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RESEARCH ARTICLE :

Yield and economics of blackgram crop effected by green manures and phosphorus levels in rice-blackgram cropping sequence

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SUMMARY : A field experiments was conducted during 2015 and 2016 to study the effect of green manures and phosphorus levels in blackgram crop at Agricultural College Farm, Bapatla. The experiment was conducted in split- split plot design on sandy clay loam soil with three main treatments three sub-treatments to *Kharif* rice and three sub-sub treatments to *Rabi* crop. The treatments consisted of *Dhaincha* green manure crop, sunnhemp green manure crop and without green manure as main plot treatments and three phosphorus levels to rice crop comprising of 45 kg P_2O_5 ha^{-1}, 60 kg P_2O_5 ha^{-1} and 75 kg P_2O_5 ha^{-1} as sub- plot treatments and are replicated thrice. The *Rabi* experiment was laid out on the same site in a split-split plot design without disturbing the soil for succeeding blackgram crop and each of the *Kharif* plot was divided into three sub-sub plots to receive three levels of phosphorus (No P, 50% RDP and 100% RDP) to each plot. Yield and economics of blackgram which received *Dhaincha* green manure incorporation with 75 kg P_2O_5 ha^{-1} to *Kharif* rice crop and 100% RDP to *Rabi* blackgram was recorded significantly higher and it was on a par with sunnhemp green manure incorporation with 75 kg P_2O_5 ha^{-1} to *Kharif* rice crop and 100% RDP to *Rabi* blackgram.

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BACKGROUND AND OBJECTIVES

India has the largest area under pulses in the world with the area is about 190.4 lakh hectares producing 124.0 lakh tonnes with an average yield of 651.2 kg ha^{-1}. Among the pluses, blackgram (Urdbean) contributes 16.28 per cent of the total area and 11.48 per cent of the total production with an average productivity of 451.6 kg ha^{-1}. Nutrient management is an important aspect in increasing the productivity of pulses.

Phosphorus is a key nutrient for increasing productivity of pulses (Deo and Khaldelwal, 2009). The adequate supply of phosphorus to legume is more important than that of nitrogen, because it has beneficial effect on root development, nodulation, growth and yield. A large portion of phosphorus remaining after the first crop is not fixed but is indeed available to the subsequent crops (Kundu *et al.,* 1986). Incorporation of green manures along with fertilizers leads to

increased productivity of the system and sustained health for longer period. Hence, the available literature on green manures, P levels and their residual effect on succeeding blackgram is meager, the present investigation was carried out with a view to evaluate the effect of phosphorus levels to *Kharif* crop and phosphorus doses to *Rabi* blackgram in rice-blackgram cropping sequence.

RESOURCES AND METHODS

A field experiment was conducted during 2015 and 2016 at Agricultural College Farm, Bapatla to study the effect of green manures and phosphorus levels to *Kharif* crop and phosphorus doses to blackgram crop. The experiment was conducted in split plot design on sandy clay loam soil with three main treatments and three sub-treatments during *Kharif* season and split-split plot design in *Rabi* season. The treatments consisted of *Dhaincha* green manure crop, sunnhemp green manure crop and without green manure as main plot treatments and three phosphorus levels to rice crop comprising of 45 kg P_2O_5 ha^{-1}, 60 kg P_2O_5 ha^{-1} and 75 kg P_2O_5 ha^{-1} as sub-plot treatments and are replicated thrice. The *Rabi* experiment was laid out on the same site in a split-split plot design without disturbing the soil for succeeding blackgram crop and each of the *Kharif* plot was divided into three sub-sub plots to receive three levels of phosphorus (No P, 50% RDP and 100% RDP) to each plot. Nitrogen, phosphorus and potassium were applied through urea, single super phosphate and murate of potash, respectively.

Nitrogen was applied as per the treatments in three equal splits in the form of urea. First split of nitrogen was applied as basal dose at the time of planting of the crop remaining two equal splits of nitrogen was broadcasted at maximum tillering and panicle initiation stages. Potassium 40 kg K_2O ha^{-1} in the form of muriate of potash was applied in two equal splits as basal dose at the time of transplanting and panicle initiation stage. Irrigation and weed management was done in time to time. The border rows were harvested first and then, the net plot area was harvested and the produce was threshed by beating on a threshing bench, cleaned and sun dried to 14 per cent moisture level. Grain from net plot area was thoroughly sun dried, threshed, cleaned and weight of grains was recorded and expressed in yield per hectare. Recommended agronomic management practices and plant protection measures were followed during crop growth. The data recorded were analyzed following standard statistical analysis of variance procedure.

