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Organic Nutrition for Potato-Cucumber-Okra Cropping Sequence

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ABSTRACT

A field experiment was conducted to study the effect of different organic nutrition against recommended dose of fertilizer on growth and yield attributes of potato-cucumber-okra vegetable sequence at Experimental Farm, Department of Horticulture, Assam Agricultural University, Jorhat during 2015-2017. The experiment was laid out in Randomized Block Design with three replications and six treatments wherein the highest growth and yield attributes were recorded in T_6 both in potato (plant height of 58.13 cm, fresh biomass of 334.53 g, dry biomass of 63.74 g, fresh haulm mass of 166.33 g, dry haulm mass of 37.47 g, tuber size of 5.04 cm and total yield of 15.90 t ha^{-1}) as well as in cucumber (vine length of 2.77 m, 4 number of primary branches, 11 number of fruits, fruit length of 14.72 cm, fruit diameter of 14.5 cm, yield vine^{-1} of 2.93 kg and yield of 78.14 t ha^{-1}). In okra, though the growth attributes were found to be non-significant, but T_6 recorded highest number of pods (16 number) which reflected directly on the highest yield plant^{-1} (362.66 g) and yield ha^{-1} (26.86 t ha^{-1}). The economics for the base crop potato under different treatments produced the highest benefit cost ratio of 5.12 in T_6 followed by 2.75 in T_5. However, in cucumber the highest benefit cost ratio of 16.32 was recorded in T_5 then followed by 13.88 in T_6. In okra, the highest benefit cost ratio of 8.65 was recorded in T_5 followed by 8.09 in T_3. When economics of the entire cropping sequence was considered, the highest benefit cost ratio of 9.61 was recorded in T_5 followed by 9.13 in T_6. Interestingly, all the treatment combinations in the cropping sequence indicated profitable propositions with a range of benefit cost ratio of 6.06 to 9.61.

Key words: *Organic nutrition, Potato, Cucumber, Okra, Economics of cultivation.*

INTRODUCTION

Potato is one of the most important food crops next to cereals and fits very well in the different cropping systems of different regions of our country. The modern day intensive crop cultivation requires the use of chemical fertilizers. But the price of inorganic fertilizers has gone up considerably which in turn has increased the cost of production. Use of inorganic fertilizers not only increase the cost of production but also deteriorate soil health[13].

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Use of organic manure can provide quality produce for human consumption by way of reduction of the chemical residues. Thus, there is a need for use of organic fertilizer for getting higher quality as well as yield which in turn is expected to substantially reduce the cost of cultivation as compared with inorganic fertilizers. The response of vegetable crops to organic manures is well recognized. Farmyard manure increased the productivity by maintaining the soil health with concomitant nutrient balance, besides minimizing the pollution hazards as well as fertilizer cost[2]. The production potential and residual effects of fertilizer applied to potato was studied by several workers[10]; Sharma and Singh[12]. Hence, it is most essential to have balanced nutrient programme for sustainable agriculture with concomitant profitability and without harming the pristine environmental resources. So, the present study has been conducted to study the role of organic nutrition on the performance of potato based vegetable cropping sequence.

