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INTEGRATED NUTRIENT MANAGEMENT FOR QUALITY PRODUCTION AND ECONOMICS OF CUCUMBER ON ACID ALFISOL OF NAGALAND

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ABSTRACT

A field experiment was conducted at experimental farm, SASRD, Medziphema, Nagaland in summer season of 2015 to evaluate the effect of integrated nutrient management on growth, yield, quality and economics of cucumber under foothill condition of Nagaland. The experiment was laid out in randomized block design with eleven treatments and three replications. Results revealed that application of different levels of fertilizers, organic manures and biofertilizers either alone or in combination significantly increased growth, yield and quality of cucumber as compared to control. The maximum vine length (133.33 cm), number of branches plant^{-1}(13.00), number of leaves plant^{-1}(103.33), fruit length (26.43cm), fruit diameter (6.23 cm), number of fruits plant^{-1}(19.00), fresh weight of fruit (469.00g), fruit yield (41.24 t ha^{-1}), ascorbic acid content (9.40 mg 100g^{-1}) and TSS content (3.56 ^{0}Brix) were recorded with the integrated application of 50% NPK + 5 t vermicompost + biofertilizers which was closely followed by 50% NPK + 7.5 t pig manure + biofertilizers). The highest net return (profit) of ₹ 4,69,530 along with cost benefit ratio of 4.97 was recorded in the treatment having 50% NPK + 7.5 t ha^{-1} pig manure + biofertilizers.

Key words: Cucumber, integrated nutrient management, growth, yield, quality, economics.

INTRODUCTION

Cucumber (*Cucumis sativus* L.) belongs to family Cucubitaceae. It is the fourth most important vegetable crop of India after tomato, cabbage and onion. Cucumber is annual summer vegetable. Immature fruits are mainly used as salad, pickle and sometimes as cooked vegetable. Tender leaves are also used as vegetable. Fruits have cooling effect and prevent jaundice, indigestion and constipation. Fruit is low calories and reduces the risk of obesity. The climatic condition of the Nagaland is quite conducive to commercial cultivation of cucumber. But inspite of the favourable agro-climatic conditions, production level is low due to lack of proper package of practices. Among various factors responsible for low production of cucumber, nutrition is of prime importance. Cucumber crop responds very well to nutrients application. The application of chemical fertilizers has led to increase in production but deteriorated ecosystem. The escalating prices of chemical fertilizers and its detrimental impact on the soil, environment and human health urged the farmer to adopt alternative source of nutrients for crop production. Therefore, to reduce dependency on chemical fertilizers and conserving the natural resources in align with sustainable crop production are vital issues in present time which is only possible through integrated plant nutrient supply system. Besides fertilizers, there are several sources of plant nutrients *viz.* organic manures, biofertilizers etc. These sources also improve soil and crop productivity. Use of organic manures in INM help in mitigating multiple nutrient deficiency. Application of organic manures to acidic soil reduces the soluble and exchangeable Al temporarily by forming complex and provides better environment for growth and development in addition to improvement in physical, chemical and biological properties of soil (Banerjee *et al.*,, 2016). Biofertilizers have also emerged promising components of nutrient supply system. Application of biofertilizers which is environment friendly and low cost input with organic and inorganic fertilizers as part of an integrated nutrient management strategy and play significant role in plant nutrition. The role of biofertilizers is perceived as growth regulators besides biological nitrogen fixation (Yeptho *et al.,* 2012). The diverse agro-climatic conditions, varied soil types and abundant rainfall under foothills condition of Nagaland enable the favourable cultivation of cucumber. But no information is available about the nutrient management of cucumber in North Eastern region including Nagaland in particular. In view of the above, the present investigation was conducted to study the effect of integrated nutrient management on growth, yield, quality and economics of cucumber under foothill condition of Nagaland.

