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Effect of Nutrient Management Levels on Soybean Grain Equivalent Yield (SGEY) and Total System Productivity (TSP) of Soybean based Cropping Sequence

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ABSTRACT

Background: Nutrient management and cropping sequence are two important factors which affect soybean grain equivalent yield and system productivity of soybean based crop sequence. System productivity is one the important part of the successful crop production. A field experiment was conducted at Akola to check effect of levels of nutrient management on soybean grain equivalent yield and system productivity of soybean-onion and soybean-potato cropping system. Agronomic crop is combined with the high daily used vegetable crop to check feasibility of combination to increase the system productivity of crop sequence.

Methods: At the research farm of the Department of Agronomy, Dr. PDKV, Akola (MS), the current experiment, titled "effect of nutrient management levels on growth, yield attributes, soybean grain equivalent yield and system productivity of soybean based cropping sequence," was carried out in 2017-18, 2018-19 and 2019-20. Three replications and a split plot design were used to set up the experiment. The data pertaining to growth characteristics, yield characteristics 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).

Result: Among the cropping sequences soybean-onion cropping sequence recorded significantly higher soybean grain equivalent yield, system productivity as compared to soybean-potato crop sequence. Application of 100% RDF + FYM 5 t ha^{-1} + Biofertilizer applied to *kharif* soybean and 125% RDF to *rabi* sequence crops (onion and potato) recorded significantly higher soybean grain equivalent yield, system productivity than rest of the combinations and found statistically similar with treatment combination of 75% RDF + FYM 5 t ha^{-1} + Biofertilizer applied to *kharif* soybean and 100% RDF to *rabi* sequence crops (onion and potato).

Key words: Agricultural productivity, Climate action, Life on land, Onion, Potato, Responsible consumption and production, Soybean equivalent yield, Soybean, Sustainable agriculture, System productivity, Zero hunger.

INTRODUCTION

One of the main oilseeds and annual legume crops is soybean. *Glycine max* (L.) Merrill is a member of the fabaceae family and is Chinese in origin. It is a significant source of dietary protein (40%) for the diets of people and animals. Soybeans are utilized these days to prepare foods like soy sauce, soy milk, soy sticks and so on. In India, the soybean crop is grown on 12.81 Million hectares of land, yielding 12.90 Million tons of production with a productivity of 1007 kg ha^{-1}. With a production of 6.20 Million tons and productivity of 1423 kg ha^{-1}, the soybean crop is grown on 4.36 Million hectares in Maharashtra (Anonymous, 2020). In collaboration with *Rhizobuim japonicum*, soybeans symbiotically fix atmospheric nitrogen, assisting crops in meeting their nitrogen needs. Furthermore, when it reaches maturity, it adds dry leaves.

In Maharashtra's Vidarbha region, onions are one of the most important and commercially farmed vegetable crops. *Allium cepa* L. is a member of the Liliaceae family and is native to Central Asia. Onion bulbs are used for value-added products like onion flakes and onion powder in addition to being used in food items like salads and pickles. Onion flavonoids offer a variety of therapeutic uses, including anti-cancer, antibacterial and anti-allergic effects. The onion crop is grown on 1638.58 ('000 hectares) of land in India, producing 26830.27 ('000 Tons) of production and 16374 kg ha^{-1} of productivity; in Maharashtra, the crop is grown on 703.80 ('000 hectares) of land producing 10476.46 ('000 Tons) of production and 14886 kg ha^{-1} of productivity. (Anonymous, 2020).

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Solanum tuberosum L. is a member of the Solanaceae family and are native to South America. Potatoes are modified stems because they grow from underground stems known as stolons. Tubers are used in a variety of ways, such as chips, slices, shredded, smashed, or as a vegetable ingredient in snacks and namkeen dishes. Potatoes are a good source of sugar, starch, proteins, carbs and vitamins. Potato powder and potato flakes are made from potato tubers. The potato is used to make alcohol and dextrin. Potatoes are grown on 2248.07 ('000 hectares) of land in India, yielding 54229.74 ('000 Tons) of production and 24123 kg ha^{-1} of productivity (Anonymous, 2020). Singh *et al.* (2015) noticed that the intended crop benefits from organic manures, but they also have a noticeable carryover effect on the crops that come after. FYM not only benefit the target crop but also have a pronounced residual effect on the subsequent crops. Veeramani *et al.* (2012) observed that the type of preceding crop and its nutrient management have significant influence on growth and development and the yield of succeeding crop.