MATERIAL AND METHODS

The field experiment "Organic nutrition for Potato-Cucumber-Okra cropping sequence" was conducted at the Experimental Farm, Department of Horticulture, College of Agriculture, Assam Agricultural University, Jorhat during 2014-2015. The experimental site was situated at 26°47' N latitude and 94°12' E longitude and at an elevation of 96.8 m above mean sea level. The soil of the experimental site had available nitrogen and potassium in medium range (329.95 kg ha^{-1} and 242.09 kg ha^{-1}, respectively) and available phosphorus in high range (58.05 kg ha^{-1})[6],with pH of 4.73. The experiment was laid out in Randomized Block Design with three replications and six treatments. The individual plot size was 15 m^2. The crops in sequence were potato, cucumber and okra with the base crop potato. The six treatment entities (**T$_1$**: Enriched compost 2 t ha^{-1} + Azotobacter + PSB, **T$_2$**: Enriched compost 3 t ha^{-1} + Azotobacter + PSB, **T$_3$**: Vermicompost 2 t ha^{-1} + Azotobacter, **T$_4$**: Vermicompost 3 t ha^{-1} + Azotobacter, **T$_5$**: FYM @ 100 kg N ha^{-1} and **T$_6$**: RDF @ FYM 20 t ha^{-1} + 120:100:100 kg NPK ha $^{-1}$) were applied to the base crop potato (Table 1). The succeeding crops i.e. cucumber and okra received 100 kg N equivalent through FYM which is about 20 t ha^{-1} (Table 1). The sources of chemical fertilizers were urea, single super phosphate (SSP) and muriate of potash (MOP). The bio-fertilizers were applied as seed treatment/dressing. The base crop potato was planted in the month of November followed by cucumber which was sown in March followed by Okra in June. The potato cultivar was farmer's potato variety "Phulwa" and cultivars taken for cucumber and okra were Malav F$_1$ and Komal-2486, respectively. Spacing for potato, cucumber and okra were 50 cm x 20 cm, 75 cm x 50 cm and 45 cm x 30 cm, respectively. All the inter-cultural operations were carried out in regular intervals. Five tagged plants of each plot were used for recording the corresponding observation. Yield was calculated by multiplying the average yield per plant with total number of plants per hectare and expressed in tonnes. Economics of production was studied through cost of cultivation and gross return of the produce. The total cost per hectare was estimated considering all the fixed and variable costs incurred in the production process. The return was estimated by multiplying the total output by farm gate price. The net profit and benefit cost ratio was then obtained.

RESULTS AND DISCUSSION

POTATO

GROWTH ATTRIBUTES

Among the various growth characters *viz*., plant height, fresh and dry biomass, haulm fresh and dry biomass, the recommended dose of fertilizer (T$_6$) produced the highest plant height (58.13 cm) which was significantly reflected by production of highest fresh and dry biomass (334.53 g and 63.74 g, respectively), highest fresh (166.33 g) and dry (37.47 g) haulm mass (Table 2). The RDF (T$_6$) was succeeded by T$_5$ which recorded higher plant height and other growth parameters as compared to other treatments under study.

YIELD ATTRIBUTES

The most important yield attributing characters *viz*., tuber size was notably recorded in T_6 with the largest tuber size of 5.04 cm. Thus, the total yield (15.90 t ha^{-1}) was significantly the highest in T_6 (Table 2). In comparison, the difference between the highest and lowest yield, there was a gap of 9.87 t ha^{-1}. The results indicated that all other treatments other than T_2 could not even produce half of the best treatment effect of T_6. The reason behind of such results could be ascribed to the source of major three nutrients i.e. NPK in inorganic form which became available to the potato plant at the earliest period resulting in the highest growth characters and tuber size. Similar reasons for such results were also reported by Gontcharenko[3], and Haraldsen *et al.,*[4]. In case of other organic treatments, nutrients availability was delayed as mineralisation from organic to inorganic form takes time. Opheusden *et al.*[7], from their experiment also reported similarly that the nitrogen of organic fertilizers does not fully mineralize within a season, and partly become available in later years. So, being a heavy feeder, potato required sufficient nutrients for initial establishment which might not been fulfilled in organic treatments and thereby reflected with low yield.

CUCUMBER

GROWTH AND YIELD ATTRIBUTES

Among the various growth characteristics of cucumber *viz*., vine length and number of branches, T_6 produced the longest vine length (2.77 m) and as more as four number of primary branches. However, T_6 was closely followed by $T_5$with at par values of 2.66m vine length and three number of primary branches leading to augmentation of the yield attributes like number of fruits (11 and 10 number, respectively), length(14.72 and 14.45 cm, respectively) and diameter of fruit (14.5 and 14.07 cm, respectively), yield $vine^{-1}$ (2.93 and 2.56 kg $vine^{-1}$,respectively) and yield ha^{-1} (78.14 and 68.18 t ha^{-1}, respectively) (Table 3). The reason behind such superior results of T_6 could probably be explained through the residual effect of RDF applied to potato in addition to application of 100 kg N equivalent through FYM to cucumber had improved the growth as well as yield characters. The residual effect of nutrients after potato crop was reported by several workers namely Satyanarayana and Arora[8], Biswas and Mitra[1], and Sharma *et al.*[10]. Similarly, higher production of T_5 might be due to slow release of nutrients that applied to potato, most of which became available to the succeeding crop cucumber and with additional application of 100 kg N equivalent through FYM improved cucumber yield but with lower potato tuber production as base crop. Corroborative slow release of nutrients in organic fertilization also reported by Koenig and Johnson[5]. According to them organic fertilizers usually contain many plant nutrients in low concentrations which need to be converted into inorganic forms by soil bacteria and fungi before plants can use them, so they typically are more slowly released, over time. The findings of Opheusden *et al.,*[7] can also be extended here for such explanation.

