

Effect of Integrated Nutrient Management on Soil Properties and Crop Yield under Black Gram-Wheat Cropping System in a Typic Haplustept

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Received: July 2010

Abstract: Field experiments were conducted during 2003-04 and 2004-05 to develop suitable integrated nutrient supply system for black gram-wheat cropping system. The study was aimed to find out the effect of integration of chemical source of phosphorus with bio-fertilizers on black gram and their residual effect on succeeding wheat crop at Udaipur. Incorporation of FYM @ 5 t ha⁻¹ considerably decreased the bulk density and increased the porosity, cation exchange capacity, organic carbon and available N, P and K status of the soil. Study showed the application of FYM @ 5 t ha⁻¹ or application of 40 kg P₂O₅ ha⁻¹ significantly increased the seed and stover yield of black gram as well as of succeeding wheat grown in sequence. Dual inoculation (PSB + VAM) to black gram also increased the yield of black gram and succeeding wheat crop grown in sequence.

Key words: INM, bulk density, NPK, C.E.C., organic carbon, productivity, black gram, wheat.

Continuous addition of chemical fertilizers poses problems like toxicity due to high amount of sales as a residue of fertilizers, deterioration of the physical properties of soil, impairing the aeration and soil-water-plant relationship resulting in decreased productivity. Farm yard manure (FYM) ameliorates this problem as organic matter helps in increasing adsorptive power of the soil for cations and anions particularly phosphorus and nitrates. These adsorbed nutrient ions are released slowly for the benefit of crops during entire growth period. It also helps to improve the organic carbon (OC) status, availability of primary and secondary nutrients in the soil (Badanur *et al.*, 1990), and also supplies sufficient amount of micronutrients in available forms. However, due to its low nutrient and slow acting nature, FYM alone may not be able to meet the high nutrient requirements of crops. Likewise, the use of NPK fertilizers alone under modern intensive farming may not be sufficient. Large number of experiments has demonstrated the importance of FYM and bio-fertilizers in supplementing the nutrient requirements of crops and providing yield stability (Venkateswarlu and Wani, 1999). Therefore, the right combination of FYM, chemical fertilizer (P) and bio-fertilizers seems to be the way-out. The objective of the present study was to investigate the changes in physico-chemical properties and levels of OC, available

N, P and K of soil and yield of black gram-wheat under integrated nutrient management practices.

Materials and Methods

The experiments were conducted during kharif and rabi seasons of 2003-04 and 2004-05 at the research farm of Rajasthan College of Agriculture, Udaipur. The experimental soil was clay loam in texture with pH 7.8 and EC 1.18 dS m⁻¹ containing 0.76% OC, 268.4 kg ha⁻¹ available N, 19.5 kg ha⁻¹ available P₂O₅ and 370.8 kg ha⁻¹ available K₂O. The experiment was conducted at the same site during both the seasons and years in split-plot design with 2 levels of FYM (0 and 5 t ha⁻¹) and 4 levels of phosphorus (0, 20, 30 and 40 kg P₂O₅ ha⁻¹) in main-plot and bio-fertilizers (untreated control, phosphate solubilizing bacteria i.e. PSB, Vesicular Arbuscular Mycorrhiza i.e. VAM and PSB + VAM) in sub-plots. The treatments were replicated thrice. The FYM was incorporated 20 days before sowing in the soil as per treatment. The recommended dose of N (20 kg ha⁻¹) was applied through urea. Phosphorus was applied through diammonium phosphate. The seed of black gram were inoculated with PSB (*Phosphorus megatherium* var. *Phosphaticum*) before sowing and VAM (*Glomus fasciculatum*) was drilled below seed just before sowing as per treatment. Black gram was sown on July 5, 2003 and July 6, 2004. After harvest of black gram, each experimental plot was prepared manually without disturbing

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Table 1. Effect of FYM, phosphorus levels and bio-fertilizers on bulk, density, CEC and organic carbon content in soil after harvest of black gram

