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Performance of soybean (*Glycine max*)–wheat (*Triticum aestivum*) cropping system under land configuration, mulching and nutrient management

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ABSTRACT

A 2-year field experiment was carried out during 2007-08 to 2008-09 at Indore to study the effects of ridge and furrow, broad bed and furrow and *Gliricidia sepium* mulch along with integrated nutrient management on soybean [*Glycine max* (L.) Merrill] – wheat [*Triticum aestivum* (L.) emend. Fiori & Paol] cropping system. Ridge and furrow planting of soybean significantly increased yield attributes, yields and net return over normal sowing, while the yield and yield attributes and net return were recorded higher with broad bed furrow planting in wheat. The incorporation of vermicompost @ 5 t/ha with 25% reduction in recommended dose of fertilizers in both the crops resulted in significantly higher yield attributes and yield of both crops. Ridge and furrow planting of soybean followed by *Gliricidia* leaves mulch in wheat increased the system yield by 11.96%. Total cropping system yield (6.98 t/ha), net return (₹60,985/ha) and benefit: cost ratio (2.31) in system were recorded under the combination of broad bed furrow in both crops and use of vermicompost @ 5 t/ha in soybean along with 75% RDF in both crops

Key words: *Gliricidia*, Land configuration, Mulching, Soybean–wheat cropping system, Vermicompost

Soybean–wheat cropping system has attained a great significance in terms of area, production and productivity, particularly in west–central region of India. Majority of the area covered under this cropping systems belongs to Vertisols and associated soils (Bhatnagar and Joshi, 1999). The area normally receives an average annual rainfall of 800-1000 mm, which is mostly erratic and undependable, causes excess and deficient moisture conditions during one or other stage of crop growth. Both the situations are unfavorable for higher production of rainy as well as post-rainy season crops. Most of the farmers in these areas generally use high analysis fertilizers indiscriminately and do not adopt integrated nutrient management approach, which results in unbalanced nutrient management resulting in lower system productivity. The non-judicious and unbalanced use of fertilizers also leads to environmental pollution. This calls for development of a sustainable system producing optimum by maintenance of natural resources like soil and water with a check on environmental pollution (Yadav *et al.*, 2005). Cultivation of crops on suitable land configurations like ridge and furrow, broad bed and furrow planting coupled with mulching and adoption of integrated nutrient management approach are important for increasing the productivity of soybean-wheat cropping system. Keeping above in view, an experiment was conducted to evaluate the productivity and economics on soybean-wheat cropping systems under various land configurations, mulching and integrated nutrient management at Indore.

