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Response of different sources and levels of phosphorus on yield, nutrient uptake and net returns on mungbean under rainfed condition

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Abstract: The result of the study indicated the application of phosphorus upto 40 kg P_2O_5 ha^{-1} recorded significantly higher number of pods per plant, number of seeds per pod, number of total and effective root nodules, test weight, seed and straw yield, nitrogen, phosphorus and potassium content in seed and straw and their uptake, protein content in seed and net return as compared to absolute control and 20 kg P_2O_5 ha^{-1} but was at par with 60 kg P_2O_5 ha^{-1}.Application of different sources of phosphorus led to significant effect on seed yield. PROM(8.36)was significantly superior in increasing the seed yield by 17.74 and 12.21 per cent, respectively, as compared to DAP (7.10) and SSP (7.45). However, both DAP and SSP being at par with each other. Application of phosphorus @ 40 (7.98) and 60 kg P_2O_5 ha^{-1} (8.44) significantly increased the seed yield by 22.95 and 30.04 per cent, respectively as compared to 20 kg P_2O_5 ha^{-1} (6.49). However, both 40 and 60 kg P_2O_5 ha^{-1} were at par with each other in increasing seed yield. The highest net return (Rs. 14865) was obtained with application of 40 kg P_2O_5 ha^{-1} over absolute control and 20 kg P_2O_5 ha^{-1} and phosphorus fertilization with PROM (Phosphorus Rich Organic Manure) fetched the highest net return (Rs. 14736 ha^{-1}) which was significantly higher over DAP and SSP.

Key words: Mungbean, PROM, Phosphorus levels, Growth, Yield, Nutrient content and uptake and Economics

Introduction

Pulses are the main source of protein particularly for vegetarians and contribute about 14 per cent of the total protein for an Indian average diet. Mungbean [*Vignaradiata* (Linn.)Wilczek], is a short duration *kharif* pulse crop, grown as catch crop also between *rabi*and *kharif* seasons, whereas, during summer, also be used as a green manure crop. Being a leguminous crop, it has the capacity to fix atmospheric nitrogen and green plants are used as fodder after removing the mature pods. Mungbean is an excellent source of protein (25%) with high quality of lysine (460 mg/ g N) and tryptophan (60 mg /g N). It also has remarkable quantity of ascorbic acid when sprouted and also bear riboflavin (0.21 mg/ 100 g) and minerals (3.84 g/ 100 g). In India mungbean occupies 3.0 million hectare area and contributes to 1.3 M tonnes and in Rajasthan the area under mungbean was 754598 hectares with the annual production of 205068 tonnes and productivity of 278 kg ha^{-1} (Anonymous, 2005-06). Phosphorus is an important nutrient next to nitrogen. Indian soils are poor to medium in available phosphorus. Only about 30 per cent of the applied phosphorus in available for crops and remaining part converted into insoluble phosphorus which is constituent of nucleic acid, ADP and ATP (Sharma and Khurana, 1997).It has beneficial effects on nodule stimulation, root development, growth and also hastens maturity as well as improves quality of crop produce. Thus the study of phosphorus to legumes is more important than that of nitrogen as later is being fixed by symbiosis with *Rhizobium* bacteria. PROM has to be a better source of phosphate application.The Indian soils are deficient in organic carbon. The rock phosphate which is a cheaper source of phosphorus but cannotapplied directly into the soil therefore enrichment of organic manure with rock phosphate can solve the both problem of the deficiency of phosphorus and organic carbon content of the soil.