Treatments	Bulk density (g cc ⁻¹)			Porosity (%)			CEC [cmol (P ⁺) kg ⁻¹]			Organic carbon (%)		
	2003	2004	Mean	2003	2004	Mean	2003	2004	Mean	2003	2004	Mean
FYM (t ha ⁻¹)												
0	1.461	1.485	1.473	45.14	45.45	45.30	21.606	22.370	21.988	0.780	0.809	0.804
5	1.426	1.436	1.431	46.11	46.22	46.17	23.685	23.557	23.621	0.850	0.868	0.869
SEm±	0.010	0.016		0.220	0.216		0.217	0.146		0.004	0.004	
CD (P=0.05)	0.030	0.048		0.668	0.639		0.658	0.443		0.011	0.012	
P levels (kg ha ⁻¹)												
0	1.447	1.467	1.457	45.64	45.80	45.72	21.902	22.324	22.113	0.802	0.826	0.814
20	1.445	1.464	1.455	45.65	45.82	45.74	22.569	22.924	22.747	0.813	0.833	0.823
30	1.443	1.462	1.453	45.66	45.83	45.75	22.659	23.024	22.842	0.820	0.844	0.832
40	1.440	1.450	1.445	45.54	45.90	45.72	23.451	23.581	23.516	0.825	0.850	0.838
SEm±	0.0142	0.023		0.312	0.298		0.307	0.207		0.005	0.005	
CD (P=0.05)	NS	NS		NS	NS		0.931	0.627		0.016	0.017	
Biofertilizers												
No inoculation	1.462	1.486	1.474	45.50	45.77	45.64	22.409	22.755	22.582	0.758	0.796	0.777
PSB	1.443	1.458	1.451	45.66	45.84	45.75	22.602	22.943	22.773	0.819	0.845	0.832
VAM	1.440	1.458	1.449	45.67	45.86	45.77	22.661	22.933	22.797	0.826	0.848	0.837
PSB+VAM	1.431	1.443	1.437	45.68	45.89	45.79	22.909	23.223	23.066	0.857	0.864	0.861
SEm±	0.011	0.022		0.291	0.250		0.193	0.136		0.004	0.005	
CD (P=0.05)	NS	NS		NS	NS		NS	NS		0.011	0.014	

original plan of the layout and wheat variety Raj. 3765 was sown. Nitrogen was applied through urea @ 90 kg N ha⁻¹ in two equal splits at sowing and at first irrigation. Physico-chemical properties of soil after harvest of wheat crop were analyzed as per standard methods.

Results and Discussion

Soil properties

The bulk density of soil after harvest of black gram and succeeding wheat crop under FYM treated plots decreased as compared to control

Table 2. Residual effect of FYM, phosphorus levels and bio fertilizers on bulk density, CEC and organic carbon content of soil after harvest of succeeding wheat

Treatments	Bulk density (g cc ⁻¹)			Porosity (%)			CEC [cmol (P ⁺) kg ⁻¹]			Organic carbon (%)		
	2003	2004	Mean	2003	2004	Mean	2003	2004	Mean	2003	2004	Mean
FYM (t ha ⁻¹)												
0	1.46100	1.48500	1.473	44.8400	45.1300	44.99	20.5000	21.1900	20.85	0.7500	0.7600	0.760
5	1.42600	1.43600	1.431	45.8100	45.9000	45.86	22.5800	22.3800	22.48	0.8100	0.8200	0.820
SEm±	0.01016	0.01529		0.2361	0.2814		0.2008	0.1395		0.0046	0.0051	
CD (P=0.05)	0.03082	0.04638		0.7162	NS		0.6089	0.4232		0.0141	0.0154	
P levels (kg ha ⁻¹)												
0	1.44700	1.46700	1.457	45.3400	45.4800	45.41	20.8000	21.1400	20.97	0.6700	0.6700	0.670
20	1.44500	1.46400	1.455	45.3500	45.5000	45.43	21.4600	21.7400	21.60	0.7800	0.7800	0.780
30	1.44300	1.46200	1.453	45.3500	45.5100	45.43	21.5600	21.8400	21.70	0.7900	0.7900	0.790
40	1.44000	1.45000	1.445	45.3600	45.5800	45.47	22.3500	22.4000	22.38	0.7900	0.8000	0.800
SEm±	0.01437	0.02182		0.3339	0.3979		0.2839	0.1973		0.0046	0.0051	
CD (P=0.05)	NS	NS		NS	NS		0.8612	0.5986		NS	NS	
Biofertilizers												
No inoculation	1.46200	1.48600	1.474	45.2000	45.4500	45.32	21.3100	21.5700	21.44	0.7700	0.7800	0.770
PSB	1.44300	1.45800	1.451	45.3600	45.5200	45.44	21.5000	21.7500	21.63	0.7800	0.7900	0.780
VAM	1.44000	1.45800	1.449	45.3700	45.5400	45.46	21.5600	21.7600	21.66	0.7900	0.7900	0.790
PSB+VAM	1.43100	1.44300	1.437	45.3800	45.5700	45.48	21.8000	22.0400	21.92	0.7900	0.8000	0.861
SEm±	0.01110	0.02121		0.2942	0.3113		0.1576	0.1446		0.0055	0.0071	
CD (P=0.05)	NS	NS		NS	NS		NS	NS		NS	NS	

