006) reported that highest P recovery can be achieved with proper P fertilizer application. In alkaline calcareous soils DAP is the best P fertilizer with highest PUE. The wheat straw accumulated less P than wheat grain and decrease in P uptake and

164 PUE was also recorded in wheat straw. This decrease may be attributed to fixation of soil P to
165 unavailable form in later stages of growth resultantly low P use efficiency (Rahim *et al.* 2010).

166 **Table 3: Cost benefit ratio of different sources of P for wheat crop**

Treatments	Grain t/ha	Cost/ha	Wheat price	Net profit	CBR
Control	3.57	0	111562.5	-----	-----
RD of P from SSP	4.56	12000	142500	30937.5	2.6
RD of P from DAP	4.98	14876	155625	44062.5	3.0
RD of P from Phosphoric Acid	4.25	33240	132812.5	21250	0.6
RD of P from SSP+Humic Acid	3.95	13688	123437.5	11875	0.9
RD of P from DAP+Humic Acid	4.31	16563	134687.5	23125	1.4

167 Cost benefit ratio on three year average yield was calculated (Table 3). Wheat price of the final
168 year was used to calculate the price of wheat grain. Similarly cost was calculated by using the
169 final year price of fertilizers. It was recorded that DAP was most economical and profitable
170 fertilizer among three P fertilizers (DAP, SSP, PA) and their use along with HA, similar results
171 were reported by Majeed *et al.* 2014. Use of HA not only increased the cost of production but
172 also not an efficient fertilizer to increase the grain yield. With the use of DAP, on expending one
173 rupee farmer can earn 3 rupees followed by 2.6 rupees from SSP. DAP saved 5 times more input cost
174 followed by SSP (4 times) as compared to PA.

175 Conclusion

176 It was concluded from this study that DAP is the best and most profitable source of P fertilizers
177 and use of DAP and SSP along with HA will earn no more benefit than alone, rather it will
178 increase cost of production. Use of DAP fertilizer saves 400 % input cost followed by SSP (333 %) as
179 compared to PA. Therefore use of PA is uneconomical as compared to SSP and DAP fertilizers and also
180 to their combined use with HA.

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