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Effect of nutrient management levels on production efficiency and economic efficiency of soybean based crop sequence

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Abstract
An experiment entitled "Effect of nutrient management levels on productivity and profitability of soybean-based crop sequence" was conducted during 2017-18 at Agronomy Farm, Panjabrao Deshmukh Krishi Vidyapeeth, Akola (MS). Among the cropping sequences, soybean-onion cropping sequences registered significantly higher production efficiency (44. 35 kg day^{-1} ha^{-1}) than soybean-potato cropping sequence (40.90 kg day^{-1} ha^{-1}). Among the cropping sequences, soybean-onion cropping sequences registered significantly higher economic efficiency (1161 Rs. day^{-1} ha^{-1}) than soybean-potato cropping sequence (1036 Rs. day^{-1} ha^{-1}). Application of 100% RDF + FYM 5 t ha^{-1}+ Biofertilizer (N_3) to soybean recorded significantly higher production efficiency (kg day^{-1} ha^{-1}) and economic efficiency (Rs. day^{-1} ha^{-1}) than application of 50% RDF + FYM 5 t ha^{-1}+ Biofertilizer (N_1) to soybean and at par with 75% RDF + FYM 5 t ha^{-1}+ Biofertilizer (N_2) to soybean. The *rabi* crops supplied with 125% RDF (F_3) level during *rabi* season registered significantly higher production efficiency (kg day^{-1} ha^{-1}) and economic efficiency (Rs. day^{-1} ha^{-1}) than 100% RDF (F_2) and 75% RDF (F_1) levels.

Keywords: Nutrient management levels, fertilizer levels, economic efficiency, production efficiency, soybean-based cropping sequence, soybean, onion, potato

Introduction
Soybean (*Glycine max.* L.) is one of the important oilseed as well as leguminous crop. Soybean as a miracle "Golden bean" of the 21st century mainly due to its high protein (40%) and oil (20%) content. In India it is mainly grown as oilseed crop. Soybean (*Glycine max* L.) is known as sojabean, soybean, Chinese pea and Manchurian bean which belongs to family Leguminoceae and has eastern Asian origin. Onion (*Allium cepa* L.) is one of the most important commercial vegetables. It is grown in western, northern as well as in southern India. It is extensively cultivated throughout India for its high nutritional and medicinal properties. It is a maligned vegetable and is widely used as salad, cooked in curries, boiled, fried, baked and pickled.

Potato (*Solanum tuberosum* L.) is one of the most important non-cereal food crops in the world after wheat, rice and maize. It provides a source of low cost energy to the human diet. It is rich in starch, vitamin especially vitamin C, B_1 and minerals. Potato contributes to world food basket just after rice, wheat and maize. It contains 20.6 per cent carbohydrates, 2.1 per cent protein, 0.3 per cent fat, 1.1 per cent crude fibre and 0.9 per cent ash. It also contains good amount of essential amino acids like Leucine, Tryptophane and isolucine.

Constraint analyses have recorded that imbalanced nutrition management is important reasons for restricted growth and declined productivity. (Tiwari *et al.*, 2002) [9]. In era of climate change maintaining yield up to required level is a challenge in coming future. Soil although being rich in nutrients but unfortunately only a small portion of it becomes available to plants especially under semi-arid climatic conditions. Nutrients availability is depend up on the physical and chemical structure of soil. Hence, a balanced nutrients application is must to increase the productivity of the crops. 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. Majority of farmers in Vidarbhra grow cotton, tur, soybean, sorghum, rice as a *kharif* crops and wheat, chickpea, linseed, safflower, sorghum, potato,

onion, garlic as a *rabi* crop on medium soil. Intensive cropping systems with high yielding improved crop varieties require a higher amount of nutrients as the system removes large amount of nutrients from the soil pool. Chemical fertilizer increases the quantity of food produced but decreases its nutritional quality and also soil fertility over the years if used in imbalanced form (Sinha *et al.*, 2010) [6].

The crops in intensive cropping system are grown in a definite sequence where each crop needs to be fortified to its optimum requirement to realize its production potential. Soybean followed by onion and potato are most commonly adopted cropping sequence in most parts of Maharashtra. The existing system of fertilizer application is based on the nutrient requirement of the individual crop ignoring the carry over effect of the manures or fertilizer application to the succeeding crop to a great extent.

Materials and Methods

The present experiment entitled "Effect of nutrient management on productivity and profitability of soybean based cropping sequence" was conducted during 2017-18 at research farm of Department of Agronomy, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (MS). 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, 100 and 125% to *rabi* season crops resulting in eighteen treatment combinations replicated three times in split plot design. The experimental soil was vertisols with a clay loam in texture, low in available nitrogen (238.34 kg ha^{-1}), medium in available phosphorus (16.79 kg ha^{-1}) and very high in potassium content (383.26 kg ha^{-1}). The soil pH, EC and organic carbon were 8.1, 0.38 dSm^{-1} and 0.50 per cent, respectively.

