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Application of lime pelletted *Rhizobium* culture for increasing the yield of blackgram (*Vigna mungo*) in the constrained acidic soils of West Bengal

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Blackgram (*Vigna mungo* L.) is an important short-duration pulse crop grown in West Bengal as a mixed crop, catch crop, sequential crop or as sole crop utilizing residual moisture conditions after rice harvest, succeeding or preceding crop of other summer crops under semi-irrigated and dryland conditions. In West Bengal, during 2005-06 the area under blackgram was 571 119 ha with a production of 40926 m while the productivity of blackgram was 717 kg/ha. In Dakshin Dinajpur district of West Bengal blackgram is mostly cultivated in the marginal soils under rainfed situation with no or minimum external nutrient input resulting in very low crop yield (0.4 tonne/ha approx.) which is attributed to the soil acidity induced poor fertility status of the soil in general and poor *Rhizobium* status in particular. Therefore, fertility management along with soil amendment is imperative to ensure better blackgram production on these constrained acidic soils. Particularly, keeping in view the amount of lime required and the cost involved thereby, method of use of lime which effectively increases the yield without much cost involved is very important. However, meager information is available on the effect of liming, method of liming along with fertilizer management practices on the enhancement of yield of blackgram.

On-station trial on productivity enhancement of blackgram was conducted at the instructional farm of Dakshin Dinajpur Krishi Vigyan Kendra during 2005-06. The variety selected for blackgram was Sarada (WBU 108) and eight treatments namely i) control - without nutrient and lime application, ii) fertilizer application @ 20:40:20 kg/ha of N, P_2O_5 and K_2O respectively (Ali 2005) totally as basal broadcasted before final land preparation plus 2% DAP spray at flowering stage (spray is necessary as these iron infested soils are having high phosphate fixation capacity), iii) lime application on the basis of lime requirement (LR) (only one third of LR was applied keeping in view the economic feasibility and acceptability by the farmers) during initial land preparation (21 days before sowing) and seed treatment with *Rhizobium* culture (1.5 kg *Rhizobium* sp. culture for seeds of one ha), iv) fertilizer application and seed treatment with *Rhizobium,* v) lime plus fertilizer application, vi) lime, fertilizer application and seed treatment with *Rhizobium* culture, vii) fertilizer application and seed treatment with lime pelleted *Rhizobium* culture (100g water soaked lime mixed with 1.5 kg culture for seeds/ha) and viii) soil application of lime, fertilizer application plus lime pelleted *Rhizobium* seed treatment were laid out in randomized block design (RBD) with three replications.

On-farm testing (OFT) was undertaken after the second year of the on station trial to validate the results in the farmers' field. OFT was designed by three economic yield options of OST (treatment iii, vii and viii) along with the farmers' practice (no lime, fertilizer and seed treating biofertilizer) which were further laid out in RBD with five replications in the plots of 5m × 4m sizes. Ten number of randomly selected plants in each plot were taken for analysis. In both the experiments the initial (pre sowing) and final (post harvest) soil fertility status (pH, lime requirement, organic carbon, available nitrogen, phosphate and potash) was determined through the standard methodology of Sparks (1996). Economics of the experiment in terms of Cost A(it includes wages of hired labour, ploughing cost, chemical input cost, interest on working capital, depreciation on farm machinery, equipments and farm buildings, etc.), Cost B (it includes Cost A + rent paid for leased land + imputed rental value of owned land + interest on owned fixed capital) and Cost C (it includes Cost B + imputed value of family labour) was evaluated by following the farm management concepts of Raju and Rao (1990). Statistical analyses were performed by using INDOSTAT software.

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Table 1 Soil fertility status of the experimental soils of on station trial and on farm testing parameters

