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Full Length Research Paper

Studies on the effect of residual and applied phosphorus on the yield and quality of fodder sorghum based cropping system and relative economics of the system

Manzoor Ahmad Ganai[1]*, Amarjeet S. Bali[2], M. A. Bhat[1]* and I. A. Bhat[2]

[1]Rice Research and Regional Station, Khudwani, India.

[2]Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu, India.

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The experiment was carried out with the objective of studying the effect of phosphorus application timings and its sources in wheat-sorghum cropping system during rabi 2004 and kharief 2005, at the main campus Chatha of Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, India. The soil was loamy in texture, neutral in reaction with low available nitrogen (N), phosphorus (P) and organic carbon (OC) and medium in available potassium (K). The treatments comprises of two factors viz. four P application timings to preceding wheat crop while the second factor which comprises of four sources of P applied to the succeeding sorghum fodder crop were laid out in split plot design. Studies indicated that wheat crop performed better with basal application of P than its delayed application through improvement in P up-take. However, in subsequent sorghum fodder crop, delayed application of P in preceding wheat crop proved instrumental in production of higher fodder yield. Among the sources used farmyard manure (FYM) as a source of P in sorghum, caused phenomenal increase in growth parameters. Delayed application of P in wheat and application of P in sorghum through different sources favoured crude protein content. However, effect on crude fibre content of the fodder sorghum was not significant. Delayed application of P in wheat followed by recommended P through FYM in sorghum proved beneficial with a benefit cost ratio ranging from 2.07 to 2.08.

Key words: Yield, quality, economics, phosphorus sources, residual effect, wheat-sorghum.

INTRODUCTION

In Jammu and Kashmir state, India, only 2% of the cultivable area is used for fodder production as against 4.4% area at country level (Misri, 1998). The main reason for such a scenario is the primary importance being given to food crops for human consumption. Most of the fodder requirement is met from alpine and sub- alpine pastures, village grazing land, crop residues and the fodder produced from cultivable lands, which are almost negligible. Very little efforts have been made to produce fodder to meet the requirement of 91.25 lakh live stock population in the state (Anonymous, 2003-2004). As a matter of fact, the fodder requirement for the above live stock population works out to be 6.00 million tonnes as against the availability of 2.74 million tonnes (Misri, 1997). To sustain such a huge live stock population, there is a dire need for the production of nutritious fodders like maize, sorghum, legumes among others through inclusion in the cropping systems in order to make up for the fodder deficit. Among the various nutrients, phosphorus is a more expensive input and its availability and mobility in the soil, absorption and up take by the plants are important considerations affecting its efficient use. Phosphorus plays important roles in the growth and development of roots, grain formation and crop maturity. It is a constituent

*Corresponding author. E-mail: manzoorfummu45@yahoo.co.in

Table 1. Influence of residual and applied sources of phosphorus on fresh and dry fodder yield of sorghum fodder crop.

Treatments	Fresh fodder yield (q ha^{-1})			Dry fodder yield (q ha^{-1})		
	1st cut	2nd Cut	Total	1st cut	2nd Cut	Total
P schedules in wheat						
Basal (T1)	398.7	197.4	594.8	103.2	45.5	148.7
10 DAS (T2)	412.8	209.8	625.5	106.0	49.4	155.4
20 DAS (T3)	414.4	212.2	627.2	108.3	50.0	158.3
30 DAS (T4)	416.5	214.6	630.9	109.1	50.8	159.9
CD (P = 0.05)	5.3	5.1	5.5	3.3	1.6	4.7
P sources in sorghum						
Control (P0)	387.4	187.6	575.0	95.3	42.0	137.3
Recommended(P1)	419.9	217.4	638.0	112.1	50.4	162.5
FYM (P2)	431.0	224.8	655.8	117.2	55.8	173.0
PSB (P3)	405.0	204.4	609.6	101.9	47.0	147.9
CD (P = 0.05)	9.3	6.9	9.1	4.2	3.0	5.0

P schedules × P sources = NS, DAS = days after sowing.

of de-oxyribose nucleic acid (DNA), ribose nucleic acid (RNA) and is required for the accumulation and release of energy during cellular metabolism. Phosphorus moves very slowly from its point of placement, as phosphate ion is almost immobile and gets fixed. Only a quarter of applied phosphorus becomes available for the plant up-take. The characteristics of the phosphorus source, time of its application, properties of soil are important considerations in a cropping system for the efficient utilization of phosphorus. So this study was made to evaluate the effect of residual and applied phosphorus through organic and inorganic sources on the yield and quality of fodder sorghum crop in wheat based cropping system.

