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Assessment of Soybean (*Glycine max Merill* L.) Based Cropping Systems through Organic and Inorganic inputs in Bundelkhand Region

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ABSTRACT

A field experiment was conducted at Tulsi Krishi Vigyan Kendra, Chitrakoot, Uttar Pradesh during 2012-13 to 2015-16 to study the effect of organic and inorganic inputs on productivity of soybean (*Glycine max* L. Merill) based cropping systems. Two cropping systems viz., soybean-wheat and soybean-chick pea along with three crop management practices viz., organic, inorganic and integrated were evaluated in strip plot design with four replications. In kharif season, soybean seed yield in soybean-wheat system (2718 kg/ha) was at par with soybean-chickpea (2662 kg/ha) cropping system. Amongst the management practices, organic practice gave significantly higher soybean seed yield (2850 kg/ha) than inorganic (2592 kg/ha) and integrated (2629 kg/ha) practice of crop management. However in rabi season, wheat (4017 kg/ha) recorded significantly higher yield than chickpea (1065 kg/ha). Inorganic management (2829 kg/ha) recorded significantly highest yield followed by integrated (2698 kg/ha) and organic practice (2097 kg/ha) during season. Soybean equivalent yield (SEY) was significantly higher in soybean-wheat cropping system (2595 kg/ha) than soybean-chickpea (1304 kg/ha). Inorganic practice showed significantly higher SEY (2129 kg/ha) than other two management practices. System net returns were higher in soybean-wheat system (Rs. 86964/-ha) and in inorganic practice (Rs. 97176/-ha) than in soybean-chickpea cropping system (Rs. 57872/-ha) and rest of the two management practices. Soybean-wheat cropping system with inorganic practice recorded higher system productivity (5573 kg/ha).

Key Words: Cropping systems, Farm yard manure, Phosphorus solubilising bacteria, Nutrient management and Soybean Equivalent yield.

INTRODUCTION

Soybean [*Glycine max* (L.) Merill] based cropping systems are important for sustaining agricultural production and also maintain soil fertility with an ecological balance. Sustainability aims at balanced use of all available resources to achieve maximum production with minimum exploitation of natural resources. Soybean grown both as an oil seed and grain legume, fixes atmospheric nitrogen in soil and makes it available to partially fulfil the nitrogen requirement of succeeding crop. Soybean-wheat cropping system in rotation gives higher yield, greater income and maintains soil fertility. The soybean-wheat cropping system reduces dependency on chemical fertilizers and helps in monetary saving. Most of the farmers grow soybean without fertilizer application and also realize the carry-over effect of the legume crop on the succeeding wheat crop. Grain legumes play an important role in improving soil fertility and increasing the yield of succeeding crops. Inorganic fertilizers used to increase crop production without organic supplements cause severe damage to soil properties and adversely affect the soil environment by polluting it. Organic manures help to increase biological activity of soil microbes and improve soil structure, water holding capacity and other physico-chemical properties of soil. Dasog *et al*

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(2011) reported that the success of any cropping system depends upon the appropriate management of resources including balanced use of manures and fertilizers. Imbalanced application of nutrients to crops leads to loss of productivity due to exhaustion of macro and micro nutrients. The present study mainly aims at finding the impact of soybean based cropping systems and crop management practices on seed yield and other yield attributes.

MATERIALS AND METHODS

A field experiment was conducted during kharif and rabi seasons of four consecutive years 2012-13, 2013-14, 2014-15 and 2015-16 at the Research farm of Krishi Vigyan Kendra, Chitrakoot, Uttar Pradesh. Total rainfall during the kharif seasons of 2012, 2013, 2014 and 2015 from July to November (during the crop growth period) was 1468, 817, 537 and 395 mm, respectively. Soil of the experimental plot belongs to pH-7.9, Ec-0.257 d s/m, Organic carbon-0.495%, Available P-16.8Kg, Available K-257Kg, Av. N-198Kg, Av.S-22.5Kg, Av.Zn-0.985Kg, Av.Fe-8.99Kg, Av.Cu-0.68Kg.