Growing evidence suggests that when crops are cultivated in a system, the cropping system's nutrient requirements matter more than those of any one crop. Sharma and Singh (2003). This emphasizes how crucial it is to create system-based integrated nutrient management in order to achieve sustained greater yield, returns and nutrient-use efficiency in the sequential cropping system, as opposed to concentrating on single-crop nutrition. Therefore, optimizing crop nutrition through integrated use of all available nutrient sources is vital for the long-term sustainability of production systems (Deshmukh *et al.,* 2005 and Thorave *et al.*, 2007).

The present nutrient application approach applies nutrients based on the specific crop's needs, disregarding the effect of applying fertilizer or organic manures or carrying over the nutrients from the previous soybean crop to the next one. Vegetables are crucial for crop diversity, which increases the revenue for small and marginal farmers. Farmers in Maharashtra, particularly in the Vidarbha region, cultivate *kharif* field crops (such as cotton, tur, maize, sorghum, rice and minor millets), which are followed by *rabi* field crops (such as safflower, sunflower, linseed and gram). There are lower economic returns when cropping sequences contain exclusively field crops. In order to determine whether it would be feasible to combine vegetable crops with agronomic crops in the Vidrabha region of Maharashtra, we thus added high value potential and demanding *rabi* vegetable crops (potato and onion). In much of Maharashtra, the soybean-onion or soybean-potato planting sequence is widely used. Therefore, the study that was presented examined the effects of inorganic, organic and biofertilizers applied to soybean to determine their residual effects on *rabi* vegetable crops (potato and onion), which were given only. Both cropping sequence *i.e* soybean-onion and soybean-potato being high nutrient requirement crops, adequate nutrition is important to obtain high yields and returns from the system on a sustainable basis. In order to find appropriate system based integrated nutrient management options for a legume-based cropping sequence present research trial was conducted in Vidarbha region of Maharashtra (India) Soybean based cropping sequence is an important cropping system followed in many parts of Country.

MATERIALS AND METHODS

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.

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*)**
N_1	50% RDN + 5 t FYM/ha + Biofertilizer (*Rhizobium japonicum*+ PSB + *Tricoderma viridi*)
N_2	75% RDN + 5 t FYM/ha + Biofertilizer (*Rhizobium japonicum*+ PSB + *Tricoderma viridi*)
N_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

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. The data pertaining to growth characteristics, yield characteristics 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) as per statistical procedures for agricultural research given by Gomez and Gomez (1984).

Cropping system evaluation

Soybean equivalent yield (SEY) in (t ha^{-1})

Soybean equivalent yield was calculated with following formula:

$$SEY\ (t\ ha^{-1}) = \frac{\text{Gross monetary value of sequence crop (Rs. } ha^{-1})}{\text{Selling price of soybean (Rs.} t^{-1})}$$

Table 1: Soybean grain equivalent yield of *rabi* crops, total system productivity of soybean based cropping sequence as influenced by different treatments.

Treatments	Soybean grain equivalent yield				System productivity			
	2017-18	2018-19	2020-21	Pooled mean	2017-18	2018-19	2020-21	Pooled mean
Crop sequences								
C_1 : Soybean-onion	9.80	9.16	8.73	9.23	12.43	11.90	11.36	11.90
C_2 : Soybean-potato	7.81	7.28	6.87	7.33	10.48	9.94	9.53	9.98
SE (m) ±	0.22	0.21	0.18	0.20	0.24	0.23	0.20	0.23
CD at 5%	1.34	1.28	1.07	0.70	1.49	1.42	1.22	0.79
Integrated nutrient management levels to soybean (*Kharif*)								
N_1	7.60	7.17	6.79	7.19	10.22	9.78	9.41	9.80
N_2	9.06	8.32	7.96	8.45	11.68	11.11	10.58	11.12
N_3	9.76	9.18	8.64	9.20	12.46	11.88	11.34	11.89
SE (m) ±	0.19	0.21	0.26	0.38	0.21	0.22	0.25	0.39
CD at 5%	0.63	0.69	0.85	1.12	0.70	0.72	0.80	1.15
Recommended dose of fertlizers to onion and potato (*Rabi*)								
F_1	7.44	6.95	6.55	6.99	9.78	9.29	8.89	9.32
F_2	9.20	8.51	8.23	8.65	11.96	11.43	10.99	11.46
F_3	9.77	9.20	8.61	9.20	12.62	12.04	11.46	12.04
SE (m) ±	0.18	0.15	0.13	0.15	0.18	0.16	0.14	0.16
CD at 5%	0.51	0.45	0.39	0.44	0.53	0.47	0.41	0.45
Interactions								
A × B	NS	NS	NS	NS	NS	NS	NS	NS
B × C (CD at 5%)	0.89	0.77	0.67	0.76	0.91	0.81	0.71	0.79
A × C	NS	NS	NS	NS	NS	NS	NS	NS
A × B × C	NS	NS	NS	NS	NS	NS	NS	NS
Grand mean	8.94	8.35	7.92	8.41	11.61	11.07	10.59	11.09



