

Crop productivity, soil fertility and economics of soybean (*Glycine max*), chickpea (*Cicer arietinum*) and blond psyllium (*Plantago ovata*) under organic nutrient management practices

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Received: 10 August 2009; Revised accepted: 9 August 2010

ABSTRACT

A field experiment was conducted during rainy (*kharif*) and winter (*rabi*) seasons of 2004–08 to study the effect of different combination of organic manures involving cowdung manure, poultry manure and vermicompost vis-à-vis recommended doses of fertilizers and control on the yield potential, soil fertility and economics of soybean [*Glycine max* (L.) Merr.], chickpea (*Cicer arietinum* L.) and blond psyllium or *isabgol* (*Plantago ovata* Forsk) in deep Vertisols of central India. The mean of 4-year data indicated that the highest soybean seed yield (1 069 kg/ha) was obtained with the application of cowdung manure 4 tonnes/ha and for chickpea, a combination of cowdung manure 2 tonnes/ha + vermicompost 1.5 tonnes/ha resulted in the highest seed yield (1 766 kg/ha) which was at par with the yield obtained by the recommended dose of fertilizers (1 693 kg/ha). *Isabgol* seed yield was the highest (1 291 kg/ha) with the combined application of cowdung manure 1 tonne/ha + vermicompost 0.7 tonne/ha + poultry manure 0.5 tonne/ha, which was superior to the yields obtained with the recommended dose of fertilizers (1 153 kg/ha). The seed quality of these crops was at par with the treatments receiving either organic manures or chemical fertilizers but was significantly superior to the control. At the end of the fourth cropping cycle, combined application of cowdung manure + vermicompost + poultry manure resulted in the improvement of soil organic carbon content, available soil N, P and K compared to either recommended dose of fertilizers or control. Soybean–chickpea recorded the highest gross returns (₹ 43 927), net returns (₹ 23 890) and benefit : cost ratio (2.19) compared to the soybean–*isabgol* cropping system. Combined application of cowdung manure + vermicompost + poultry manure resulted in the highest gross returns (₹ 45 008), net returns (₹ 24 786) and benefit : cost ratio (2.22) compared to either chemical fertilizers or the control.

Key words: Chickpea, Economics, *Isabgol*, Organic farming, Seed yield, Soil fertility, Soybean

Soybean (*Glycine max* L. Merr.) in rainy season (July–October) and chickpea (*Cicer arietinum* L.) in winter season (November–March) is the major cropping system in central India. Of late, medicinal crops like *isabgol* (*Plantago ovata* Forsk) are being recommended in these climatic conditions (Maiti and Mandal 2000) as there is a huge export demand of *isabgol*, especially when it is grown under organic management practices without agrochemicals. Since the nutrient requirement of soybean, chickpea and *isabgol* are relatively low, there is a scope to grow these crops exclusively with organic manures as a source of nutrients. The management of manures within a crop rotation can have large

effects on yields and crop quality (Ramesh *et al.* 2008). Organic manures influence soil productivity through their effect on soil physical, chemical and biological properties (Ramesh *et al.* 2009a). There is scarcity of information on the organic nutrient management practices for these cropping systems. Therefore, the present study was undertaken to study the crop productivity, soil fertility and economics of soybean, chickpea and *isabgol* under organic nutrient management practices in comparison to chemical fertilizers.

MATERIALS AND METHODS

Field experiments were conducted in 2004–08 during rainy (*kharif*) and winter (*rabi*) seasons in the organic farm block of the Institute, Bhopal on deep Vertisols. The soil was clayey in texture (clay 56.8%, silt 18.0% and sand 25.2%) and classified as Typic Haplustert having pH 7.9, cation exchange capacity 44.5 c mol (p+)/kg and electrical conductivity 0.52 dS/m in the top 15 cm of soil. The available

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soil nitrogen, phosphorus and potassium were 154, 12.77 and 530 kg/ha, respectively. The organic carbon content of the soil was 0.53%. The water-holding capacity, bulk density and porosity of the surface (0–15 cm) soil were 62% on volume basis, 1.47 Mg/m³ and 45%, respectively. The experiment was repeated on the same site throughout the 4 years.

