Enhancement of productivity potential of greengram (*Vigna radiata* L.) through integrated nutrient management (INM) in a legume based cropping system

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Abstract: Two field experiment were conducted during *Kharif* seasons of 1998 and 1999 at Allahabad (U.P.) in sandy loam alluvial soils to study the effect of fertilizer levels, organic manures and biofertilizer along with organic spray on the yield of greengram in blackgram - wheat - greengram system. The treatments consisted of three levels of fertilizer (control, 33% and 100% recommended dose fertilizers - RDF), three forms of organic manures (control, farm compost 5 t ha^{-1} + vermicompost 1 t ha^{-1} and farm compost 5 t ha^{-1} + poultry manure 0.5 t ha^{-1}) and three forms of biofertilizers (control, biofertilizers [PSB + *Rhizobium*] and biofertilizer (PSB) + foliar spray of 33% cow's urine). One hundred per cent RDF (20:50:20 kg NPK ha^{-1}) significantly increased the yield parameters and yield over 33 per cent RDF and control. Organic manure significantly increased the yield over no manure application. Biofertilizer and organic spray (cow's urine 33% spray on 25 and 45 DAS) helped increasing the DMP, pods/plant, test weight and yield over no biofertilizer application.

Key words : Greengram, Legume based cropping system, Fertility level, Biofertilizer, Organic manure, Yield.

Introduction

Wheat-pulse sequence is most feasible and acceptable to the farmer in the wheat growing belt of north India, especially with assured irrigation. The inclusion of legumes in a cropping system improves the structure and productivity of soil and increases the plant growth owing to provision of nitrogen and other growth promoting factors.

Application of organic manure along with fertilizer not only increase the efficiency of the latter, but also has beneficial effects on the succeeding crop and soil. Despite several hurdles, for overall interest of sustaining soil productivity, the use of organic manure has to be encouraged (Prasad, 1990). Integrated nutrient management includes the intelligent use of organic, inorganic, and on-line biological resources so as to sustain optimum yields, improve or maintain the soil physical and chemical properties, and provide crop nutrition packages which are technically sound, economically attractive, practically feasible and environmentally safe (Tandon, 1995).

Materials and Methods

The field experiment was carried out *Kharif, rabi* and summer (*zaid*) seasons during 1997-1999 at the Crop Research Farm of the Allahabad Agricultural Institute-Deemed University (25°.57' N, 81°.50' E and 98 m). The soil was sandy-loam alluviam and analysed low in organic carbon, nitrogen and phosphorus but high in potassium and the pH was 7.5. The cropping system chosen was :

Kharif	*Rabi*	Summer (*Zaid*)
Blackgram (*Vigna mungo* L.)	Wheat (*Triticum aestivum* L.)	Greengram (*Vigna radiata* L. Wilezeck)

Treatment combinations were 27, replicated thrice. The experiment was laid out in a Randomized Complete Block. Fertilizer doses (F) were: F_0 - Nil application, F_1 - 33% recommended dose (RDF) 6.66, 16.66, 6.66 kg NPK ha^{-1} and F_2 - 100% RDF 20, 50, 20 kg NPK ha^{-1}. Forms of organic manures (C) were C_0 - Nil application, C_1 - Farm compost

Table 1. Effect of INM on dry weight (g/plant) of greengram at 30 & 45 DAS and the post-cropping analysis of the soil physico-chemical properties during 1997-98 and 1998-99

Factors	Plant dry weight (g/plant)				Soil organic carbon (%)		Soil available phosphorus (kg ha^{-1})		Soil available potassium (kg ha^{-1})	
	30 DAS		45 DAS							
	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99
Fertilizer levels (F):										
F_0	3.917	2.364	10.81	11.48	0.268	0.401	25.56	36.81	291.30	345.50
F_1	4.882	3.563	13.98	14.40	0.350	0.420	29.81	41.26	337.60	376.80
F_2	5.132	3.972	13.63	16.58	0.328	0.451	22.78	34.59	329.70	336.20
	*	*	*	*	*	NS	NS	NS	*	NS
Forms of manure (C):										
C_0	3.777	2.744	11.65	11.79	0.275	0.331	16.22	30.33	293.20	339.40
C_1	5.073	3.579	13.69	15.63	0.306	0.471	28.33	41.52	343.50	340.70
C_2	5.081	3.376	13.16	15.03	0.366	0.470	33.59	40.81	321.90	378.40
	*	*	*	*	*	*	*	*	*	NS
Biofertilizer & /or organic spray (B):										
B_0	4.323	3.231	12.52	13.47	0.255	0.397	24.11	30.59	279.40	325.70
B_1	4.490	3.252	12.65	14.57	0.322	0.432	27.37	41.07	337.30	392.30
B_2	5.117	3.461	13.25	14.42	0.370	0.443	26.67	41.00	341.90	340.50
	*	NS	NS	NS	*	NS	NS	*	*	NS
SEd ±	0.3492	0.2367	0.8120	1.1256	0.0327	0.0340	4.419	4.555	18.498	29.130
CD (0.05)	0.7007	0.4749	1.6290	2.2587	0.0656	0.0680	8.859	9.141	37.119	-
FxC FxB CxB:										
SEd ±	0.6049	0.4100	1.4060	1.9500	0.0566	0.0589	7.647	7.891	32.040	50.460
CD (0.05)	1.2140	0.8228	2.8120	3.1300	0.1137	0.1183	15.340	15.830	64.300	101.27