Materials and Methods

A field experiment was conducted during the rainy (***kharif***) season of 2008 at Agronomy farm of SKN College of Agriculture, Jobner (Rajasthan) in western side at $26^0$05' North latitude, $75^0$28' East longitude and at an altitude of 427 metres above mean sea level. In Rajasthan, this region falls under Agro climatic zone III a Semi-Arid Eastern Plain Zone. To study the effect of different sources and levels of phosphorus on growth, yield, nutrient uptake and the economics involved. The experiment comprised of three sources of phosphorus (D.A.P., S.S.P., P.R.O.M.) three levels of phosphorus (20, 40, 60) and absolute control in each replication thereby making ten treatment combinationswere replicated thrice in randomized block design. Mungbean variety RMG-268 was developed at Agriculture Research Station, Durgapura (Jaipur), the plants mature in about 64-73 days. Drought resistance suitable for arid and semi-arid areas generally all pods of crop are mature at same time. The average yield of variety is 8-9 q ha^{-1} and suitable for sole cropping was used as a test crop in rows 30 cm apart using a seed rate of 20 kg/ha.Fertilizer details (i)Nitrogen is applied according to recommended dose of one hectare through urea and D.A.P. for management of fertility status of field (ii) Phosphorus as per treatment. Phosphorus was applied through D.A.P., S.S.P and P.R.O.M. fertilizer as per treatments as basal application in furrows and uniform dose of 25 kg nitrogen per hectare was applied as basal through urea. The experimental soil was loamy sand in texture, slightly alkaline in reaction (PH 8.27), poor in organic carbon (0.14%) available nitrogen (129.79 kg/ha), available potassium (150.64 kg K_2O/ha) and medium in phosphorus (16.01 kg P_2O_5 /ha). The climate of this region is a typically semi-arid, characterized by extremes of temperatures during both summers and winters. During summers the mean weekly weather parameters for the crop season recorded at college meteorological observatory have been depicted graphically in fig.1.

Results and Discussion

Growth characters: Application of phosphorus rich organic manure significantly increased the total and effective number of root nodules per plant as compared to DAP and SSP (Table:1). The total and effective number of root nodules per plant at 40 DAS increased significantly upto application of 40 kg P_2O_5 ha^{-1} over absolute control and 20 kg P_2O_5 ha^{-1}. So addition of PROM enhance the population and activity of *Rhizobium* bacteria in roots of mungbean and increase the number of effective and total root nodules. These results are in conformity with the findings of Sharma *et al.* (2001), Shanmugam (2001), Shakhawat and Sharma (2001).

Yield attributes and yield: That phosphorus application irrespective of sources and levels, significantly increased the number of effective nodules per plant as compared to control (no phosphorus). Among the different sources, phosphorus rich organic manure (32.27) significantly increased the number of effective nodules per plant by 13.02 and 10.89 per cent, respectively in comparison to diammonium phosphate (28.55) and single super phosphate (29.10). PROM (33.97) significantly increased the number of total nodules per plant by 11.81 and 10.11 per cent over DAP (30.38) and SSP (30.85), respectively (Table:1). The SSP and DAP remained statistically at par with each other. Application of 40 (30.53) and 60 kg P_2O_5 ha^{-1}(31.97) significantly increased the number of effective nodules per plant by 11.34 and 11.59 per cent, respectively as compared to 20 kg P_2O_5 ha^{-1} (27.42). However, both 40 and 60 kg P_2O_5 ha^{-1} were at par with respect to number of effective nodules per plant.Application of 40 (32.32) and 60 kg $P_2O_5ha^{-1}$ (33.93),

