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Effect of integrated nutrient management on growth, yield and quality of broccoli (*Brassica oleraceae* var. *italica* L.) cv. Calabrese under foothill condition of Nagaland

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Abstract

A field experiment was carried out at the Experimental Farm, Department of Horticulture, School of Agricultural Sciences and Rural Development, Nagaland University, Medziphema Campus, during 2012-2013 and 2013-2014 to find out the response of integrated nutrient management on growth, yield and quality of broccoli cv. Calabrese under the foothill condition of Nagaland. Results revealed that integrated application of 50% NPK + 50% vermicompost + Biofertilizers recorded significantly higher plant height (70.33 cm), number of leaves (20.45), stem diameter (3.25 cm), plant spread (74.25 cm), equilateral head diameter (16.97 cm), polar head diameter (18.37 cm), head size (310.59 cm^2), gross head weight (956.0 g), net head weight (330.86 g), yield ha^{-1} (11.96 t ha^{-1}), protein content (3.77%), vitamin C content (132.50 mg 100 g^{-1}), total soluble solids (5.52) and pH of the head (5.12). While treatment T_{16}- 50% NPK + 50% Pig manure + Biofertilizers gave the highest net return (^{1} 260450) and cost benefit ratio (1:3.48) and was found to be significantly at par for all growth, yield and quality parameters with treatment T_{18}(50% NPK + 50% vermicompost + biofertilizers).

Key words: Broccoli, integrated nutrient management (INM), growth, yield and quality

Introduction

Broccoli (*Brassica oleracea* var. *italica* L.) belongs to family Brassicaceae (mustard family) with chromosome no. 2n = 18. Broccoli most closely resembles cauliflower, which is a different cultivar group of the same species. The edible part of broccoli is a tender stem and unopened flower buds that are rich in nutritional content. Its rich green colour is indicative of its high carotene content, and broccoli is well known as a good source of vitamin A, vitamin C, calcium, iron, and potassium. Broccoli has the highest levels of carotenoids in the brassica family. It is particularly rich in lutein and also provides a modest amount of â-carotene. A high intake of broccoli has been found to reduce the risk of aggressive prostate cancer. This is possibly due to the glucosinolates found in cole crops, which stimulate the production of detoxifying enzymes that remove carcinogens created during metabolism.

Broccoli is a cool-weather crop that does poorly in hot summer weather. The foothills and valleys of the North Eastern region of India has been blessed with varied climatic conditions which offers conducive conditions for the cultivation of vegetables, including cole crops (Singh et al. 2013). But despite the favourable agro-climatic condition, production level is low due to lack of proper package of practices. Among various factors of production, nutritional requirement play a vital role in measuring the production of the crop. Long term studies on 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 increase use of fertilizers no doubt increases production of commodities very remarkably but it has a long-term detrimental impact on soil health. Therefore, reduced dependence on chemical fertilizers along with maintenance of sustainable production is vital issues in modern agriculture which is only possible through integrated plant nutrient (Chumyani et al. 2012). The results of a large number of experiments on manures and fertilizers conducted in several parts of the country revealed that neither chemical fertilizers alone, nor organic sources used extensively, can sustain the productivity of soils under highly intensive cropping. Nutrients added through combined inorganic and organic sources are better utilized than inorganic alone, besides reducing cost of production and maintaining soil health.

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The cost of chemical fertilizers is also increasing day by day; hence, adoption of integrated plant nutrient offers scope for sustainable crop production and improves soil fertility. Uses of organic manures in INM help in mitigating multiple nutrient deficiencies. 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 (Avitoli et al. 2012). Being environmental friendly and low cost input, greater emphasis has been given on application of bio-fertilizers with organic and inorganic fertilizers as a part of an integrated nutrient management strategy which plays a significant role in plant nutrition. The role of biofertilizers is perceived as growth regulators besides biological nitrogen fixation collectively leading to much higher response on various growth and yield attributing characters (Yeptho et al. 2012). The agro-climatic condition prevailing in the low hills of Nagaland have been found to be highly favourable for broccoli cultivation. But very limited information is available about the nutrient requirement of broccoli in North Eastern region including acidic soils of Nagaland in particular. Taking into account the various facts and aspects, the present investigations was undertaken to study the effect of different sources of nutrients of locally available organic and bio-fertilizers along with chemical fertilizers in broccoli under the topic "Effect of integrated nutrient management on growth, yield and quality of broccoli (*Brassica oleracea* var. *italica*) cv. Calabrese under the foothill condition of Nagaland".