MATERIALS AND METHODS

A field experiment was carried out at Experimental Farm, Department of Horticulture, School of Agricultural Sciences and Rural Development, Medziphema Campus, Nagaland University, Nagaland during the period of March-July, 2015. The field lies at the altitude of 304.8 m above mean sea level with geographical location at 20º 45' 43'' N latitude and 93 º 53' 04'' E longitude. Soil of experimental site was sandy loam, acidic (pH 5.4), high in organic carbon (12.4g kg^{-1}), low in available N (265 kg ha^{-1}) and P (21 kg ha^{-1}) and medium in available K (143 kg ha^{-1}). The experiments were laid out in randomized block design with eleven treatments consisted of T_1- Control, T_2 - 100% RDF (100:60:60 kg NPK ha^{-1}), T_3 - FYM (20 t ha^{-1}), T_4 - Pig manure (15 t ha^{-1}), T_5 - Vermicompost (10 t ha^{-1}), T_6- 50% NPK + 10 t FYM, T_7- 50% NPK + 7.5 t Pig manure, T_8- 50% NPK + 5 t Vermicompost, T_9- 50% NPK + 10 t FYM + biofertilizers, T_{10}- 50% NPK + 7.5 t Pig manure + biofertilizers, T_{11} - 50% NPK + 5 t Vermicompost + biofertilizers with three replications. The seedlings of cucumber were transplanted at 125 x 90 cm spacing and 2.5 m x 1.8 m plot size was maintained. N, P and K were given through Urea, SSP and MOP respectively. Full dose of P and K and half dose of N were applied at the time of transplanting and remaining half dose of N was given at 30 days after transplanting. Manures *viz.,* FYM, pig manure and vermicompost were incorporated as per treatment in respective plot 20 days prior to transplanting. Biofertilizer *Azospirillum* and phosphotica was inoculated as soil treatment @ 5 kg ha^{-1}each. The doses of organic manures were applied equivalent basis. Observations on growth, yield and quality characters were recorded at harvest. Ascorbic acid content was determined by 2, 6-dichlorophenol indophenol visual titration method (Ranganna, 2000) and expressed in mg $100g^{-1}$. Total soluble solid (TSS) was determined using hand refractometer and results expressed in ^{o}brix. The composite soil samples were collected before and after the experiment from the experimental plots. Soil samples were analysed for pH, organic carbon, available nitrogen, phosphorus and potassium using standard procedure (Jackson, 1973). The economics of the various treatments was calculated on the basis of prevailing market price of different inputs and output. Gross income was calculated by yield multiplied with whole sale rate of cucumber (₹ 15.0 kg^{-1}). Net income was estimated by deducting the cost of cultivation from gross income of the particular treatment. Benefit cost ratio was worked out by dividing cost of cultivation from net income. The date was analysed statistically following the method of Panse and Sukhatme (1989).

RESULTS AND DISCUSSION

Growth characters

Integrated use of inorganic fertilizers, organic manures and biofertilizers alone or in combination had significant effect on growth parameters of cucumber (Table 1). Growth behaviour of all the eleven treatments varied considerably. Treatment T_{11} (50% NPK + 5 t vermicompost + biofertilizers) recorded the maximum vine length (133.33 cm) which was found significantly superior over other treatments. Minimum vine length (68.44 cm) was recorded in T_1 (control). The additional supply of vermicompost in INM improved physical properties of soil, availability of NPK in soil and well developed root system resulting in better absorption of nutrients and water, due to which vine length might be increased. The increase in vine length might be due to the role of nitrogen in promoting vegetative growth and enhancing cell division and elongation as well as greater chlorophyll synthesis, phosphorus is easily mobilized in the plant and translocated to the meristematic zone and increase the activity of leaf formation and development in cucumber and potassium activates many enzymes involved in respiration and photosynthesis. Biofertilizers used in INM might have helped in production of growth promoting substances leading to increased vine length. All the treatments showed significant increase in number of branches as compared to control. Treatment T_{11} (50% NPK + 5 t vermicompost + biofertilizers) recorded significantly higher number of branches (13.00) as compared to other treatments except T_{10} (50% NPK + 7.5 t Pig manure + biofertilizers).

While, the lowest number of branches (6.00) was recorded in T_1 (control). The added vermicompost and biofertilizers in integrated nutrient management might have improved the physical, chemical and biological properties of soil which helps in better nutrient absorption and utilization by plant and more translocated to the aerial parts for protoplasmic protein and synthesis of other compound resulting better plant growth and thereby increase in number of branches. Number of leaves plant^{-1} due to different treatments was found to have significant difference among different treatments. The maximum number of leaves plant^{-1} (103.33) was recorded under treatment T_{11} (50% NPK + 5 t vermicompost + biofertilizers) which was at par with T_9 (50% NPK + 10 t FYM + biofertilizers), T_{10} (50% NPK + 7.5 t pig manure + biofertilizers). The minimum number of leaves plant^{-1} (81.33) was recorded in T_1 (control). Leaves are the main site of photosynthesis as such its effective number per plant is considered an important factor in determining the growth and productivity of crop. The increase in the number of leaves might be due to effective function of biofertilizer which provided bioactive substances having similar effects as that of growth regulators which enhance the number of leaves when applied in combination with vermicompost and inorganic fertilizers. This finding has close conformity with Bindiya *et al.,* (2006) who recorded maximum growth parameters in cucumber with application of 50% NPK + 50% vermicompost + biofertilizers. Similar results were also reported by Moakala *et al.,* (2015) in broccoli.