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MATERIALS AND METHODS

The field experiment was conducted at Krishi Vigyan Kendra, Indore during rainy and post-rainy seasons of 2007-08 and 2008-09. The experimental crop of soybean received 819.6 mm rain in 35 days and 510 mm rains in 31 days, respectively, during first and second year of the experiment. Succeeding wheat crop did not receive any winter rain in 2007-08, but 41.4 mm of winter rains were recorded in 5 rainy days during 2008-09. Three irrigations were provided to wheat at the critical crop stages of growth, namely, crown root initiation (20-21 DAS), late jointing stage (55-60 DAS) and milky stage (90-95 DAS). At each 5 ha-cm irrigation water was applied equally to all the plots of wheat irrespective to the land configurations and fertilizers applied. Pre-experimental soil samples at 15 cm depth revealed 0.54% organic carbon with 0.52 dSm-1 EC, 231 kg/ha available N, 12.5 kg/ha available P and 505 kg/ha available K. The soil was clay loam in texture having 18% sand, 37% silt and 45% clay fractions and had a pH value of 7.8. The experiment was comprised of a total of 28 treatment combinations involving 4 land configurations and mulching levels and 7 nutrient management practices. These treatment combinations were replicated thrice under strip plot design in permanent fixed layout for both the years. The levels of land configurations incorporated were: (i) flat bed sowing (FBS) in soybean as well as in wheat, (ii) ridge and furrow planting (RFP) in soybean followed by flat bed sowing with organic mulch of *Gliricidia* leaves @ 2 t/ha (GLM) in wheat, (iii) broad bed and furrow planting (BBF) of soybean and the same in wheat and (iv) flat bed sowing with organic mulch of *Gliricidia* leaves @ 2 t/ha of soybean and the same in wheat. The nutrient management treatments were: (i) no fertilizers and manure application (control) in soybean and wheat, (ii) vermicompost @ 5 t/ha in soybean followed by no fertilizers and manure in wheat, (iii) 100% RDF in soybean followed by 100% RDF in wheat, (iv) vermicompost @ 5 t/ha + 100% RDF in soybean followed by 50% RDF in wheat, (v) vermicompost @ 5 t/ha + 75% RDF in soybean followed by 50% RDF in wheat, (vi) vermicompost @ 5 t/ha + 75% RDF in soybean followed by 75% RDF in wheat and (vii) vermicompost @ 5 t/ha + 50% RDF in soybean followed by 75% RDF in wheat. Soybean 'JS 93-05' and wheat 'HI 1418' were grown following standard package of practices. The recommended dose of NPK for soybean was 20 kg N, 60 kg P_2O_5 and 20 K_2O per ha, while for wheat it was 120 kg N, 60 kg P_2O_5 and 40 K_2O/ha. The vermicompost used in the experiment analysed 1.52% nitrogen, 1.12% Phosphorus and 0.86% Potassium, while *Gliricidia* leaves had 3.3% nitrogen, 0.3% phosphorus and 3.36% potassium. From each plot consisted five randomly chosen plants were collected for chemical analysis. The yields were recorded from net plot area and converted in to kilograms per hectare. Treatment- wise balance sheets of NPK indicating the available nutrients in soil at initials stage, nutrients added for raising the crop, nutrients uptake by the crop and nutrients left in the soil after the harvesting of the crops were worked out and presented prepared. The data were computed following the procedure of Panse and Sukhatme (1978). The error variance of the 2-year experiment were subjected to a homogeneity test (Bartlett's test) and found to be homogenous, so the results were pooled.

RESULTS AND DISCUSSION

Yield attributes and yield of soybean

Yield attributing characters like pods/plant, seeds/pod, seed index and seed yield of soybean showed remarkable improvement by adopting changed land configuration over flat bed planting (Table 1). Among the four combinations of land configuration, planting soybean on ridge and furrow followed by mulching with *Gliricidia* leaves was most efficient giving the highest values of growth attributes and yield with a maximum net profit of ₹ 9,061/ha and B: C ratio of 2.22. The treatment in order of superiority followed this treatment was planting soybean as well as wheat on broad bed furrow. Although planting of soybean on flat bed added with *Gliricidia* leaves in wheat did not influence the seed index but brought in significant improvement in remaining attributes as well as seed yield of soybean. Significantly lower values of yield attributing characters and seed yield were associated with flat bed planting of soybean and wheat. These results are in line with those reported by Sakthivel *et al.* (2003).

All the nutrient management practices recorded higher values of yield attributes and increased the seed yield of soybean (Table 1). Application of vermicompost alone to soybean and wheat did not increase the yield attributes to the level of significance, but significantly improved the yield with lower B: C ratio than control. Among the treatments wherein organic and inorganic fertilization was integrated, in general, there was a remarkable improvement in yield attributes and significant improvement in seed yield and monitory net returns. The best performance was revealed by application of 75% RDF to soybean coupled with vermicompost and 75% RDF to wheat, which yielded (2.54 t/ha) almost 24% higher and generated 30% revenues with B: C ratio of 2.02. This treatment was statistically on par with other integrated nutrient management treatments except with application of vermicompost with 50% RDF to soybean and 75% RDF to wheat. It brings out that application of fertilizer to soybean can be reduced to the extent of at least 25% and get an enhanced yield with higher net profit can be achieved. The increase in seed yield due to vermicompost might be due to its beneficial effects by way of regulated release of and balanced supply of nutrients including secondary and micronutrients, tilting microbial dynamics in favour of crop growth and modifying soil environment favorably for crop growth. Maximum values of yield and yield attributes were also observed with the use of vermicompost in wheat by Nehra *et al*. (2001). The results are in conformity with those of Rajkhowa *et al*. (2002) in green gram and Patel and Puraji (2003) in soybean. Vermicompost has been reported as a good organic manure and a essential component of integrated nutrient management practices in field crops (Shroff and Devasthali, 1992).