Production efficiency

Production efficiency was calculated by the following formula.

$$\text{Production efficiency (kg ha}^{-1}\text{ day}^{-1}\text{)} = \frac{\text{Soybean equivalent yield of cropping system (kg ha}^{-1}\text{)}}{\text{Total duration of cropping sequence (days)}}$$

Economic efficiency

Economic efficiency was calculated by the following formula.

$$\text{Economic efficiency (Rs. ha}^{-1}\text{ day}^{-1}\text{)} = \frac{\text{Net monetary value of sequence crop (Rs.ha}^{-1}\text{)}}{\text{Total duration of cropping sequence (days)}}$$

Results and Discussion

Production efficiency (kg day^{-1} ha^{-1}) and economic efficiency (Rs. day^{-1} ha^{-1})

Cropping sequence

The data production efficiency (kg day^{-1} ha^{-1}) and economic efficiency (Rs. day^{-1} ha^{-1}) of the cropping system was presented in Table-1 and graphically depicted in Fig. 1(a) and Fig. 1(b). Among the cropping sequences, soybean-onion cropping sequences registered significantly higher production efficiency (44. 35 kg day^{-1} ha^{-1}) than soybean-potato cropping sequence (40.90 kg day^{-1} ha^{-1}). Among the cropping sequences, soybean-onion cropping sequences registered significantly higher economic efficiency (1161 Rs. day^{-1} ha^{-1}) than soybean-potato cropping sequence (1036 Rs. day^{-1} ha^{-1}) during years 2017-18. Pacharne (2014) [3] reported that groundnut-onion cropping system registered significantly highest production and economic efficiencies due to the yield potential of onion crop.

Nutrient management to soybean (*kharif*)

Application of 100% RDF + FYM 5 t ha^{-1}+ Biofertilizer (N_3) to soybean recorded significantly higher production efficiency (kg day^{-1} ha^{-1}) and economic efficiency (Rs. day^{-1} ha^{-1}) than application of 50% RDF + FYM 5 t ha^{-1}+ Biofertilizer (N_1) to soybean and at par with 75% RDF + FYM 5 t ha^{-1}+ Biofertilizer (N_2) to soybean. Similarly, application of 75% RDF + FYM 5 t ha^{-1}+ Biofertilizer (N_2) to soybean recorded significantly higher production efficiency (kg day^{-1} ha^{-1}) and economic efficiency (Rs. day^{-1} ha^{-1}) than application of 50% RDF + FYM 5 t ha^{-1}+ Biofertilizer (N_1) to soybean. This might be due to application GRDF (General Recommended Dose of Fertilizer) to preceding *kharif* soybean increases the nutrient use efficiency of added nutrients and it increases the yield potential of onion. Similar results findings reported by Thimmegowda (2006) [8].

Table 1: Production efficiency (kg $day^{-1}ha^{-1}$) and Economic efficiency (Rs. Day ^{1} ha^{-1}) as influenced nutrient management to soybean (*kharif*) and fertilizer levels to onion and potato (*rabi*)

Treatment	Production efficiency (kg day^{-1} ha^{-1})	Economic efficiency (Rs. day^{-1} ha^{-1}
Cropping sequence		
C_1: soybean- onion	44.35	1161
C_2: soybean-potato	40.90	1036
SE (m)+	1.05	34
CD at 5%	NS	NS
Nutrient management to soybean (*kharif*)		
N_1	36.73	931
N_2	43.96	1134
N_3	47.18	1232
SE(m)+	1.00	32
CD at 5%	3.25	105
Fertilizer levels to onion and potato (*rabi*)		
F_1	35.96	870
F_2	44.54	1170
F_3	47.37	1257
SE (m)+	0.86	25
CD at 5%	2.51	74

Interaction		
A x B	NS	NS
B x C (CD at 5%)	4.34	129
A x C	NS	NS
A x B x C	NS	NS
G. M.	43.40	1122