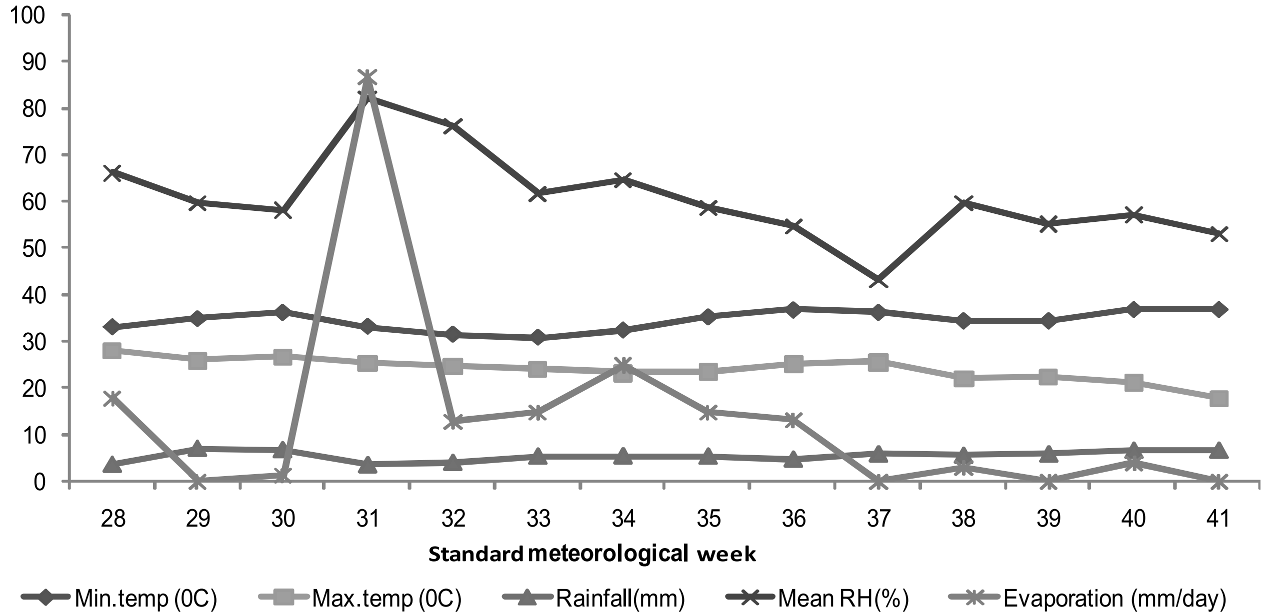

Fig. 1: Mean weakly meteorological data for crop season (kharif, 2008)

Table-1: Effect of different P sources and P levels on number of effective and total nodules and yield attributes

Treatment	Effective root nodule	Total root nodules	Pods / plant	Number of seeds / pod	Test weight (g)	Seed yield (q/ha)	Straw yield (q/ha)	Net returns (Rs ha^{-1})	B:C ratio
Control v/s others	23.21	25.16	21.16	7.95	29.05	4.15	7.15	4534	0.49
'F' test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
P sources									
DAP	28.55	30.38	27.06	10.01	31.45	7.1	12.18	12640	1.14
PROM	32.27	33.97	31.97	11.46	33.12	8.36	13.73	14736	1.12
SSP	29.1	30.85	28.85	10.55	31.85	7.45	11.62	13756	1.26
SEm+	0.94	1.08	0.95	0.27	0.71	0.24	0.36	767	0.06
C.D. (P=0.05)	2.78	3.21	2.81	0.8	2.1	0.7	1.08	1271	NS
P levels (kg ha^{-1})									
20	27.42	28.95	25.83	9.64	30.22	6.49	10.58	10516	0.95
40	30.53	32.32	29.84	10.9	32.4	7.98	13.12	14865	1.27
60	31.97	33.93	32.21	11.49	33.8	8.44	13.82	15751	1.39
SEm+	0.94	1.08	0.95	0.27	0.71	0.24	0.36	767	0.06
C.D. (P=0.05)	2.78	3.21	2.81	0.8	2.1	0.7	1.08	2271	0.18

significantly increased the number of total nodules per plant by 11.64 and 17.20 per cent, respectively as compared to 20 kg P_2O_5 ha^{-1}. However, both 40 and 60 kg P_2O_5 ha^{-1}were at par with respect to number of total nodules per plant.

Number of pods per plant: PROM recorded significantly higher number of pods per plant compared to SSP and DAP. However, SSP and DAP remained statistically at par with each other. The PROM (31.97) registered 18.14 and 10.81 per cent higher number of pods per plant over DAP (27.06) and SSP (28.85), respectively. The application of 60 kg P_2O_5 ha^{-1} (32.21) registered 24.69 and 7.94 per cent higher number of pods per plant than 20 (25.83) and 40 kg P_2O_5 ha^{-1} (29.84), respectively.

