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Effect of cropping systems and nutrient management practices on growth, productivity, economics and nutrient uptake of soybean (*Glycine max*)

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ABSTRACT

A field experiment was conducted during *kharif* seasons of 2011 and 2012 at the research farm of Indian Agricultural Research Institute, New Delhi to evaluate the performance of soybean [*Glycine max* (L.) Merril] as affected by 4 soybean-based cropping systems and 5 nutrients management practices. Significantly higher pods/plant and seed yield of soybean were recorded in soybean–wheat (*Triticum aestivum* L.)–mungbean [*Vigna radiata* (L.) Wilczek] system compared to soybean–wheat–fallow system. Soybean grown under soybean–wheat–mungbean system had significantly higher total uptake N and K over soybean–wheat–fallow system. Application of 25% RDF + 50% RDN through FYM along with *Rhizobium* and PSB gave significantly highest pods/plant, seeds/pod and seed and stover yields of soybean over control during both the years of study. Application of 50% RDF + 25% RDN thorough FYM + biofertilizers or 25% RDF + 50% RDN through FYM + biofertilizers, remaining on par with each other fetched maximum net returns. Significantly maximum total uptake of N and P were recorded with the application of 25% RDF + 50% RDN thorough FYM + biofertilizers over control.

Key words: Cropping systems, Economics, Net returns, Nutrient uptake, Root growth

Soybean [*Glycine max* (L.) Merrill] has become the premier oilseed crop in India by producing 14.7 mt from 10.5 m ha area. It contributes 40% of oilseed area and 25% of edible oil production, besides 8 mt of soya-meal production in the country. Soybean is mainly grown in central part of the country, Madhya Pradesh, Maharashtra and Rajasthan contributing about 95% of the production. Soybeans are looked upon not merely as a means to supply food for humans and animals, but also at the same time to serve as a means for improving the soil through their ability to fix atmospheric nitrogen. It has capacity to fix 49-450 kg atmospheric N/ha (Wani *et al*. 1995) and adds about 1 tonne/ha leaf litter to soil thus enhances organic carbon and soil fertility *per se* (Vyas *et al*. 2008). Soybean is generally followed by wheat in *rabi* season. Low productivity and profitability of this system strives for suitable alternative crops like chickpea and potato during *rabi* and mungbean and sorghum during summer seasons which would make the system economically competitive to high yielding cereal-based cropping systems.

The existing system of fertilizer application is based on the nutrient requirement of individual crop ignoring the carryover effect of fertilizer or organic manure applied to the succeeding crop (Singh *et al*. 2008). Integration of inorganic fertilizers with organic manures and biofertilizers will not only sustain the crop production but also be effective in improving soil health and enhancing the nutrient use efficiency (Verma *et al*. 2005). Therefore, an attempt was made to study the effect of soybean-based cropping systems under different nutrient management practices on performance of soybean.

MATERIALS AND METHODS

Field experiments were conducted during *kharif* seasons of 2011and 2012 at the research farm of Indian Agricultural Research Institute, New Delhi situated in north western India (28.38° N, 77.09° E) and at 228.6 m above msl. The soil of the experimental site was sandy clay loam in texture (sand 63.8%, silt 12.2% and clay 24.0%) with pH 7.9, cation exchange capacity 10.5 c mol/kg and EC 0.34 dS/m in the top 15 cm. The soil was low in available nitrogen (157 kg/ha) and organic carbon (0.42%), medium in available phosphorus (14.2 kg/ha) and potassium (240 kg/ha). The treatments comprised of four cropping systems [soybean–wheat (*Triticum aestivum* L.)–fallow (CS_1), soybean–wheat–mungbean [*Vigna radiata* (L.) Wilczek] (CS_2), soybean–chickpea (*Cicer arietinum* L.)–fodder sorghum (CS_3) and soybean–potato (*Solanum tuberosum* L.)–mungbean (CS_4)] and five nutrient management practices [control (NS_0), 100% RDF through fertilizers (NS_1), 50% RDF through fertilizers + 50% RDN through FYM (NS_2), 50% RDF through

