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Response of broccoli (*Brassica oleracea* var. *italica*) to integrated nutrient management

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ABSTRACT

A field experiment was conducted at Experimental Farm, Nagaland University, Medziphema campus, Nagaland during rabi season of 2019-2020 to study the response of broccoli (Brassica oleracea var. italica) to integrated nutrient management.The 12 treatments were evaluated in RBD with three replications. Results revealed that application of different levels of fertilizes and organic manures either alone or in combination significantly increased the growth, yield and quality of broccoli as compared to control. Application of full dose of RDF exhibited maximum plant height (50.3 cm), number of leaves (18.2), stem diameter (20.7 mm), plant spread (69.2 cm), ascorbic acid content (60.9 mg 100^{-1} g), protein content in head (1.58%) and yield (8.20 t ha^{-1}). However, these parameters were found statistically at par with poultry manure 2.5 t ha^{-1} + ½ of RDF. There was a significant build up of organic carbon and available nutrients in post harvest soil with INM practices and maximum values of organic carbon (19.0 g kg^{-1}), available P (20.9 kg ha^{-1}) were recorded and available K (171.2 kg ha^{-1}) with poultry manure 2.5 t ha^{-1} + ½ of RDF. While maximum value of available nitrogen (221.6 kg ha^{-1}) in post harvest soil was recorded with full dose of RDF as inorganics. The highest net return (Rs. 1,96,145.51)along with benefit: cost ratio (2.16) were recorded in full dose of RDF followed by poultry manure 2.5 t ha^{-1} + ½ of RDF with net return of Rs.1,81220.35 and cost benefit ratio of 1.90.

Keywords: Integrated nutrient management, broccoli, yield, quality, economics

INTRODUCTION

Vegetablesare a rich source of nutrients and provide a balanced diet consisting of carbohydrates, proteins, fat, vitamins and minerals, dietary fiber etc. Vegetables are considered as the best supplement to nutritional security as they are the cheapest source of nutritional supplementary food. They provide many health benefits to our body as they are laxative, anti-diabetic, diuretic and helps in good functioning of heart and also possess unique combination of bioflavonoids and anti-oxidants which scavenge free radicals and thus, lower the risk of cancer (Kanaujia*et al.*, 2020).Among these vegetables, broccoli plays a predominant role as it is highly nutritious, rich in minerals, palatable and also have anti-oxidant properties.But inspite of the favourableagro-climatic conditions, production level is low due to lack of proper package of practices. Among various factors responsible for low production of broccoli, nutrition is of prime importance. Broccoli responds very well to nutrients application. The aim of integrated nutrient management is to integrate the use of natural and man-made soil nutrients to increase crop productivity and preserve soil productivity for future generation. Long term studies on vegetable crops indicated that the balanced use of NPK fertilizers could not maintain the higher yields over years because of emergence of secondary and micro-nutrient deficiencies and deterioration of soil physical properties. The increased use of fertilizers no doubt increases production of vegetables remarkably but it has a long-term detrimental impact on soil health. Soil fertility as well as economic return can be improved on sustainable basis by supplying all the nutrients in judicious way if INM approaches are followed (Longmatula*et al.*, 2021). Hence, this present study was conducted to study the effect of integrated nutrient management on growth, yield and quality of broccoli within the prevailing condition of Nagaland.

