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# Effect of Residual Phosphorus on Sorghum Fodder in Two Different Textured Soils

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## ABSTRACT

A field experiment was conducted to observe the effect of residual phosphorus on sorghum fodder applied to wheat @ 0, 25, 50, 75, 100, 125, 150 kg $P_2O_5$ P $ha^{-1}$. Residual phosphorus increased sorghum fodder with increasing rate of phosphorus application in both soils. Fresh and oven dry weight of sorghum, phosphorus concentration and its uptake by sorghum significantly increased with the increasing quantity of residual phosphorus. Phosphorus use efficiency was maximum with 25 kg and minimum with 50 kg P $ha^{-1}$ in loam soil. In case of clay loam soil, it was maximum at 50 kg and minimum with 25 kg P $ha^{-1}$. After harvest of the of the sorghum fodder, the residual P was still more where great amount of P was applied suggesting a P build up. Effect of Residual P was maximum where 150 kg P $ha^{-1}$ was applied to the wheat crop.

**Key Words:** Sorghum fodder; Residual P; Phosphorus use efficiency (PUE).

## INTRODUCTION

Phosphorus is one of the major essential plant nutrients and after N, is the second most deficient plant nutrient as more than ninety percent soils of our country require moderate to high P for optimum crop growth (Rashid, 1994). The efficiency of phosphatic fertilizer in soil ranges between 15-25% due to factors such as soil texture, aeration, compaction, temperature, soil pH, and $CaCO_3$ contents. These factors also control chemical reactions of applied P in the soil resulting in its conversion into forms, which are not available to crops. Residual effect of phosphorus refers to the carry over effect on the succeeding crop. Amount and longevity of the residual effect of P depends primarily upon rate, duration and frequency of P application, solubility of P fertilizer, soil properties, type of crops, yield levels and extent of P removal (Tandon, 1987).

Residual P accumulates in the soil when P fertilization exceeds its utilization by crops. Continuous use of P fertilizers in excess of crop needs thus result in a gradual increase in available P status of a soil. The duration of response will be influenced by amount of residual P (Memon, 2001). Shaukat *et al.* (1992) carried out an experiment for two years to see the yield response of maize to residual soil phosphorus and found that the application of 120 kg P $ha^{-1}$ to a wheat crop left sufficient residual P for the following maize crop to increase its dry matter yield over the control with no extra fertilizer. Singaram and Kothandaraman (1994) conducted field experiment at Tamil Nadu, the maize was grown on the same plots after finger millet (*Eleusine coracana*) given 30, 60 or 90 kg $P_2O_5$ $ha^{-1}$ as single super phosphate, rock phosphate, On average, maize grain yield was slightly lower with residual P (3.47 t. $ha^{-1}$) compared with direct application (3.49 t. $ha^{-1}$ or combine residual + direct P application (3.49 t). Mehdi and De Data (1997) performed two field experiments to evaluate residual recoveries of fertilizer phosphorus during 1991 dry season, under irrigated condition. Average grain yield increase was 0.5-0.9 t $ha^{-1}$ due to residual effect of inorganic fertilizer P, regardless of source. Residual effect of fertilizer P with *Sesbania rostrata* or alone increased grain yield by 0.3-1.0 t $ha^{-1}$ over control. Results revealed a promising effect of residual P from the applied P sources in increasing rice grain yield. Total P uptake increased due to residual P from fertilizer P applied. Tomar *et al.* (1999) evaluated the residual efficiency of P to maize crop in wheat maize cropping sequence with 3.0, 6.4, 10.0, 14.8 or 22.0 mg available P $kg^{-1}$, wheat was given 20, 40 or 60 mg P $kg^{-1}$ as diammonium phosphate or ammonium polyphosphate. Residual effect of treatments was determined in two succeeding maize crops. Dry matter yield and uptake in the first maize crop was 1.69-2.93 times great than in the second crop. Yield and P uptake of both maize crops increased with P rate applied to wheat and initial soil P level. Daba and Zewedie (2001) determined the residual value of P fertilizer for sorghum using phosphate levels 0, 23, 46, 69, 92 and 115 $P_2O_5$ kg $ha^{-1}$. Results showed that the residual effect of P fertilizer varied. Generally it was observed that 23 and 46 kg $P_2O_5$ $ha^{-1}$ levels were not of significant importance to have practical residual value for subsequent cropping as observed from the yield responses. On the other hand, when the phosphate level was greater than or equal to 69 $P_2O_5$ kg $ha^{-1}$, the residual P fertilizer value was of practical significance. Keeping all this in view a field study was conducted with the objective “To see the response of sorghum fodder to different levels of residual phosphorus for economical plant growth in loam and clay loam soils”.