The experiment comprised two cropping systems viz., soybean-wheat and soybean-chickpea & three management practices viz., organic, inorganic and integrated was laid out in the strip plot design with four replications. The net plot size was 5.0 m x 3.6 m. same plots were used for the same cropping system and management practice in each of the four years. In kharif, soybean was grown followed by wheat and chickpea in rabi season.

In the organic management practice, well decomposed farmyard manure (FYM) was applied before sowing of crop based on nitrogen equivalent basis @ 10 t/ha and nutrient requirement of each crop (Laxminarayan and Patiram, 2006). The FYM consisted 0.59, 0.28 and 0.54 per cent of N, P and K, respectively. Phosphorus requirement of the crops were supplemented through rock phosphate. Seed inoculation with bio-fertilizer cultures of PSB (5g/kg seed) and phosphate solubilising micro-organism (5g/kg seed) was done. Seeds were treated with Trichoderma viridae (5g/kg seed) before sowing. Pest control was achieved through bio-pesticides viz., neem extract @ 1.2 l/ha and HaNPV [Trade name: HELIO-KILL, Manufacturer: Mahatma Phule Agricultural University Rahuri, Maharshtra (India)] @ 2.5 l/ ha. Weed free condition in the plots were maintained by hand weeding.

For the inorganic practice, nutrients were supplied through inorganic fertilizers as per recommended doses (RDF) for soybean 20:80:20, wheat 120:60:40 and chickpea 25:50:30 NPK kg/ha. Seed treatment with Carbendazim 50 WP [Trade name: BAVISTIN, Manufacturer: BASF Corporation, Missouri (USA)] @ 3 g/ kg of seed for soybean and gram while, Thiram @ 3 g/kg of wheat seed was done without inoculation with bio inoculants. Weeds were controlled by pre emergence spray of recommended herbicide Pendimethalin [Trade name: STOMP XTRA, Manufacturer: BASF Corporation, Missouri (USA)] @ 1.5 l/ha and pests with the spray of Quinalphos 25 EC [Trade name: EKALUX 25, Manufacturer: Syngenta India Limited Pune, Maharastra (India)] @ 1.5l/ha. For integrated practice, FYM @ 5t/ha and 50 per cent RDF were applied. Seeds were inoculated with Bradyrhizobium japonicum and phosphate solubilising micro-organism culture before sowing. Weeds were controlled through pre emergence spray of Pendimethalin @ 1.5 l/ ha followed by one hand weeding whereas, plant protection were carried through integrated pest management practices whenever the incidence of pest and disease was noticed.

Soybean crop was sown in the first week of July during all the kharif seasons. Before sowing, land was brought to good tilth to facilitate good germination and favourable conditions for crop stand. FYM and rock phosphate were mixed well and applied in soil before sowing as per the treatment. NPK fertilizers were applied through di-ammonium phosphate, single super phosphate and muriate of potash as a basal dose as per treatments. Seeds of soybean cv. NRC 7 were sown manually in

rows 30 cm apart with 10 cm between plants within rows. All cultivation practices were carried out to raise good crop. Crop was manually harvested at physiological maturity stage in the second week of October.

After harvesting the soybean, plots were harrowed twice to facilitate ease in sowing of the rabi crops. Wheat (cv. HD 2967) and Chickpea (cv. Pusa 1103) were manually sown at the rate of 100 and 110 kg/ha, respectively. All sources of nutrients (organic, inorganic and integrated) as per the treatments and RDF of respective crop were applied before sowing, except half the quantity of N was applied through urea as a top dressing to wheat 21 days after sowing at crown root initiation stage. All cultivation practices were carried out to raise good crop. After attaining the physiological maturity, the crop was harvested manually.

Data on growth, yield contributing characters and seed yield (kg/ha) were recorded. Economic yields of the component crops were converted to soybean-equivalent yield (SEY), by considering prevailing market prices of the crops. System productivity was calculated by adding the SEY of the component crops.

$$\text{Soybean equivalent yield} = \frac{\text{Yield of rabi crop X Market price of rabi crop}}{\text{Market price of soybean}}$$

Pooled analysis of the data for four years was carried out using standard analysis of variance suggested by Lee, Lee and M. O'Neill (2008).