Treatment	pH		Lime requirement (tonnes/ha)		Soil organic carbon (%)		Soil available nutrients (kg/ha)					
							N		P_2O_5		K_2O	
	I*	F*	I	F	I	F	I	F	I	F	I	F
On station trial (OST)												
Control		5.34		5.75		0.423		206		25.5		139
NPK fert.		5.41		5.53		0.429		220		30.1		155
Liming + *Rhizobium*		5.85		4.18		0.485		238		31.4		166
NPK fert. + *Rhizobium*		5.41		5.46		0.435		225		30.4		160
NPK fert. + liming	5.38	5.92	5.65	3.77	0.425	0.494	214	248	27.5	32.0	150	173
NPK fert. + liming + *Rhizobium*		5.95		3.42		0.496		250		32.3		174
NPK fert+ lime pelleted *Rhizobium*		5.50		5.14		0.450		243		32.6		170
NPK fert + liming + lime pelleted *Rhizobium*		6.00		3.28		0.505		258		34.1		185
CD (P =0.05)		0.337	1.94		0.046		23.8		5.4		16.1	
On farm testing (OFT)												
Farmers' Practice		5.2		5.97		0.35		142		23.2		152
NPK fert. + *Rhizobium*		5.3		5.88		0.39		145		25.6		160
NPK fert. + lime pelleted *Rhizobium*	5.2	5.32	5.97	5.82	0.31	0.39	136	151	24.1	33.1	149	162
NPK fert. + liming + lime pelleted *Rhizobium*		5.7		4.29		0.42		165		33.6		163
CD (P = 0.05)		0.230		1.24		0.068		16.1		3.01		NS

I*, Pre-sowing soil fertility status before the start of experiment ; F*, Pooled soil fertility status after harvesting of the 2nd year crop

Pre sowing and post harvest fertility status of the experimental soils were found to be low in organic carbon (<0.5%), available nitrogen (< 280 kg/ha), available phosphate (<45 kg/ha) and available potash (< 200 kg/ha) as per Ali 2005. The pH of all the (initial fertility status of the OST and OFT field) soils showed moderate acidity and the application of lime in soil coupled with seed treatment and fertilizer recommendation in these soils significantly increased the post harvest fertility status of experimental soils (Table 1). Calcium in lime materials reacts with soil acidity as well as soil iron and hence increased the availability of phosphorus and potassium in soil. However due to increase in favourable pH, microbial acitivity in soil got triggered which resulted in nitrogen availability and increase in carbon content in soil.

Regarding the yield parameters in the on station trial, plant height, number of nodule (having leghaemoglobin)/ plant, number of pods/plant were found to be significantly increased by lime application, seed treatment with lime pelleted *Rhizobium* coupled with NPK fertilizer application in soil (Table 2 and 3). The branches/plants and seeds/pod varied over the treatments non-significantly varied among the treatments. The increase in the nodules/plant by balanced nutrition was reported by Bhattacharya *et al.* (2004). Seed treatment with *Rhizobium* without lime fortification was found less effective in these acidic soil as it works well within the pH range 6 to 8 (Mensah *et al*. 2006). Significant increase (55.6%) of yield in blackgram could be achieved through lime pelleted *Rhizobium* application plus NPK fertilization while liming in soil to this treatment provided 18.5% additional yield over control. Kumpawat (2010) found similar results by combined application of NPK fertilizer and *Rhizobium*. Caddel *et al.* (2004) observed significant yield attributes and yield increase in red clover and alfalfa through grades doses of liming in soil facilitating increase in soil pH. Such increases in yield-attributing characters by *Rhizobium* inoculation might be attributed to increased root nodulation, development and nutrient acquisition which resulted in better flowering, fruiting, pod formation and seed yield (Sardana *et al*. 2006). The legheamoglobin contents of the nodules might have increased which has resulted in larger nitrogen assimilation resulting in increased productivity. The above mentioned effect was also reported by Das and Bandopadhyay (2011) in frenchbean crop.

The yield parameters in the On-farm testing (OFT) showed lower value compared to OST as the later was conducted in a more managed system with comparatively higher soil pH. Significant increase in the plant height, branches/plant, seeds/pod, pods/plant, test weight in blackgram was obtained in the treatments with lime application in soil or lime pelleting with seed. Proper NPK application along with lime pelleted seed treatment with *Rhizobium* increased the yield by 34.5% over farmers' practice while addition of lime in soil increased 30% additional yield. Yield increment through lime pelleting with *Rhizobium* was also reported by Evans *et al*. (1993) in field pea.

