Pak. J. Agri. Sci., Vol. 44(1), 2007

EFFECT OF RESIDUAL PHOSPHORUS ON THE YIELD AND QUALITY OF SORGHUM FODDER IN THREE DIFFERENT TEXTURED CALCAREOUS SOILS

M. Rashid[1], A.M. Ranjha*, M. Waqas*, A. Hannan* and A. Bilal*
[1]Directorate of Small Ruminants Punjab, L&DD, Multan
Research & Development, Rakh Khairewala, District Layyah
(mruaf@yahoo.com)
*Institute of Soil and Environmental Sciences, UAF.

A field experiment was conducted to observe the effect of residual phosphorus on the yield and quality of sorghum fodder in three soils i.e. Loamy sand (Torripsamment), clay loam (Ustochrept) and sandy clay loam (Haplargid).Different quantities of residual P in different soils significantly improved the fresh yield (t ha^{-1}) and quality traits like dry matter content, P concentration in plant, crude protein and crude fiber content (%) in sorghum fodder. Maximum fodder yield of 36, 45 and 37 t ha^{-1} was obtained where residual P was 26, 33 and 31 mg P kg^{-1} in sandy loam, clay loam and sandy clay loam soils, respectively. After the harvest of sorghum fodder, still adequate quantity of residual P was there in all the soils.
Keywords: Residual P, sorghum fodder, quality, calcareous soils

INTRODUCTION

P is one of the major essential plant nutrients after N and is the second most deficient plant nutrient as >90 % soils of Pakistan require moderate to high P for optimum crop growth (Rashid, 1994). The efficiency of P 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 soil resulting in its conversion into forms, which are not available to crops (Larsen, 1987 and Delgado *et al*, 2002). Residual effect of phosphorus refers to the carry over effect of applied P on the succeeding crops. 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, and type of crop, yield levels and extent of P removal (Tandon, 1987 and Ogoke, 2006). Residual P accumulates in the soil when P fertilization exceeds its utilization by crops. Continuous use of fertilizer P in excess of crop needs, results in a gradual increase in available P status of a soil. The duration of response will be influenced by amount of residual P (Shaukat *et al*, 1992, Mehdi and De Data, 1997, Daba and Zewedie, 2001, Memon, 2001 and Eijk *et al*, 2006). The quality of certain fruits, forage, vegetable and grain crops is said to be improved when these crops have satisfactory P nutrition (Tisdale *et al*, 1985).It was also reported that P application on low P soils gave higher yield and superior crop quality (Cisar *et al*,.1992).It has also been observed that crop give better response to applied P than to residual P (Singaram and Kothandaraman, 1994). Quality fodder is important for livestock. Use of P along with N and K is known to increase the yield (Patel *et al*, 1997 and Ayub *et al*, 2002), crude protein, crude fiber, DM, ash contents and P concentration (%) in maize (Chaudhary and Karwasra, 1984, Hussain, 1991, Ayub *et al*, 1999 and Cheema, 2000). Keeping all this in view a field study was conducted with the objective "To see the effect of residual P on yield and quality of sorghum fodder in three different textured calcareous soils".

MATERIALS AND METHODS

Field experiments were carried out to observe the residual effect of P (applied to oat fodder crop) on sorghum fodder under farmer's field conditions. Three soils varying in Physico chemical properties (table I) were selected. Soil samples were collected from ten plots to assess the effect of residual P on sorghum fodder in three repeats laid out according to RCBD. Nitrogen and potash were applied @ 80 and 70 kg ha^{-1} to all the plots. The sorghum fodder was harvested at head initiation stage and fresh fodder yield was recorded. Dry matter content (%) was determined by taking fresh and oven dry weight of the plant samples. Plant samples were ground and analyzed for P concentration, crude protein and crude fiber contents (%) (AOAC, 1995). After the harvest of crop, soil samples were again collected from each plot and analyzed for Olsen P. 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 analyzed using Analysis of Variance technique as described by Steel and Torrie (1980).

Table III. Effect of residual P on P concentration (%) in sorghum

Residual P	Sandy loam	Residual P	Clay loam	Residual P	Sandy clay loam
mg P kg^{-1}	%	mg P kg^{-1}	%	mg P kg^{-1}	%
4	0.10 h	5	0.12 j	7	0.11 i
6	0.13 g	8	0.14 i	9	0.13 h
11	0.16 f	11	0.15 h	12	0.13 h
17	0.17 ef	14	0.16 g	13	0.15 g
18	0.18 d	17	0.17 ef	15	0.17 ef
20	0.18 d	21	0.18 d	18	0.19 d
22	0.20 c	24	0.18 d	22	0.20 c
23	0.20 c	26	0.19 c	25	0.21 b
24	0.21 b	30	0.21 b	28	0.21 b
26	0.22 a	33	0.22 a	31	0.21 a