RESULTS AND DISCUSSION

Effect of cropping system and management practice on soybean yield

Growth, yield attributes and yield of soybean were not significantly affected by cropping systems. However, soybean yield in soybean-wheat (2718kg/ha) cropping system was numerically higher than soybean-chickpea (2662 kg/ha) cropping system (Table 1). Legume followed by cereal crops is considered to be helpful in soil ameliorating benefits and attaining the sustainability (Billore *et al* , 2013) also reported that soybean yields were more sustainable when grown before wheat rather than chickpea in rotation. Management practice had significantly influenced the growth and yield attributes viz., number of pods per plant and seed yield (Table 1). Crop management through organic inputs produced significantly higher number of pods per plant and seed yield (2850kg/ha) than inorganic (2592kg/ha) and integrated (2629kg/ha) practice. Crop with organic sources showed about 9.95 per cent increase in yield over inorganically managed crop. Increase in yield might be due to increased biological nitrogen fixation and solubilisation of more amount of P by phosphate solubilising bacteria and organic manure (FYM) also acts as a substrate for microorganisms and improved soil condition favourable for availability of nutrients to crop throughout the growth period (Prajapat *et al,* 2014). Laxminarayan (2006) has reported increase in yield of soybean due to application of organic sources of nutrients. Interaction of the cropping system and management practices had no significant effect on growth, yield attributes and soybean seed yield.

Effect of cropping system and management practice on yield of rabi crops

Data for seed yield of rabi crops given in Table 2 showed that among cropping systems, wheat (4017kg/ha) yield was higher in soybean-wheat system than soybean-chickpea system (1065kg/ha). Wheat yielded higher because the residual effect of preceding legume crop on succeeding crops in sequence is evident and easily availability of nitrogen at critical growth stages.

Inorganic practice (4607kg/ha) yielded significantly higher wheat yield than integrated practice (4208kg/ha) and organic practice (3236kg/ha). Low productivity of wheat under organic practice may be due to low availability of nitrogen at various growth stages, which should be more for cereals and also might be due to slow mineralization and unavailability of required nutrients, resulted

Table 1. Growth, yield contributing characters and yield of kharif soybean as affected by cropping systems and management practices.

Treatment	Plant height (cm)	Pods/ Plant	Branches/ Plant	Seed Index (g)	Harvest index (%)	Seed Yield (kg/ha)
Cropping system (C)						
Soybean-Wheat	51.20	33.38	2.88	13.54	48.31	2718
Soybean-Chick pea	49.54	33.06	2.91	13.51	48.62	2662
SEm+	1.09	0.36	0.03	0.04	0.22	36.15
CD at 5%	NS	NS	NS	NS	NS	NS
Management practices (M)						
Organic	51.11	34.85	3.08	13.56	48.77	2850
Inorganic	48.04	31.74	2.90	13.40	49.14	2592
Integrated	51.96	33.08	2.69	13.60	47.18	2629
SEm+	1.11	0.60	0.12	0.08	0.63	15.82
CD at 5%	NS	1.69	NS	NS	NS	44.66
Interaction (C x M) SEm+	3.02	1.63	0.21	0.44	1.71	88.65
CD at 5 %	NS	NS	NS	NS	NS	NS

in setback to crop growth at early stage of its development and thus influenced the crop productivity. The chickpea yield was significantly highest with integrated practice (1188kg/ha) over inorganic (1050kg/ha) and organic practice (958kg/ ha). Significantly higher chickpea yield with the application of 50per cent recommended dose of fertilizer and 50 per cent FYM was reported by Prajapat *et al* (2014)

Interaction of cropping system and management practices (Table 3) showed significantly the highest wheat yield in soybean-wheat with inorganic practice (4607 kg/ha) and it was at par with soybean-wheat with integrated practice (4208kg/ ha). Soybean equivalent yield was significantly influenced by cropping system and management practices. Soybean-wheat cropping system (2595kg/ha) produced significantly higher soybean equivalent yield than soybean-chickpea cropping system (1304 kg/ ha) (Table 2). As regards to management practice, inorganic practice recorded the highest soybean equivalent yield (2129kg/ha) followed by integrated practice (2090kg/ha). For interaction components, soybean-wheat cropping system with inorganic practice (2974kg/ ha) recorded significantly the highest SEY followed by integrated practice (2718kg/ha) (Table 4). This might be due to the fertilizer responsiveness of wheat.

