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Impact of Levels of Nutrient Management on Economics of Soybean-onion and Soybean-potato Cropping System

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ABSTRACT

Background: Nutrient management and cropping sequence are two important factors which affect productivity and profitability of crop. Profitability is one the important part of the successful crop production. Soybean fixes atmospheric nitrogen in soil and partially fulfills the nitrogen requirement of succeeding crops. There is a need for a suitable substitute crop or cropping systems after soybean to improve the soil fertility and productivity to maximize the profitability. The plains of Maharashtra are well suited for onion and potato cultivation. There is scope for increasing the area, production and productivity of onion and potato crop. Majority of farmers in Maharashtra following soybean-wheat and soybean-chickpea crop sequence while in present investigation soybean is grown in sequence with vegetable crop such as onion and potato which could help to increase profitability through higher net return and B: C ratio.

Methods: The experiment was laid out in split plot design with three replications. Six combinations of two crop sequences (soybean-onion and soybean-potato) and three levels of nutrient management *viz.,* 50% RDF+FYM 5 t ha^{-1} + biofertilizer (N_1), 75% RDF+ FYM 5 t ha^{-1} + biofertilizer (N_2) and 100 % RDF+ FYM 5 t ha^{-1} + biofertilizer (N_3) were the main plot treatments in *kharif* season replicated three times in randomized block design. During *rabi* season each main plot treatment of nutrient management level was split into three sub plot treatments with three levels of recommended dose of fertilizer *viz.,* 75% RDF (F_1), 100% RDF (F_2) and 125% RDF (F_3) to *rabi* season crops resulting in eighteen treatment combinations replicated three times in split plot design. The data pertaining to growth characteristics, yield characteristics, economics of soybean (*kharif*) and onion or potato (*rabi*) was collected at regular interval in 2017-18, 2018-19 and 2019-20 at Agronomy Farm, Dr. PDKV, Akola which was analyzed statistically in SPD (split plot design).

Result: Soybean-onion crop sequence registered higher profitability in terms of GMR, NMR and B:C in comparison with soybean - potato crop sequence. Soybean crop supplied with 100% RDN+ 5 t FYM ha^{-1} + Biofertilizer (*Rhizobium japonicum*+ PSB+ *Tricoderma viridi*) recorded highest GMR, NMR and B:C ratio over lower levels of treatments in all year experimentation. *Rabi* crops treated with 125% RDF recorded GMR, NMR and B:C ratio over lower levels of treatments in all years of experimentation.

Key words: B:C ratio, Climate action, Economics, Gross monetary returns, Life on land, Net monetary returns, Production, responsible consumption.

INDRODUCTION

Glycine max L. is grown in India as major oilseed and legume crop. Soybean crop belongs to family Leguminoceae. China is the country from whence soybeans originated. 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. Soybean fixes atmospheric nitrogen in soil and partially fulfills the nitrogen requirement of succeeding crops. There is a need for a suitable substitute crop or cropping systems after soybean to improve the soil fertility and productivity to maximize the net returns. Choice of a cropping systems is very much location specific. In India, soybean crop is cultivated on 12.81 M ha area with 12.90 MT production and 1007 kg ha^{-1} production per unit area. In Maharashtra, soybean crop is cultivated on 4.36 million hectares area with 6.20 million tonnes production and 1423 kg ha^{-1} productivity (Anonymous, 2020).

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Onion (*Allium cepa* L.) belongs to family Amaryllidaceae. The most economical part of onion is the bulb onion. In addition, 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 1.64 M ha area with 26.83 M T production and 16360 kg ha^{-1} productivity. In Maharashtra, onion crop is cultivated on 703.80 '000 hectares) area with 6.20 '000 tonnes production and 1423 kg ha^{-1} production per unit area. (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 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 2.25 M ha area with 54.23 M T production and 24102 kg ha^{-1} productivity (Anonymous, 2020). Since intensive cropping systems remove a significant amount of nutrients from the soil pool, they require more nutrients than less intensive cropping systems with high yielding enhanced crop types. When applied in an unbalanced manner, chemical fertilizer boosts crop yields but over time reduces soil fertility and food quality (Sinha *et al*., 2010). Limitation analysis has shown that one of the main causes of limited growth and decreased output is unbalanced nutrition management (Tiwari *et al.,* 2002). Jate and 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. After China, India has the second-highest population in the world. Every day, the amount of arable land available is decreasing due to the growing human population. Increased agricultural land production is necessary to feed the rising population's needs for food, fiber, fuel, fodderand other necessities without compromising the health of the soil. Vegetable crops have been strongly promoted as a solution to the issue of food security. A new industry in agricultural diversification is the cultivation of vegetables, which might increase the income of small and marginal landowners and provide jobs in rural areas.

