RESEARCH ARTICLE Indian Journal of Agricultural Research, Volume 58 Issue 5: 816-819 (October 2024)

Effect of Integrated Nutrient Management Levels on Soybean and its Residual Effect on Production Efficiency and Economic Efficiency under Soybean-Onion and Soybean-Potato Cropping System

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10.18805/IJARe.A-6059

ABSTRACT

Background: Inclusion of high value vegetable crops like onion and potato in soybean based crop sequence may help to improve the productivity and profitability on sustainable basis. Nutrient management and cropping sequence are two important factors which affect productivity and profitability of crop. As such, information on soybean followed by onion and potato is lacking and it will be very useful for exploring the productivity and profitability of soybean followed by high value vegetable crop sequence.

Methods: The data pertaining to growth characteristics, yield characteristics, gross monetary returns and net monetary returns of Soybean (*kharif*) and Onion or Potato (*rabi*) was collected at regular interval in 2017-18, 2018-19 at Agronomy Farm, Dr. PDKV, Akola which was analyzed statistically in RBD (Randomized Block Design) and SPD (Split Plot Design).

Result: S_1- soybean-onion recorded more production efficiency than S_2- soybean-potato. S_1- soybean-onion reported greater economic efficiency than S_2- soybean-potato. Soybean crop supplied with IN_3 (100% RDN applied with FYM@ 5 t per ha and biofertilizer) registered highest production efficiency and economic efficiency than IN_1 (50% RDN applied with FYM 5 t per ha and biofertilizer) to soybean and found at par with IN_2 (75% RDN applied with FYM 5 t per ha and biofertilizer) to soybean. *Rabi* crop (onion/potato) supplied with F_3 (125% RDF) level registered significantly greater production and economic efficiency than lower levels of recommended dose nutrient.

Key words: Agricultural Productivity, Climate action, Economics, Food, Integrated nutrient management levels, Life on land, Nutrition, Onion, Potato, Productivity, Responsible consumption and production, Soybean, Soybean-based cropping sequence, Sustainable Agriculture, Zero hunger.

INTRODUCTION

Soybean (*Glycine max* L.) is grown in India as one most important oilseed and legume crop. Soybean crop belongs to family Leguminoceae. Soybean originated from country China. Soybean seed contains oil (20%) and protein (40%). Soybean is known as vegetarian meat, because it is important source of protein to vegetarian population of the country. In India, soybean crop is cultivated on 12.81 (million hectares) area with 12.90 (million tonnes) production and 1007 kg/ha productivity. In Maharashtra, soybean crop is cultivated on 4.36 (million hectares) area with 6.20 (million tonnes) production and 1423 kg/ha productivity (Anonymous, 2020).

Onion (*Allium cepa* L.) belongs to family Amaryllidaceae. The most economical part of onion is the bulb onion. In addition to this, bulb of onion is used for preparation of value added products like onion powder and onion flakes. A volatile compound allyl propyl disulphide gives pungency to onion. Onion has its own nutritional and medicinal properties. Onion is source of flavonoids which decrease risk of heart disease, cancer and diabetes. Flavonoids have anti-cancer, antibacterial, antiviral and anti-allergic properties. In India, onion crop is cultivated on 1638.58 ('000 hectares) area with 26830.27 ('000 tonnes) production and 16374 kg/ha productivity. In Maharashtra, onion crop is cultivated on 703.80 '000 hectares) area with 10476.46 ('000 tonnes) production and 14886 kg/ha productivity (Anonymous, 2020).

Potato (*Solanum tuberosum* L.) belongs to family solanaceae and originated from South America. It is important food crops both in India as well as world. Potato

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How to cite this article: Patil, S.S., Hiwale, S.D., Shinde, R.S., Yadav, K.R. and Patil, S.R. (2024). Effect of Integrated Nutrient Management Levels on Soybean and its Residual Effect on Production Efficiency and Economic Efficiency under Soybean-Onion and Soybean-Potato Cropping System. Indian Journal of Agricultural Research. 58(5): 816-819. doi: 10.18805/IJARe.A-6059.

Submitted: 03-10-2022 **Accepted:** 22-09-2023 **Online:** 03-10-2023

acts as a low cost energy source to diet of people. Potato is popular as 'poor man's food' because of its supplying high nutrition, low cost energy source to people of different of economic classes. It contains 2.1% of protein, 20.6% Carbohydrate, 2% Sugar, 1.1% crude fibre and 0.3% fat. The most important economical part of potato is the tuber of potato. Tuber of potato is a modified stem developed underground on stolon. It is consumed in various forms of vegetable ingredient in different cooked dishes. In addition to this, tuber of potato is used for preparation of value added products like potato powder and potato flakes. Potato has important value in food industries due to its utilization in synthesis of dextrin and starch. In India, potato crop is cultivated on 2248.07 ('000 hectares) area with 54229.74 ('000 tonnes) production and 24123 kg/ha productivity (Anonymous, 2020).