The treatments comprising 2 cropping systems, viz soybean–chickpea and soybean–*isabgol* and 6 manurial treatments in split-plot design with 4 replications. In *kharif*, soybean was taken up with cowdung manure, recommended dose of fertilizers and control. In *rabi*, chickpea and *isabgol* were taken up with 4 combinations involving cowdung manure, poultry manure and vermicompost; recommended dose of fertilizers and control. The dose of organic manures was calculated based on N equivalence and were applied on dry weight basis 2 weeks before sowing. Phosphorus requirement of soybean crop was supplemented through rock phosphate (containing 13.9% P) addition after adjusting the amount of P supplied through manures. Urea, single superphosphate and muriate of potash were applied as per the recommended dose of fertilizers at sowing. The nutrient composition of cowdung, poultry manure and vermicompost were 0.75–0.4–0.8, 1.55–1.6–1.4 and 1.0–0.8–0.8% N, P and K respectively. The quantity of organic manures applied for each crop and season is given in Table 2. The quantity of N and P applied through organic manures for each crop is equivalent to the N and P supplied through the recommended dose of fertilizers, ie 30 kg N, 26.2 kg P for soybean, 30 kg N, 17.5 kg P for chickpea and 20 kg N, 17.5 kg P/ha for *isabgol*. ‘JS 335’ soybean was sown during the first week of July and harvested in the second week of October. ‘JG 74’ chickpea and ‘GI 2’ *isabgol* were sown during the second week of November and harvested during the second week of March. Soybean was raised as rainfed crop, whereas, chickpea and *isabgol* received 1 pre-sowing and 2 post-sowing irrigations of 70 mm each at 30 and 90 days after sowing. The amount of rainfall received during the rainy season (July–October) was 798, 888, 1514 and 783 mm during 2004, 2005, 2006 and 2007, respectively. No major

pests and diseases were occurred during the crop growth. Soil samples (0–15 cm depth) were collected at the end of the cropping cycle and analyzed for organic carbon, available N, P and K by following the standard methods.

RESULTS AND DISCUSSION

Yield component

Application of cowdung manure to soybean gave significantly higher pods/plant (27 to 29) compared to the control (23) but was at par with the treatment receiving the recommended dose of fertilizers (28). However, seeds/pod and 100-seed weight of soybean were not affected significantly due to treatments (Table 1). In chickpea, combination of cowdung manure + vermicompost recorded the highest pods/plant (105) which was at par with recommended dose of fertilizers (102), but significantly superior to control (66). The 100-seed weight of chickpea was the highest (19.0 g) in cowdung manure + vermicompost treatment compared to either recommended dose of fertilizers (18.2 g) or the control (13.4 g). However, such differences were not observed with reference to the number of seeds/pod in chickpea. In *isabgol*, highest number of spikes/m row length (442) and seeds/spike (45) were observed in the treatment receiving cowdung manure + vermicompost + poultry manure combination of organic manures. However, 100-seed weight of *isabgol* was not affected significantly due to nutrient management practices.

Seed yield

In general, the productivity of soybean was less in 2004 and 2006. This was due to deficit rainfall during pod-filling stage in 2004 and waterlogging during 2006 causing poor pod setting and smaller seed yields (Table 2). Even though the total rainfall was low (783 mm) in 2007, but its distribution favoured the soybean productivity. In soybean, application of cowdung manure recorded similar seed yield compared to the treatment receiving the recommended dose of fertilizers but was superior to the control in all the years. On an average, cowdung manure application recorded 1 014 to 1 069 kg/ha seed yield and recommended dose of fertilizers and control

Table 1 Yield attributes of soybean, chickpea and *isabgol* as influenced by nutrient management practices (mean of 4 years)

Treatment		Soybean			Chickpea			Isabgol		
<i>Kharif</i>	<i>Rabi</i>	Pods/ plant	Seeds/ pod	100-seed weight(g)	Pods/ plant	Seeds/ pod	100-seed weight(g)	Spikes/m rowlength	Seeds/ spike	100-seed weight(g)
CDM	CDM + PM	28	2.8	9.6	93	1.3	18.5	418	39	0.18
CDM	CDM + VC	28	2.7	9.5	105	1.3	19.0	420	40	0.19
CDM	PM + VC	27	2.7	9.4	90	1.2	17.9	410	41	0.18
CDM	CDM + VC + PM	29	2.8	9.7	100	1.3	18.5	442	45	0.19
RDF	RDF	28	2.7	9.6	102	1.3	18.2	419	40	0.18
Control	Control	23	2.5	9.2	66	1.2	13.4	312	31	0.16
CD (<i>P</i> = 0.05)		2.6	NS	NS	6.6	NS	0.52	20.1	4.4	NS

CDM, Cowdung manure; PM, poultry manure; VC, vermicompost; RDF, recommended dose of fertilizers

recorded 1 028 and 869 kg/ha, respectively. Applications of organic manures were reported to sustain the productivity of soybean in soybean–durum wheat cropping system in vertisols (Ramesh *et al.* 2008).