Materials and Methods

The experiment was carried out in the Experimental Farm, School of Agricultural Sciences and Rural Development, Medziphema Campus, Nagaland University, Nagaland during 2012-2013 and 2013-2014. The field is located at the altitude of 304.8 m above mean sea level with geographical location at 20º45'43'' N latitude and 93º53'04'' E longitudes. Plot size measured 1.8 m x 1.8 m and spacing was maintained at 45 x 60 cm. The experiments were laid out in Randomized Block Design (RBD) with three replications. The treatments consisted of T_1- control, T_2- 100% NPK (120:60:60 kg ha^{-1}), T_3- FYM 30 t ha^{-1}, T_4- pig manure 20 t ha^{-1}, T_5- poultry manure 15 t ha^{-1}, T_6- vermicompost 10 t ha^{-1}, T_7- 50% NPK + 50% FYM, T_8- 50% NPK + 50% pig manure, T_9 - 50% NPK+ 50% poultry manure, T_{10}- 50% NPK + 50% vermicompost T_{11}- FYM + biofertilizers, T_{12}- pig manure + biofertilizers, T_{13}- poultry manure + biofertilizers, T_{14}- vermicompost + biofertilizers, T_{15}- 50% NPK + 50% FYM + biofertilizers, T_{16}- 50% NPK + 50% pig manure + biofertilizers, T_{17}- 50% NPK + 50% poultry manure + biofertilizers, T_{18}- 50% NPK + 50% vermicompost + biofertilizers. 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 in two equal doses i.e. 30 and 60 days after transplanting. Manures viz., FYM, pig manure, poultry manure and vermicompost were incorporated as per treatment in respective plot prior to transplanting. Biofertilizers were inoculated to seedling prior to transplanting as seedling dip method @ 2 kg ha^{-1}. Data were recorded on different vegetative growth parameters (plant height, plant spread, number of leaves, stem diameter), yield and yield attributing parameters (head size, gross head weight, net head weight, head yield) and Quality attributes (vitamin C content in head, head compactness, protein content in head, pH content of the head, total soluble sugar (TSS) of the head. Total soluble solid was determined using hand refractometer and results expressed in ºbrix. Vitamin C content was determined by 2, 6-dichlorophenol indophenol visual titration method (AOAC 1984) and expressed in mg 100^{-1}g. Treatment-wise economics was carried out by calculating the cost of cultivation based on prevailing rates of input and output. Gross income was calculated by yield multiplied by whole sale rate of broccoli @ ¹ 30 kg^{-1}. Net income was estimated by deducting the total cost of cultivation (fixed cost + treatment cost) from gross income of the particular treatment and cost benefit ratio was also worked out. Soil samples were collected before and after harvest of crop from different locations of the experimental plot to a depth of 15 cm with the help of screw type auger. Soil samples were analysed for pH, organic carbon, available nitrogen, phosphorus and potassium which were determined by Digital pH meter, Walkley and Black Rapid titration method, Alkaline potassium permanganate method, Olsen's method, flame photometer method, respectively. The statistical analysis was carried out as per procedure given by Panse and Sukhatme (1978).

Results and Discussion

Growth attributes: The NPK fertilizers with organic manures along with biofertilizers alone or in combination were found to have significant effect on growth characters as compared to control. Pooled data on response of integrated nutrient management on plant growth parameters of broccoli at harvest is given in table-1. As evident from the table that the maximum plant height (70.33 cm) was recorded with application of 50% NPK + 50% vermicompost + biofertilizers (T_{18}). The minimum plant height was recorded in case of