Plate 1: Number of pods of soybean (*Kharif*) as influenced by different levels of nutrient management to soybean.

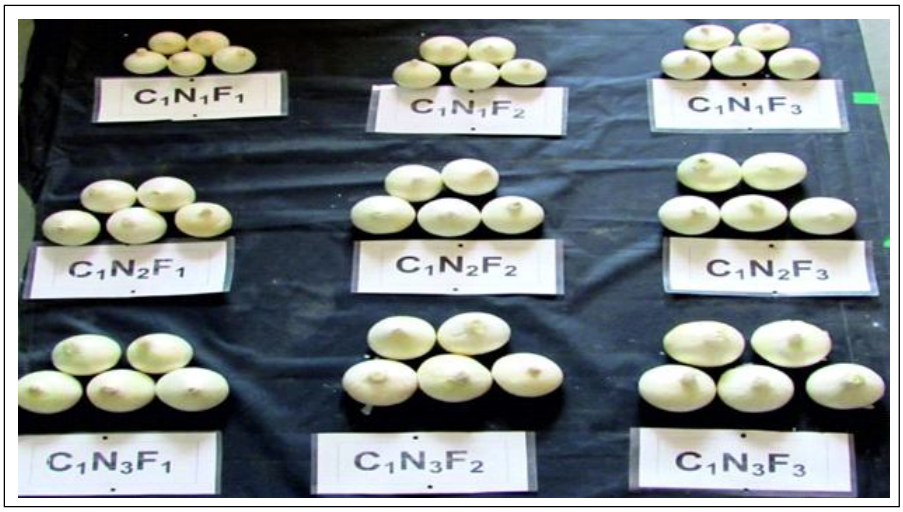


Plate 2: Size of onion (*Rabi*) as influenced by different treatment.

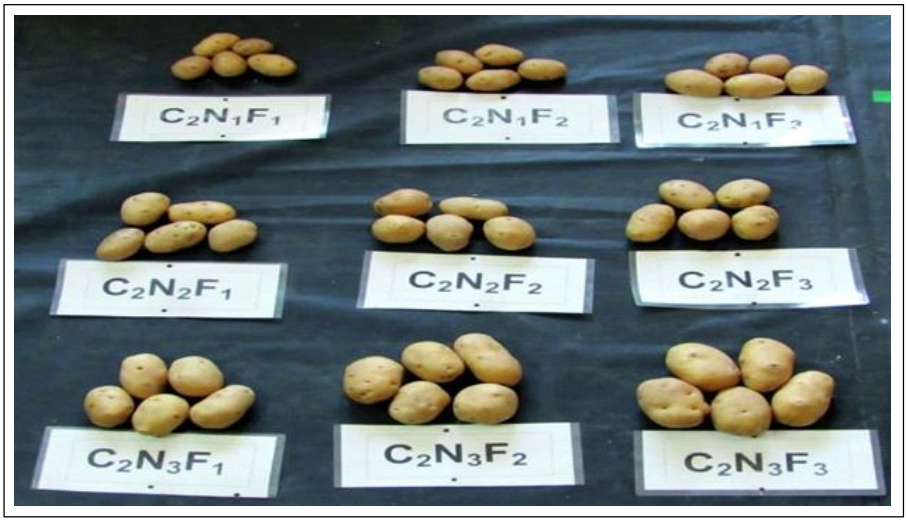


Plate 3: Size of potato (*Rabi*) as influenced by different treatment.