OBSERVATIONS AND ANALYSIS

The findings of the present study as well as relevant discussion have been summerized under following heads:

Seed yield (kg ha^{-1}):

A perusal of the data reveals that seed yield was

Table 1: Seed yield (kg ha^{-1}) of blackgram at harvest as influenced by green manures and phosphorus levels applied to *Kharif* rice crop and phosphorus doses to *Rabi* blackgram during 2015

Phosphorus levels to rice (kg ha^{-1}) (L)	Green manures (M)												Means of treatments		
	Dhaincha				Sunnhemp				Without green manure						
	P doses in blackgram (D)				P doses in blackgram (D)				P doses in blackgram (D)						
	No P	50% RDP	100 % RDP	Mean	No P	50% RDP	100 % RDP	Mean	No P	50% RDP	100 % RDP	Mean	Main	Sub	Sub –sub
45 kg P_2O_5	797	823	845	822	786	818	841	815	763	814	827	801	869	813	803
60 kg P_2O_5	824	914	928	889	828	896	924	883	777	847	855	826	863	866	867
75 kg P_2O_5	837	915	936	896	831	913	931	892	787	864	871	841	823	876	884
Mean	819	884	903		815	876	899		776	842	851				
						S.E.±	C.D. (P=0.05)	CV (%)							
Green manures (M)						8.3	32	5.0							
Phosphorus levels to rice (L)						15.6	51	9.5							
Phosphorus doses to blackgram (D)						16.6	50	10.1							
Interaction															
MXL						27.1	NS								
MXD						28.8	NS								
LXD						28.8	NS								
MXLXD						49.9	NS								

NS= Non-significant

significantly influenced by green manure incorporation and phosphorus levels to *Kharif* rice and phosphorus doses to *Rabi* blackgram but not due to their interaction during both the years of study and pooled data. Green manure incorporation to rice differed significantly. The seed yield of *Rabi* blackgram was significantly higher with *Dhaincha* green manure (869, 851 and 860 kg ha^{-1} during first and second years and pooled, respectively) and was followed by (863, 848 and 856 kg ha^{-1} during first and second years and pooled, respectively) sunnhemp incorporation. No green manure to the *Kharif* rice recorded significantly lower (823, 797 and 811 kg ha^{-1} during the first and second years and pooled, respectively) yield. Pooled analysis also revealed the similar trend as that was observed in the individual years. The increase in the seed yield of preceding rice with *Dhaincha* green manure over the no green manure was 31.47 and 12.17 per cent during first and second years, respectively. It might be due to more drymatter accumulation, more number of branches, higher number of plants^{-1} and seeds pod^{-1} and higher 100 grain weight recorded with those treatments and reflected in the higher seed yield of *Rabi* blackgram during both the years of study.

With increase in the phosphorus level to *Kharif* rice, there was a gradual and significant increase in the seed yield of *Rabi* blackgram. Significantly higher (876 and 851 kg ha^{-1} grain yield in 2015 and 2016, respectively) and lower seed yield (813 and 801 kg ha^{-1} during the 2015 and 2016, respectively) were registered with 75 kg P_2O_5 ha^{-1} and 45 kg P_2O_5 ha^{-1} phosphorus application to rice crop, respectively. The per cent increase of seed yield with 75 kg P_2O_5 ha^{-1} was 24.48 per cent over 45 kg P_2O_5 ha^{-1} in first year of experimentation and 9.7 per cent during second year of experimentation. Higher available residual phosphorus at higher level of phosphorus to *Kharif* rice might have made the blackgram which was evidenced through the better growth and yield attributes of the succeeding blackgram.

All the phosphorus doses applied to *Rabi* blackgram differed significantly with one and another in terms of its effect on seed yield of blackgram. Each increment in phosphorus doses to *Rabi* blackgram was significantly and gradually increased the seed yield in both the years of study. Significantly the higher 884 kg ha^{-1} to kg 855 ha^{-1} seed yield in first year and second year of study, respectively was registered when 100 per cent RDP was supplied which was closely followed by 50 per cent of RDP. However, lower seed yield (803 kg ha^{-1} and 796 kg ha^{-1} in first and second years, respectively) was

Table 2 : Seed yield (kg ha^{-1}) of blackgram at harvest as influenced by green manures and phosphorus levels applied to *Kharif* rice crop and phosphorus doses to *Rabi* blackgram during 2016