Jate and Joachim Lammel (2022) reported that balanced nutrient management with integrated principles of plant nutrition is the one of the best nutrient management strategies to enhance crop production without decrease in the soil fertility. Nutrient management is one of the important management factor which affects productivity and profitability of crop hence it is included in present investigation. Agronomic crop is combined with the high daily used vegetable crop to check feasibility of combination to increase the productivity and profitability of crop sequence.

MATERIALS AND METHODS

The present experiment was carried out in 2017-18 and 2018-19 at research farm of Department of Agronomy, Dr. PDKV, Akola (MS). The seeds of soybean were inoculated with *Rhizobium japonicum* @ 250 g 10 kg^{-1}, PSB @ 250 g 10 kg^{-1} and *Tricoderma viridi* @ 250 g 10 kg^{-1} before sowing. The data pertaining to growth characteristics, yield characteristics, gross monetary returns, net monetary returns and B: C ratio of Soybean in (*kharif*) and Onion or Potato crops (*rabi*) was collected at regular intervals which was analyzed statistically in RBD (Randomized Block Design) and SPD (Split plot design). Treatment details given in Table 1.

Production efficiency

Production efficiency was calculated by the following formula:

Production efficiency (kg ha^{-1} day^{-1}) =

$$\frac{\text{SEY of cropping system (kg ha}^{-1}\text{)}}{\text{Total duration of cropping sequence (days)}}$$

SEY- Soybean equivalent yield.

Economic efficiency

Economic efficiency was calculated by the following formula:

Economic efficiency (Rs. ha^{-1} day^{-1}) =

$$\frac{\text{NMR of sequence crop (Rs.ha}^{-1}\text{)}}{\text{Total duration of cropping sequence (days)}}$$

NMR- Net monetary returns.

RESULTS AND DISCUSSION

Production efficiency (kg/day/ha) and economic efficiency (Rs./day/ha)

The data pertaining to production efficiency (kg ha^{-1} day^{-1}) and economic efficiency (Rs. ha^{-1} day^{-1}) of the cropping system during both the years are presented in Table 2, 3 and 4. The mean production efficiency (kg ha^{-1} day^{-1}) were 43.30, 41.18, 42.29 and economic efficiency (Rs. ha^{-1} day^{-1}) were 1122, 1231, 1177 during first year, second year and on pooled mean basis, respectively.

Crop sequences

The data in Table 1 show that Soybean-onion (CS_1) recorded significantly more economic efficiency and production efficiency than soybean-potato (CS_2) in first year of research. This might be due to higher yield of onion than potato in soybean based cropping sequence. Similar results were reported by Pacharne (2014) and Thorat *et al.* (2018).

Integrated nutrient management levels to soybean (*kharif*)

Soybean crop supplied with IN_3 (100% RDN applied with FYM@ 5 t per ha and biofertilizer) and IN_2 (75% RDN applied with FYM@ 5 t per ha and biofertilizer) both being at par with each other registered significantly higher production efficiency and economic efficiency than IN_1 (50% RDF applied with FYM@ 5 t per ha+ biofertilizer (Table 2). This might be due to rapid release of nutrients through inorganic sources of nutrient during early phase of growth and development of soybean and gradual release of nutrients during later phase of growth and development of soybean by the organic sources. In addition to that seed of soybean treated with biofertilizer which help to fix atmospheric nitrogen and solublize insoluble phosphorus in soil. Similar results were recorded by Thimmegowda (2006) and Thorat *et al.* (2018).

Table 1: Treatment details.

I.	**Main plot treatments**
A.	**Crop sequences**
CS_1	Soybean-Onion
CS_2	Soybean-Potato
B.	**Integrated nutrient management levels to soybean (*Kharif*)**
IN_1	50% RDN + 5 t FYM/ha + Biofertilizer (*Rhizobium japonicum* +PSB+*Tricoderma viridi*)
IN_2	75% RDN + 5 t FYM/ha + Biofertilizer (*Rhizobium japonicum* +PSB+*Tricoderma viridi*)
IN_3	100% RDN+ 5 t FYM/ha + Biofertilizer (*Rhizobium japonicum* +PSB+*Tricoderma viridi*)
II.	**Sub plot treamtents**
	Recommended dose of fertlizers to Onion and Potato (*Rabi*)
F_1	75% RDF
F_2	100% RDF
F_3	125% RDF

Recommended dose of fertilizer levels to onion and potato (*rabi*)

The application of 125 % RDF (F_3) level to *rabi* crop recorded significantly higher production efficiency and economic efficiency than lower levels of recommended dose of fertilizer (Table 2). This might be due to residual effect of integrated nutrient management levels applied to *kharif* crop enhanced the nutrient uptake and yield potential of *rabi* crops. These results were similar findings of Gaud (2004), Gudhade (2008), Senthivelu *et al.* (2009), Shanwad *et al.* (2010), Subehia and Sepehya (2012), Thorat *et al.* (2018).