* Significant at P = 0.05 NS = Non-significant

F_0 - No fertilizer (control); F_1 - 33% RDF; and F_2 - 100% RDF)

C_0 - No organic manure (control); C_1 = farm compost + vermicompost; C_2 - farm compost + poultry manure

B_0 - No biofertilizers (control); B_1 - biofertilizers; B_2 - biofertilizer + foliar spray

Table 2. Effect of interaction of fertilizer levels and manurial forms on dry weight of greengram (g/plant) at 45 DAS

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	9.87	11.73	10.82	10.81	8.55	13.76	12.12	11.48
F_1	12.26	15.55	14.13	13.98	12.06	14.72	16.42	14.40
F_2	12.81	13.57	14.52	13.63	14.77	18.41	16.56	16.58
Mean	11.65	13.62	13.16		11.79	15.63	15.03	
		SEd ± 1.41	CD (0.05) 2.82			SEd ± 1.95	CD (0.05) 3.91	

(FC) @ 5 t ha^{-1} + Vermicompost (VC) @ 1 t ha^{-1}. Forms of biofertilizers and/or foliar application of organic manure (B) used were B_0 - Nil application, B_1 - Phosphate solubilizing bacteria (PSB) + *Rhizobium* (Rhz) or *Azospirillum* (Azsp) and B_2 - Phosphate solubilizing bacteria (PSB) + 2 foliar application of 33% cow's urine (CU). The manures and basal dose of fertilizer was administered by placement method into furrows and incorporated well prior to sowing. The plots with CU treatment were administered foliar spray of 33 per cent CU at 25 and 45 DAS to each crop in both the years. Recommended plant protection measures and other agronomic practices were followed as and when required. Observations on growth and yield parameters were recorded at harvest from the plants drawn randomly. Soil samples were taken before the experiment and after the harvest of crop. Plot-wise analysis of soil samples for organic carbon, available phosphorus and potassium were conducted for each of the treatment. Statistical analyses for plant dry weight and yield parameters were done as per the standard procedures.

Results and Discussion

Dry matter accumulation

The fertilizer levels in the INM package administered for greengram in the cropping system influenced the dry matter accumulation at all stages in both the years (Table 1). The treatment 100% RDF level registered higher plant dry weight at 30 and 45 DAS in both the years. The treatment 33% RDF level recorded markedly higher values at 45 DAS (13.98 g/plant) in the 1st year. Statistical parity between the two levels was observed at all stages in respect of DMP.

The dry matter accumulation pattern in greengram component of the cropping system was markedly influenced by the varying manurial forms (Table 1). At 30 DAS in the 2nd year and at 45 DAS in both the years the treatment FC + VC recorded significantly higher DMP (3.579, 13.61 and 15.63 g/plant, respectively). At 30 DAS in the 1st year, the treatment FC + PM produced the maximum DMP (5.081 g/plant), which was significantly higher than the control. In both the years, the DMP was on par.

The dry weight showed significant difference due to biofertilizer treatment and/or organic spray at 30 DAS in the 1st year (Table 1). However, the higher DMP were registered in either of the treatments PSB + CU or PSB + Rhz.

Significantly higher plant dry weight due to the fertilizer levels and manurial forms was noted practically during the entire cropping cycle. This is definitely due to the better availability of essential nutrients and also the favourable conditions prevailing, particularly during the critical growth phases, as a result of the addition of organic matter combined with the inorganic, mineral forms of nutrients.