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fertilizers + 25% RDN through FYM + biofertilizers (NS_3) and 25% RDF through fertilizers + 50% RDN through FYM + biofertilizers (NS_4)]. The experiment was laid out in strip-plot design and replicated thrice. The soybean Pusa 9712 was taken for experiment and sown at 45 cm × 5 cm spacing. The recommended dose of fertilizer (RDF) was decided based on soil test crop response (STCR) approach equations available for IARI condition, with initial soil test values of available N, P and K at the beginning of experiment and targeted yield as 2.0 tonnes/ha for soybean. The RDF was 50:75:26 of N:P_2O_5:K_2O kg/ha, respectively. The FYM consisted 0.57 and 0.55% N, 0.28 and 0.27% P and 0.52 and 0.51% K during 2011 and 2012, respectively. Required quantity of fertilizer and FYM were applied as per treatments. Seeds were treated with *Rhizobium* and PSB for respective treatments. The crop was grown with recommended package of practices. For studying the growth and yield parameters of soybean, five plants were tagged randomly in second row of either side in the field. Dry matter accumulation (DMA) and leaf area studies were done from the randomly selected three plants from second row and the yield and yield attributes were recorded at harvest. The mean values of growth rate (CGR), relative growth rate (RGR) and net assimilation rate (NAR) were computed according to formula given by Watson *et al.* (1952) and Watson (1958). For root studies, root samples were taken from third row of the crop at 50% flowering stage with a root auger of 8.0 cm diameter and 15 cm height (core volume = 754.28 cm^3) to take root samples up to 0–15 cm depth of soil profile. The core ring was kept at the base of the stem at the centre. The root samples taken from each plot were washed in water to remove soil. The root parameters, i.e. root length and root volume were recorded through scanning and image analysis using RHIZO system, operated in a computer mounted with the scanner of RHIZO system. After scanning, the root samples were dried at 60ºC for 48 hrs for recording root dry weight. The estimated values of agronomic efficiency (AE), crop recovery efficiency (CRE) and physiological efficiency (PE) of N under different nutrient practices were computed using the expressions: $AE = (Y_t - Y_c)/N_a$; $CRE = [(U_N - U_c)/N_a] \times 100$; $PE = (Y_t - Y_c)/(U_N - U_c)$. Wherein, Y_t and U_N refer to the seed yield (kg/ha) and total N uptake (kg/ha), respectively, of soybean in N applied plots; Y_C and U_C refer to the seed yield (kg/ha) and total N uptake (kg/ha), respectively of soybean in control; N refers to the N applied under different treatments (kg/ha). The chemical analysis of plant samples for concentration of NPK was done as per standard procedures. Statistical analysis of the data was carried out using standard analysis of variance (Gomez and Gomez 1984).

RESULTS AND DISCUSSION

Growth parameters and crop growth indices

Soybean recorded significantly maximum DMA/plant at harvest and LAI at 60 and 90 DAS of crop in soybean–wheat–mungbean system during 2012 (Table 1). Similarly mean values of CGR, RGR and NAR were also found significantly superior under soybean–wheat–mungbean system between different growth stages of soybean (Table 2). Significantly higher values of CGR between 30–60 DAS were recorded in soybean–wheat–mungbean compared to soybean–wheat–fallow and soybean–chickpea–fodder sorghum systems during 2012. The significantly maximum values of RGR at 60–90 DAS and NAR at 30–60 and 60–90 DAS were registered in soybean–wheat–mungbean compared to soybean–wheat–fallow system.

Table 1 Effect of cropping systems and nutrient management on plant height (cm), dry matter accumulation (DMA) (g/plant) and leaf area index (LAI)

Treatment	Plant height at harvest		DMA at harvest		LAI					
					30 DAS		60 DAS		90 DAS	
	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
Cropping systems										
Soybean–wheat–fallow	67.0	64.1	25.14	22.38	0.55	0.55	3.17	2.66	2.25	1.91
Soybean–wheat–mungbean	66.8	66.2	24.98	24.20	0.54	0.56	3.24	3.00	2.25	2.11
Soybean–chickpea–fodder sorghum	67.0	65.5	25.03	23.03	0.53	0.54	3.10	2.82	2.24	2.06
Soybean–potato–mungbean	67.1	65.9	23.98	23.94	0.54	0.54	3.08	2.94	2.22	2.09
SEm±	0.49	0.86	0.361	0.296	0.007	0.009	0.041	0.046	0.028	0.023
LSD (P=0.05)	NS	NS	NS	1.025	NS	NS	0.140	0.158	0.095	0.079
Nutrient management practices										
Control	59.2	57.5	18.33	16.83	0.48	0.47	2.48	2.23	1.63	1.43
100% RDF	67.4	66.6	22.99	21.35	0.53	0.54	2.99	2.64	2.09	1.89
50% RDF+50% RDN-FYM	68.5	67.1	26.08	24.54	0.54	0.55	3.32	3.01	2.42	2.21
50% RDF+25% RDN-FYM +BF	69.7	67.6	27.45	26.33	0.55	0.57	3.33	3.03	2.44	2.26
25% RDF+50% RDN-FYM + BF	70.2	68.3	29.08	27.90	0.59	0.60	3.62	3.37	2.62	2.44
SEm±	1.84	1.69	0.521	0.438	0.022	0.013	0.139	0.117	0.053	0.049
LSD (P=0.05)	6.01	5.50	1.699	1.429	NS	0.041	0.454	0.381	0.174	0.161