Table 3. Effect of FYM, phosphorus levels and biofertilizers on available nitrogen, phosphorus and potassium status of soil after harvest of black gram

Treatments	Nitrogen (kg ha ⁻¹)			Phosphorus (kg ha ⁻¹)			Potassium (kg ha ⁻¹)		
	2003	2004	Mean	2003	2004	Mean	2003	2004	Mean
FYM (t ha ⁻¹)									
0	284.870	280.340	282.60	19.500	20.290	19.89	359.550	329.250	344.40
5	301.180	298.990	300.08	23.860	24.550	24.20	370.840	343.340	357.09
SEm±	1.020	1.459		0.104	0.098		1.809	2.417	
CD (P=0.05)	3.094	4.425		0.315	0.299		5.487	7.333	
P levels (kg ha ⁻¹)									
0	285.610	278.950	282.28	18.400	20.560	19.48	359.060	327.280	343.17
20	293.610	289.920	291.75	21.700	22.350	22.02	364.490	335.960	350.22
30	295.950	293.410	294.68	22.830	23.330	23.08	366.750	338.520	352.63
40	296.930	296.380	296.66	23.770	23.430	23.60	370.480	343.430	356.95
SEm±	1.442	2.063		0.146	0.139		2.558	3.419	
CD (P=0.05)	4.375	6.258		0.445	0.422		7.760	10.372	
Biofertilizers									
No inoculation	289.510	284.710	287.11	18.890	20.830	19.86	361.150	332.790	346.97
PSB	293.940	290.850	292.39	22.270	22.570	22.42	366.020	337.240	351.63
VAM	293.970	290.940	292.46	22.500	22.780	22.64	366.060	337.460	351.76
PSB+VAM	294.680	291.160	293.42	23.050	23.500	23.27	367.530	337.700	352.61
SEm±	1.382	1.993		0.133	0.137		2.533	3.094	
CD (P=0.05)	3.935	5.673		0.379	0.390		NS	NS	

resulting in significant increase in soil porosity (Table 1 and 2). Similar results were recorded by Babhulkar *et al.* (2000). The improvement in the soil physical properties might be due to increased organic matter and improved soil structure. Bhatnagar *et al.* (1992) also reported that the total

porosity was significantly higher in treatments receiving FYM. P application and bio-fertilizers did not significantly influence the bulk density and porosity (Table 1).

The CEC of soil was significantly increased by the application of 5 t ha⁻¹ of FYM and higher dose

Table 4. Residual effect of FYM, phosphorus levels and bio-fertilizers on available nitrogen, phosphorus and potassium (kg ha⁻¹) status of soil after harvest of succeeding wheat

Treatments	Nitrogen (kg ha ⁻¹)			Phosphorus (kg ha ⁻¹)			Potassium (kg ha ⁻¹)		
	2003-04	2004-05	Mean	2003-04	2004-05	Mean	2003-04	2004-05	Mean
FYM (t ha ⁻¹)									
0	277.9700	273.560	275.77	17.40	18.120	17.76	340.000	309.050	324.52
5	285.1500	281.060	283.11	19.76	20.380	20.07	246.260	317.990	332.13
SEm±	1.0480	1.495		0.114	0.105		1.850	2.446	
CD (P=0.05)	3.1790	4.534		0.338	0.319		5.610	7.420	
P levels (kg ha ⁻¹)									
0	276.9600	271.850	274.41	16.80	18.890	17.85	338.760	310.430	324.59
20	282.2100	277.140	279.67	18.60	19.180	18.89	341.890	311.110	326.50
30	283.0500	278.630	280.84	18.98	19.410	19.20	344.150	313.670	328.91
40	284.0300	281.600	282.82	19.92	19.520	19.72	347.730	318.880	333.30
SEm±	1.4820	2.114		0.157	0.149		2.616	3.443	
CD (P=0.05)	4.4970	6.412		0.478	0.451		NS	NS	
Biofertilizers									
No inoculation	278.3600	273.240	275.80	15.79	17.660	16.73	339.090	309.940	324.51
PSB	282.4200	278.190	280.30	19.17	19.400	19.29	343.960	314.390	329.17
VAM	282.5700	278.290	280.43	19.40	19.610	19.51	344.000	314.610	329.31
PSB+VAM	282.9000	279.500	281.20	19.95	20.330	20.14	345.470	315.150	330.31
SEm±	1.4720	2.009		0.152	0.143		2.557	3.202	
CD (P=0.05)	NS	NS		0.432	0.408		NS	NS	