Land configuration and mulching with nutrient management interaction effect on seed yield was significant. Ridge and furrow planting of soybean with vermicompost @ 5 t/ha and 75% reduced recommended dose of fertilizers gave highest seed yield, which was significantly higher than all other combinations (Table 2). Similar trends were also visualized in case of net profit and benefit: cost ratio.

Table 1. Yield attributes yields and economics of soybean, wheat and productivity and economics of the system under various levels of land configuration and nutrient management (data pooled over 2 years)

Treatment	Yield attributes and yield of soybean				Yield attributes and yield of wheat				System productivity and economics		
	Pods/ plant	Seeds/ pod	Seed index (g)	Seed yield (t/ha)	Spikes/ plant	Grains/ spike	Test weight (g)	Grain yield (t/ha)	SYE (t/ha)	Net Profit (×10^3 ₹/ha)	B : C ratio
Land configuration and mulching											
FBS in soybean and wheat	32.7	2.5	11.2	2.09	6.5	37.7	41.2	3.26	4.11	38.4	1.86
RFP in soybean followed by FBS with GLM in wheat	48.2	2.9	11.7	2.65	6.6	39.6	42.4	3.34	4.72	50.4	2.11
BBF in soybean and wheat	41.7	2.6	11.3	2.47	6.9	44.3	43.2	3.61	4.70	50.5	2.12
FBS with GLM in soybean and wheat	39.1	2.6	11.2	2.19	6.5	38.2	41.8	3.33	4.26	40.5	1.89
SEm ±	0.26	0.02	0.03	0.014	0.06	0.59	1.89	0.051	0.04	0.6	0.01
CD (P=0.05)	0.90	0.09	0.09	0.049	0.19	2.04	NS	0.177	0.13	2.3	0.05
Nutrient management											
Control in soybean and wheat	37.5	2.5	11	2.04	5.9	37.8	39.5	3.08	3.95	39.3	1.96
VC in soybean and no fertilizers and manure in wheat	38.1	2.5	11.1	2.24	6.0	38.3	39.7	3.30	4.29	43.4	2.00
100 % RDF in soybean and 100 % RDF in wheat	39.8	2.6	11.2	2.32	6.6	39	41.8	3.32	4.38	43.4	1.96
VC + 100 % RDF in soybean and 50% RDF in wheat	41.7	2.8	11.7	2.49	7.2	41.1	44.6	3.48	4.65	47.3	2.01
VC + 75 % RDF in soybean and 50% RDF in wheat	42.9	2.8	11.5	2.46	6.7	39.9	42.4	3.40	4.57	46.1	2.00
VC + 75 % RDF in soybean and 75% RDF in wheat	43.5	2.8	11.5	2.54	7.4	44.5	44.8	3.78	4.88	51.9	2.11
VC + 50 % RDF in soybean and 75% RDF in wheat	39.6	2.7	11.3	2.35	6.6	39.1	42.2	3.33	4.41	43.0	1.93
SEm±	1.04	0.05	0.08	0.042	0.06	0.60	2.01	0.045	0.05	0.7	0.02
CD (P=0.05)	3.20	0.15	0.23	0.130	0.2	1.84	NS	0.138	0.14	3.0	0.06