In chickpea, during the first year (2004–05), recommended dose of fertilizers recorded the highest seed yield (1 695 kg/ha) which was at par with the treatment receiving cowdung manure + vermicompost combination (1 582 kg/ha). From the second year (2005–06) onwards, cowdung manure + vermicompost combination recorded the highest seed yields, which were at par with the treatment receiving recommended dose of fertilizers. On an average, this combination of organic manures recorded 1 766 kg/ha of seed yield which was at par with the recommended dose of fertilizers (1 693 kg/ha) and were superior to the control (Table 2). Similar increase in chickpea seed yield with the application of farmyard manure @ 5 tonnes/ha under limited water conditions was reported by Shivakumar *et al.* (2002).

In *isabgol*, combined application of cowdung manure + vermicompost + poultry manure recorded the highest seed yield in all the years. However, the seed yield in this treatment was at par with the yields obtained in the recommended dose of fertilizers during the first (2004–05) and second year (2005–06). Whereas in the third (2006–07) and fourth year (2007–08), this combination of organic manures recorded

significantly the highest seed yield compared to the yields obtained with the recommended dose of fertilizers. On an average, this treatment resulted 1 291 kg/ha of seed yield compared to 1 153 kg/ha in the recommended dose of fertilizers and 922 kg/ha in the control (Table 2). Higher seed yield of crops due to manure application was due to higher yield attributes and favourable residual and cumulative effect of applied manures. Yadav *et al.* (2003) also reported that conjunctive use of N through farmyard manure resulted in the higher productivity of *isabgol*. In general, the productivity of crops in organic farming was reported to be low, especially in the initial years of conversion (Berry *et al.* 2002). However, in the present study, such conspicuous decline in yield was not observed. This may be due to low nutrient requirement of the test crops, besides nitrogen fixation by soybean and chickpea as reported by Ramesh *et al.* (2009 b).

Seed quality

In general, application of either organic manures or chemical fertilizers recorded higher seed quality parameters of soybean, chickpea and *isabgol* compared to the control. In soybean, application of cowdung manure resulted in the seed protein content, which ranges from 35 to 35.09% whereas it is 34.96% in the recommended dose of fertilizers and was significantly less (34.22%) in the control. Similarly,

Table 2 Seed yield and quality of soybean, chickpea and *isabgol* as influenced by nutrient management practices

Treatment	2004	2005	2006	2007	Mean	Protein (%)	Oil (%)
	<i>Soybean seed yield (kg/ha)</i>					<i>Soybean seed quality**</i>	
CDM (4.0)*	764	1 374	848	1 092	1 019	35.00	18.73
CDM (4.0)	783	1 403	803	1 068	1 014	35.07	18.75
CDM (4.0)	785	1 401	833	1 080	1 024	35.09	18.53
CDM (4.0)	785	1 420	913	1 160	1 069	35.08	18.35
RDF (30-26.2-16.6 kg NPK/ha)	775	1 478	830	1 030	1 028	34.96	18.29
Control	654	1 218	609	996	869	34.22	16.75
CD (<i>P</i> =0.05)	90	96	137	91	88	0.38	0.51
	<i>Chickpea seed yield (kg/ha)</i>					<i>Protein (%)</i>	<i>Mineral (%)</i>
CDM (2.0) + PM (1.0)	1 444	1 450	1 777	1 692	1 591	20.64	2.7
CDM (2.0) + VC (1.5)	1 582	1 551	2 060	1 876	1 766	19.40	2.8
PM (1.0) + VC (1.5)	1 386	1 511	1 756	1 710	1 589	19.91	2.8
CDM (1.5) + VC (1.0) + PM(0.7)	1 410	1 471	1 966	1 820	1 666	19.84	2.8
RDF (30-17.5 -0 kg NPK/ha)	1 695	1 520	1 750	1 813	1 693	19.88	2.8
Control	1 042	1 185	1 296	1 080	1 150	18.12	2.7
CD (<i>P</i> =0.05)	132	121	212	206	184	1.22	NS
	<i>Isabgol seed yield (kg/ha)</i>					<i>Swelling factor</i>	<i>Mucilage</i>
						<i>(cc/g)</i>	<i>content (%)</i>
CDM (1.5) + PM (0.7)	1 225	1 138	1 200	1 056	1 154	12.17	36.22
CDM (1.5) + VC (1.0)	1 229	1 231	1 213	1 165	1 209	11.83	36.70
PM (0.7) + VC (1.0)	1 231	1 160	1 210	1 096	1 174	12.17	36.44
CDM (1.0) + VC(0.7) + PM(0.5)	1 310	1 260	1 303	1 292	1 291	11.67	36.02
RDF (20-17.5-0 kg NPK/ha)	1 210	1 160	1 120	1 123	1 153	11.92	36.21
Control	910	1 027	904	849	922	10.50	35.90
CD (<i>P</i> =0.05)	105	104	92	115	108	0.44	NS