Table 5. Effect of FYM and phosphorus levels on yield of black gram (Pooled over two years)

Phosphorus (kg ha ⁻¹)	FYM levels (t ha ⁻¹)			FYM levels (t ha ⁻¹)		
	0	5	Mean	0	5	Mean
	Seed yield (q ha ⁻¹)			Stover yield (q ha ⁻¹)		
0	7.430	9.010	8.220	13.850	16.770	15.310
20	8.040	10.070	9.060	15.220	19.100	17.160
30	8.460	11.110	9.780	16.110	21.160	18.630
40	9.260	11.470	10.360	17.640	21.850	19.740
Mean	8.300	10.470		15.710	19.720	
	FYM	P	FYM x P	FYM	P	FYM x P
SEm±	0.048	0.067	0.095	0.091	0.129	0.183
CD (P=0.05)	0.138	0.198	0.276	0.264	0.374	0.529

FYM – Farm yard manure.

of phosphorus (40 kg ha⁻¹). The OC of soil after the harvest of black gram and wheat was higher where FYM had been applied (Table 1 and 2). The highest OC content was recorded where FYM was applied @ 5 t ha⁻¹, it may be due to addition of organic manure, which stimulated the growth and activity of micro-

before start of the experiment (Table 3 and 4). The increase was maximum where FYM (5 t ha⁻¹) and phosphorus (40 kg ha⁻¹) were applied. It may be due to sufficient nutrients supplied through FYM and P fertilizers (Rao *et al.*, 1987). The results clearly indicate that the legume crop fixed and increased the

Table 6. Effect of FYM and biofertilizers on yield of black gram (Pooled over two years)

Biofertilizers	FYM levels (t ha ⁻¹)			FYM levels (t ha ⁻¹)		
	0	5	Mean	0	5	Mean
	Seed yield (q ha ⁻¹)			Stover yield (q ha ⁻¹)		
Control	7.930	9.610	8.770	15.010	18.180	16.590
PSB	8.180	10.310	9.250	15.470	19.520	17.500
VAM	8.290	10.590	9.440	15.690	20.040	17.860
PSB+VAM	8.790	11.150	9.970	16.650	21.140	18.880
Mean	8.300	10.410				
	FYM	BF	FYM x BF	FYM	BF	FYM x BF
SEm±	0.048	0.064	0.090	0.091	0.122	0.183
CD (P=0.05)	0.138	0.179	0.253	0.264	0.343	0.529

BF – Biofertilizer, FYM – Farm yard manure.

organisms and also due to better root growth. These observations are in conformity with the findings of Varalakshmi *et al.* (2005). Higher production of biomass might have also increased the OC content (Babhulkar *et al.*, 2000).

The available nitrogen in soil after harvest of both the crops was higher than the initial content

available nitrogen content in the soil. Similar results were reported by Rao (2003) and Badanar *et al.* (1990).

The available phosphorus content in soil increased significantly due to various nutrient management practices (Table 3 and 4) and was highest with application of 5 t FYM ha⁻¹ and 40 kg P₂O₅ ha⁻¹ and dual inoculation with PSB and VAM

Table 7. Effect of phosphorus and biofertilizers on yield of black gram (Pooled over two years)