MATERIALS AND METHODS

The field experiment was conducted at Experimental Farm, Nagaland University, School of Agricultural Sciences and Rural Development, Medziphema campus, Nagaland, during rabi

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season of 2019-20. The field is located at an altitude of 304.8 m above the mean sea level and is positioned geographically at Latitude of 20° 45' 43" N and a Longitude of 93° 53' 04" E, under sub-tropical humid climatic condition experiencing distinct cool winter season. The initial status of the soil was highly acidic with a pH of 4.4, 12.5 $gkg^{-1}$of organic carbon and available NPK of 176 kg ha^{-1}, 9.2 kg ha^{-1} and 128 kg ha^{-1}, respectively. The experiment comprises of 12 treatments*viz.* T_1 (Full dose of RDF), T_2 (FYM 20 t ha^{-1}), T_3 (FYM 10 t ha^{-1} + ½ of RDF), T_4 (Neem cake 5 q ha^{-1}), T_5 (Neem cake 2.5 q ha^{-1} + ½ of RDF), T_6 (Vermicompost 5 t ha^{-1}), T_7 (Vermicompost @ 2.5 t ha^{-1} + ½ of RDF), T_8 (Poultry manure @ 5 t ha^{-1}), T_9 (Poultry manure 2.5 t ha^{-1} + ½ of RDF), T_{10} (Pig manure 20 t ha^{-1}), T_{11} (Pig manure 10 t ha^{-1} + ½ of RDF) and T_{12} (control) which was designed in randomized block design with three replications. The variety Captain 488 was used as test crop. Spacing was maintained 60 cm row to row and 40 cm plant to plant. Recommended dose of N, P, K in the ratio 120:60:60 kg ha^{-1}, respectively were applied through urea, SSP and MOP. Full dose of manures, P, K and half dose of N were applied at the final land preparation. The other half dose of N was applied at 30 and 60 days after transplanting. The treatments were evaluated on the basis of growth, yield and yield attributes, quality, soil nutrients and economics. Soil samples collected after harvest of crop were analyzed for pH, organic carbon, available nitrogen, phosphorus and potassium as per standard procedures (Jackson, 1973). The statistical analysis was carried out as per procedure given by Panse and Sukhatme (1989). Economics of the treatments was calculated as per prevailing market price of input and output.

RESULTS AND DISCUSSION

Growth parameters

Integrated use of fertilizers and organic manures alone or in combination was found to have significant effect on growth characters as compared to control (Table 1). The effect of different INM treatments on growth parameters of broccoli was statistically significant except plant spread.Maximum plant height, number of leaves, stem diameter and plant spread with 52.3 cm, 18.2, 20.7 mm and 69.2 cm, respectively were observed in treatment T_1 where application of full dose of RDF was done. The lowest values of growth characters were recorded with control Application of poultry manure 2.5 t ha^{-1} + ½ dose of RDF was also statistically at par with T_1 (Full dose of RDF). It may be due to better availability of plant nutrients throughout the growth period, better uptake of nutrients, better nutrient absorption and utilization thereby resulting in higher vegetative growth. Comparable findings were reported by Kayesh*et al.* (2019) and Wani *et al.* (2010).

Yield and yield attributes

Integrated use of fertilizers and organic manures significantly increased yield and yield attributing characters of broccoli compared to control (Table 1). Maximum head diameter (Polar and equatorial), head size, gross head weight, net head weightand yield were reported in T_1 (Full dose of RDF) with 14.2 cm and 17.3 cm, 249.7 cm^2, 953.0 g, 313.4 gand 8.20 t ha^{-1}, respectively. The lowest values of yield and yield attributing characters were recorded with control. Application of poultry manure 2.5 t ha^{-1} + ½ dose of RDF recorded yield with 7.90 t ha^{-1} which was statistically similar with full dose of RDF. This increase in yield may be due to better vegetative growth, higher activity of beneficial soil microorganism in the soil and better response to nutrients. Adequate supply of N and P plays an important role in metabolic process of photosynthesis and carbohydrate metabolism which helps in increasing the vegetative growth thereby increasing its yield. Similar findings were recorded by Moakala*et al.* (2015) and Arjun and Bairwa (2018).