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

Crude protein (CP) and crude fiber (CF) contents (%) in sorghum

The data regarding effect of residual P on CP and CF contents are presented in table IV and V. The CP and CF contents (%) increased significantly with increasing residual P. The maximum CP and CF contents (%) were 10.35, 8.38, 9.75 and 30.75, 30.14, 30.32 % in sorghum fodder where residual P was 33, 26 and 31 mg P kg^{-1} at clay loam, loamy sand and sandy clay loam soils, respectively. The minimum CP and CF contents (%) were 5.88, 6.51, 6.56 and 28.39, 28.15,

Table IV. Effect of residual P on crude protein contents (%) in sorghum

Residual P	Sandy loam	Residual P	clay loam	Residual P	Sandy clay loam
mg P kg^{-1}	%	mg P kg^{-1}	%	mg P kg^{-1}	%
4	6.51 e	5	5.88 g	7	6.56 h
6	7.25 e	9	6.05 g	9	6.84 g
11	7.31 e	11	6.29 f	12	7.17 f
17	7.33 e	14	7.15 e	13	7.28 f
18	7.54 de	17	7.47 d	15	7.33 ef
20	7.73 cd	21	7.73 d	18	7.48 e
22	7.88 bc	24	8.16 c	22	8.20 d
23	8.06 ab	26	9.32 b	25	8.38 c
24	8.16 ab	28	10.17 a	28	9.45 b
26	8.38 a	31	10.35 a	31	9.75 a

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

Table V. Effect of residual P on crude fiber contents (%) of sorghum fodder

Residual P	Sandy loam	Residual P	Clay loam	Residual P	Sandy clay loam
mg P kg^{-1}	%	mg P kg^{-1}	%	mg P kg^{-1}	%
4	28.15 d	5	28.39 c	7	28.44 c
6	28.19 d	9	28.67 c	9	28.49 c
11	28.21 d	11	28.77 c	12	28.69 bc
17	28.26 d	14	29.51 b	13	28.83 bc
18	28.39 d	17	29.68 b	15	28.85 bc
20	28.84 c	21	30.29 a	18	29.25 b
22	29.00 c	24	30.33 a	22	29.80 a
23	29.38 b	26	30.66 a	25	30.08 a
24	30.07 a	28	30.67 a	28	30.17 a
26	30.14 a	31	30.75 a	31	30.32 a

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

28.44 % from control plots at clay loam, sandy loam and sandy clay loam soils, respectively. It was reported by Chaudhary and Karwasra (1984) and Hussain (1991) that crude protein contents increased with increase in P application. Similarly Ayub *et al* (2002) reported that CP and CF contents (%) increased significantly with increasing level of N and P. This increase in crude protein content was due to the fact that P is involved in protein synthesis (Mengel and Kirkby, 2001). This increase in crude fiber content was due to the dry matter accumulation with P application (Chand *et al*, 1992).

Available P status of soils at post harvest of sorghum fodder

Crop seldom absorb more and often less than 20 % of fertilizer P during the first cropping season after application (Tandon, 1987). P fertilizers have long lasting residual effects on succeeding crops and due to accumulated residues, the level of soil P gradually raises contributing more to phosphorus pool available to growing plants (Harapiak and Beaton, 1986). As the sorghum fodder was raised on the residual P applied to previous oat crop, so a marked reduction in Olsen P was observed (table VI) and the values decreased after sorghum harvest. But still there was sufficient available P for raising an other crop after sorghum. Maximum values of 22, 18 and 18 mg kg^{-1} were observed where residual P was 33, 26 and 31mg kg^{-1} after oat in clay loam, sandy loam and sandy clay loam soils respectively. Native Olsen P further dropped to 4.08, 3.59 and 5.48 mg kg^{-1} in the clay loam, sandy loam and sandy clay loam soils, respectively. The results also get support from those of Rathi and Yadav (1992), Ram *et al.* (1993), Zhou *et al.* (1994), Singaram and Kothandaraman (1994) , Amrani *et al.* (1999), Ejik *et al.*(2006) and Sharma *et al.* (2006).

Table VI. Olsen P (mg P kg^{-1}) after harvesting sorghum fodder

Sandy loam		Clay loam		Sandy clay loam	
Pre sowing	Post harvesting	Pre sowing	Post harvesting	Pre sowing	Post harvesting
mg P kg^{-1}					
4	3.59j	5	4.08j	7	5.48j
6	6.58i	9	6.58i	9	4.07i
11	8.08h	11	8.08h	12	5.32h
17	9.08g	14	9.07g	13	10.07g
18	10.07f	17	11.06f	15	13.36f
20	11.07e	21	13.06e	18	14.06e
22	12.57d	24	16.57d	22	16.11d
23	14.56c	26	19.55c	25	16.71c
24	16.55b	30	20.54b	28	17.50b
26	18.05a	33	22.04a	31	18.45a

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 Cycl. Agro Ecosys. 55: 231–238 (8).

AOAC. 1995. Official methods of Analysis, 16th ed. Association of official Analytical Chemists, Washington, DC.