Table 1: Effect of integrated nutrient management on growth, yield and quality of cucumb

Treatments	Vine length (cm)	No. of branches	No. of leaves	Fruit length (cm)	Fruit diameter (cm)	No. of fruit plant^{-1}	Fresh weight	Fruit yield (t ha^{-1})	Ascorbic acid (mg 100 g^{-1})	TSS (^{o}Brix)
T_1	68.44	6.00	81.33	22.06	5.00	7.16	400.33	22.04	6.80	2.33
T_2	126.40	8.00	97.88	25.43	5.93	15.66	431.83	34.48	8.43	3.17
T_3	107.00	7.00	82.33	23.26	5.20	8.33	407.83	22.75	7.30	2.34
T_4	109.07	7.00	87.60	23.00	5.43	10.33	412.67	23.46	7.60	2.38
T_5	110.66	8.00	88.11	23.45	5.66	13.00	418.83	26.48	7.74	2.50
T_6	108.33	8.00	91.00	23.28	5.69	13.66	423.33	27.73	7.83	2.53
T_7	110.00	9.00	94.66	23.82	5.86	15.16	424.33	29.67	7.93	2.76
T_8	117.00	9.00	94.66	24.79	5.95	15.66	428.83	32.62	8.03	2.96
T_9	124.00	10.00	101.66	26.26	5.93	16.00	442.83	36.62	8.86	3.20
T_{10}	129.20	12.00	102.33	26.33	6.06	18.00	452.00	37.60	9.20	3.34
T_{11}	133.33	13.00	103.33	26.43	6.23	19.00	469.00	41.24	9.40	3.56
SEm$\pm$	0.70	0.37	0.70	0.37	0.11	0.97	1.87	1.57	0.06	0.05
CD (5%)	2.06	1.10	2.06	1.11	0.34	2.87	5.53	4.63	0.17	0.16

T_1- Control, T_2 - 100% RDF (100:60:60 kg NPK ha^{-1}), T_3 - FYM (20 t ha^{-1}), T_4 - Pig manure (15 t ha^{-1}), T_5 - Vermicompost (10 t ha^{-1}), T_6- 50% NPK + 50% FYM, T_7- 50% NPK + 50% Pig manure, T_8- 50% NPK + 50% Vermicompost, T_9- 50% NPK + 50% FYM + biofertilizers, T_{10}- 50% NPK + 50% Pig manure + biofertilizers, T_{11} - 50% NPK + 50% Vermicompost + biofertilizers

Yield and yield attributes

It is revealed from the Table 1 that integrated use of 50% NPK + 5 t vermicompost + biofertilizers (T_{11}) recorded the significant variation in yield and yield attributes. Fruit length and diameter was found to be significantly different among all the treatments. Maximum fruit length and diameter (26.43cm and 6.23cm) was recorded under treatment T_{11} (50% NPK + 5 t vermicompost + biofertilizers) followed by treatment (T_{10}) 50% NPK + 7.5 t pig manure + biofertilizers (26.33cm and 6.06cm). However, the minimum fruit length and diameter (22.06 cm and 5.00 cm) was recorded in T_1 (control). Higher vegetative growth under integrated application of nutrients might have helped in synthesis of greater amount of food material which was later translocated into developing fruit resulting in increased fruit length and diameter. As was apparent from the data, number of fruit plant^{-1} was found to be significantly different among all the treatments. Maximum number of fruit plant^{-1} (19.00) was recorded under treatment T_{11} (50%