MATERIALS AND METHODS

A field experiment with an objective to study the effect of P application timings and its sources on wheat-sorghum cropping system was conducted during *rabi* 2004 and *Kharif* 2005 at Chatha campus of Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, India. The soil with loamy texture tested neutral in reaction with available N 248 kg ha^{-1}, Phosphorus Pentoxide (P_2O_5) 10.77 kg ha^{-1}, Potassium oxide (K_2O) 166 kg ha^{-1} and organic carbon of 0.43%. The treatments comparing two factors of four phosphorus application timings to the preceding wheat crop and four sources of phosphorus applied to fodder sorghum were laid out in a split plot design. Recommended doze of phosphorus (50 kg ha^{-1}) was applied to preceding wheat as basal (T1), 10 days after sowing (T2), 20 days after sowing (T3) and 30 days after sowing (T4) in the main plots. N and K_2O were uniformly applied at 100 and 20 kg ha^{-1} as per the recommendations. Phosphorus was applied to fodder sorghum through different sources viz. no phosphorus (P0), Phosphorus through diammonium phosphate (DAP) at 60 kg ha^{-1} (P1), phosphorus through FYM equivalent to recommended phosphorus (P2) and inoculation with phosphorus-solubilizing bacteria (PSB) (P3) as the treatments applied to the sub-plots. Wheat crop was irrigated pre sown and at critical stages and sorghum was irrigated as per requirement and after first cut. Grain and straw yield of wheat were recorded at harvest. Two cuts were taken from sorghum crop, first 60 days after sowing (DAS) and the second cut 120 DAS. Plant height and dry matter accumulation in sorghum were recorded at 30, 60, 90 and 120 DAS. The crude protein of grounded samples of sorghum was determined by using Subbaih and Asija's (1956) method and was obtained by multiplying nitrogen content with a factor of 6.25. However, crude fibre content was determined using procedure of AOAC (1995). The formulae used for crude protein and crude fibre determinations are shown below:

$$\text{Crude protein (\%)} = \frac{A \times (B-B_c) \times 0.0014 \times 100 \times 6.25}{C \times W}$$

Where, A = Volume (ml) made out of digested samples, B = volume (ml) of standard (N/10) H_2SO_4 consumed for titration of samples, C = volume (ml) of aliquot taken from distillation, B_c = volume of standard (N/10) H_2SO_4 consumed for titration of blank distillate, W = Weight of sample.

$$\text{Crude fibre (\%)} = \frac{(X - Y) \times 100}{W}$$

Where, X = Weight (g) of silica basin plus oven dried residue left after acid and alkali digestion, Y = Weight (g) of silica basin plus ash, W = Weight (g) of oven dried samples (g).

The data for different characters were analyzed statistically according to the procedure given by Cochran and Cox (1963).

RESULTS AND DISCUSSION

Fresh and dry fodder yield of sorghum at 1st and 2nd cut indicated significant improvement under delayed phosphorus application over basal application in the proceeding wheat crop (Table 1). Total dry and fresh fodder yields also followed similar trends. Delay in

Table 2. Effect of residual and applied sources of phosphorus on crude protein (%) and crude fibre (%) content of fodder sorghum.

Treatments	First cut (60 DAS)		Second cut (120 DAS)	
	Crude protein	Crude fibre	Crude protein	Crude fibre
P schedules in wheat				
Basal (T1)	8.08	22.9	5.17	26.8
10 DAS (T2)	8.13	22.9	5.20	26.7
20 DAS (T3)	8.17	22.9	5.22	26.8
30 DAS (T4)	8.18	22.9	5.23	26.8
CD (P = 0.05)	NS	NS	NS	NS
P sources in sorghum				
Control (P0)	7.90	22.3	5.02	26.3
Recommended (P1)	8.22	23.4	5.26	27.4
FYM (P2)	8.32	23.3	5.29	27.2
PSB (P3)	8.12	22.6	5.24	26.3
CD (P = 0.05)	0.17	NS	0.18	NS

DAS = Days after sowing; P x S = Non significant.

P application timings from 10 to 30 DAS in wheat did not result in any significant improvement in both fresh and dry fodder yield of sorghum. Application of P at 30 DAS inwheat improved fresh fodder yield by 4.32 and 8.67% over basal application of P in wheat at 1st and 2nd cut of the fodder sorghum, respectively. The increase in the total fresh fodder yield was due to delayed application schedule, that is, 10, 20 and 30 DAS over basally applied P in preceding wheat crop ranged from 26.5 to 35.09 q ha^{-1}. The corresponding per cent improvement in the dry fodder yield increase ranged from 0.74 to 5.72 for first cut and 1.60 to 11.64 for the second cut.