Table 2 Effect of cropping systems and nutrient management on crop growth indices

Treatment	Mean CGR (g/m²/day)				Mean RGR (mg/g/day)				Mean NAR (g/m² leaf area/day)			
	30-60 DAS		30-60 DAS		60-90 DAS		30-60 DAS		60-90 DAS		30-60 DAS	
	2011	2011	2012	2011	2012	2011	2012	2011	2012	2012	2011	2012
Cropping systems												
Soybean–wheat–fallow	11.88	9.64	9.71	7.58	68.8	61.8	17.9	16.7	5.88	5.38	2.66	2.48
Soybean–wheat–mungbean	12.08	11.11	9.63	9.06	71.5	66.1	17.7	17.6	6.07	5.79	2.59	2.60
Soybean–chickpea–fodder sorghum	11.63	10.34	9.84	8.34	69.1	64.1	18.2	17.2	5.85	5.58	2.76	2.56
Soybean–potato–mungbean	11.72	10.91	9.24	8.64	69.1	66.4	17.4	17.2	5.85	5.69	2.74	2.58
SEm±	0.178	0.135	0.220	0.195	1.09	0.88	0.18	0.22	0.074	0.074	0.035	0.041
LSD (P=0.05)	NS	0.468	NS	NS	NS	NS	NS	0.75	NS	0.258	NS	0.141
Nutrient management practices												
Control	9.13	8.00	6.29	4.72	65.6	60.2	15.5	13.3	5.58	5.25	2.30	1.97
100% RDF	10.89	9.59	9.10	7.72	68.0	62.5	18.2	17.4	5.85	5.43	2.61	2.59
50% RDF+50% RDN-FYM	12.58	11.14	10.79	9.44	71.9	66.3	18.8	18.3	6.14	5.79	2.81	2.73
50% RDF+25% RDN-FYM+BF	12.58	11.24	10.96	9.89	70.7	66.5	19.0	18.9	6.05	5.72	2.84	2.82
25% RDF+50% RDN-FYM+BF	13.96	12.54	10.87	10.27	72.0	67.4	17.5	17.9	5.93	5.87	2.88	2.66
SEm±	0.339	0.227	0.255	0.226	2.01	1.62	0.20	0.44	0.242	0.131	0.066	0.057
LSD (P=0.05)	1.104	0.741	0.831	0.737	6.55	5.29	0.64	1.43	NS	0.428	0.214	0.186

Among the different nutrient management practices, application of 25% RDF + 50% RDN through FYM + biofertilizers registered significantly maximum values of plant height and DMA/plant at harvest and LAI at 60, 90 DAS and harvest of soybean. Significantly maximum CGR was observed with the application of 25% RDF + 50% RDN thorough FYM + biofertilizers at 30–60 DAS during both the years and at 0–30 and 60–90 DAS, only during 2012. The RGR was significantly higher with the application of 25% RDF + 50% RDN thorough FYM + biofertilizers at 30–60 DAS during both the years. Similarly, application of 25% RDF + 50% RDN thorough FYM + biofertilizers recorded significantly higher NAR at 30–60 DAS during 2012 and at 60–90 DAS during 2011. Beneficial effect of FYM in conjunction with RDF and biofertilizers may be due to the effect of organic matter in improving physical, chemical and biological environment of soil conducive to better plant growth (Deshmukh *et al.* 2005).

Nodulation

The total number of nodules/plant of soybean did not differ significantly under different cropping systems during both the years. Though, the dry weight of nodules/plant was significantly higher under soybean–wheat–mungbean cropping system over soybean–wheat–fallow system (Table 3).