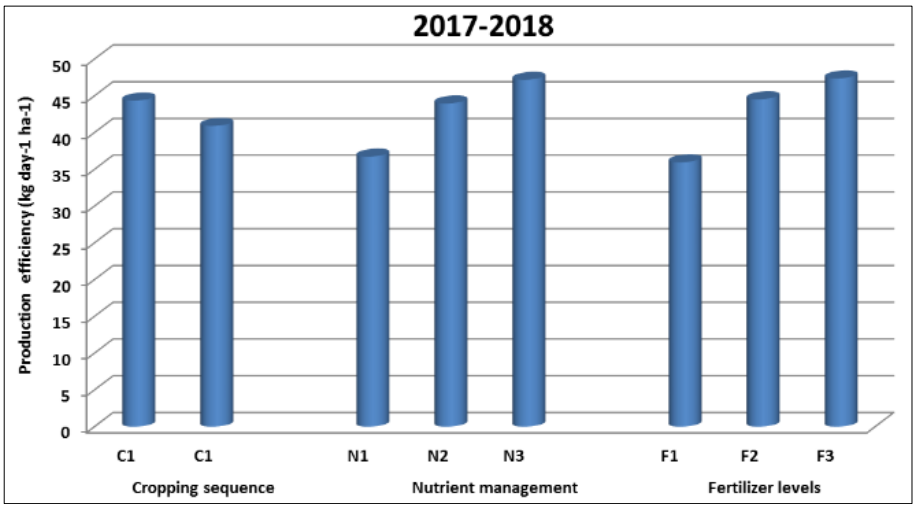

Fig 1(a): Production efficiency (kg day^{-1} ha^{-1}) as influenced nutrient management to soybean (*kharif*) and fertilizer levels to onion and potato (*rabi*)

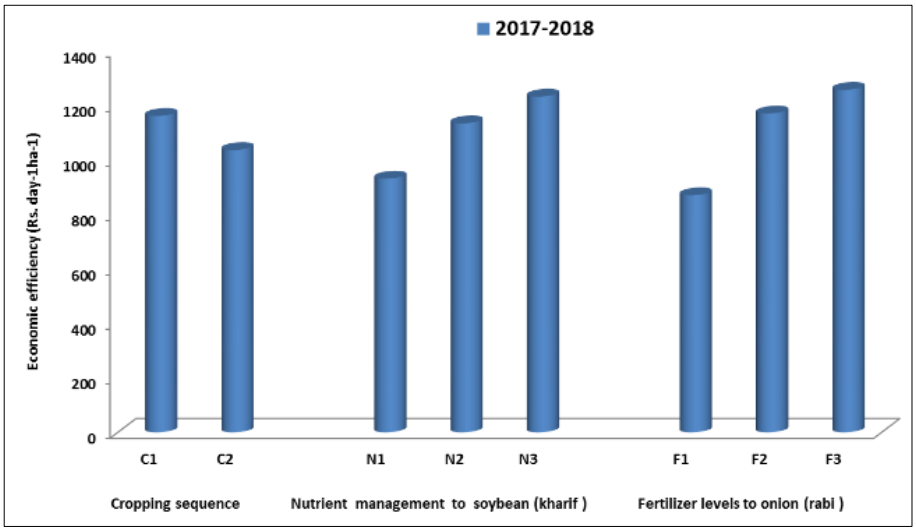

Fig 1(b): Economic efficiency (Rs. day^{-1}ha^{-1}) as influenced nutrient management to soybean (*kharif*) and fertilizer levels to onion and potato (*rabi*)

Fertilizer levels to onion and potato (*rabi*)

The *rabi* crops supplied with 125% RDF (F_3) level during *rabi* season registered significantly higher production efficiency (kg day^{-1} ha^{-1}) and economic efficiency (Rs. day^{-1} ha^{-1}) than 100% RDF (F_2) and 75% RDF (F_1) levels. These results corroborate findings of Gaud (2004) [1], Gudhade (2008) [2], Senthivelu *et al.* (2009) [4], Shanwad *et al.* (2010) [5], Subehia and Sepehya (2012) [7].

Interaction

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

Table 2: Production efficiency (kg day^{-1} ha^{-1}) as influenced by interaction between nutrient management to soybean (*kharif*) and fertilizer levels to onion and potato (*rabi*)

Nutrient management to soybean (*kharif*)	Fertilizer levels to onion and potato (*rabi*)		
	F1	F2	F3
N1	27.82	42.21	40.16
N2	33.42	47.11	50.61
N3	46.63	44.30	51.35
B x C			
SE (m)+	1.48		
CD at 5%	4.34		

Data for interaction presented in Table-2 reveals that the treatment combinations N_3F_3 recorded significantly higher production efficiency over other treatment combinations and remained at par with N_2F_3, N_2F_2.

Economic efficiency (kg day^{-1}ha^{-1})

Table 3: Economic efficiency (Rs. day^{-1} ha^{-1}) as influenced by interaction between nutrient management to soybean (*kharif*) and fertilizer levels to onion and potato (*rabi*)

Nutrient management to soybean (*kharif*)	Fertilizer levels to onion and potato (*rabi*)		
	F1	F2	F3
N1	634	1105	1053
N2	786	1245	1347
N3	1191	1159	1371
B x C			
SE (m)+	44		
CD at 5%	129		

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

Data for interaction presented in Table-3 reveals that the treatment combinations N_3F_3 recorded significantly higher economic efficiency over other treatment combinations and remained at par with N_2F_3, N_2F_2.

Conclusion

Based on above results, it is concluded that for achieving higher production efficiency as well as economic efficiency, the adoption of soybean-onion cropping sequence with application of 75% RDF + FYM 5 t ha^{-1} + Biofertilizer to soybean and 100% RDF to *rabi* onion crops appears to be a better nutrient management option.

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