Phosphorus doses to rice (kg ha^{-1}) (L)	Green manures (M)												Means of treatments		
	Dhaincha				Sunhemp				Without green manure						
	P doses in blackgram (D)				P doses in blackgram (D)				P doses in blackgram (D)						
	No P	50% RDP	100 % RDP	Mean	No P	50% RDP	100 % RDP	Mean	No P	50% RDP	100 % RDP	Mean	Main	Sub	Sub – sub
45 kg P_2O_5	807	783	825	805	796	834	841	824	743	784	797	775	851	801	796
60 kg P_2O_5	824	894	891	870	820	879	881	860	757	827	825	803	848	844	845
75 kg P_2O_5	830	895	910	878	821	880	884	862	767	831	841	813	797	851	855
Mean	820	857	875		812	864	869		756	814	821				
						S.E.±	C.D. (P=0.05)	CV (%)							
Green manures (M)						8.3	32	5.2							
Phosphorus levels to rice (L)						12.6	41	7.8							
Phosphorus doses to blackgram (D)						14.7	44	9.2							
Interaction															
MXL						21.8	NS								
MXD						25.4	NS								
LXD						25.4	NS								
MXLXD						44.0	NS								

NS= Non-significant

recorded with the control. Per cent increase in seed yield due to 100 per cent RDP over 50 per cent and control was 13.3, 26.7 and 51.3 per cent, respectively during first year where as 13.3, 27.4 and 51.2 per cent more during the second year of experimentation. It might have resulted in higher growth characters, yield attributes and finally the higher yield. Similar reports of increased yield of *Rabi* blackgram at higher doses of phosphorus was also reported by various researchers like Bairwa *et al.* (2012); Patel *et al.* (2013); Kokani *et al*. (2014); Kumari *et al.* (2015) and Verma *et al.* (2015).

The increase in the seed yield of succeeding blackgram with phosphorus applied to rice at later stages could be ascribed to the increased residual available phosphorus which might have helped in developing profused root system resulting in increased nutrient uptake, higher drymatter accumulation and translocation of photosynthates from vegetative parts to seeds. These results confirm with the findings of Patel *et al.* (2013) and Shubhangi *et al*. (2014). The pooled analysis over two years also followed the similar trend of response in respect of seed yield.

Haulm yield (kg ha^{-1}) :

Data on haulm yield of blackgram shows that it was influenced by different treatments under test. It was significantly influenced by green manures and phosphorus levels to *Kharif* rice as well as phosphorus doses to *Rabi* blackgram but not due to their interaction during both the years of study. The haulm yield of blackgram followed the same trend as that was noticed in respect of seed yield of blackgram.

Significantly higher haulm yield (1362 and 1248 kg ha^{-1} during first and second years, respectively) of blackgram was recorded when the preceding rice was incorporated with *Dhaincha* green manure which was closely followed by sunnhemp incorporation (1353 and 1273 kg ha^{-1} during first and second years, respectively) treatment. Without green manure incorporation plot registered the lower (1287 and 1153 kg ha^{-1} during the first and second years, respectively) haulm yield. This might be due to more drymatter accumulation more number of branches plant^{-1} which might have the higher haulm yield in *Rabi* blackgram during the both the year of study.

With increase in the phosphorus levels to *Kharif* rice, there was a gradual and significant increase in the haulm yield of *Rabi* blackgram. Significantly the higher (1371 and 1270 kg ha^{-1} haulm yield in 2015-16 and 2016-17, respectively) and the lower haulm yield (1278 and

Table 3 : Haulm yield (kg ha^{-1}) of blackgram at harvest as influenced by green manures and phosphorus levels applied to *Kharif* rice crop and phosphorus doses to *Rabi* blackgram during 2015

Phosphorus levels to rice (kg ha^{-1}) (L)	Green manures (M)												Means of treatments		
	Dhaincha				Sunnhemp				Without green manure						
	P doses in blackgram (D)				P doses in blackgram (D)				P doses in blackgram (D)						
	No P	50% RDP	100 % RDP	Mean	No P	50% RDP	100 % RDP	Mean	No P	50% RDP	100 % RDP	Mean	Main	Sub	Sub – sub
45 kg P_2O_5	1263	1314	1338	1305	1260	1325	1329	1305	1187	1226	1264	1226	1362	1278	1282
60 kg P_2O_5	1326	1396	1436	1386	1278	1403	1417	1366	1241	1319	1348	1303	1353	1352	1349
75 kg P_2O_5	1338	1416	1433	1396	1333	1408	1420	1387	1314	1335	1346	1332	1287	1371	1370
Mean	1309	1375	1402		1290	1379	1389		1247	1293	1319				
						S.E.±	C.D. (P=0.05)	CV (%)							
Green manures (M)						14.0	55	5.5							
Phosphorus levels to rice (L)						22.1	72	8.6							
Phosphorus doses to blackgram (D)						20.0	60	7.8							
Interaction															
MXL						38.3	NS								
MXD						34.7	NS								
LXD						34.7	NS								
MXLXD						60.1	NS								