control. The increase in vegetative growth might be due to the role of nitrogen in promoting vegetative growth and enhancing cell division and elongation as well as greater chlorophyll synthesis and increased activity of leaf formation and development in broccoli. The added vermicompost in integrated nutrient management would have improved the physical, chemical and biological properties of soil which helps in better nutrient absorption and utilization by plant resulting better plant growth. This might be attributed to certain growth promoting substances secreted by the biofertilizers which in turn might have led to better root development, better transportation of water, uptake and deposition of nutrients. Kanwar et al. (2002) and Kumar et al. (2013) ascribed that application of 50% NPK along with vermicompost in cauliflower significantly increased plant height. These findings are in agreement with Maurya et al. (2008) who reported that vermicompost (2.5 t ha^{-1}) + 50% RDF (120:60:60 kg NPK ha^{-1}) resulted in greatest plant height in broccoli. With respect to leaf number, the maximum number of leaves (28.45) at harvest was recorded with application of 50% NPK + 50% vermicompost (5 t ha^{-1}) + biofertilizers (T_{18}) which was *at par* with application of 50% NPK + 50% pig manure + biofertilizers (T_{16}). Kumar et al. (2008) reported that application of NPK (80:80:60 kg ha^{-1}) + Zinc Sulfate+ vermicompost (5 t ha^{-1}) in cabbage gave the highest values for growth attributing parameters. Similarly, the maximum stem diameter (3.25 cm) at harvest was recorded with application of 50% NPK + 50% vermicompost + biofertilizers (T_{18}) which was at par with application of 50% NPK + 50% pig manure + biofertilizers (T_{16}). The maximum plant spread (74.25 cm) at harvest was recorded with application of 50% NPK + 50% vermicompost + (T_{18}) which was at par with application of 50% NPK + 50% pig manure + biofertilizers (T_{16}). Ghuge et al. (2007) reported that treatment with 50% RDF (150:80:75 kg NPK ha^{-1}) + 50% vermicompost (2.5 t ha^{-1}) gave the maximum plant spread in cabbage cv. Pride of India. These findings are also in agreement with Merentola et al. (2012) in cabbage.

Yield attributes: Integrated application of chemical fertilizers, organic manures and biofertilizers alone or in combination significantly increased yield and yield attributing characters of broccoli compared to control. Pooled data on response of integrated nutrient

Table 1: Response of integrated nutrient management on growth & yield parameters of broccoli cv. Calabrese

Treatment	Plant height (cm)	Number of leaves	Stem diameter (cm)	Plant spread (cm)	Equilateral head diameter (cm)	Head size (cm^2)	Gross head weight (g)	Net head weight (g)	Head yield per hectare (tonnes)
T_1 - Control	40.95	13.45	1.55	29.08	7.52	70.46	308.83	88.17	3.27
T_2 - 100% NPK (120:60:60 kg ha^{-1})	55.72	18.92	2.41	56.42	14.07	200.91	556.33	154.33	5.72
T_3 - FYM (30 t ha^{-1})	51.17	15.52	1.99	41.78	10.03	102.57	412.00	101.67	3.77
T_4 - Pig manure (20 t ha^{-1})	52.45	16.35	2.07	45.78	10.50	117.86	448.33	109.00	4.04
T_5 - Poultry Manure (15 t ha^{-1})	46.95	14.95	1.31	35.18	9.43	92.16	391.17	133.33	4.94
T_6 - Vermicompost (10 t ha^{-1})	53.80	16.68	2.07	49.25	10.97	132.54	450.67	109.83	4.08
T_7 - 50% NPK + 50% FYM	60.90	20.95	2.92	60.28	12.80	176.30	731.00	185.00	6.85
T_8 - 50% NPK + 50% Pig manure	65.87	21.82	3.01	65.02	13.50	191.42	749.33	210.67	7.81
T_9 - 50% NPK+ 50%Poultry Manure	64.77	21.22	2.93	61.08	13.32	185.59	749.00	206.00	7.63
T_{10}- 50 % NPK + 50 % Vermicompost	66.23	23.62	3.09	68.48	13.87	205.11	749.67	235.00	8.7
T_{11}- FYM + Biofertilizers (*Azospirillum* + Phosphotica)	54.27	18.32	2.27	53.88	11.90	151.07	475.17	107.33	3.98
T_{12}- Pig manure + Biofertilizers (*Azospirillum* + Phosphotica)	57.87	19.88	2.39	54.05	12.00	162.91	610.67	118.67	4.40
T_{13}-Poultry manure + Biofertilizers *(Azospirillum* + Phosphotica)	53.93	16.95	2.11	49.12	10.60	132.97	452.17	109.33	4.05
T_{14}- Vermicompost + Biofertilizers *(Azospirillum* + Phosphotica)	63.60	20.28	2.49	59.37	12.50	171.23	672.33	134.17	4.96
T_{15}- 50 % NPK + 50 % FYM + Biofertilizers *(Azospirillum* + Phosphotica)	68.43	26.22	3.13	73.30	16.30	277.06	843.33	268.33	9.95
T_{16}- 50 % NPK + 50 % Pig manure + Biofertilizers *(Azospirillum* + Phosphotica)	69.83	26.78	3.21	73.95	16.67	300.77	881.00	301.17	11.17
T_{17}- 50 % NPK + 50 % Poultry Manure + *Azospirillum* + Phosphotica	67.17	24.88	3.12	72.85	14.40	221.73	786.00	224.00	8.31
T_{18}- 50 % NPK + 50 % Vermicompost + *Azospirillum* + Phosphotica	70.33	28.45	3.25	74.25	16.97	310.59	956.00	330.83	11.96
SEm $\pm$	2.59	0.87	0.13	2.39	0.57	3.07	22.63	13.27	0.51
CD(P=0.05)	7.46	2.48	.37	6.86	1.64	8.83	65.04	38.12	1.44