Quality parameters

It is evident from Table 1 that various treatments showed appreciable impact on the quality characters in broccoli over control. Maximum values of ascorbic acid content (60.9 mg 100^{-1} g)and TSS (9.97 °B) of head were recorded at T_1 (Full dose of RDF) whereas, protein content (1.60%) was found highest in T_9 (Poultry manure 2.5 t ha^{-1}+½ dose of RDF). Higher TSS content in the broccoli suggests that all the treatments significantly influence quality parameters of broccoli. This could be due to genetic makeup of the variety. Similar findings were reported by Arjun and Bairwa (2018), Wani *et al.* (2010). The recorded of ascorbic acid ranged from 44 to 60 mg 100^{-1} g. Disparity in vitamin C content between the treatments showed stimulus effect of nutrient application in broccoli.

Table 1: Effect of INM on growth, yield and quality attributes of broccoli

Treatments	Plant height (cm)	Number of leaves	Stem diameter (mm)	Plant spread (cm)	Head diameter (cm)		Head size (cm^2)	Gross head weight (g)	Net head weight (g)	Yield (t ha^{-1})	Head compactness	Ascorbic acid (mg 100^{-1} g)	Protein in head (%)	TSS of head (°B)
					P	E								
T_1	50.3	18.2	20.7	69.2	14.2	17.3	249.7	953.0	313.4	8.20	10.54	60.9	1.58	9.97
T_2	44.8	15.1	16.0	57.6	11.9	11.3	137.0	532.4	228.8	4.77	14.41	51.6	1.14	8.93
T_3	46.7	15.4	19.4	67.5	13.7	14.0	196.4	768.2	343.0	7.15	13.48	57.0	1.38	9.43
T_4	40.3	13.1	14.7	53.0	10.4	9.5	100.7	420.6	166.4	3.47	17.32	47.9	0.96	7.97
T_5	45.0	15.0	17.2	58.4	11.1	11.2	125.2	583.9	227.9	4.75	16.11	47.8	0.97	9.20
T_6	42.9	14.8	15.3	55.9	10.9	10.3	115.7	420.9	192.0	4.00	16.77	50.5	1.24	9.23
T_7	46.0	14.0	18.7	63.6	13.9	13.9	196.0	713.7	309.8	6.45	11.41	57.6	1.56	9.67
T_8	44.1	15.0	16.0	55.3	12.3	11.9	151.3	528.2	246.2	5.13	14.47	48.0	1.08	9.17
T_9	47.5	16.5	19.5	68.5	13.6	14.9	205.5	828.4	379.3	7.90	13.36	60.7	1.60	9.57
T_{10}	41.8	14.8	15.9	60.9	11.8	11.1	132.1	476.4	202.4	4.22	13.39	54.0	1.00	8.37
T_{11}	46.7	14.9	17.2	62.6	12.3	12.2	155.2	595.2	251.0	5.23	13.59	52.8	1.30	9.33
T_{12}	41.0	11.8	12.9	51.6	8.8	8.1	72.43	347.6	165.8	3.45	27.34	44.3	0.85	7.42
SEm±	1.83	0.63	0.96	1.04	0.77	0.86	20.09	63.41	22.36	0.47	2.17	2.37	0.11	0.45
CD (0.05)	5.56	1.89	2.91	NS	2.33	2.60	60.95	192.32	67.81	1.41	6.60	7.19	0.34	1.37