Table 3 Effect of cropping systems and nutrient management on nodulation and root parameters at 50% flowering stage

Treatment	Nodules/ plant		Dry weight of nodules/plant (mg)		Root length (cm)		Root volume (cm³)		Root dry weight (mg)	
	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
Cropping systems										
Soybean–wheat–fallow	29.1	25.3	149	130	923	866	3.49	3.24	840	792
Soybean–wheat–mungbean	28.7	27.1	147	139	929	915	3.55	3.42	843	822
Soybean–chickpea–fodder sorghum	29.1	26.6	149	137	926	896	3.55	3.31	845	812
Soybean–potato–mungbean	28.6	26.8	147	137	915	910	3.40	3.39	831	821
SEm±	1.45	0.31	7.4	1.5	12.1	8.8	0.047	0.043	10.5	7.9
LSD (P=0.05)	NS	NS	NS	5.3	NS	30.4	0.164	0.148	NS	NS
Nutrient management practices										
Control	20.8	18.4	107	95	838	810	2.74	2.64	745	717
100% RDF	25.5	22.9	131	117	869	841	2.92	2.82	782	754
50% RDF+50% RDN-FYM	31.2	28.8	160	148	930	901	3.70	3.60	828	800
50% RDF+25% RDN-FYM+BF	32.2	29.8	165	153	980	952	3.88	3.75	870	842
25% RDF+50% RDN-FYM+BF	34.7	32.4	178	166	1000	980	4.26	3.91	974	946
SEm±	0.83	1.10	4.3	5.5	40.1	34.8	0.159	0.149	28.5	24.8
LSD (P=0.05)	2.71	3.60	13.9	17.8	130.7	113.4	0.518	0.487	92.8	80.9

Different nutrient management practices recorded significantly higher number of nodules/plant and dry weight of nodules/plant over control (Table 3). Further, an increase in nodules was observed with substitution of RDN with FYM and biofertilizers, whereby maximum values were observed under the application of 25% RDF + 50% RDN thorough FYM + biofertilizers followed by 50% RDF + 25% RDN thorough FYM + biofertilizers. Improved nodulation under this treatment was due to that nitrogen was released slowly after decomposition of FYM which tends to formation of more nodules to fulfil N requirement of crop (Salvagiotti *et al*. 2008). In addition, organic manure also provides better soil environment in terms of physical and chemical properties for nitrogenise activity (Hati *et al*. 2001).

Root growth

The values of root length and root dry weight were significantly maximum in soybean grown under soybean–wheat–mungbean system during 2012, which was found on par with soybean–potato–mungbean and soybean–chickpea–fodder sorghum systems. The different cropping systems did not show any marked variation in root dry weight of soybean.

Different nutrient management treatments also had pronounced effect on root growth of soybean (Table 3). Application of 25% RDF + 50% RDN thorough FYM + biofertilizers registered significantly maximum values of root length, root volume and root dry weight during both the years. The higher values of root parameters under inorganic + organic treatments attributed to better nutrient supply and creation of better physical environment by way of lowering of bulk density and penetration resistance in the presence of organic manure. Similar findings also reported by Bandyopadhyay *et al*. (2010).

Yield attributes and yield

Significantly higher pods/plant of soybean were recorded in soybean–wheat–mungbean system, which remained on par with soybean–potato–mungbean and soybean–chickpea–fodder sorghum systems (Table 4). Significantly highest soybean seed yield was recorded in soybean–wheat–mungbean system than soybean–wheat–fallow system. The soybean–potato–mungbean and soybean–chickpea–fodder sorghum systems remained statically similar to soybean–wheat–mungbean for soybean seed yield. Soil is a dynamic medium for plant growth and keeping the land fallow in summer season increases compaction, temperature soil profile, reduces pore space and aeration (Bastia *et al*. 2008). This might have deteriorated the biological activities of soil and ultimately reduced the yield of soybean in the succeeding season after fallow.