The economics of blackgram cultivation in OST and OFT are depicted in Table 3. In OST, Cost B and C remained

Table 2 Effect of different treatments on the yield parameters of black gram by on farm testing (pooled data for 2 years)

Treatment	Plant height (cm)	Branches/ plant	Nodules/ plant	Pods/ plant	Pod length (cm)	Seeds/ pod	100 seed wt. (g)	Yield (tonnes/ha)
Farmers' Practice	37.4	4.6	20.4	12.0		5.0	4.21	0.423
NPK fert. + *Rhizobium*	42.8	5.6	22.6	19.4		5.8	4.51	0.507
NPK fert. + lime pelleted *Rhizobium*	47.2	6.4	24.6	21.8		6.2	4.61	0.569
NPK fert. + liming + lime pelleted *Rhizobium*	47.6	7.0	29.0	22.6		6.8	4.63	0.695
CD(P = 0.05)	5.55	0.723	4.74	2.3		0.991	0.335	0.146

Table 3 Economics involved in the on station trial (pooled data for 2 years) and on farm testing

Treatment	On station trial							
	Cost of cultivation (₹/ha)			Gross return (₹/ha)	Net return (₹/ha)			B:C ratio
	Cost A	Cost B	Cost C		Cost A	Cost B	Cost C	
Control	5 018	7 207	7 207	14 653	9 635	7 446	7 446	2.03:1
NPK fert.	6 545	8 734	8 734	16 153	9 608	7 419	7 419	1.85:1
Liming+ *Rhizobium*	8 900	11 089	11 089	19 713	10 813	8 624	8 624	1.78:1
NPK fert. + *Rhizobium*	7 114	9 303	9 303	20 465	13 351	11 162	11 162	2.20:1
NPK fert. + liming	9 855	12 044	12 044	25 296	15 441	13 252	13 252	2.10:1
NPK fert. + liming+ *Rhizobium*	10 426	12 615	12 615	26 495	16 069	13 880	13 880	2.10:1
NPK fert + *lime pelleted Rhizobium*	8 069	10 258	10 258	22 630	14 561	12 372	12 372	2.21:1
NPK fert + liming+ *lime pelleted Rhizobium*	10 431	12 620	12 620	28 476	18 045	15 856	15 856	2.26:1
CD (P =0.05)	811	811	811	2,804	2 641	2 641	2 641	
	On farm testing							
Control (Farmers' practice)	2 875	4 973	5 523	8 883	6 008	3 910	3 360	1.61:1
NPK fert. + *Rhizobium*	6 773	8 871	9 421	14 196	7 423	5 325	4 775	1.51:1
NPK fert + lime pelleted *Rhizobium*	6 607	8 705	9 425	15 932	9 325	7 227	6 507	1.69:1
NPK fert + liming + lime pelleted *Rhizobium*	8 243	10 341	11 381	19 460	11 217	9 119	8 079	1.71:1
CD (P =0.05)	3 791	3 294	2 693	6 351	4 052	3 666	3 530	

same as there is no imputation of family labour in the experimental farm. However for OFT there is difference in Cost B and C due to the involvement of family labour along with the hired one. In OST all the treatments showed significant increase in cost of cultivation as well as in gross and net return but in OFT lime applied treatments showed significant increase in above mentioned aspects. Both the experiment incurred additional income of nearly ₹ 3 000/ha in the treatments with lime application in soil. However, the B:C ratio indicates that economic returns can be expected from lime pelleting along with *Rhizobium* seed treatment.

Table 4 Multiple regression equations for productivity enhancement factors for blackgram

Equations	R^2	Individual Contribution
Y = 0.352 + 0.256NPK fert.	0.364	36.4
Y, = –0.035 + 0.256 NPK fert.+ 0.258 Liming in soil	0.858	49.4
Y = –0.137 + 0.238 NPK fert.+ 0.232 Liming in soil + 0.106 Rhizobium seed treatment	0.929	7.10
Y = –0.164 + 0.213 NPK fert.+ 0.241 Liming in soil + 0.068 Rhizobium seed treatment 0.096 lime pellet in seed treatment	0.966	3.70

Stepwise Multiple Regression Coefficient analysis revealed the fact that liming in soil was the highest contributor among the production factors followed by NPK application and further seed treatment with *Rhizobium* (Table 4).

SUMMARY

A study was conducted in the Instructional farm of Dakshin Dinajpur Krishi Vigyan Kendra (on-station trial) as well as in the framers' field (on farm testing) to study the productivity enhancement of *Vigna mungo* L. in the selected acidic soils of West Bengal. Proper NPK application along with lime pelleted seed treatment with *Rhizobium* increased the yield by 34.5% over farmers' practice while addition of lime in soil increased 30% additional yield. In OST and

OFT significant productivity increase (94.6% and 64% respectively) in blackgram was achieved through the application of lime, balanced fertilization, *Rhizobium* seed treatment while best economic returns were obtained through lime pelleted *Rhizobium* seed treatment in blackgram compared to least management practices.

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