Total system productivity (TSP) in (t ha^{-1})

Total system productivity was calculated with following formula.

$$TSP\ (t\ ha^{-1}) = \frac{\text{Gross monetary value of sequence crop (Rs. ha}^{-1})}{\text{Selling price of soybean (Rs.t}^{-1})} + \text{Soybean yield (t ha}^{-1})$$

RESULTS AND DISCUSSION

System analysis

Soybean grain equivalent yield, system productivity

Crop sequences

Soybean-onion cropping sequence (CS_1) registered higher Soybean grain equivalent yield (SGEY) and system productivity than soybean-potato cropping sequence (CS_2) during 2017-18, 2018-19, 2019-20 and pooled mean basis (Table 1). In the soybean-onion cropping system, better onion yields led to increased system productivity, which in turn was immediately reflected in higher overall system productivity. It was discovered that a cropping sequence that includes legumes works quite effectively. The introduction of legume crops into cropping systems may have benefits for onion yield that go well beyond the provision of nitrogen through biological nitrogen fixation, such as nutrient recycling from deeper soil layers. Similar results were noticed by Kushwah *et al.* (2011) and Raskar (2012).

Integrated nutrient management levels to soybean (*Kharif*)

Application of 100% RDF + FYM 5 t ha^{-1} + Biofertilizer (N_3) to soybean recorded significantly higher Soybean grain equivalent yield and system productivity than application of 50% RDF + FYM t ha^{-1} + Biofertilizer (N_1) and at par with 75% RDF + FYM 5 t ha^{-1} + Biofertilizer (N_2) to soybean during 2017-18, 2018-19, 2019-20 and pooled mean basis. RDF + FYM 5 t ha^{-1} + Biofertilizer (N_1) to soybean on pooled mean basis (Table 1 and Plate 1). The improvement in the productivity of crops be due to fixation of atmospheric nitrogen by preceding *kharif* crop and addition of organic matter with fertilizer built up the soil fertility. The results match those that were released by Thimmegowda (2006) and Thorat *et al.* (2018).

Recommended dose of fertlizers to onion and potato (*Rabi*)

Significantly higher soybean grain equivalent yield and system productivity was recorded by *rabi* crops which were supplied with 125% RDF level during *rabi* season than 75% RDF and at par with 100% RDF (Table 1 and Plate 2 and 3). These results corroborate findings of Gaud (2004); Gudhade (2008); Senthivelu *et al.* (2009); Shanwad *et al.* (2010) and Subehia and Sepehya, (2012).

Table 2: Soybean grain equivalent yield as influenced by interaction between nutrient management for soybean (*Kharif*) and nutrient management for onion and potato (*Rabi*).

Integrated nutrient management to soybean (*kharif*)	Soybean grain equivalent yield (t ha^{-1})											
	Fertilizer levels to onion and potato (*rabi*)											
	2017			2018			2019			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	5.75	8.73	8.32	5.42	8.25	7.83	5.15	7.84	7.39	5.44	8.28	7.85
N_2	6.80	10.35	9.73	6.37	9.84	8.65	6.03	9.26	8.67	6.40	9.82	9.01
N_3	9.77	9.15	10.65	9.16	8.63	9.93	8.48	8.19	9.28	9.13	8.66	9.92
SE (m) ±		0.31			0.27			0.23			0.27	
CD at 5%		0.90			0.80			0.66			0.75	

Table 3: System productivity as influenced by interaction between nutrient management for soybean (*Kharif*) and nutrient management for onion and potato (*Rabi*).

Integrated nutrient management to soybean (*kharif*)	System productivity (t ha^{-1})											
	Fertilizer levels to onion and potato (*rabi*)											
	2017			2018			2019			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	8.05	11.46	11.15	7.72	10.97	10.66	7.44	10.57	10.22	7.74	11.00	10.68
N_2	9.08	12.49	13.22	8.65	11.91	12.70	8.31	11.43	12.13	8.68	11.94	12.68
N_3	12.22	11.93	13.48	11.52	11.41	12.77	10.93	10.97	12.20	11.56	11.43	12.82
SE (m) ±		0.31			0.28			0.23			0.28	
CD at 5%		0.91			0.81			0.67			0.78	

Interactions

Data regarding interaction presented in Table 2 and 3 reveals that the treatment combination N_3F_3 recorded significantly higher soybean grain equivalent yield and system productivity over other treatment combinations and remained at par with N_2F_2 and N_3F_1 in both years and on pooled mean basis.

CONCLUSION

The aforementioned results lead to the conclusion that a better option for nutrient management in terms of soybean grain equivalent yield and system productivity would be to adopt a soybean-onion cropping sequence with applications of 75% RDF + FYM 5 t ha^{-1} + Biofertilizer for soybean and 100% RDF for *rabi* onion crops.

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Conflict of interest

All authors declare that they have no conflicts of interest.

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