Number of seeds per pod: There was significant effect of different sources of phosphorus on number of seeds per pod. The SSP and DAP remained statistically at par with each other but PROM found significantly superior over both SSP (10.55) and DAP (10.01). The PROM (11.46) registered 14.48 and 8.62 per cent higher seeds per pod over DAP and SSP, respectively (Table:1). The significant response of P_2O_5 was recorded only upto 40 kg P_2O_5 ha^{-1}. The application of 60 g P_2O_5 ha^{-1} (11.49) registered 19.19 and 5.41 per cent higher number of seeds per pod than 20 (9.64) and 40 kg P_2O_5 ha^{-1} (10.90). However, 40 and 60 kg P_2O_5 ha^{-1} were at par with each other.

Table-2: Effect of different P sources and P levels on protein content in grain and nitrogen content and uptake in seed and straw

Treatment	Protein content in seed (%)	N content (%) Seed	N content (%) Straw	N uptake (kg ha^{-1}) Seed	N uptake (kg ha^{-1}) Straw
Control v/s others	21.56	3.45	1.11	14.32	7.93
'F' test	Sig.	Sig.	Sig.	Sig.	Sig.
P sources					
DAP	22.44	3.59	1.17	25.57	14.27
PROM	24.06	3.85	1.29	32.27	17.77
SSP	23.19	3.71	1.22	27.78	14.27
SEm+	0.4	0.06	0.02	0.93	0.47
C.D. (P=0.05)	1.18	0.19	0.06	2.77	1.39
P levels (kg ha^{-1})					
20	22.13	3.54	1.17	23	12.37
40	23.36	3.74	1.23	29.89	16.23
60	24.2	3.87	1.28	32.73	17.7
SEm+	0.4	0.06	0.02	0.93	0.47
C.D. (P=0.05)	1.18	0.19	0.06	2.77	1.39

Test weight: Application of phosphorus from different sources gave significant impact on test weight. PROM (33.12) significantly increased the test weight by 5.31 and 3.98 per cent (Table:1), respectively in comparison to DAP (31.45) and SSP (31.85) when used as source of phosphorus fertilization. However, both DAP and SSP remained statistically at par with each other. There was significant increased in test weightdue to addition of different levels of phosphorus. Both 40 (32.40) and 60 kg P_2O_5 ha^{-1} (33.80), significantly increased the test weight by 7.21 and 11.84 per cent, respectively over 20 kg P_2O_5 ha^{-1} (30.22). However, both 40 and 60 kg P_2O_5 ha^{-1} were at par with respect to test weight.

Seed yield: Application of different sources of phosphorus led to significant effect on seed yield. PROM (8.36) significantly superior in increasing the seed yield by 17.74 and 12.21 per cent, respectively (Table:1), as compared to DAP (7.10) and SSP (7.45). However, both DAP and SSP being at par with each other. Application of phosphorus @ 40 (7.98) and 60 kg P_2O_5 ha^{-1} (8.44) significantly increased the seed yield by 22.95 and 30.04 per cent, respectively as compared to 20 kg P_2O_5 ha^{-1} (6.49). However, both 40 and 60 kg P_2O_5 ha^{-1} were at par with each other in increasing seed yield.

Straw yield: Among the different sources the maximum straw yield of mungbean was recorded in PROM followed by SSP and DAP. The SSP and DAP being at par each other, but PROM found statistically superior over SSP and DAP. The PROM (13.73) registered 12.72 and 18.17 per cent higher straw yield over DAP (12.18) and SSP (11.62), respectively. Application of phosphorusupto 40 kg P_2O_5 ha^{-1} recorded significant response to increase straw yield. However, maximum straw yield was recorded in 60 kg P_2O_5 ha^{-1} being at par with 40 kg P_2O_5 ha^{-1}. The application of 60 g P_2O_5 ha^{-1} (13.82) registered 30.62 and 5.33 per cent higher straw yield over 20 (10.58) and 40 kg P_2O_5 ha^{-1} (13.12), respectively.