NS= Non-significant

1177 kg ha^{-1} during both the years) were registered with 75 kg P_2O_5 ha^{-1} and 45 kg P_2O_5 ha^{-1} phosphorus application to rice crop, respectively. Higher available residual phosphorus at higher level of phosphorus to *Kharif* rice might have made the blackgram which was evidenced through the better growth and yield attributes of the succeeding blackgram which were discussed earlier in this chapter. These results are in conformity with the findings of Kumawat *et al*. (2013): Kumar *et al*. (2014) and Rathore *et al*. (2015).

All the phosphorus doses to *Rabi* blackgram differed significantly with one and another. Each increment in phosphorus application to *Rabi* blackgram, there was a gradual and significant increase in the haulm yield during both the years of study. Significantly the higher (1370 and 1287 kg ha^{-1} during 1st and 2nd year, respectively) haulm yield, respectively was registered when 100 per cent RDN was supplied which was closely followed by 50 per cent of RDN followed this treatment. However, lower haulm yield (1282 and 1165 kg ha^{-1} in first and second years, respectively) was recorded with control. The role of phosphorus as part of chlorophyll pigment, its roll in enzymatic reactions is well documented. This might have resulted in higher growth characters, yield attributes and finally the higher haulm yield. Rao and Bharadwaj (1979) also opinioned that the haulm yield of summer greengram was improved due to the residual effects of phosphorus fertilizers supplied at higher levels to wheat and maize grown in the preceding *Kharif* and *Rabi* season, respectively. This indicates that in cereal-cereal-legume rotation, the legume is benefited from the phosphorus applied to the preceding crops. Similar reports of increased haulm yield of *Rabi* blackgram at higher doses of phosphorus was also reported by Ghulam *et al.* (2011) and Nawange *et al*. (2011).

Economics:

Gross returns, net returns and return per rupee invested were worked out for different green manures and phosphorus levels to rice and phosphorus doses to blackgram crop. *Dhaincha* green manure incorporation to rice recorded maximum gross returns (Rs. 45759 and Rs. 48032), net returns (Rs. 25677, Rs. 27785), benefit cost ratio (2.28 and 2.33) and return per rupee invested (1.28 and 1.33) during 1st and 2nd years of study, respectively, which was closely followed by sunnhemp green manures incorporation.

Table 4 : Haulm yield (kg ha^{-1}) of blackgram at harvest as influenced by green manures and phosphorus levels applied to *Kharif* rice crop and phosphorus doses to *Rabi* blackgram during 2016

Phosphorus doses to rice (kg ha^{-1}) (L)	Green manures (M)												Means of treatments		
	Dhaincha				Sunnhemp				Without green manure						
	P doses in blackgram (D)				P doses in blackgram (D)				P doses in blackgram (D)						
	No P	50% RDP	100 % RDP	Mean	No P	50% RDP	100 % RDP	Mean	No P	50% RDP	100 % RDP	Mean	Main	Sub	Sub – sub
45 kg P_2O_5	1152	1187	1308	1216	1160	1215	1251	1209	1091	1099	1133	1108	1248	1177	1165
60 kg P_2O_5	1201	1376	1366	1314	1199	1344	1353	1299	1138	1172	1204	1171	1273	1261	1257
75 kg P_2O_5	1202	1384	1378	1321	1200	1366	1368	1311	1145	1171	1221	1179	1153	1270	1287
Mean	1185	1316	1351		1186	1308	1324		1125	1147	1186				
						S.E.±	C.D. (P=0.05)	CV (%)							
Green manures (M)						11.6	46	5.0							
Phosphorus levels to rice (L)						25.4	83	10.7							
Phosphorus doses to blackgram (D)						25.5	77	10.7							
Interaction															
MXL						44.0	NS								
MXD						44.2	NS								
LXD						44.2	NS								
MXLXD						76.6	NS								

NS= Non-significant

Phosphorus application @75 kg P_2O_5 ha^{-1} to rice crop as well as 100 per cent P application to succeeding *Rabi* blackgram recorded maximum gross returns, net returns and return per rupee invested were noticed during two years of experimentation. This might be due to higher yields of both rice and blackgram were recorded in rice-blackgram sequence that resulted in higher net returns and benefit cost ratio. These results are in conformity with the findings of Anitha and Jose Mathew (2010).