OKRA

GROWTH AND YIELD ATTRIBUTES

Among the various growth characteristics *viz*., plant height, fresh and dry weight of plant including pod at harvest have found to be non-significant in respect of different treatments. Similarly yield attributes *viz*., length and weight of pod was also found to be statistically insignificant (Table 4). The reason behind such results might be due to lower and non-significant result of major soil nutrients i.e. NPK which were revealed by the post cropping sequence soil data (Table 5).

Yield characters i.e. number of pods found to be maximum by T_6 (16 number) against other treatments i.e. 12-13 number of fruits. As there was no significant difference in individual pod weight but due to higher number of pods in T_6, the yield $plant^{-1}$ (362.66 g) and yield ha^{-1} (26.86 t ha^{-1}) gave the highest figures (Table 4).

ECONOMICS OF CULTIVATION

Economics of cultivation is the most important criterion of adoption of any improved practices by the farmer. In the present study, the economics for the base crop potato under different treatments produced the highest benefit cost ratio of 5.12 in T_6 followed by 2.75 in T_5(Table 5).

However, in cucumber the highest benefit cost ratio of 16.32 was recorded in T_5 then followed by 13.88 in T_6 (Table 5). Though the lowest benefit cost ratio of 9.91 was obtained under treatment T_3 in cucumber but in comparison, it was higher than that of the highest benefit cost ratio (5.12) of the base crop potato.

In the 3rd crop of the sequence i.e. okra, the highest benefit cost ratio of 8.65 was recorded in T_5 followed by 8.09 in T_3 (Table 5). The lowest benefit cost ratio of 7.96 was obtained in okra under treatment T_6 that also reported to be higher than the highest benefit cost ratio (5.12) obtained in potato.

When economics of the entire cropping sequence is considered, the highest benefit cost ratio of 9.61 was recorded in T_5 which was followed by 9.13 in T_6 due to higher yield and lower cost of cultivation under the treatments (Table 5). Even though the T_6 recorded the highest yield as compared to other treatments, T_5 recorded maximum profit than that of T_6 due to its high farm gate price.

Interestingly, all the treatment combinations in the cropping sequence i.e. potato-cucumber-okra indicated a profitable propositions with a range of benefit cost ratio of 6.06-9.61 and the best treatment in respect of high benefit cost ratio for the entire cropping sequence in the present study was found to be T_5.

Table 1: Treatments for different crops in the sequence

Notation	Potato	Cucumber	Okra
T_1	Enriched compost 2 t ha^{-1} + Azotobacter + PSB	(Enriched compost 2 t ha^{-1} + Azotobacter +PSB) for potato followed by 100 kg N equivalent for cucumber	(Enriched compost 2 t ha^{-1} + Azotobacter + PSB) for potato followed by 100 kg N equivalent each for cucumber and okra
T_2	Enriched compost 3 t ha^{-1} + Azotobacter + PSB	(Enriched compost 3 t ha^{-1} + Azotobacter + PSB) for potato followed by 100 kg N equivalent for cucumber	(Enriched compost 3 t ha^{-1}+ Azotobacter +PSB) for potato followed by 100 kg N equivalent each for cucumber and okra
T_3	Vermicompost 2 t ha^{-1} + Azotobacter	(Vermicompost 2 t ha^{-1} + Azotobacter) for potato followed by 100 kg N equivalent for cucumber	(Vermicompost 2 t ha^{-1}+ Azotobacter) for potato followed by 100 kg N equivalent each for cucumber and okra
T_4	Vermicompost 3 t ha^{-1} + Azotobacter	(Vermicompost 3 t ha^{-1} + Azotobacter) for potato followed by 100 kg N equivalent for cucumber	(Vermicompost 3 t ha^{-1} + Azotobacter) for potato followed by 100 kg N equivalent each for cucumber and okra
T_5	FYM @ 100 kg N ha^{-1}	(FYM @ 100 kg N ha^{-1})for potato followed by 100 kg N equivalent for cucumber	(FYM @ 100 kg N ha^{-1}) for potato followed by 100 kg N equivalent each for cucumber and okra
T_6	RDF @ FYM 20 t ha^{-1} + 120:100:100 kg NPK ha^{-1}	(RDF @ FYM 20 t ha^{-1} + 120:100:100 kg NPK ha^{-1}) for potato followed by 100 kg N equivalent for cucumber	(RDF @ FYM 20 t ha^{-1} + 120:100:100 kg NPK ha^{-1}) for potato followed by 100 kg N equivalent each for cucumber and okra