FBS, flat bed sowing; RFP, ridge and furrow planting; BBF, broad bed and furrow; GLM, *Gliricidia* leaves mulching @ 2 t/ha; RDF, recommended dose of fertilizers; VC, vermicompost @ 5 t/ha; SYE, soybean yield equivalent; NS, non-significant

Table 2. Yields of soybean, wheat and cropping system under various levels of land configuration and nutrient management (data pooled over 2 years)

Nutrient management practices	Seed yield of soybean (t/ha)				Grain yield of wheat (t/ha)				SYE (t/ha)			
	Land configuration				Land configuration				Land configuration			
	FBS in soybean and wheat	RFP in soybean followed by FBS with GLM in wheat	BBF in soybean and wheat	FBS with GLM in soybean and wheat	FBS in soybean and wheat	RFP in soybean followed by FBS with GLM in wheat	BBF in soybean and wheat	FBS with GLM in soybean and wheat	FBS in soybean and wheat	RFP in soybean followed by FBS with GLM in wheat	BBF in soybean and wheat	FBS with GLM in soybean and wheat
Control in soybean and wheat	1.654	2.503	2.081	1.928	2.921	3.173	3.167	3.056	3.46	4.46	4.05	3.82
VC in soybean and no fertilizers and manure in wheat	1.893	2.556	2.547	1.976	3.214	3.257	3.393	3.325	3.89	4.57	4.65	4.04
100% RDF in soybean and 100% RDF in wheat	2.143	2.468	2.379	2.304	3.241	3.298	3.222	3.509	4.15	4.51	4.38	4.48
VC + 100% RDF in soybean and 50% RDF in wheat	2.241	2.816	2.599	2.289	3.281	3.495	3.804	3.347	4.28	4.99	4.96	4.36
VC + 75% RDF in soybean and 50% RDF in wheat	2.286	2.662	2.587	2.303	3.373	3.207	3.797	3.214	4.38	4.65	4.94	4.30
VC + 75% RDF in soybean and 75% RDF in wheat	2.184	3.057	2.569	2.332	3.618	3.559	4.419	3.537	4.43	5.26	5.32	4.53
VC + 50% RDF in soybean and 75% RDF in wheat	2.202	2.491	2.494	2.205	3.172	3.377	3.436	3.341	4.17	4.59	4.62	4.28
SEm±	0.081				0.094				0.09			
CD (P=0.05)	0.234				0.272				0.27			

FBS, flat bed sowing; RFP, ridge and furrow planting; BBF, broad bed and furrow; GLM, *Gliricidia* leaves mulching @ 2 t/ha; RDF, recommended dose of fertilizers; VC, vermicompost @ 5 t/ha; SYE, soybean yield equivalent

Yield attributes and yield of wheat

All the land configuration treatments led to increase in spikes per plant, grains per spike, grain yield as well as net monetary return and benefit: cost ratio in subsequent wheat crop (Table 1). Contrary to the results obtained in soybean, maximum values of all the yield attributes and grain yields were recorded with broad bed and furrow planting of soybean and the same in wheat followed by ridge and furrow planting in soybean and flat bed sowing with organic mulch of *Gliricidia* leaves @ 2 t/ha in wheat. The treatment differences were significant with each other as well as with flat bed sowing in both crops; however the differences in test weight were not significant. The results are in conformity with the findings of Kantawa *et al.* (2006).

The results on account of nutrient management were similar to that of soybean. Application of vermicompost coupled with 75% RDF to soybean and 75% RDF to wheat performed best in promoting yield attributes and yield of wheat crop. This treatment yielded (3.78 t/ha) almost 23% higher than control (3.08 t/ha) and was significantly superior over other treatments. It yielded nearly 34% higher net returns with B: C ratio of 2.21. The yield levels ranged between 3.32 and 3.48 t/ha for other integrated nutrient management treatments and were significantly superior over control, but inferior over the best treatment as above. Vermicompost alone yielded superior over control (Table 1). Similar results were also reported by Patil and Bhilare (2000).