Nutrient content and uptake and quality -

Nitrogen content in seed: PROM significantly increased the nitrogen content in seed as compared to SSP and DAP. However,

Table-3: Effect of different P sources and P levels on phosphorus and potassium content and uptake in seed and straw

Treatment	P content (%) Seed	P content (%) Straw	P uptake (kg ha^{-1}) Seed	P uptake (kg ha^{-1}) Straw	K content (%) Seed	K content (%) Straw	K uptake (kg ha^{-1}) Seed	K uptake (kg ha^{-1}) Straw
Control v/s others	0.346	0.175	1.43	1.25	0.32	1.08	1.33	7.22
'F' test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
P sources								
DAP	0.375	0.198	2.68	2.42	0.36	1.08	2.57	13.19
PROM	0.46	0.211	3.42	2.91	0.39	1.15	3.27	15.84
SSP	0.389	0.202	2.92	2.27	0.37	1.11	2.77	12.98
SEm+	0.007	0.004	0.1	0.08	0.01	0.02	0.1	0.41
C.D. (P=0.05)	0.021	0.011	0.3	0.23	0.02	0.05	0.28	1.23
P levels (kg ha^{-1})								
20	0.362	0.188	2.35	1.99	0.35	1.05	2.28	11.16
40	0.394	0.206	3.16	2.71	0.38	1.12	3.01	14.72
60	0.415	0.217	3.51	3	0.39	1.17	3.32	16.14
SEm+	0.007	0.004	0.1	0.08	0.01	0.02	0.1	0.41
C.D. (P=0.05)	0.021	0.011	0.3	0.23	0.02	0.05	0.28	1.23

SSP and DAP remained statistically at par with each other. The PROM (3.85) registered 7.24 and 3.77 per cent higher nitrogen content in seedover DAP (3.59) and SSP (3.71), respectively (Table:2). Nitrogen content in seed was significantly affected due to application different levels of phosphorusupto 40 kg P_2O_5 ha^{-1} thereafter, the effect was found non-significant. Application of 40 kg P_2O_5 ha^{-1}, significantly increased the nitrogen content in seed. However, the 60 kg P_2O_5 ha^{-1} recorded maximum number of nitrogen content in seedbut remained at par with 40 kg P_2O_5 ha^{-1}. The application of phosphorus @ 40 (3.74) and 60 kg P_2O_5 ha^{-1} (3.87) registered 5.64 and 9.32 per cent higher nitrogen content in seed over 20 kg P_2O_5 ha^{-1} (3.54). Similar results were also reposted by Basak and Subodh (2002) and Kumar *et al.* (2002).

Nitrogen content in straw: Among the sources PROM significantly increased the nitrogen content in straw as compared to DAP and SSP. The per cent increase in nitrogen content in straw due to PROM (1.29) was 10.25 and 5.73 per cent, respectively as compared to DAP (1.17) and SSP (1.22). The application of 40 kg P_2O_5 ha^{-1} significantly increased the content of nitrogen in straw. However, the 60 kg P_2O_5 ha^{-1} recorded maximum nitrogen content in straw but remained at par with 40 kg P_2O_5 ha^{-1}. The application of phosphorus @ 40 (1.23) and 60 kg P_2O_5 ha^{-1} (1.28) significantly increased the content of nitrogen in straw by 5.12 and 9.40 per cent, respectively as compared to 20 kg P_2O_5 ha^{-1} (1.17).