The farming community in Maharashtra has experienced significant improvements thanks to the environmentally friendly commodities that are farmed there: potatoes and onions. When cultivated alone, it is regarded as an exhausting crop that requires high nutrition. Soybean-based cropping systems may be able to maintain their production by applying general recommended doses of fertilizer (GRDF) to the kharif soybean crop and appropriate recommended doses of fertilizer (RDF) to the onion and potato crops that follow in the *rabi* season. 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. Maharashtra's soil and climate are ideal for growing potatoes and onions. Both potatoes and onions are high in energy, have a lot of potential for cultivating in a sequence based on soybeans and have shown to be superior options for both crop diversification and preserving soil sustainability. In terms of cropping sequence, soybeans are legumes, onions are bulbs and potatoes are tuber crops that complement one another. But in order to realize their full potential, each of these crops needed improved fertilizer management. The productivity of the soil has decreased due to extended crop cultivation using the recommended amount of inorganic fertilizer alone and imbalanced manner. By adding FYM to the soil in conjunction with inorganic fertilizers, the plant's constant access to nutrients during its growth cycle was enhanced. Therefore, it is now necessary to add organic manure with biofertilizers in addition to inorganic fertilizers, at least to one crop in the cropping sequence, in order to maintain the fertility and productivity of the soil.

MATERIALS AND METHODS

A field experiment was conducted at Akola to check impact of levels of nutrient management on economics of soybean-onion and soybean-potato cropping system. The present experiment was carried out in 2017-18, 2018-19 and 2019-20 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 SPD (Split Plot Design). The observations of experiment were recorded as per standard procedure. The experimental data was statistically analysed given by Gomez and Gomez (1984). The differences among treatments were calculated by using 'F' test and critically differences at 5% probability.

Treatment details	
I.	**Main plot treatments**
A.	**Crop sequences**
C_1	Soybean-Onion
C_2	Soybean-Potato
B.	**Integrated nutrient management levels to Soybean (*Kharif*)**
N_1	50% RDN + 5 t FYM ha^{-1} + Biofertilizer (*Rhizobium japonicum* + PSB+ *Tricoderma viridi*)
N_2	75%RDN + 5 t FYM ha^{-1} + Biofertilizer (*Rhizobium japonicum* + PSB+ *Tricoderma viridi*)
N_3	100%RDN+ 5 t FYM ha^{-1} + Biofertilizer (*Rhizobium japonicum* + PSB+ *Tricoderma viridi*)
II.	**Sub plot treamtents**
	Recommended dose of fertlizers to *Rabi* (Onion and potato)
F_1	75% RDF
F_2	100% RDF
F_3	125% RDF

RESULTS AND DISCUSSION

Economics

The economics in forms of gross monetary returns (GMR), net monetary returns (NMR), cost of production and benefit to cost (B:C) ratio realized during 2017-18, 2018-19,2019-20 and on pooled mean basis. The data of economics of different cropping sequences are presented in Table 1.

The mean gross monetary returns were (3.39, 3.62, 3.82 and 3.61 lakh Rs. ha^{-1}) and net monetary returns were (2.31, 2.51, 2.66 and 2.50 lakh Rs. ha^{-1}) during first year, second year, third year and on pooled mean basis, respectively.

Cropping sequences

Among the cropping sequence, significantly maximum gross monetary returns (3.63, 3.88 4.09 and 3.87 lakh Rs. ha^{-1}), net monetary returns (2.56, 2.79, 2.94 and 2.77 lakh Rs. ha^{-1}) and B:C ratio (3.40, 3.56, 3.54 and 3.50 Rs. lakh ha^{-1}) were realized from soybean-onion cropping sequence than soybean-potato cropping sequence during first year, second year, third year and on pooled mean basis, respectively. Higher yield of onion over potato in soybean based cropping sequence during experimentation years is might be reason behind these results. These results are in consonance with results of Kumarsen *et al.* (2014).

Nutrient management treatments to *kharif* crop

Application of 100% RDF + FYM 5 t ha^{-1}+ Biofertilizer (N_3) to soybean recorded significantly higher gross monetary returns (3.64, 3.87, 4.08 and 3.86 lakh Rs. ha^{-1}), net monetary returns (2.55, 2.76, 2.91 and 2.74 lakh Rs. ha^{-1}) than application of 50% RDF + FYM 5 t ha^{-1} + Biofertilizer (N_1) to soybean and 75 % RDF + FYM 5 t ha^{-1} + Biofertilizer (N_2) to soybean in first year, second year, third year.