The interaction effect of land configuration and mulching with nutrient management had significant effect on grain yield of wheat yield, net monetary return and benefit: cost ratio (Table 2). Use of vermicompost @ 5 t/ha + 75% RDF in soybean and 75% RDF in wheat in broad bed and furrow sowing of both crops showed significant increase in grain yield of wheat.

Effects on total system productivity and economics of soybean-wheat system

The computed data on total system productivity (Table 2) revealed that planting of crops on broad bed furrow configuration gave the highest B: C ratio of 2.12. Adoption of ridge and furrow configuration in soybean followed by flat bed sowing with *Gliricidia* leaves as mulch to wheat followed the suit with insignificant differences in system productivity. Both the treatments remained significantly superior to flat bed planting of soybean and wheat crops. As has been observed in cases of individual crops, the

Table 3. Total nitrogen, phosphorus and potassium uptake in soybean-wheat cropping system under various levels of land configuration and nutrient management (data pooled over 2 years)

Treatment	Total uptake by Soybean (kg/ha)			Total uptake by wheat (kg/ha)		
	N	P	K	N	P	K
Land configuration and mulching						
FBS in soybean and wheat	178.6	12.3	58.4	79.7	14.2	83.8
RFP in soybean followed by FBS with GLM in wheat	230.8	17.7	81.5	84.4	15.0	89.2
BBF in soybean and wheat	211.0	16.0	70.0	91.9	17.4	99.1
FBS with GLM in soybean and wheat	188.7	13.7	64.0	81.0	15.0	86.6
SEm ±	1.38	0.19	0.81	0.89	0.21	1.06
CD (P=0.05)	4.79	0.67	2.79	3.06	0.73	3.65
Nutrient management						
Control in soybean and wheat	175.3	12.6	56.9	74.2	14.0	84.6
VC in soybean and no fertilizers and manure in wheat	193.3	13.5	66.1	81.3	14.7	86.1
100% RDF in soybean and 100% RDF in wheat	200.4	14.7	67.4	81.9	14.6	86.9
VC + 100% RDF in soybean and 50% RDF in wheat	214.3	15.6	73.0	87.3	15.8	92.1
VC + 75% RDF in soybean and 50% RDF in wheat	211.0	16.1	71.3	84.9	15.8	91.3
VC + 75% RDF in soybean and 75% RDF in wheat	218.3	17.1	75.1	97.6	17.7	98.3
VC + 50% RDF in soybean and 75% RDF in wheat	203.2	14.9	69.5	82.6	15.2	88.4
SEm±	2.83	0.51	1.31	1.54	0.38	1.93
CD (P=0.05)	8.74	1.56	4.03	4.76	1.20	5.96

FBS, flat bed sowing; RFP, ridge and furrow planting; BBF, broad bed and furrow; GLM, *Gliricidia* leaves mulching @ 2 t/ha; RDF, recommended dose of fertilizers; VC, vermicompost @ 5 t/ha

integrated nutrient management through application of vermicompost along with 75% RDF to soybean and 75% RDF to wheat remained significantly superior in system productivity.

Nitrogen, phosphorus and potassium uptake and balance sheet

The total uptake of nitrogen, phosphorus and potassium were significantly affected by land configuration and nutrient management practices in both the crops (Table 3). The total uptake of all the three nutrients by soybean was recorded highest under the ridge and furrow planting of soybean followed by flat bed sowing and *Gliricidia* leaf mulching in wheat land configuration treatment, while in case of wheat, the uptake was found under broad bed and furrow land configuration in both the crops. The uptake was significantly higher over all the other land configurations. Among nutrient management practice, the maximum uptake was found under the use of vermicompost in soybean with 75% recommended dose of fertilizers to the system. The minimum values were recorded under control.