All the nutrient management practices produced significantly maximum pods/plant, seeds/pod, seed, stover and biological yield of soybean over control (Table 4). Soybean responded better to organic source (FYM) and biofertilizers, whereby application of 25% RDF + 50% RDN through FYM along with inoculation of *Rhizobium* and PSB produced significantly highest pods/plant, seeds/pod and seed and stover yields of soybean over control. These treatments received lower levels of fertilizer nitrogen and inoculation with *Rhizobium* increased the nodulation (Table 3), might resulted in higher BNF (Salvagiotti *et al*. 2008) and solubilisation of more amount of P by PSB. At the same time, organic manure (FYM) acts as a substrate for microorganisms and also improves soil condition favourable for availability of nutrients to crop (Sharma *et al*. 2008). Therefore, synergistic effect of biofertilizers and FYM results in higher growth, yield attributes and yields of

Table 4 Effect of cropping systems and nutrient management on yield attributes and yield

Treatment	Pods/ plant		Seeds/ pod		100-seed weight (g)		Seed yield (t/ha)		Stover yield (t/ha)		HI (%)	
	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
Cropping systems												
Soybean–wheat–fallow	37.5	34.2	2.6	2.5	10.44	10.40	1.76	1.59	3.33	3.02	34.5	34.4
Soybean–wheat–mungbean	38.2	36.8	2.6	2.6	10.50	10.58	1.75	1.64	3.31	3.09	34.6	34.6
Soybean–chickpea–fodder sorghum	37.6	36.0	2.6	2.5	10.56	10.44	1.77	1.60	3.36	3.08	34.5	34.2
Soybean–potato–mungbean	38.0	36.5	2.6	2.6	10.50	10.48	1.77	1.62	3.33	3.09	34.6	34.4
SEm±	0.47	0.43	0.04	0.03	0.114	0.130	0.014	0.010	0.042	0.040	0.39	0.553
LSD (P=0.05)	1.63	1.50	NS	NS	NS	NS	NS	0.034	NS	NS	NS	NS
Nutrient management practices												
Control	32.1	29.3	2.1	2.0	10.20	10.20	1.57	1.40	3.01	2.70	34.2	34.1
100% RDF	37.9	35.9	2.7	2.6	10.45	10.45	1.75	1.64	3.35	3.15	34.3	34.2
50% RDF+50% RDN-FYM	38.9	37.1	2.7	2.7	10.55	10.53	1.78	1.65	3.37	3.15	34.6	34.4
50% RDF+25% RDN-FYM+BF	39.7	38.0	2.8	2.7	10.60	10.58	1.83	1.66	3.44	3.17	34.7	34.4
25% RDF+50% RDN-FYM+BF	40.5	39.2	2.9	2.8	10.70	10.63	1.88	1.72	3.49	3.20	35.0	34.9
SEm±	1.62	1.57	0.11	0.11	0.315	0.437	0.060	0.024	0.121	0.095	1.01	0.891
LSD (P=0.05)	5.29	5.11	0.35	0.37	NS	NS	0.195	0.078	0.395	0.309	NS	NS

soybean. The similar findings had been reported by Suryawanshi *et al*. (2006) and Kanase *et al*. (2006).

Economics

Economic analysis of soybean as influenced by cropping systems and nutrient management practices revealed that cost of cultivation and returns were relatively higher during 2012 than 2011 (Table 5). Significantly highest net returns were obtained in soybean grown under soybean–wheat–mungbean system over soybean–wheat–fallow system and it was almost similar to that obtained in soybean grown under soybean–potato–mungbean and soybean–chickpea–sorghum system during 2012.

Among the nutrient management practices, application of 50% RDF + 25% RDN thorough FYM + biofertilizers fetched maximum gross returns during both the years and net returns only during 2012, whereas during 2011, the highest net returns was obtained under the application of 25% RDF + 50% RDN thorough FYM + biofertilizers. The net returns under application of 25% RDF + 50% RDN thorough FYM + biofertilizers and 50% RDF + 25% RDN thorough FYM + biofertilizers, remained on a par during both the years. The higher cost of organic manure (FYM) as compared the fertilizers, increased the cost of cultivation during 2011 in the treatment 25% RDF + 50% RDN thorough FYM + biofertilizers which reduced net returns. But during 2012, the comparative cost of fertilizers increased and higher net returns obtained under the treatment 25% RDF + 50% RDN thorough FYM + biofertilizers.

Nutrient uptake

Data presented in Table 5 showed that among the different cropping systems, total P uptake by soybean did not differ significantly among the different cropping systems during both the years. Soybean grown under soybean–wheat–mungbean system had significantly higher total uptake of N as well as K over soybean–wheat–fallow system. No significant variation was noticed among soybean–wheat–mungbean system and soybean–potato–mungbean in case of total uptake of N and K by soybean.