However, application of 100% RDF + FYM 5 t ha^{-1}+ Biofertilizer (N_3) to soybean and 75% RDF + FYM 5 t ha^{-1}+ Biofertilizer (N_2) to soybean both being at par recorded significantly higher gross monetary returns, net monetary returns as compared to application of 50% RDF + FYM 5 t ha^{-1} + Biofertilizer (N_1) on pooled mean basis.

Soybean crop supplied with N_3 (100% RDN applied with FYM@ 5 t ha^{-1} biofertilizer) registered higher benefit to cost (B:C) ratio (3.34, 3.48, 3.49 and 3.44) than N_2 (75 % RDN applied with FYM@ 5 t ha^{-1} and biofertilizer) and N_1 (50% RDF applied with FYM@ 5 t ha^{-1}+ biofertilizer) in first year, second year, third year and on pooled mean basis.

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. The results are in close agreement with the findings by Thorat (2018). Patel and Thanki (2022); Bhadre *et al.* (2022); Gudadhe *et al.* (2022); Biswas *et al.* (2023); Samant *et al.* (2023).

Fertilizer levels to *rabi* crops

The *rabi* crops (onion and potato) supplied with 125% RDF (F_3) registered significantly higher gross monetary returns (3.68, 3.93, 4.15 and 3.93 lakh Rs. ha^{-1}) than with 100% RDF (F_2) and with 75% RDF (F_1) to succeeding *rabi* potato in first year, second year, Third year and on pooled mean basis.

The *rabi* crops (onion and potato) supplied with 125% RDF (F_3) registered significantly higher net monetary returns (2.59, 2.81, 2.98 and 2.80 lakh Rs. ha^{-1}) than with 100% RDF (F_2) and with 75% RDF (F_1) in first and second year. However, application of 125% RDF (F_3) to *rabi* crops and 100% RDF (F_2) to *rabi* crops both remained at par recorded significantly higher net monetary returns as compared to application of 75% RDF (F_1) to *rabi* crops on pooled basis. The B:C ratio recorded (3.38,3.58,3.53 and 3.48) was highest with application of 125% RDF (F_3) to *rabi* crops in all years experimentation and on pooled mean basis.

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*

Table 1: Economics of soybean based crop sequence as influenced by nutrient management to soybean (*kharif*) and fertilizer levels to onion and potato (*rabi*).

Treatments	Gross monetary return Rs ha^{-1} (lakh)				Cost of cultivation Rs ha^{-1} (lakh)				Net monetary return Rs ha^{-1} (lakh)				B:C ratio			
	2017-18	2018-19	2019-20	Pooled mean basis	2017-18	2018-19	2019-20	Pooled mean basis	2017-18	2018-19	2019-20	Pooled Mean basis	2017-18	2018-19	2019-20	Pooled mean basis
A. Cropping sequence																
S_1 : Soybean-onion	3.63	3.88	4.09	3.87	1.07	1.09	1.15	1.10	2.56	2.79	2.94	2.77	3.40	3.56	3.54	3.50
S_2 :Soybean-potato	3.06	3.24	3.44	3.25	1.09	1.11	1.16	1.12	1.97	2.14	2.28	2.13	2.82	2.93	2.97	2.90
SEm±	0.07	0.07	0.07	0.07	-	-	-	-	0.07	0.07	0.07	0.07	-	-	-	-
CD at 5%	0.43	0.46	0.44	0.25	-	-	-	-	0.43	0.46	0.44	0.25	-	-	-	-
B. Nutrient management to soybean (*kharif*)																
N_1 : 50%	2.99	3.20	3.42	3.21	1.06	1.09	1.14	1.10	1.93	2.12	2.27	2.11	2.82	2.95	2.98	2.92
N_2 : 75%	3.41	3.62	3.80	3.61	1.08	1.10	1.16	1.11	2.33	2.53	2.65	2.50	3.17	3.29	3.29	3.25
N_3 : 100%	3.64	3.87	4.08	3.86	1.09	1.11	1.17	1.12	2.55	2.76	2.91	2.74	3.34	3.48	3.49	3.44
SEm±	0.06	0.06	0.08	0.12	-	-	-	-	0.06	0.06	0.08	0.12	-	-	-	-
CD at 5%	0.20	0.21	0.25	0.35	-	-	-	-	0.20	0.21	0.25	0.35	-	-	-	-
C. Fertilizer levels to onion and potato (*rabi* crops)																
F_1 : 75%	2.86	3.02	3.18	3.02	1.06	1.08	1.13	1.09	1.80	1.94	2.05	1.93	2.70	2.80	2.80	2.77
F_2 : 100%	3.49	3.74	3.97	3.73	1.08	1.10	1.16	1.11	2.42	2.64	2.81	2.62	3.25	3.40	3.43	3.36
F_3 : 125%	3.68	3.93	4.15	3.93	1.09	1.12	1.18	1.13	2.59	2.81	2.98	2.80	3.38	3.52	3.53	3.48
SEm±	0.05	0.05	0.05	0.05	-	-	-	-	0.05	0.05	0.05	0.05	-	-	-	-
CD at 5 %	0.15	0.15	0.15	0.15	-	-	-	-	0.15	0.15	0.15	0.15	-	-	-	-
Interaction																
A × B	NS	NS	NS	NS	-	-	-	-	NS	NS	NS	NS	-	-	-	-
B × C (CD at 5 %)	0.26	0.26	0.26	0.25	-	-	-	-	0.26	0.26	0.26	0.25	-	-	-	-
A × C	NS	NS	NS	NS	-	-	-	-	NS	NS	NS	NS	-	-	-	-
A × B × C	NS	NS	NS	NS	-	-	-	-	NS	NS	NS	NS	-	-	-	-
Mean	3.39	3.62	3.82	3.61	1.08	1.10	1.16	1.11	2.31	2.51	2.66	2.50	3.15	3.28	3.29	3.24