The biological forms of nutrient carriers, particularly when administered in combination

Table 3. Effect of INM on yield parameters and biological yield of greengram during 1997-98 and 1998-99

Factors	Pods/plant		Seeds/pod		Test weight (g)		Seed yield (kg ha^{-1})		Biological yield (kg ha^{-1})	
	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99
Fertilizer levels (F):										
F_0	59.28	70.52	7.32	10.57	33.76	33.63	741	1068	3705	3543
F_1	66.67	80.67	7.88	11.31	34.63	34.93	859	1512	4297	6674
F_2	67.44	84.06	7.33	11.44	34.95	35.34	752	1503	3760	7626
	NS	*	NS	*	*	*	NS	*	NS	*
Forms of manure (C):										
C_0	61.91	72.39	725	10.94	34.04	34.31	719	1313	3596	5366
C_1	64.62	79.61	7.66	11.19	34.67	34.87	895	1292	4476	6212
C_2	66.85	83.24	7.62	11.20	34.63	34.72	738	1477	3689	6265
	NS	*	NS	NS	NS	NS	*	NS	*	*
Biofertilizer & /or organic spray (B):										
B_0	52.35	77.63	7.18	10.67	34.07	34.28	712	1235	3576	5675
B_1	69.14	79.65	7.60	11.57	34.49	34.60	806	1367	4032	6007
B_2	71.89	73.96	7.76	11.09	34.78	35.02	831	1481	4153	6161
	*	NS	NS	NS	NS	*	NS	*	NS	NS
SEd ±	5.391	4.304	2.915	0.242	0.473	0.279	66	104	332	97
CD (0.05)	10.820	8.638	-	0.487	0.950	0.560	133	209	666	195
FxC FxB CxB:										
SEd ±	9.3390	7.456	0.505	0.420	0.820	0.484	115	180	575	168
CD (0.05)	18.743	14.964	1.013	0.844	1.646	0.971	231	361	1154	337

* Significant at P = 0.05 NS = Non-significant

F_0 - No fertilizer (control); F_1 - 33% RDF; and F_2 - 100% RDF)

C_0 - No organic manure (control); C_1 = farm compost + vermicompost; C_2 - farm compost + poultry manure

B_0 - No biofertilizers (control); B_1 - biofertilizers; B_2 - biofertilizer + foliar spray

Table 4. Effect of interaction of fertilizer levels and manurial forms on seed yield of greengram (kg ha^{-1}) at harvest

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	672	884	667	741	921	1001	1283	1068
F_1	812	960	807	859	1405	1546	1583	1511
F_2	674	842	739	752	1611	1330	1566	1502
Mean	719	895	738		1313	1292	1477	
		SEd ± 115	CD (0.05) 231			SEd ± 180	CD (0.05) 362	

Table 5. Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on seed yield of greengram (kg ha^{-1}) at harvest

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	574	741	908	741	926	1143	1136	1068
F_1	854	976	748	859	1351	1620	1564	1512
F_2	718	703	835	752	1428	1338	1742	1503
Mean	715	807	831		1235	1367	1481	
		SEd ± 115	CD (0.05) 231			SEd ± 180	CD (0.05) 361	

with the organic spray also registered higher DMP throughout the crop period but there was no significant variation due to biofertilizer alone or due to cow's urine as foliar spray. Subbian and Palaniappan (1992) also observed almost similar results.

Interaction effect between fertilizer levels, manurial forms and biofertilizer and/or organic spray on DMP was found significant at 45 DAS. In the 1st year the treatment 33% RDF with FC + VC registered significantly higher DMP than treatment 33% RDF alone (15.55 and 12.26 g respectively). The treatments 100% RDF with FC + PM and 33% RDF with FC + PM (14.52 and 14.13 g, respectively) showed parity with the most effective treatment.

In the 2nd year the maximum DMP was produced by the treatment 100% RDF with FC + VC followed by 100% RDF with FC + PM, 33% RDF with FC + PM and 100% RDF alone, all of which were comparable with each other and significantly better than the treatment FC + PM alone. The interaction between the three factors, *viz.* fertilizer levels, manurial forms and biofertilizer and/or organic spray was noted to be positive for dry weight in comparison to zero level combinations. This indicated that the legume species in a cropping system with INM has a potential to produce larger dry weight. These findings further corroborate the results reported by Chinnusamy and Rangasamy (1997) and Chittapur (1998).

Yield attributes

The varying levels of fertilizer influenced the yield attributes of greengram crop component in the system (Table 3). The pod numbers per plant (84.06), seeds per pod (11.44), seed

yield (1503 kg ha^{-1}) and biological yield (7626 kg ha^{-1}) in the 2nd year and the test weight of seeds in both the years (34.95 and 35.34 g, respectively) were significantly higher in treatment 100% RDF than the control. Statistical parity was noticed in the treatment 33% RDF for all parameters except the biological yield.

The manurial forms markedly affected some of the yield attributes (Table 3). The pod numbers per plant (83.24) in the 2nd year was significantly higher in treatment FC + PM and the pods in treatment FC + VC (79.61) was statistically comparable. The seed and biological yield (895 and 4476 kg ha^{-1}) in the 1st year were markedly higher in treatment FC + VC. However, the biological yield was significantly higher in the treatment FC + PM and the yield obtained in treatment FC + VC was on par (6265 and 6212 kg ha^{-1}, respectively).