Interaction

Production efficiency (kg/day/ha) and Economic efficiency (Rs./day/ ha)

The data presented in Table 3 and 4 indicate that soybean crop supplied with IN_3 and *rabi* crops (onion and potato) supplied with F_3 registered highest production economic

Table 2: Production efficiency (kg/day/ha) and Economic efficiency (Rs./day/ha) as influenced by integrated nutrient management to soybean (*kharif*) and recommended fertilizer levels to onion and potato (*rabi*).

Treatments	Production efficiency (kg ha^{-1} day^{-1})			Economic efficiency (Rs. ha^{-1} day^{-1})		
	2017-2018	2018-2019	Pooled mean	2017-2018	2018-2019	Pooled mean
Cropping sequence						
CS_1: soybean- onion	44.35	42.34	43.35	1161	1277	1219
CS_2: soybean-potato	40.90	38.51	39.70	1036	1134	1085
SE (m)±	1.05	1.01	1.26	34	37	44
CD at 5%	NS	NS	NS	NS	NS	NS
Integrated nutrient management levels to soybean (*kharif*)						
IN_1	36.73	34.94	35.83	931	1033	982
IN_2	43.96	41.56	42.76	1134	1237	1185
IN_3	47.18	44.78	45.98	1232	1346	1289
SE (m)±	1.00	1.11	1.82	32	34	58
CD at 5%	3.25	3.61	5.46	105	112	173
Recommended dose fertlizers to onion and potato (*Rabi*)						
F_1	35.96	33.94	34.95	870	949	910
F_2	44.54	42.39	43.47	1170	1290	1230
F_3	47.37	44.94	46.16	1257	1376	1316
SE (m)±	0.86	0.75	0.99	25	25	31
CD at 5%	2.51	2.20	2.81	74	74	88
Interaction						
A × B	NS	NS	NS	NS	NS	NS
B × C (CD at 5%)	4.34	3.80	4.87	129	128	153
A × C	NS	NS	NS	NS	NS	NS
A × B × C	NS	NS	NS	NS	NS	NS
G. M.	43.40	41.18	42.29	1122	1231	1177

Table 3: Response of production efficiency (kg/day/ha) under soybean based cropping system to interaction effect between integrated nutrient management to soybean (*kharif*) and recommended dose of fertilizer levels to onion and potato (*rabi*).

Integrated nutrient management levels to soybean (*kharif*)	Recommended dose of fertilizer levels to onion and potato (*rabi*)								
	F_1			F_2			F_3		
	2017-2018	2018-2019	Pooled mean	2017-2018	2018-2019	Pooled mean	2017-2018	2018-2019	Pooled mean
IN_1	27.82	26.49	27.16	42.21	40.26	41.23	40.16	38.06	39.11
IN_2	33.42	31.62	32.52	47.11	44.75	45.93	50.61	48.31	49.46
IN_3	46.63	43.71	45.17	44.30	42.17	43.23	51.35	48.76	50.05
B × C									
Year	**2017-2018**			**2018-2019**			**Pooled mean**		
SE (m)±	1.48			1.30			1.71		
CD at 5%	4.34			3.80			4.87		

Table 4: Response of economic efficiency (Rs./day/ha) under soybean based cropping system to interaction effect between integrated nutrient management to soybean (*kharif*) and recommended dose of fertilizer levels to onion and potato (*rabi*).

Integrated nutrient management levels to soybean (*kharif*)	Recommended dose of fertilizer levels to onion and potato (*rabi*)								
	F_1			F_2			F_3		
	2017-2018	2018-2019	Pooled mean	2017-2018	2018-2019	Pooled mean	2017-2018	2018-2019	Pooled mean
IN_1	634	708	671	1105	1223	1164	1053	1168	1111
IN_2	786	864	825	1245	1367	1306	1347	1479	1413
IN_3	1191	1276	1233	1159	1280	1220	1371	1480	1425
B × C									
Year	**2017-2018**			**2018-2019**			**Pooled mean**		
SE (m)±	44			44			54		
CD at 5 %	129			128			153		

efficiency over other treatments except combination of IN_2 to soybean and F_2 to *rabi* crops(onion and potato).

CONCLUSION

Soil application of 75% RDN applied with FYM@ 5 t per ha, seed treatment of biofertilizer to soybean and soil application of 100% RDF to *rabi* onion secured higher production as well as economic efficiency in soybean based cropping sequence.

Conflict of interest

All authors declare that they have no conflict of interest.

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