Nitrogen uptake: Significant increase in nitrogen uptake by crop was observed on account of different sources of phosphorus application. PROM significantly increased the nitrogen uptake by 26.20 and 16.16 per cent in seed and 24.52 and 24.52 in straw, respectively as compared with DAP and SSP. However, SSP and DAP remained statistically at par with each other. The application of phosphorus @ 40 and 60 kg P_2O_5 ha^{-1} significantly increased the nitrogen uptake by 29.95 and 42.30 per cent in seed and 31.20 and 9.05 per cent in straw, respectively in comparison to 20 kg P_2O_5 ha^{-1}. However, 40 and 60 kg P_2O_5 ha^{-1} were at par in increasing nitrogen uptake.

Phosphorus content in seed: Application of different sources of phosphorus led to significant effect on phosphorus content in seed. Among the sources, PROM recorded significantly higher content of phosphorus in seed compared to SSP and DAP. However, SSP and DAP remained statistically at par with each other. The PROM (0.460) registered 22.66 and 18.25 per cent higher phosphorus content over DAP (0.375) and SSP (0.389), respectively (Table:3). The increasing dose of phosphorus increased the content of phosphorus in seed but significantly was found only upto 40 kg P_2O_5 ha^{-1}. However, the 60 kg P_2O_5 ha^{-1} recorded maximum phosphorus content in seed but remained at par with 40 kg P_2O_5 ha^{-1}. The application of 60 kg P_2O_5 ha^{-1} (0.415) registered 14.64 and 5.32 per cent higher phosphorus content in seed over 20 (0.362) and 40 kg P_2O_5 ha^{-1} (0.394).

Phosphorus content in straw: PROM (0.211) significantly increased the phosphorus content in straw by 6.56 and 4.45 per cent in comparison to DAP (0.198) and SSP (0.202), respectively when used as source of phosphorus fertilization. However, both SSP and DAP were at par to each other with respect to phosphorus content in straw.Both 40 and 60 kg P_2O_5 ha^{-1} significantly increased the phosphorus content in straw by 9.57 and 15.42 per cent, respectively as compared 20 kg P_2O_5 ha^{-1}. However, phosphorus application @ 40 (0.206) and 60 kg P_2O_5 ha^{-1} (0.217) were at par with each other as far as phosphorus content in straw is concerned.

Phosphorus uptake: PROM significantly increased the phosphorus uptake by 27.61 and 17.12 per cent in seed and 20.24 and 28.19 per cent in straw, respectively as compared with DAP and SSP. However, both DAP and SSP remained statistically at par with each other. Phosphorus uptake by crop was significantly affected due to application of different levels of phosphorus.Both 40 and 60 kg $P_2O_5$$ha^{-1}$ significantly increased the phosphorus uptake by 34.46 & 49.36 in seed and 36.18 & 55.75 per cent in straw, respectively over 20 kg P_2O_5 ha^{-1}. However, 40 and 60 kg P_2O_5 ha^{-1} proved equally effective from phosphorus uptake point of view.These results are in the line with the findings of Singh *et al.* (1997), Pawar*et al.* (1998), Bhakare and Sonar (2000).

Potassium content in seed: The potassium content in seed was found to enhance significantly due to different sources of phosphorus application (Table:3). Among the sources PROM (0.39) significantly increased the potassium content in seed by 8.33 and 5.40 per cent over DAP (0.36) and SSP (0.37), respectively. However, both DAP and SSP being statistically at par with respect to potassium content in seed. Application of different levels of phosphorus gave significant increased on potassium content in seed. Application of 40 (0.38) and kg P_2O_5 ha^{-1} (0.39) significantly increased the potassium content in seed by 8.57 and 11.42 per cent, respectively as compared to 20 kg P_2O_5 ha^{-1} (0.35). However, the 40 and 60 kg P_2O_5 ha^{-1} were statistically at par each other. These results are in the line with the findings of Shukla and Dixit (1996).