NPK + 5 t vermicompost + biofertilizers (T_{11}) followed by treatment T_{10} (50% NPK + 7.5 t pig manure + biofertilizers) with the value of 18.00. The treatment difference between T_{11} (50% NPK + 5 t vermicompost + biofertilizers (T_{11}) and T_{10} (50% NPK + 7.5 t pig manure + biofertilizers) was found at par. However, the minimum number of fruit plant^{-1} (7.16) was recorded in T_1 (control). Similarly maximum fresh weight of fruit (469.00g) was also recorded under treatment T_{11} (50% NPK + 5 t vermicompost + biofertilizers) which was closely followed by T_{10} (50% NPK + 7.5 t pig manure + biofertilizers). The minimum fresh weight of fruit (400.33g) was recorded in T_1 (control). There was a significant difference in fruit yield among all the treatments. The treatment T_{11} (50% NPK + 5 t vermicompost + biofertilizers) recorded the maximum fruit yield (41.24 t ha^{-1}) closely followed by yielded 37.60 tones ha^{-1} with the treatment T_{10} (50% NPK + 7.5 t pig manure + biofertilizers) which was at par with each other. The minimum fruit yield (22.04 t ha^{-1}) was found in T_1 (control). The treatment T_{11} (50% NPK + 5 t vermicompost + biofertilizers) recorded 19.60 % higher fruit yield over T_2 (100:60:60 kg NPK ha^{-1}). This result indicates positive effects of integrating NPK with manures as well as biofertilizers on yield and yield attributing characters of cucumber. This might be due to favourable effect of integrated application of organic manure, biofertilizer and inorganic fertilizer in supplying all essential nutrients in balanced ratio and improved the fertility status of soil. Biofertilizers inoculant also might have played a vital role in increasing the fruit yield. This finding has close conformity with Bindiya *et al.,* (2006) who recorded maximum yield and yield attributing characters in cucumber with application of 50% NPK + 50% vermicompost + biofertilizers. Khate *et al.,* (2008) reported that combined application of organic and inorganic fertilizers recorded maximum yield and yield attributing characters in cucumber. Similar results were also reported by Moakala *et al.,* (2015) in broccoli.

Table 2: Effect of integrated nutrient management on the nutrient status of the soil after harvest and economics of cucumber

Treatments	Avail. N (kg ha^{-1})	Avail. P_2O_5 (kg ha^{-1})	Avail. K_2O (kg ha^{-1})	Org. carbon (g kg^{-1})	Soil pH	Gross income (₹ha^{-1})	Net income (₹ ha^{-1})	Cost benefit ratio
T_1	203.00	22.00	114.33	11.5	5.03	330660	243600	1:2.79
T_2	269.33	23.50	136.60	16.3	5.06	517320	426060	1:4.66
T_3	231.00	23.93	122.50	12.2	5.18	341250	244190	1:2.51
T_4	248.50	24.66	124.00	16.1	5.00	351900	254340	1:2.60
T_5	249.33	25.33	155.17	16.1	5.01	397200	160140	1:0.67
T_6	254.66	25.20	146.61	16.7	5.15	415950	321790	1:3.41
T_7	255.25	26.34	142.96	14.7	4.96	445050	350640	1:3.71
T_8	262.66	27.36	160.20	15.5	5.11	489300	325140	1:1.98
T_9	263.33	26.84	153.00	18.1	5.03	549300	455080	1:4.82
T_{10}	264.66	28.33	163.52	16.7	4.95	564000	469530	1:4.97
T_{11}	267.33	29.48	164.63	16.9	5.17	618600	454380	1:2.76
SEm$\pm$	3.35	0.69	4.02	1.8	-	-	-	-
CD (5%)	9.88	2.04	11.86	5.3	NS	-	-	-