The uptake of NPK by soybean was also influenced significantly due to different nutrient management practices. Significantly maximum total uptake of N and P was recorded with the application of 25% RDF + 50% RDN thorough FYM + biofertilizers over control during both the years. The total uptake of K by soybean was significantly higher with the application of 100% RDF and 50% RDF + 50% RDN thorough FYM during 2011 and 2012, respectively. As the nutrient uptake is the function of nutrient concentration and yield, therefore, higher concentration along with higher yields under these treatments resulted in their higher uptake by soybean.

Nitrogen use efficiency

The agronomic efficiency (AE, the quantity of seed yield increased for 1 kg of N), crop recovery efficiency (CRE) and physiological efficiency (PE, the quantity of seed yield increased for 1 kg of N uptake) varied among the different nutrient management practices (Fig 1). These were generally higher with all the nutrient treatments where part of RDF was substituted with FYM and biofertilizers compared to the fertilizer application alone (100% RDF). The highest values of AE, CRE and PE were observed under the application of 25% RDF + 50% RDN thorough FYM + biofertilizers (NS_4). The reduction in fertilizer N and better utilization of nitrogen through FYM and biofertilizers

Table 5 Effect of cropping systems and nutrient management on economics and nutrient uptake

Treatment	Gross returns (₹/ha)		Net returns (₹/ha)		B:C ratio		Total N uptake (kg/ha)		Total P uptake (kg/ha)		Total K uptake (kg/ha)	
	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
Cropping systems												
Soybean–wheat–fallow	34 701	40 121	17 848	21 577	2.07	2.17	186.3	166.9	16.7	15.1	62.0	56.2
Soybean–wheat–mungbean	34 584	41 363	17 732	22 819	2.07	2.25	184.5	175.9	16.7	15.8	63.2	60.1
Soybean–chickpea–fodder sorghum	34 947	40 552	18 094	22 008	2.09	2.20	188.8	169.5	16.9	15.5	63.1	58.3
Soybean–potato–mungbean	34 875	40 956	18 023	22 412	2.09	2.23	187.3	175.3	16.8	15.7	63.0	59.0
SEm±			200	265	0.025	0.028	2.41	1.82	0.20	0.18	0.57	0.51
LSD (P=0.05)			NS	917	NS	NS	NS	6.28	NS	NS	NS	1.77
Nutrient management practices												
Control	31 010	35 392	17 714	20 840	2.33	2.43	153.2	136.7	10.9	9.8	51.9	47.0
100% RDF	34 636	41 421	18 017	21 260	2.08	2.05	186.6	175.2	17.8	16.7	66.3	61.0
50% RDF + 50% RDN-FYM	35 170	41 697	16 234	21 548	1.86	2.07	191.9	178.6	17.8	16.6	64.8	62.4
50% RDF + 25% RDN-FYM + BF	36 063	41 988	18 936	23 056	2.11	2.22	198.3	181.3	18.5	17.0	65.4	59.9
25% RDF + 50% RDN-FYM + BF	37 004	43 242	18 719	24 315	2.02	2.28	203.7	187.6	19.0	17.5	65.6	61.6
SEm±			537	557	0.048	0.051	4.43	2.93	0.39	0.37	1.37	1.28
LSD (P=0.05)			1750	1816	0.156	0.165	14.45	9.55	1.28	1.20	4.48	4.16

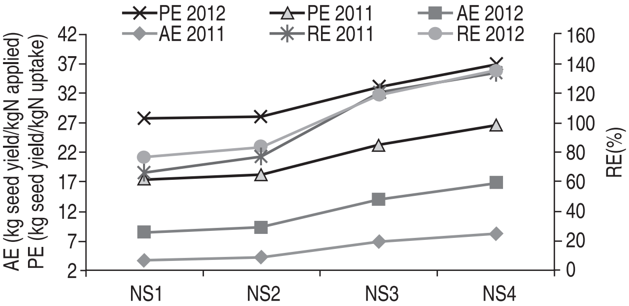

Fig 1 Effect of nutrient management practices on nitrogen use indices

with increased seed yield might have increased the N use indices under this treatment.

The findings of two years study inferred that soybean performed better in terms of growth and yield under soybean-wheat-mungbean and soybean–potato–mungbean systems than soybean–wheat–fallow system. Among the different nutrient management, application of 25% RDF + 50% RDN thorough FYM + biofertilizers was found to be most effective in increasing the growth, productivity and returns of soybean.

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