Potassium content in straw: There was significant effect of different sources of phosphorus application on potassium content in straw. Among different sources PROM (1.15) significantly increased potassium content in straw by 6.48 and 3.60 per cent, respectively over DAP (1.08) and SSP (1.11) when used as source of phosphorus fertilization. However, SSP and DAP remained statistically at par with each other. Different levels of phosphorus application also led to significant difference in potassium content in straw. Both 40 and 60 kg P_2O_5 ha^{-1} significantly increased the potassium content in straw by 6.66 and 11.42 per cent, respectively as compared to 20 kg P_2O_5 ha^{-1}. However, both 40 and 60 kg P_2O_5 ha^{-1} were at par with respect to potassium content in straw.

Potassium uptake: Potassium uptake by crop was influenced significantly due to sources of phosphorus application. Among the sources, PROM significantly increased the potassium uptake in seed by 27.23 and 18.05 per cent and in straw by 20.09 and 22.03 over DAP and SSP, respectively (Table:3). Application of phosphorus at different levels significantly affected the potassium uptake by seed and straw. The application of phosphorus @ 40 and 60 kg P_2O_5 ha^{-1} levels significantly increased the potassium uptake by 32.01 and 45.61 per cent in seed and by 31.89 and 44.62 per cent in straw, respectively as compared to 20 kg P_2O_5 ha^{-1}. However, 40 and 60 kg P_2O_5 ha^{-1} were at par in influencing potassium uptake in seed and straw. These results are in the line with the findings of Patel and Patel (1991).

Protein content in seed: Applied phosphorus from different sources produced significant impact on protein content in seed. Application of PROM (24.06) significantly increased the protein content in seed by 7.21 and 3.75 per cent over DAP (22.44) and SSP (23.19), respectively. However, both DAP and SSP were at par with each other. Application of phosphorus significantly influenced the protein content in seed. Both 40 (23.36) and 60 (24.20) significantly increased the protein content in seed by 5.55 and 9.35 per cent, respectively in comparison to 20 kg P_2O_5 ha^{-1} (22.13). However, both 40 and 60 kg P_2O_5 ha^{-1} proved equally good in increasing protein content in seed.

Net returns: Significant increase in net return was observed due to different sources of phosphorus application. Among the sources PROM recorded significantly higher net return Rs. 2096 ha^{-1} and 980 over DAP and SSP, respectively (Table:1). Application of 40 kg P_2O_5 ha^{-1} gave significantly higher net return in compassion to 20 kg P_2O_5 ha^{-1}. However, it was at par with 60 kg P_2O_5 ha^{-1}. The application of 40 and 60 kg P_2O_5 ha^{-1} levels registered an increase in net return by Rs 4349 and 5235 ha^{-1} as compared 20 kg P_2O_5 ha^{-1}.

B:C ratio: Application of phosphorus with different sources and levels significantly increased the benefit cost ratio in comparison to control. Non-significant difference was recorded in cost benefit ratio irrespective of sources of phosphorus. Application of phosphorus upto 40 kg P_2O_5 ha^{-1} recorded significant response to increase cost benefit ratio. However, maximum cost benefit ratio was recorded in 60 kg P_2O_5 ha^{-1} (1.39) being at par with 40 kg P_2O_5 ha^{-1} (1.27).

Based on this experimentation, it may be concluded that phosphorus fertilization through PROM (Phosphorus Rich Organic Manure) was able to fulfill the phosphorus requirement of the crop from initial growth to maturity stage, resulting higher crop growth, yield attributes, yield, N, P and K uptake, quality attributes as well as gave higher return over DAP and SSP. Application of phosphorus upto 40 kg P_2O_5 ha^{-1} proved beneficial with respect to yield attributes, yield, N, P and K uptake, quality attributes and net returns. Thus, on the basis of one year field experimentation, it can be concluded that under agro-climatic conditions of zone IIIA (semi-arid eastern plain), application of phosphorus through PROM and fertilizing the crop with 40 kg P_2O_5 ha^{-1} is a remunerative approach in maximizing the crop productivity. However, these results are only indicative and require of further field experimentation for confirmation and generating recommendation for the farming community

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