Conclusion:

Overall, the field studies conducted for two consecutive years clearly indicated that incorporation of green manures preceding to rice crop and application with 75 kg P_2O_5 ha^{-1} to *Kharif* rice crop and 100 per cent RDP to *Rabi* blackgram treatment had a significant influence in increasing productivity and profitability in rice - blackgram sequence. Therefore, from this study, it was concluded that application of green manures with

Table 5 : Economics of rice-blackgram sequence as influenced by green manures and phosphorus levels applied to *Kharif* rice crop and phosphorus doses to blackgram during 2015

	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B:C ratio	Rupee per rupee invested (Rs.)
Green manures				
Dhaincha	45759	25677	2.28	1.28
Sunnhemp	45062	25006	2.24	1.21
Without green manure	42318	22290	2.14	1.11
S.E.±	426.6	416.1	0.024	0.016
C.D. (P=0.05)	1675	1634	0.09	0.06
CV (%)	5.0	8.9	5.56	7.0
P levels				
45 kg $P_2O_5$$ha^{-1}$	42869	22787	2.13	1.10
60 kg $P_2O_5$$ha^{-1}$	44968	24966	2.24	1.24
75 kg $P_2O_5$$ha^{-1}$	45302	25220	2.27	1.26
S.E.±	808.8	806.5	0.037	0.039
C.D. (P=0.05)	2638	2630	0.12	0.13
CV (%)	9.5	17.2	8.78	17.0
P doses				
No P	41791	21818	2.11	1.05
50% RDP	45231	25047	2.25	1.25
100% RDP	46117	26109	2.29	1.29
S.E.±	859.5	819.5	0.046	0.055
C.D. (P=0.05)	2577	2457	0.14	0.16
CV (%)	10.1	17.5	10.71	23.8
Interaction				
S.E.±	1400.9	1397.0	0.065	0.068
C.D. (P=0.05)	NS	NS	NS	NS
S.E.±	1488.7	1419.5	0.079	0.095
C.D. (P=0.05)	NS	NS	NS	NS
S.E.±	1488.7	1419.5	0.079	0.095
C.D. (P=0.05)	NS	NS	NS	NS
S.E.±	2578.5	2458.6	0.137	0.164
C.D. (P=0.05)	NS	NS	NS	NS

NS= Non-significant

Table 6: Economics of rice-blackgram sequence as influenced by green manures and phosphorus levels applied to *Kharif* rice crop and phosphorus doses to blackgram during 2016

	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B:C ratio	Rupee per rupee invested (Rs.)
Green manures (M)				
Dhaincha	48032	27785	2.33	1.33
Sunnhemp	47468	27179	2.30	1.30
Without green manure	44731	24435	2.17	1.17
S.E.±	481.4	470.68	0.023	0.023
C.D. (P=0.05)	1890.3	1848.1	0.09	0.09
CV (%)	5.4	9.2	5.29	9.5
P levels (L)				
45 kg P_2O_5ha^{-1}	45111	24805	2.19	1.19
60 kg P_2O_5ha^{-1}	47334	27052	2.30	1.30
75 kg P_2O_5ha^{-1}	47786	27543	2.32	1.32
S.E.±	829.0	830.31	0.040	0.040
C.D. (P=0.05)	2703.6	2707.8	0.13	0.13
CV (%)	9.2	16.3	9.11	16.3
P doses (D)				
No P	44216	23999	2.15	1.15
50% RDP	47504	27251	2.31	1.31
100% RDP	48510	28150	2.34	1.34
S.E.±	924.4	910.68	0.044	0.044
C.D. (P=0.05)	2771.3	2730.2	0.13	0.13
CV (%)	10.3	17.9	10.04	18.0
Interaction				
S.E.±	1435.9	1438.14	0.069	0.069
C.D. (P=0.05)	NS	NS	NS	NS
S.E.±	1601.1	1577.34	0.076	0.076
C.D. (P=0.05)	NS	NS	NS	NS
S.E.±	1601.1	1577.34	0.076	0.076
C.D. (P=0.05)	NS	NS	NS	NS
S.E±	2773.2	2732.03	0.131	0.131
C.D. (P=0.05)	NS	NS	NS	NS

NS= Non-significant

60 kg P_2O_5 ha^{-1} to *Kharif* rice crop and 50 per cent RDP to succeeding *Rabi* blackgram is the best and the most profitable cropping sequence of Krishna zone of A.P.

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