CDM, Cowdung manure; PM, poultry manure; VC, vermicompost; RDF, recommended dose of fertilizers
*tonnes/ha; **mean of 4 years

Table 3 Soil fertility and economics of cropping systems and nutrient management practices

Treatment	Soil available nutrient status (kg/ha)				Economics*			
	Soil organic carbon (%)	N	P	K	Gross returns (Rs/ha/year)	Cost of cultivation (Rs/ha/year)	Net returns (Rs/ha/year)	Benefit: cost ratio
<i>Cropping system</i>								
Soybean–chickpea	0.64	174	22.4	585	43 927	20 037	23 890	2.19
Soybean–isabgol	0.60	170	18.9	577	38 984	19 568	19 416	1.99
CD ($P=0.05$)	NS	NS	2.1	NS				
<i>Nutrient management</i>								
CDM + PM	0.65	179	23.9	597	42 163	20 030	22 133	2.10
CDM + VC	0.64	177	21.3	590	44 208	20 355	23 853	2.17
PM + VC	0.64	176	22.8	597	42 425	20 175	22 250	2.10
CDM + VC + PM	0.68	179	24.6	603	45 008	20 222	24 786	2.22
RDF	0.55	170	19.5	574	43 215	21 050	22 165	2.05
Control	0.50	148	10.7	517	33 474	18 230	15 244	1.83
CD ($P=0.05$)	0.08	8.6	2.4	18.6				

CDM, Cowdung manure; PM, poultry manure; VC, vermicompost; RDF, recommended dose of fertilizers

*mean of 4 years

Cost of Cowdung, poultry manure and vermicompost are ₹ 250, 300 and 500 /tonne respectively

Cost of urea, SSP and MOP are ₹ 13.0, 21.8 and 8.3 /kg N, P and K, respectively

Sale price of soybean, chickpea and isabgol are ₹ 16, 18 and 20 /kg, respectively

the oil content of soybean ranges from 18.29 to 18.75% among the manure treatments, while it was 16.75% in the control (Table 2). In chickpea, the highest protein content (20.64%) was recorded with the treatment receiving cowdung manure + poultry manure combination and 19.88% with the recommended dose of fertilizers and 18.12% in the control. However, mineral content of chickpea seed was not affected due to treatments. In *isabgol*, the swelling factor was the highest (12.17 cc/g) in the treatment receiving cowdung manure + poultry manure or poultry manure + vermicompost combination and the lowest swelling factor (10.50 cc/g) in the control treatment. The mucilage content of *isabgol* varies from 35.90 to 36.70% among the treatments but was not affected significantly due to treatments.

Soil fertility

At the end of 4 cropping cycles, soybean–chickpea cropping system resulted in the higher soil organic carbon (0.64%) and available N (174 kg/ha), P (22.4 kg/ha) and K (585 kg/ha) compared to soybean–*isabgol* cropping system (Table 3). Among the manure treatments, cowdung manure + vermicompost + poultry manure combination recorded the maximum organic carbon (0.68%) which was significantly higher than the recommended dose of fertilizers (0.55%) and the control (0.50%). This combination of organic manures also resulted in the highest soil available N (179 kg/ha), P (24.6 kg/ha) and K (603 kg/ha) compared to either recommended dose of fertilizers or the control. Increased nutrient content of soil was due to more retention of nutrients, especially P and K, which are added through organic manure

treatments. Long-term applications of organic manures were reported to improve the soil organic carbon, available N, P and K in soil, thereby sustaining the soil health (Panwar *et al.* 2010).

Economics

Soybean–chickpea cropping system recorded the highest gross returns (₹. 43 925), net returns (₹ 23 890) and benefit : cost ratio (2.19) compared to soybean–*isabgol* cropping system. Among the manure treatments, cowdung manure + vermicompost + poultry manure combination resulted in the highest gross returns (₹ 45 008), net returns (₹ 24 786) and benefit : cost ratio (2.22) compared to other combination of manures or the recommended dose of fertilizers. Lower cost of cultivation and better response of crops to organic manures resulted in the favourable economics of this treatment compared to other nutrient management practices.

It can be concluded that the application of cowdung manure 4 tonnes/ha to soybean, combination of cowdung manure 2 tonnes/ha + vermicompost 1.5 tonnes/ha to chickpea and cowdung manure 1 tonne/ha + vermicompost 0.7 tonne/ha + poultry manure 0.5 tonne/ha to *isabgol* could sustain the production, improves the soil fertility and enhances economic returns.

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