Biofertilizers	P levels (kg ha ⁻¹)					P levels (kg ha ⁻¹)				
	0	20	30	40	Mean	0	20	30	40	Mean
	Seed yield (q ha ⁻¹)					Stover yield (q ha ⁻¹)				
Control	7.780	8.770	9.120	9.40	8.77	14.480	16.620	17.380	17.90	16.59
PSB	8.060	9.090	9.640	10.20	9.25	15.000	17.220	18.370	19.43	17.50
VAM	8.270	9.270	9.820	10.39	9.44	15.400	17.260	18.710	19.79	17.86
PSB+VAM	8.770	9.100	10.550	11.47	9.97	16.360	17.550	20.090	21.85	18.88
Mean	8.220	9.060	9.780	10.36		15.310	17.160	18.630	19.74	
	P	BF	P x BF			P	BF	P x BF		
SEm±	0.067	0.064	0.128			0.129	0.122	0.244		
CD (P=0.05)	0.195	0.179	0.358			0.374	0.343	0.686		

BF – Biofertilizer.

Table 8. Residual effect of FYM, phosphorus levels and bio-fertilizers on yield of succeeding wheat

Treatments	Grain yield (q ha ⁻¹)			Straw yield (q ha ⁻¹)		
	2003-04	2004-05	Pooled	2003-04	2004-05	Pooled
FYM (t ha ⁻¹)						
0	40.900	52.070	46.490	60.230	77.460	68.840
5	45.420	54.520	49.970	65.970	81.450	73.710
SEm±	0.502	0.631	0.403	0.520	0.489	0.357
CD (P=0.05)	1.521	1.914	1.680	1.578	1.482	1.034
P levels (kg ha ⁻¹)						
0	37.620	48.970	43.300	50.970	70.190	60.580
20	42.380	52.200	47.200	60.810	76.920	68.870
30	45.380	55.030	50.200	67.830	82.790	75.310
40	47.260	56.970	52.110	72.810	87.910	80.360
SEm±	0.709	0.892	0.570	0.736	0.691	0.505
CD (P=0.05)	2.152	2.707	1.651	2.320	2.096	1.462
Biofertilizers						
No inoculation	40.370	48.130	44.250	56.400	72.480	64.440
PSB	43.320	53.370	48.350	63.660	80.000	71.830
VAM	43.510	53.850	48.680	64.080	80.460	72.270
PSB+VAM	45.440	57.830	51.630	68.280	84.870	76.570
SEm±	0.643	0.680	0.468	0.595	0.573	0.413
CD (P=0.05)	1.831	1.935	1.314	1.695	1.632	1.160

bio-fertilizers. Incorporation of FYM along with inorganic P increased the availability of P and this may be due to reduction in fixation of water soluble P, increased mineralization of organic P due to microbial action and enhanced availability of P (Varalakshmi *et al.*, 2005). Inoculation of black gram seed with PSB and VAM enhances available P status of soil by solubilizing bound phosphate into available forms (Singh and Yadav, 2008).

Application of FYM @ 5 t ha⁻¹ in black gram crop significantly increased the available potassium content of soil after harvest of black gram and succeeding wheat crop. The higher availability of potassium due to FYM may be ascribed to the reduction of K fixation and release of K due to the interaction of organic matter with clay (Tandon, 1987). Similar results were reported by Jagadeeshwari and Kumaraswamy (2000).

Crop yields

The seed and stover yields of black gram increased significantly due to application of FYM, P and inoculation with various bio-fertilizers. Interaction effect of FYM and P, FYM and bio-fertilizers, and P and bio-fertilizers on seed and stover yield of black gram was found significant (Table 5 to 7). In general, combined application of FYM @ 5 t ha⁻¹ + 40 kg P₂O₅ ha⁻¹, 5 t ha⁻¹ of FYM + dual inoculation of PSB + VAM and 40 kg P₂O₅ ha⁻¹ + dual inoculation of PSB + VAM gave higher seed

and stover yields of black gram. This combination was found significantly superior over other combinations. However, the interaction effect of FYM and P, FYM and bio-fertilizers and P and bio-fertilizers was non-significant with respect to grain and straw yields of residual succeeding wheat crop (Table 8). It might be attributed to the response of wheat to the residual effect of nutrients and legume crop on account of balanced supply of inorganic P fertilizers, FYM and bio-fertilizers. These results are in line with the findings of Anilkumar *et al.* (2003) and Singh and Yadav (2008).

This study indicated that integrated use of 5 t FYM ha⁻¹, 40 kg P₂O₅ ha⁻¹ and dual inoculation of PSB and VAM resulted in significantly higher seed/grain and stover/straw yield of black gram/wheat as well as improved fertility status of soil.

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