Ayub, M., A. Tanveer, K. Mahmud, A. Ali and M. Azam. 1999. Effect of Nitrogen and Phosphorus on the fodder yield and quality of two sorghum cultivars (*Sorghum bicolor* L.).Pakistan J.Biol.Sci.2 (1):247-250.

Ayub, M., M.A. Nadeem, M.S. Sharar and N. Mahmood. 2002. Response of maize (*Zea mays* L.) fodder to different levels of Nitrogen and Phosphorus. Asian J. Plant Scie.1(4): 352-354.

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. Agronomy J., 92: 657–662.

Chand, K., M.L. Dixit and S.K. Arora. 1992. Yield and quality of forage sorghum as affected by phosphorus fertilization. J. Indian Soc. Soil Sci. 40:302-306.

Chaudhary, S.L. and S.P.S. Karwasra. 1984. Effects of Phosphorus application on yield and quality of forage sorghum. Nepalese J.Agric.15:27-32.

Cheema, H.N.A. 2000. Yield and quality response of maize (*Zea mays* L.) fodder grown on different levels phosphorus and seedling densities. M.Sc. (Hons.) Agric. Thesis. Dept. Agron. Univ. Agric. Faisalabad, Pakistan.

Cisar, G.D., G.H. Snyder and G.S. Swanson. 1992. Nitrogen, P and K fertilization for Histosols grown St. Augustine grass sod. Agronomy J.84 (3):475-479.

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: 175–181.

Delgado, A., J.R. Ruiz, M.C. del. Campillo, S. Kassem, and L. Anbdreu. 2002. Calcium and Iron related Phosphorus in calcareous and calcareous marsh soils: Sequential chemical fractionation and 31 P NMR study. Commun. Soil Sci. and plant Anal. 31:2483-2499.

Eijk, D.V.D., B.H. Janssen and O. Oenema. 2006. Initial and residual effects of fertilizer phosphorus on soil phosphorus and maize yields on phosphorus fixing soils. Agri. Ecosystem and Environment.116 (1-2):104-120.

Harapiak, J.T. and J.D. Beaton. 1986. Review of Phosphorus fertilizer, considerations for maximum yields in the great plant. Jour. Fert. Issues. 3 (3): 113-123.

Hussain, A. 1991. Effects of different phosphorus application on growth and yield behaviour of maize. M.Sc. (Hons.) Agric. Thesis. Dept. Agron. Univ. Agric. Faisalabad, Pakistan.

Larsen, S. 1987. Soil phosphorus. Adv.Agron.19:151-210.

Mehdi, D.N. and S.K. De Datta. 1997. Residual effect of fertilizer phosphorus in lowland rice. Nutrient Cycling in Agro Ecosystems.,46: 189–193.

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

Mengel, K. and E.A. Kirkby. 2001. Principles of plant nutrition.5th (ed.). Kluwer Academic Publishers, London.

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: 409–411

Ogoke, I.J. 2006. Rsidual effects of Phosphorus and soybean crop on maize in the Guinea Savanna. Proc.18th world congress of Soil Science. Philadelphia, Pennsylvania, USA. 9-15 July, 2006, pp: 15-25.

Patel, J.R., K.R. Thaker, A.C. Patel and H.P. Parmar. 1997. Effects of seed rate and nitrogen and phosphorus level on forage maize varities. Gujrat Agric. Uni. Res. J. 23:1-8.

Ram, S., R.S. Dhukia, S. Kanwar and K. Singh. 1993. Effect of residual phosphorus applied to forages and nitrogen on maize yield. Crop Res. Hisar., 6: 362–369.

Rashid, A., 1994. Phosphorus use efficiency in soils of Pakistan. Proc. 4th National Congress of Soil Science, Islamabad, May 22–24, 1992. Soil Science Society of Pakistan.

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: 178–179.

Sahrawat, K.L. 2000. Criteria for assessment of the residual value of fertilizer Phosphorus. Jour. Indian Soil Sci. Soc., 48: 113–118.

Sharma, K.L., K.V. Padmaja, M.S. Reddy, P.C. Rao, J.K. Grace, K.S rinivas and V. Ramesh. 2006. Direct and Residual effects of Phosphorus fertilization of rainfed sorghum (*Sorghum vulgare* L.) and its effect on P adsorption and availability in semi-arid tropic Alfisols. 18th World Congress of Soil Science, July 9-15, 2006, Philadelphia, Pennsylvania, USA.

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. Agric., 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: 425–429.

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

Tandon, H.L.S. 1987. Phosphorus Research and Agricultural Production in India. 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: 203–204. 5th Ed. Prentice Hall of India Pvt. Ltd. New Dehli–110001

Tisdale, S.L., W.L. Nelson and J.D. Beaton. 1985. Soil fertility and fertilizers.4th (ed.) McMillan Pub. Co. NY, USA.

Tomar, N.K. 2000.ynamics of phosphorus in soils. J. Indian Soc. Soil Sci. 48(4):640-673.

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: 125–133.

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., 29:677–678.

Zhou, 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: 60–65.