## MATERIALS AND METHODS

A field experiment was carried out to observe the residual effect of P, applied to wheat crop, on sorghum fodder under farmer's field conditions. Soil samples were collected from each plot in which phosphorus was applied to wheat crop @ 0, 25, 50, 75, 100, 125, and 150 kg $P_2O_5$ $ha^{-1}$. After wheat, sorghum was sown using seed @ 75 kg $ha^{-1}$. Nitrogen and potash were applied @ 140 and 70 kg $ha^{-1}$ to all the plots except control. The sorghum fodder was harvested after 50 days of sowing. Fresh and oven dry weights were recorded. Plant samples were analysed for P concentration. Phosphorus uptake and Phosphorus use efficiencies were calculated. After the harvest of crop, soil samples were again collected from each plot and analysed for Olsen P. The system of layout was RCBD with three replications. All the analysis was done according to methods given in Hand book No. 60 (U.S. Salinity Lab. Staff, 1954) except available P by Olsen method (Watanabe & Olsen, 1965) and texture by Moodie *et al.* (1959). All the data were statistically analysed using Analysis of Variance technique as described by Steel and Torrie (1980).

## RESULTS AND DISCUSSION

The results indicated (Table I) that soils were free from salinity/sodicity hazard, deficient in available P and organic matter and adequate in available K. The soils used were loam and clay loam in texture. Olsen P contents in both soils after the harvest of wheat crop increased linearly with the increase of P application (Table II). The maximum residual P (20.36 and 19.14 mg $kg^{-1}$) was noted where 150 kg $P_2O_5$ $ha^{-1}$ was applied to wheat crop and minimum in control where no phosphorus was applied. The results get support from the work of Amrani *et al.* (1999) and Singaram and Kothandaraman (1994). The reason might be that the higher P application rates to the first crop increased, linearly increases the residual quantity of P for the succeeding crops resulting in more available P in the soil. Fresh and oven dry weights of the sorghum are presented in Table III. The results indicated that maximum fodder yield was recorded in $T_7$ where residual P was 20.36 mg $kg^{-1}$ followed by $T_6$, $T_5$, $T_4$, $T_3$, $T_2$ and least in control where no phosphorus was applied to wheat crop. These results revealed a promising effect of residual P from the applied P in increasing sorghum fodder yield on fresh and oven dry basis in both the soils. The results are in line with those of Daba and Zewedie (2001) and Sahrawat (2000) who studied that residual phosphorus increased the fodder yield.

The residual phosphorus contents were almost similar in both the soils, but the yield of sorghum fodder had an edge in clay loam over that in loam soil. This might be due to reason that fine textured soils have greater water holding capacities and moisture is crucial for P diffusion and availability.

Phosphorus concentration in plant can be related to phosphorus extraction power of roots from soil. Normally plant roots having wider contact with soil are better extractor of phosphorus from soil and feed well to above ground plant. This is true for extensive root system (Tisdale *et al.*, 1997). The data regarding the effect of residual phosphorus on P concentration and its uptake by sorghum in two textured soils is given in Table IV. Like fresh and oven dry weight, P concentration and its uptake was increased significantly with the increasing level of residual of P in

**Table I. Physical and chemical characteristics of the two soils used**

| Depth (cm) | Loam | | Clay Loam | |
|---|---|---|---|---|
| | 0-15 | 15-30 | 0-15 | 15-30 |
| $pH_s$ | 7.70 | 7.60 | 7.60 | 7.50 |
| $EC_e$ (d $Sm^{-1}$) | 1.29 | 1.18 | 0.87 | 0.68 |
| $CaCO_3$ (%) | 2.43 | 2.42 | 4.48 | 4.30 |
| Available K(mg $kg^{-1}$) | 165 | 149 | 204 | 210 |
| Organic matter (%) | 0.66 | 0.60 | 0.78 | 0.73 |

**Table II. Olsen P content (mg $kg^{-1}$) at pre sowing of Sorghum**

| Treatments | P applied to wheat (kg $ha^{-1}$) | Loam | Clay Loam |
|---|---|---|---|
| $T_1$ | 0 | 2.10 g | 2.42 g |
| $T_2$ | 25 | 4.62 f | 4.12 f |
| $T_3$ | 50 | 5.98 e | 6.52 e |
| $T_4$ | 75 | 8.12 d | 8.06 d |
| $T_5$ | 100 | 11.56 c | 10.76 c |
| $T_6$ | 125 | 16.82 b | 14.38 b |
| $T_7$ | 150 | 20.36 a | 19.14 a |