The biofertilizer and/or organic spray markedly influenced only one yield attribute (Table 3). In the 1st year the pod count per plant was significantly higher in treatment PSB + CU, and the treatment PSB + Rhz were on par (71.89 and 69.14 respectively). The test weight and seed yield in the 2nd year were significantly higher in treatment PSB + CU. The maximum values in all other parameters were registered in either of the treatments PSB + CU and PSB + Rhz.

All the three factors, *viz.* fertilizer levels, manurial forms and biofertilizer and/or organic spray registered higher yield parameters, *viz.* pods/plant, seeds/pot, test weight, seed yiedl and biological yield. The fertilizer dose of 100% RDF or 33% RDF increased the yield parameters. Similarly, the manurial treatment FC + PM or FC + VC combination and the biofertilizer and/or organic spray treatment PSB + Cu or PSB + Rhz combination have increased the yield parameters. This may be ascribed to the growth promoting properties of manures and biofertilizers, which has been observed by Sarmah *et al.* (1992), Maheshwari (1974) and Kale (1993).

In the 1st year the treatment 33% RDF with FC + VC recorded significantly higher seed yield than the treatment 100% RDF alone (960 and 674 kg ha^{-1}, respectively). No other treatment showed statistical significance (Table 4). In the 2nd year the treatment 100% RDF registered significantly higher seed yield (1611 kg ha^{-1}) than control (921 kg ha^{-1}). All other treatments except FC + VC alone were statistically on par with the most effective treatment.

In the 1st year the treatment 33% RDF with PSB + Rhz was observed to be highly significant (976 kg ha^{-1}) over treatment PSB + Rhz alone (741.00 kg ha^{-1}). The minimum of 574 kg ha^{-1} was recorded in the control (Table 5). In the 2nd year the treatment 100% RDF with PSB + CU recorded maximum yield with statistical significance over other treatment combinations. The minimum yield was recorded in the control plot. Madhavi *et al.* (1995) and Nambiar and Abrol (1992) corroborated the findings with regard to interaction between these three factors on bilateral basis, which showed that there was a definite positive relationship between them. The complimentary effect was beneficial in making the source to sink trasnlocation function at its optimal peak. This resultant effect can be assumed as sustainable in terms of fulfilling the cultivators' objective of maximising productivity in the cropping system.

Post-cropping soil status

The varying fertilizer levels in the INM package administered to the greengram crop in the system influenced certain physico-chemical properties of the soil (Table 1).

In the 1st year the percentage organic carbon was significantly higher in treatment 33% RDF than control plot (0.350 and 0.268% respectively).

The available potassium status of the soil in the 1st year at the post-cropping stage was markedly higher in treatment 33% RDF and the value analysed in treatment 100% RDF was comparable (337.60 and 329.70 kg ha^{-1}), respectively.

Though the soil analyses data on percentage organic carbon and available potassium in the 2nd year and available phosphorus in both years did not show any significant differences, the maximum values were registered in either of the treatments 100% RDF or 33% RDF levels.

The percentage organic carbon was significantly higher in treatment FC + PM during the 1st year and in treatment FC + VC in the 2nd year and were statistically on par (0.366 and 0.306%, respectively in the 1st year and 0.471 and 0.470, respectively in the 2nd year).

The available phosphorus was significantly higher in treatment FC + PM during the 1st year and treatment FC + VC in the 2nd year. Statistical parity between the two treatments was observed (33.59 and 28.33 kg ha^{-1}, respectively in the 1st year and 41.52 and 40.81 kg ha^{-1}, respectively in the 2nd year). The available potassium status in the 1st year was markedly higher in treatment FC + VC than control (343.50 and 293.20 kg ha^{-1}). In the 2nd year the maximum and minimum available potassium were registered in treatments FC + PM and control plot respectively (378.40 and 339.40 kg ha^{-1}).

The percentage organic carbon and available potassium in the 1st year were significantly higher in treatment PSB + CU (0.370% and 341.90 kg ha^{-1}, respectively) than control and statistical parity in treatment PSB + Rhz was noticed (0.322% and 337.30 kg ha^{-1}, respectively).

The positive effect of greengram cropping under INM system on the physico-chemical properties of the soil was evident. These treatments were responsible for the highest values of organic carbon, available phosphorus and potassium in both the years. Mahanta and Borah (1998) observed that poultry manure was the most effective in increasing the yield of blackgram. The treatments with 33% RDF showing higher values of organic carbon, available P_2O_5 and K_2O may be due to the reduced volatilization and leaching losses. Similar trend was maintained by the interactive effect of these factors, thereby proving the principle of synergy active in the rhizosphere.

Increase in organic carbon with integratd nutrient supply was mainly due to addition of organic matter (Patnaik *et al.* 1989). Dayal and Agarwal (1998) concluded that this might be due to the improvement in physical, chemical and biological properties of soil by addition of organic manures. The interaction effect between organic sources and fertilizer levels was also significant.

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