System productivity

System productivity was considered in terms of total productivity of the system calculated based on yield of kharif and rabi crops converted into soybean equivalent yield (Table 4). Soybean-wheat cropping system with inorganic management practice (5573kg/ha) recorded the highest total productivity followed by soybean-wheat cropping system with integrated practice (5345 kg/ha).

System economics

Soybean-wheat system gave higher gross and net monetary returns for the whole cropping system period. Increased wheat yield under soybean-wheat system resulted higher net returns over soybean-chickpea system during all years under study. Inorganically managed wheat crop produced the highest net returns over soybean-chickpea system and rest of the two management practices. Use

Table 2. Rabi crop yield, SEY and economics of cropping system as affected by cropping systems and management practices.

Treatment	Wheat yield (kg/ha)	Chickpea yield (kg/ha)	SEY (kg/ha)	System net returns (Rs/ ha)	
				S-W	S-C
Cropping systems (C)					
Soybean-Wheat	4017	-	2595	86964	-
Soybean-Chickpea	-	1065	1304	-	57872
SEm+	-	-	54.28	-	-
CD at 5%	-	-	244	-	-
Management practices (M)					
Organic	3236	958	1630	74882	56494
Inorganic	4607	1050	2129	97176	55775
Integrated	4208	1188	2090	88834	61347
SEm+	85.81	24.40	30.27	-	-
CD at 5%	245	70.46	85.4	-	-

of alone organic and integration of organic and inorganic sources increased the cost of cultivation as FYM was costlier than inorganic fertilizers, therefore reduced the system net returns (Prajapat *et al,* 2014).

CONCLUSION

From the studies, it was seen that the organic management practice helps in sustainable and higher yield in soybean. Soybean crop management with organic sources was more productive while wheat cultivation using inorganic sources was more productive and remunerative. Residual fertility of soybean was beneficial for growing wheat after harvest of soybean. For getting highest yield and maximum returns from soybean-wheat cropping system, throughout the year organic practice for soybean followed by inorganic practice for wheat should be followed.

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Table 3. Rabi crop yield (kg/ha) as influenced by interaction between cropping system and management practices.

Treatment	Cropping system (C)		
Management practices (M)	Soybean - Wheat	Soybean - Chick pea	Mean
Organic	3236	958	2097
Inorganic	4607	1050	2829
Integrated	4208	1188	2698
Mean	4017	1065	
SEm+		177.50	
CD at 5%		500.97	

Table 4. Soybean yield, soybean equivalent yield and system productivity as affected by cropping systems and management practices (Pooled).

Treatment		Soybean yield (kg/ha)					Soybean Equivalent Yield (kg/ha)					System productivity (kg/ha)
Cropping systems and management practices		2012	2013	2014	2015	Mean	2012	2013	2014	2015	Mean	Mean
Soybean-Wheat	Organic	3294	2930	2610	2611	2861	2146	2603	2284	1330	2091	4952
	Inorganic	2971	2804	2110	2510	2599	2910	3636	3162	2190	2974	5573
	Integrated	3108	2675	2367	2356	2627	2495	3306	3062	2010	2718	5345
Soybean-Chick pea	Organic	3112	3022	2620	2576	2832	1165	1867	669	972	1168	4000
	Inorganic	2758	2984	2661	2557	2740	1336	1486	851	1464	1284	4024
	Integrated	2976	2727	2333	2488	2631	1923	1575	1016	1371	1471	4102
CD at 5 %		NS	NS	NS	NS		241.00	361.79	250.52	162.38	374.87	

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