Means sharing the same letters are non significant at 5 % level of probability

**Table III. Effect of residual Phosphorus on sorghum fodder yield (t. $ha^{-1}$)**

| Treatments | P applied to wheat (kg $ha^{-1}$) | Fresh Wt. | | Oven dry Wt. | |
|---|---|---|---|---|---|
| | | Loam | Clay Loam | Loam | Clay Loam |
| $T_1$ | 0 | 31.16 g | 29.33 f | 7.04 g | 5.78 g |
| $T_2$ | 25 | 35.43 f | 33.40 e | 8.01 f | 6.32 f |
| $T_3$ | 50 | 36.53 e | 39.90 d | 8.26 e | 7.04 e |
| $T_4$ | 75 | 41.27 d | 43.87 c | 9.32 d | 7.86 d |
| $T_5$ | 100 | 42.60 c | 44.93 c | 9.36 c | 8.01 c |
| $T_6$ | 125 | 45.33 b | 47.20 b | 10.25 b | 9.32 b |
| $T_7$ | 150 | 46.83 a | 50.37 a | 10.59 a | 9.92 a |

Means sharing the same letters are non significant at 5 % level of probability

**Table IV. Residual effect of Phosphorus on P conc. and P uptake in sorghum fodder**

| Treatments | P applied to wheat (kg $ha^{-1}$) | P Concentration (%) | | P uptake (kg $ha^{-1}$) | |
|---|---|---|---|---|---|
| | | Loam | Clay Loam | Loam | Clay Loam |
| $T_1$ | 0 | 0.104 e | 0.109 f | 7.31 f | 6.30 f |
| $T_2$ | 25 | 0.118 d | 0.123 e | 9.48 e | 8.09 e |
| $T_3$ | 50 | 0.122 d | 0.140 d | 10.08 e | 10.90 d |
| $T_4$ | 75 | 0.131 c | 0.149 c | 12.24 d | 12.88 c |
| $T_5$ | 100 | 0.138 b | 0.156 b | 13.32 c | 13.79 c |
| $T_6$ | 125 | 0.145 a | 0.171 a | 14.82 b | 15.93 b |
| $T_7$ | 150 | 0.150 a | 0.174 a | 15.87a | 17.27 a |

Means sharing the same letters are non significant at 5 % level of probability both the soils. The values were more in clay loam soil than loam soil of both the parameters. The results are confirmed by the findings of Buah *et al.* (2000) and Sahrawat (2000). Alavarez *et al*. (2000) also reported similar results.

Estimates of fertilizer use efficiency usually differ depending upon the climate, crop and soil conditions and fertilizer parameters (fertilizer kind, rate, time and method of application) and management practices. The results regarding the effect of residual phosphorus on phosphorus use efficiency (PUE) of sorghum are presented in Table V. The analysis of variance showed that there was a significant difference between the treatments. In case of loam soil, maximum PUE was noted in $T_2$ (4.62 mg $kg^{-1}$ residual P) which was 8.68% , while in clay loam soil it was noted in $T_3$ (6.52 mg $kg^{-1}$ residual P) with value of 9.20%. It was further noted that all other rates remained non significant with each other while minimum values were recorded in $T_3$ (5.95 mg $kg^{-1}$ residual P) in loam soil having value of 5.53% and $T_2$ (4.12 mg $kg^{-1}$ residual P) in clay loam soil with a value of 7.17%. The results are in line with Buah *et al*. (2000), Alvarez *et al.* (2000), Niraj *et al*. (2001) and Daba and Zewedie (2001).

The data regarding the Olsen P content in soil at post harvest of sorghum fodder in both the soils is depicted in Table VI. The data showed that the same trends as in case of Table II but the values were decreased. Treatments remained significantly different with each other and maximum values were noted in $T_7$ in both the soils where phosphorus was applied @ 150 kg $P_2O_5$ $ha^{-1}$. The results are supported with the work of Ram *et al*. (1993), Zhu *et al*. (1994) and Rathi and Yadav (1992)

**Table V. Residual effect of Phosphorus on the PUE (%) by sorghum fodder**

| Treatments | P applied to wheat (kg $ha^{-1}$) | Loam | Clay Loam |
|---|---|---|---|
| $T_1$ | 0 | - | - |
| $T_2$ | 25 | 8.68 a | 7.17 b |
| $T_3$ | 50 | 5.53 c | 9.20 a |
| $T_4$ | 75 | 6.58 b | 8.77 a |
| $T_5$ | 100 | 6.01 b | 7.49 a |
| $T_6$ | 125 | 6.01 b | 7.71 a |
| $T_7$ | 150 | 5.71 b | 7.31 a |

Means sharing the same letters are non significant at 5 % level of probability

**Table VI. Olsen P content (mg $kg^{-1}$) at post harvest of sorghum**

| Treatments | P applied to wheat (kg $ha^{-1}$) | Loam | Clay Loam |
|---|---|---|---|
| $T_1$ | 0 | 2.04 g | 2.18 g |
| $T_2$ | 25 | 3.36 f | 3.82 f |
| $T_3$ | 50 | 4.48 e | 4.82 e |
| $T_4$ | 75 | 6.10 d | 5.32 d |
| $T_5$ | 100 | 8.00 c | 6.90 c |
| $T_6$ | 125 | 10.92 b | 8.27 b |
| $T_7$ | 150 | 13.06 a | 9.84 a |