Table 2: Effect of INM on soil fertility status after harvest and economics

Treatments	Available N (kg ha^{-1})	Available P (kg ha^{-1})	Available K (kg $ha^{-1)}$	Org. C (gkg^{-1})	Soil pH	Net return (Rs. ha-^{1})	B:C ratio
T_1- Full dose of RDF	221.6	17.3	162.5	16.1	4.3	1,96,145.51	1:2.16
T_2- FYM 20 t ha^{-1}	183.9	11.4	146.7	13.7	4.6	41,981.94	1:0.34
T_3- FYM 10 t ha^{-1} + ½ of RDF	213.2	16.2	169.5	18.5	4.8	1,42,324.52	1:1.32
T_4- Neem cake 5 q ha^{-1}	188.1	13.4	134.7	12.9	4.5	16,433.33	1:0.16
T_5- Neem cake 2.5 q ha^{-1} + ½ RD	192.3	17.4	148.5	15.4	4.7	68,373.13	1:0.70
T_6- Vermicompost 5 t ha^{-1}	204.8	15.8	153.7	15.1	4.4	5148.61	1: 0.04
T_7- Vermicompost 2.5 t ha^{-1} + ½ of RDF	209.0	19.8	156.0	18.0	4.8	1,13,067.57	1:1.01
T_8- Poultry manure 5 t ha^{-1}	196.5	16.8	151.5	14.3	4.5	79,620.83	1: 0.80
T_9- Poultry manure 2.5 t ha^{-1} + ½ of RDF	217.4	20.9	171.2	19.0	4.9	1,81,220.35	1:1.90
T_{10}- Pig manure 20 t ha^{-1}	179.8	16.8	144.5	15.1	4.5	22,683.33	1: 0.18
T_{11}- Pig manure 10 t ha^{-1} + ½ of RDF	200.7	19.7	156.2	15.9	4.7	75,241.18	1:0.70
T_{12}- Control	150.5	7.6	120.0	11.3	4.4	35,995.83	1:0.42
SEm±	5.81	3.12	13.75	1.2	0.04	-	-
CD (0.05)	17.84	9.48	41.70	3.5	NS	-	-

Fertility status of post harvest soil

Sustainability of a cropping system is being evaluated on the basis of crop yield as well as nutrient status of the soil after harvest of the crop. Available NPK, organic carbon and pH in soil after harvest were significantly influenced by application of NPK fertilizers and organic manures alone or in combination over control (Table 2). Application of different nutrients increased the available NPK and organic carbon as compared to control in the soil. Maximum amount of available N (221.6 kg ha^{-1}) in the soil was recorded with full dose of RDF which might be due to poor soil physical structure, lack of organic manures and microbial activities, thus resulting in poor utilization of nitrogen by plants. As such the applied N could bring about higher residual nitrogen in soil after harvest. However, before experimentation available nitrogen was 176 kg ha^{-1}.On the other hand, poultry manure 2.5 t ha^{-1} + ½ of RDF (T_9) reported maximum available P (20.9 kg), available K (171.2 kg),organic carbon (19.0 g kg^{-1}) and soil pH (4.9). The higher organic carbon maybe due to application of organic manures which enhances the growth and activity of micro-organisms and successive decomposition of these plants may result in higher content of carbon. These findings are in line with the researches done by Masanta and Biswas (2009),Moakala *et al.*(2015).

Economics

It is evident from table 2 that highest net return of Rs.1,96,145.51 along with cost benefit ratio of 2.16 were recorded with T_1 (Full dose of RDF) followed by treatment T_9 (Poultry manure 2.5 t ha^{-1} + ½ dose of RDF) with net return of Rs.1,81220.35 and cost benefit ratio of 1.90. The lowest BCR (0.04) was recorded with T_6 (Vermicompost 5 t ha^{-1}). The high expenditure in treatment T_6 might be due to the high cost of vermicompost. The result is in agreement with the findings of Moakala*et al.* (2015), Kanaujia and Daniel (2016) they found highest net return with combined application of 50% NPK + 50% poultry manure.

From the experiment, it may be included that the application of full dose of RDF recorded the maximum vegetative growth and quality, higher yield and net return as compared to other treatments. Integrated use of poultry manure 2.5 t ha^{-1} + ½ dose of RDF highly outperformed over full dose of RDF in respect of available soil nutrients after harvest of the crop with statistically similar yield, quality and net return. Based on the results application of poultry manure @ 2.5 t ha^{-1} + ½ dose of RDF can be recommended to the farmers of Nagaland for cultivation of broccoli as it produces an optimum yield, quality and retaining the fertility status of the soil.

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