Table 2: Growth and yield attributes of potato

Treatment	Plant height (cm)	Fresh biomass (g)	Dry biomass (g)	Haulm mass (g)	Dry haulm mass (g)	Tuber size (cm)	Tuber yield (t ha^{-1})	Marketable tuber yield (t ha^{-1})	Non marketable tuber yield (t ha^{-1})
T_1	34.31	86.33	24.67	28.47	12.80	3.34	5.28	4.69	0.59
T_2	34.42	122.47	32.97	41.07	17.60	3.40	7.37	6.42	0.95
T_3	32.22	87.67	25.91	31.33	14.13	3.37	5.13	4.54	0.92
T_4	38.46	125.27	33.22	49.67	18.27	3.10	6.71	5.75	0.96
T_5	45.29	138.00	39.86	63.73	25.13	3.55	6.52	5.66	0.87
T_6	58.13	334.53	63.74	166.33	37.47	5.04	15.90	14.85	1.05
S.Ed	3.83	34.06	8.11	17.81	4.40	0.30	2.00	1.65	0.49
CD $_{(5\%)}$	8.54	75.89	18.08	39.68	9.81	0.66	4.46	3.67	NS*

NS*- Non-significant

Table 3: Growth and yield attributes of cucumber

Treatment	Vine length(m)	No. of branch	Length of fruit (cm)	Diameter of fruit (cm)	No. of fruit	Fresh weight of fruit (g)	Yield vine^{-1} (kg)	Yield ha^{-1} (t)
T$_1$	2.42	2	14.19	14.12	8	209.90	1.74	46.40
T$_2$	2.29	3	13.11	12.84	8	184.30	1.88	50.05
T$_3$	2.42	3	12.72	12.80	8	209.53	1.61	42.94
T$_4$	2.15	3	12.85	12.55	7	215.06	1.80	48.09
T$_5$	2.66	3	14.45	14.07	10	240.99	2.56	68.18
T$_6$	2.77	4	14.72	14.50	11	247.87	2.93	78.14
S.Ed	0.18	0.39	0.53	0.6	1.00	26.62	0.28	7.33
CD $_{(5\%)}$	0.39	0.88	1.17	1.34	2.22	NS*	0.61	16.34

NS*- Non-significant

Table 4: Growth and yield attributes of okra

Treatment	Plant height (cm)	Fresh weight of plant including pods (g)	Dry weight of plant including pods (g)	Pod number	Pod length (cm)	Pod weight (g)	Yield plant^{-1} (g)	Yield ha^{-1} (t)
T$_1$	89.51	354.65	43.60	12	12.05	21.79	287.65	21.31
T$_2$	86.67	347.34	47.86	12	11.91	21.39	292.01	21.63
T$_3$	89.71	371.72	47.24	13	11.40	19.59	301.06	22.30
T$_4$	83.69	336.90	38.76	12	10.57	19.43	280.24	20.76
T$_5$	97.63	410.13	53.26	13	11.57	21.42	319.46	23.67
T$_6$	106.07	482.32	68.26	16	12.32	20.98	362.66	26.86
S.Ed	13.06	43.19	9.78	1.04	0.70	1.07	20.75	1.54
CD $_{(5\%)}$	0.39	0.88	1.17	2.32	NS*	NS*	46.22	3.42