Means sharing the same letters are non significant at 5 % level of probability

## REFERENCES


Alvarez, V.H., R.F. Novais, L.E. Dias and J.A. Oliveira, 2000. *Boletim–Information–da–Scoiedade–Brasilera–d–Ciencia–do–Solo*., 25: 27–32

Amrani, M., D.G. Westfall, and L. Mughli, 1999. Evaluation of residual and cumulative phosphorus effects in contrasted Moroccan calcareous soils. *Nutrient Cycling in Agro Ecosystems* 55: 231–8

Buah, S.S.J., T.A. Polito and R. Kollorn, 2000. No tillage soybean response to banded and broadcast and direct and residual fertilizer phosphorus and potassium application. *Agron. J*., 92: 657–62

Daba, S. and E. Zewedie, 2001. Evaluation of the residual value of phosphorus fertilizer for sorghum (*Sorghum bicolor* L.) grown on a vertisol. *Bodenkultur*., 52: 175–81

Mehdi, D.N. and S.K. De Datta, 1997. Residual effect of fertilizer phosphorus in lowland rice. *Nutrient Cycling in Agro Ecosystems*., 46: 189–93

Memon, K.S., 2001. Soil and fertilizer phosphorus. *In*: E. Bashir and R. Bentel (eds.) Soil Science, pp: 306–7. National Book Foundation, Islamabad, Pakistan

Moodie, C.D., H.W. Smith and P.R. McCreery, 1959. *Laboratory Manual of Soil Fertility*. p: 175. Stat College of Washington, D.C. USA.

Niraj, S., S.D. Sah and S. Singh, 2001. Residual effect of phosphorus and green manuring on wheat in rice–wheat sequence. *Environ. and Ecology*., 19: 409–11

Ram, S., R.S. Dhukia, S. Kanwar and K. Singh, 1993. Effect of residual phosphorus applied to forages and nigrogeon on maize yield Crop Res. *Hisar*., 6: 362–9

Rathi, K.S. and A.K. Yadav, 1992. Response of succeeding wheat to residual effect of phosphorus, method of sowing and topping operations assigned to summer–sown pigeon pea. *Indian J. Agron*., 37: 178–9

Rashid, A., 1994. Phosphorus use efficiency in soils of Pakistan. In proc. *Fourth National Congress of Soil Science*, Islamabad, May 22–24, 1992. Soil Science Society of Pakistan.

Sahrawat, K.L., 2000. Criteria for assessment of the residual value of fertilizer Phosphorus, *J. Indian Soil Sci. Soc*., 48: 113–8

Shaukat, A., Farmanullah, M. Afzal, J.K. Khattak, A.U. Bhatti, M. Shah and S. Ali, 1992. Two years study on the yield response of maize to residual soil phosphorus. *Sarhad J. Agri*c., 8: 495–502

Singaram, P. and G.V. Kothandaraman, 1994. Studies on residual, direct and cumulative effect of phosphorus source on the availability, content and uptake of phosphorus and yield of maize. *Madras Agri. J*., 81: 425–9

Steel, R.G.D. and J.H. Torrie, 1980. *Principles and Procedures of Statistics. A Biometrical Approach*. 2nd Ed. Mc. Graw–Hill Book Corp. Inc; NY, USA

Tandon, H.L.S., 1987. *Phosphorus Research and Agricultural Production in India*. pp: 40–1. Fertilizer Development and Consultation Organization, New Delhi

Tisdale, S.L., W.L., Nelson, J.D. Beaton and J.L. Havlin, 1997. *Soil Fertility and Fertilizer*, p: 203–4. 5th Ed. Prentice Hall of India Pvt. Ltd. New Dehli–110001

Tomar, N.K., R.S. Pundir and M.K. Sharma, 1999. Residual efficiency of diammonium orthophosphate and ammonium polyphosphate to maize crop in wheat–maize–maize cropping system on a typic Ustochrept varying in available phosphorus. *Ann. Agric. Biol. Res*., 4: 125–33

U.S. Salinity Lab. Staff, 1954. *Diagnosis and Improvement of Saline Alkali Soils*, p. 160. USDA Hand Book No. 60, Washington, D.C.

Watanabe, F.S. and S.R. Olsen, 1965. Test of an ascorbic acid method for determining P in water and bicarbonate extracts from soil. *Soil Sci. Soc. America Proc*., 29: 677–8

Zhu, X., C.Y. Cao, R.H. Shi and X.P. Zhu, 1994. Estimating residual phosphate in calcareous soils in Xuzhou– Huaiyin district. III. Forms and availability of residual phosphorus. *J. Nanjing Agri. Univ*., 17: 60–5


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