The higher fodder yield of sorghum recorded under delayed P application schedules appeared to be associated with the additive effect of higher plant height, dry matter accumulation favoured due to higher availa-bility of soil phosphorus, which may have favoured better root development, cell division and expansion and there by resulted in the production of higher biomass. Patel et al. (1997) and Jat and Shaktawat (2003) have reported similar results. The fresh fodder yield and its subsequent dry fodder yield, at 1st and 2nd cut, recorded significant highest fodder yield with the application of P through FYM than obtained with other sources (Table 1) . The magnitude of superiority in the total fresh fodder yield with FYM was 2.71, 7.04 and 12.32% over DAP, PSB and control (no P), respectively, whereas the corres-ponding values of superiority with regard to total dry fodder yield were 6.07, 14.5 and 20.64%. The superiority exhibited by FYM as P source over other sources (DAP and PSB) may be attributed primarily to the beneficial role of FYM in improving the soil physico-chemical properties due to the formation of organic acids during the process of decomposition. The results were in line with those of Singh et al. (2004). The superiority of FYM as P source over DAP may be ascribed to decrease in phosphate fixation due to presence of sufficient phosphorus organic matter which by the formation of sufficient phospho- humic complexes were being easily assimilated by the plants. The results corroborate the findings of Tiwari (2002). Furthermore, the lower efficiency of PSB as source of phosphorus in sorghum in the present study could be attributed to lower supply of carbon for the growth and activity of microorganisms.

Although residual P could not influence the crude protein content of sorghum at both cuts, the P source (FYM) which was at par with DAP recorded significantly higher crude protein than PSB and no P application at first cut. Subsequently at the second cut, all the sources remained at par but superior over no P application (Table 2). The increased root biomass associated with higher available P may have improved the nutrient up-take including nitrogen nutrient and also phosphorus being component of ATP the energy carrier for the metabolic processes. This might have directly contributed to large photosynthetic activity and synthesis of higher protein content. Similar results were found by Mukherjee and Rai (2000), Ayoub et al. (2002) and Patidar and Mali (2004). Various treatments did not produce any effect in the crude fibre content of the sorghum fodder at any of the cuts (Table 2). Patel et al. (1994) and Cheema (2000) also did not notice any effect on crude fibre content of sorghum fodder with the phosphorus fertilization.

Relative economics of the cropping system

Relative economics of the sorghum -wheat sequence on the basis of grain and straw yield of wheat and fresh fodder yield of sorghum worked out is presented in

Table 3. Economics of sorghum-wheat sequence as influenced by applied and residual phosphorus (Rs. ha^{-1}).

Treatments	Total cost of cultivation	Gross return			Net returns	B:C Ratio
		Wheat	Sorghum	Total		
T1P0	29682	28181	55842	84023	54341	1.83
T1P1	31242	28181	61501	89682	58440	1.87
T1P2	30267	28181	63044	91225	60958	2.01
T1P3	30112	28181	56970	85151	55039	1.83
T2P0	29682	26345	57565	83910	54228	1.83
T2P1	31242	26345	63310	89655	58413	1.87
T2P2	30267	26345	64210	90555	60288	1.99
T2P3	30112	26345	58277	84622	54510	1.81
T3P0	29682	26155	58887	85042	55360	1.87
T3P1	31242	26155	65102	91257	60015	1.92
T3P2	30267	26155	67095	93250	62983	2.08
T3P3	30112	26155	60319	86474	56362	1.87
T4P0	29682	25406	59311	84717	55035	1.85
T4P1	31242	25406	66009	91415	60173	1.93
T4P2	30267	25406	67558	92964	62697	2.07
T4P3	30112	25406	60677	86086	55971	1.86

Table 3. The data indicated that treatment combinations of delayed application of P in wheat 20 DAS followed by application of P through FYM in sorghum acquired highest net returns and benefit cost ratio corresponding to Rs. 62983/= $ha^{-1}$and 2.08, respectively, followed by values of Rs.62697/= ha^{-1} and 2.07 under treatment combinations of delayed application of P in wheat 30 DAS followed by application of P through FYM in sorghum. Treatment with P application 10 DAS in wheat and subsequently no P fertilization in sorghum crop recorded lowest returns (Rs. 54228/=). The higher output of the system may be the reason for realization of higher net returns and benefit cost ratio. Jat and Shaktawat (2003) also noticed improvement in the net returns and benefit cost ratio with the P application.

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