Table 2: Gross monetary returns (GMR) as influenced by interaction between nutrient management to soybean (*kharif*) and fertilizer levels to onion and potato (*rabi*).

Nutrient management to soybean (*kharif*)	Gross monetary returns (GMR)											
	Fertilizer levels to onion and potato (*rabi*)											
	2017-18			2018-19			2019-20			Pooled mean		
	F_1	F_2	F_3	F_1	F_2	F_3	F_1	F_2	F_3	F_1	F_2	F_3
N_1	2.36	3.35	3.26	2.52	3.60	3.51	2.68	3.82	3.75	2.52	3.59	3.51
N_2	2.66	3.65	3.86	2.82	3.90	4.14	2.97	4.12	4.28	2.82	3.89	4.10
N_3	3.57	3.49	3.94	3.74	3.73	4.16	3.89	3.96	4.31	3.73	3.73	4.14
SE (m) ±	0.09			0.09			0.09			0.09		
CD at 5%	0.27			0.26			0.26			0.25		

crops. These results are in consonance with Gudhade (2008); Patel and Thanki (2022); Bhadre *et al.* (2022); Gudadhe *et al.* (2022); Samant *et al.* (2023).

Interactions (GMR- Gross monetary returns)

Soybean crop supplied with 100% RDF + FYM 5 t ha^{-1}+ Biofertilizer (N_3) and *rabi* crops (onion and potato) supplied with F_3- 125% RDF registered highest GMR- Gross Monetary Returns over other treatments except combination of 75% RDF + FYM 5 t ha^{-1} + Biofertilizer (N_2) to soybean with F_3- 125% RDF to *rabi* crops (onion and potato) and 75% RDF + FYM 5 t ha^{-1}+ Biofertilizer (N_2) to soybean with F_2- 100% RDF to *rabi* crops (onion and potato) as shown in Table 2.

Interactions (NMR- Net monetary returns)

Soybean crop supplied with 100% RDF + FYM 5 t ha^{-1}+ Biofertilizer (N_3) and *rabi* crops (onion and potato) supplied with F_3- 125% RDF registered highest net monetary returns over other treatments except combination of 75% RDF + FYM 5 t ha^{-1}+ Biofertilizer (N_2) to soybean with F_3- 125% RDF to *rabi* crops (onion and potato) and 75% RDF + FYM 5 t ha^{-1}+ Biofertilizer (N_2) to soybean with F_2- 100% RDF to *rabi* crops (onion and potato) as shown in Table 2. The integrated use of organic and inorganic sources shows residual effect due to slow and gradual release of nutrients during life cycle of crop and thus might have improved the growth and yield performance of crop. Increase in yield was therefore due to significant increase in yield parameter. These results are similar with the findings of Thorat (2018).

CONCLUSION

Application of 75% RDN applied with FYM@ 5 t ha^{-1}, seed treatment of bio fertilizer to soybean and soil application of 100% RDF to *rabi* onion secured higher gross monetary returns (GMR), net monetary returns (NMR) in soybean based cropping sequence.

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Conflict of interest

All authors declare that they have no conflicts of interest.

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