The data in respect of nutrient balance after soybean and wheat crops indicated that the maximum addition of nitrogen, phosphorus and potassium to the soil native pool was observed under the use of vermicompost in soybean with 75% recommended dose of fertilizers to the system in case of the nutrient management practice treatments, while Among the land configuration treatments, it was found maximum under flat bed sowing with *Gliricidia* leaf mulching in both the crops (Table 4). The balance she*et al*so indicated that the nutrient balance after the wheat crop under soybean–wheat cropping system, was higher under the land configuration ridge furrow planting in soybean followed by flat bed sowing in wheat with *Gliricidia* mulching, while in case of nutrient management practices, it was found highest under the use of vermicompost in soybean with 75% recommended dose of fertilizers to the system. Under all the other land configuration and nutrient management treatments, the nutrient balance was found lower or negative, which showed the loss in soil fertility.

From the results, it may be inferred that planting on broad bed or ridge and furrow configuration and adopting integrated approach for nutrient management, the system productivity of soybean-wheat cropping system on Vertisols of Madhya Pradesh can be economically increased with curtailing the expenditure by 25% on nutrient management.

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Table 4. Nutrient balance sheet for soybean- wheat cropping system (data pooled over 2 years)

Treatment	Nutrient applied in cropping system (kg/ha)			Total nutrient uptake by both the crops (kg/ha)			Nutrient status at harvest of wheat crop (2008-09)			Nutrient balance after harvesting of wheat (kg/ha)		
	N	P	K	N	P	K	N	P	K	N	P	K
Land configuration and mulching												
FBS in soybean and wheat	115.4	104.3	62.1	516.6	53.0	284.4	232.3	12.2	490.4	1.6	-0.3	-14.4
RFP in soybean followed by FBS with GLM in wheat	177.6	109.9	116.9	630.2	65.4	341.5	239.6	12.6	505.8	8.9	0.1	1.0
BBF in soybean and wheat	115.4	104.3	62.1	605.8	66.9	338.2	238.9	12.3	497.4	8.2	-0.2	-7.4
FBS with GLM in soybean and wheat	239.8	115.5	171.7	539.4	57.4	301.1	233.3	12.2	493.3	2.6	-0.3	-11.5
SEm±				3.3	0.5	3.0	5.0	0.1	7.4			
CD (P=0.05)				11.3	1.8	10.4	NS	NS	NS			
Nutrient management												
Control in soybean and wheat	46.7	4.2	41.1	498.9	53.3	282.9	229.0	12.1	486.5	-1.7	-0.4	-18.3
VC in soybean and no fertilizers and manure in wheat	122.2	60.2	84.1	549.1	56.4	304.3	232.1	12.3	489.5	1.4	-0.2	-15.3
100% RDF in soybean and 100% RDF in wheat	166.7	124.2	101.1	564.6	58.8	308.6	233.5	12.4	494.8	2.8	-0.1	-10.0
VC + 100% RDF in soybean and 50% RDF in wheat	192.2	150.2	124.1	603.3	62.8	330.2	238.6	12.3	500.5	7.9	-0.2	-4.3
VC + 75% RDF in soybean and 50% RDF in wheat	187.2	135.2	119.1	591.8	63.9	325.2	241.0	12.3	502.3	10.3	-0.2	-2.5
VC + 75% RDF in soybean and 75% RDF in wheat	212.2	150.2	129.1	631.8	69.6	346.7	242.0	12.6	505.3	11.3	0.1	0.5
VC + 50 % RDF in soybean and 75% RDF in wheat	207.2	135.2	124.1	571.5	60.1	315.9	235.9	12.2	496.8	5.2	-0.3	-8.0
SEm±				6.2	1.4	4.9	6.9	0.2	15.9			
CD (P=0.05)				19.1	4.4	15.0	NS	NS	NS			
Initial value of nutrient	230.7	12.47	504.8									

FBS, flat bed sowing; RFP, ridge and furrow planting; BBF, broad bed and furrow; GLM, *Gliricidia* leaves mulching @ 2 t/ha; RDF, recommended dose of fertilizers; VC, vermicompost @ 5 t/ha; NS, non-significant

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