Quality characters

The value of a crop is not only assessed by its yield but also by the quality of the produce. The quality of cucumber fruit is often determined on the basis of ascorbic acid and TSS content. Though these characters are generally considered as varietal, however, it has also been observed that it is influenced by the nutrient management. Ascorbic acid content of fruit was found to be significantly different among all the treatments (Table 1). Maximum ascorbic acid content (9.40 mg 100g^{-1}) was observed with 50% NPK + 5 t vermicompost + biofertilizers followed 50% NPK + 7.5 t pig manure + biofertilizers with 9.20 mg 100g^{-1}. The treatment T_{11} (50% NPK + 5 t vermicompost + biofertilizers) proved significantly superior to other treatments. However, the minimum ascorbic acid content (6.80 mg 100g^{-1}) was recorded in control. This might be due to the more availability of micronutrient like B, Cu, Mn, Zn etc. with the application of vermicompost in INM which might have increased ascorbic acid content of fruit. It is evident from the table 1 that various treatments had positive impact on the TSS content of fruit. The application of 50% NPK + 5 t vermicompost + biofertilizers (T_{11}) recorded the maximum TSS content of fruit (3.56 ^{o}Brix) which was followed by treatment T_{10} (50% NPK + 7.5 t pig manure + biofertilizers) with the value of 3.34 ^{o}Brix. The treatment T_{11} (50% NPK + 5 t vermicompost + biofertilizers) was significantly superior over other treatments. The lowest TSS content of fruit (2.33 ^{o}Brix) was observed in T_1 (control). The combined application of vermicompost, inorganic manures and biofertilizers might have led to balance C:N ratio which resulted in satisfactory nutrient availability and increased plant metabolism, which ultimately lead to increased carbohydrate accumulation in fruit as a result TSS increased. These results are in accordance with the findings of Triveni *et al.,* (2015) in bitter gourd and Das *et al.,* (2015) in bottle gourd they reported maximum content of ascorbic acid and TSS content was recorded with the integrated application of 50% NPK + 50% vermicompost + biofertilizers.

Nutrient status of the soil after harvest

The data (Table 2) showed significant increase in available N, P_2O_5 and K_2O due to various treatments over control. Among the treatments, the highest amount of available nitrogen (269.3 kg ha^{-1}) was recorded in T_2 (100 RDF) which was followed by treatment T_{11} (50% NPK + 5 t vermicompost + biofertilizers) and T_{10} (50% NPK + 7.5 t pig manure + biofertilizers) with the value of 267.6 and 264.6 kg ha^{-1}, respectively. The lowest amount of available nitrogen (203.0 kg ha^{-1}) was found in control. The probable cause of high available nitrogen in post harvest soil in 100% RDF might be due to poor soil physical structure, lack of organic manures and microbial activities thus resulting in poor utilization of N to plants at its growth stages. As such the applied N could bring about higher residual nitrogen. The highest amount of available P_2O_5 (29.4 kg ha^{-1}) and K_2O (164.6 kg ha^{-1}) in the soil after harvest was recorded under treatment T_{11} (50% NPK + 5 t vermicompost + biofertilizers). The lowest amount of available P_2O_5 and K_2O were recorded in T_1 (control). The comparative higher level of P_2O_5 and K_2O in soil after harvest under treatment T_{11} (50% NPK + 5 t vermicompost + biofertilizers) might be attributed to increased microbial activities in the root zone which decomposes organic manures and also fixed unavailable form of mineral nutrients into available form in soil thereby, substantiates crop requirements and also further enhances residual P_2O_5 and K_2O. The affects of integrated nutrient management on the general nutrient availability in the soil after harvest is better than those treatments without integration with the exception to application of 100% NPK which gave the highest available N after harvest. The highest amount of organic carbon (18.1g kg^{-1}) was recorded in treatment T_9 (50% NPK + 10 t FYM + biofertilizers). However, there was no significant difference in pH due to various treatments. These findings are in corroboration with the findings of Choudhury *et al.,* (2005) who reported that the incorporation of Az, PSB and FYM with inorganic fertilizers significantly improved the organic carbon content and available N, P_2O_5 and K_2O status of the soil in tomato field. Similar results were also reported by Moakala *et al.,* (2015) in broccoli and Dutta *et al.,* (2016) in rice.

Economics

It is evident from Table 2 that the integration use of 50% NPK + 7.5 t pig manure + biofertilizers (T_{10}) was found to be the most profitable treatment in cucumber exhibiting highest net return ₹ 4,69,530. The high profitability may be due to lower cost of pig manure. Similar results were also reported by Moakala *et al.,* (2015) in broccoli who obtained maximum net return ₹ 2,60,450 along with cost benefit ratio of 1:3.48 with the use of 50% NPK + 705t pig manure + biofertilizers. Based on the present findings, it may be concluded that integrated use of 50 % NPK + 7.5 t pig manure + biofertilizers produced the higher fruit yield with quality produce and profits in cucumber under Nagaland conditions. By adopting this treatment, 50% chemical fertilizers can be reduced without any adverse effect on yield, quality and fertility of soil.

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