NS*- Non-significant

Table 5: Available N, P_2O_5 and K_2O of soil at the end of cropping sequence

Treatments	Available N (kg ha^{-1})	Available P_2O_5 (kg ha^{-1})	Available K_2O (kg ha^{-1})
T$_1$	152.17	48.32	63.36
T$_2$	208.69	33.07	128.19
T$_3$	177.63	39.63	98.40
T$_4$	204.00	45.99	201.79
T$_5$	182.34	34.76	82.63
T$_6$	169.27	48.32	149.22
S.Ed	26.62	10.09	3.81
CD $_{(5\%)}$	NS*	NS*	8.49
Initial values	329.95	58.05	242.09

NS*- Non-significant

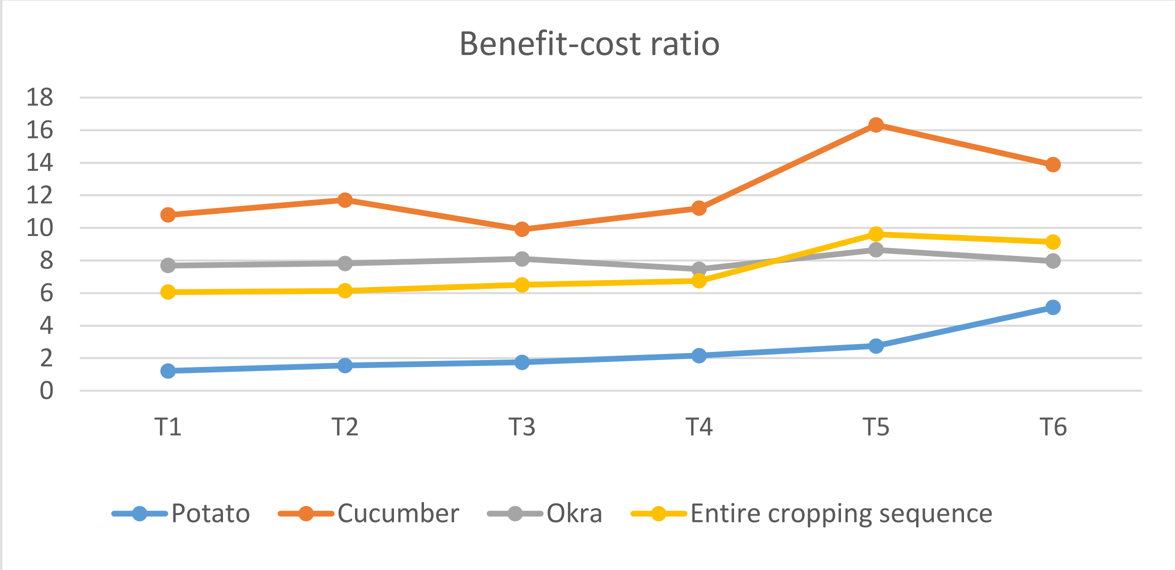
Table 6: Benefit-cost ratio of the crops in sequence

Treatment	Potato	Cucumber	Okra	Entire cropping sequence (potato-cucumber-okra)
T$_1$	1.22	10.79	7.69	6.06
T$_2$	1.55	11.71	7.82	6.14
T$_3$	1.75	9.91	8.09	6.50
T$_4$	2.16	11.21	7.46	6.75
T$_5$	2.75	16.32	8.65	9.61
T$_6$	5.12	13.88	7.96	9.13

Sale price for potato : Inorganic:Rs. 30 kg^{-1}, Organic: Rs. 40kg^{-1}

Sale price for cucumber : Inorganic:Rs. 15 kg^{-1}, Organic: Rs. 20kg^{-1}

Sale price for okra : Inorganic:Rs. 18 kg^{-1}, Organic: Rs. 22 kg^{-1}



CONCLUSION

With the results of the present investigation, it is concluded that the most efficient fertilizer management practice was found to be application of T_5 (FYM @ 100 kg N ha^{-1} for potato followed by 100 kg N equivalent each for cucumber and okra) with the highest benefit cost of 9.61 at the end of cropping sequence. Although the existing RDF produced the maximum yield but due to comparatively less farm gate price, benefit-cost ratio was found to be less. There was no loss in the crop sequence as all the treatments produced better benefit cost ratio. The benefit cost ratio varied within a range of 6.06 to 9.61 among all the treatments as of the cropping sequence. In the present study, the lowest benefit cost ratio of 2nd and 3rd crop of the sequence; produced higher benefit cost ratio than the highest return for the base crop potato.

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