management on yield attributes of broccoli at harvest is given in table-2. The maximum head diameter (16.97 cm) was recorded with application of 50% NPK + 50% vermicompost + biofertilizers (T_{18}) which was at par with application of 50% NPK + 50% pig manure + biofertilizers (T_{16}). Higher vegetative growth might have helped in synthesis of greater amount of food materials that were later translocated into developing heads resulting in increased yield attributing characters. In addition, organic manures supply essential nutrient in balanced ratio and improved physical, chemical and biological properties of soil which helps in better nutrient absorption and utilization by plant resulting higher value of yield attributing characters. Similarly, Kanwar et al. (2002) also reported that significant increase in curd diameter in cauliflower was obtained when vermicompost was applied with 50% NPK level. The minimum head diameter was recorded in case of control. The maximum head (330.83 cm^2) size was recorded with application of 50% NPK + 50% vermicompost + biofertilizers (T_{18}) which was at par with application of 50% NPK + 50% pig manure + biofertilizers (T_{16}). The minimum head size was recorded in case of control. With respect to gross head weight, the maximum gross head weight (956.0 g) at harvest was recorded with application of 50 % NPK + 50% vermicompost + biofertilizers (T_{18}). The minimum value was recorded in case of control. The maximum net head weight (330.83 g) at harvest was recorded with application of 50% NPK + 50% vermicompost + biofertilizers (T_{18}) which was at par with application of 50% NPK + 50% Pig manure + biofertilizers (T_{16}). Maurya et al. (2008) in his findings observed that vermicompost (2.5 t ha^{-1}) + 50% RDF (120:60:60 kg NPK ha^{-1}) resulted in greatest head weight in broccoli. Similarly, Kanwar et al. (2002) also reported that significant increase in curd weight in cauliflower was obtained when vermicompost was applied with 50% NPK level. Similar results were obtained by Pandey et al. (2008) for growth of broccoli curd in terms of head depth, girth and apical head weight with application of vermicompost @ 2.5 t ha^{-1} + ½ dose of recommended NPK + *Azotobacter*. Ghuge et al. (2007) reported that the treatment with 50% RDF at 150:80:75 kg ha^{-1} NPK + 50% vermicompost of 2.5 t ha^{-1} gave the maximum head circumference (57.50 cm) and head weight (1232 g) and in cabbage. The minimum value was recorded in case of control. It is revealed from the table-3, that application of 50% NPK + 50% vermicompost + biofertilizers (T_{18}) recorded the maximum projected yield (11.96 t ha^{-1}) which was at par with application of 50% NPK + 50% pig manure + biofertilizers (T_{16}). It was also reported by Kumar et al. (2013) that the maximum yield of broccoli curd ha^{-1} was obtained in case of application of 200% of recommended dose of inorganic nutrients of which 25% being supplemented with vermicompost. Mishra et al. (2012) reported that application of organic manure vermicompost @10 t ha^{-1} along with 90 kg nitrogen, 25 kg phosphorus, 25 kg murate of potash ha^{-1} proved to be the most effective treatment to obtain higher yield per unit area of cabbage. As observed by Das et al. (2008)

Table2: Response of integrated nutrient management on quality characters of broccoli cv. Calabrese

Treatment	Head compactness	Protein content (%)	Vitamin C (mg/100g)	TSS (°Brix)	pH of head
T_1 - Control	14.47	1.65	92.50	3.22	4.15
T_2 - 100% NPK (120:60:60 kg ha^{-1})	5.39	3.69	112.50	4.62	4.85
T_3 - FYM (30 t ha^{-1})	9.70	2.36	104.17	3.75	4.57
T_4 - Pig manure (20 t ha^{-1})	8.45	2.44	105.83	3.95	4.80
T_5 - Poultry Manure (15 t ha^{-1})	14.88	2.13	104.17	3.65	4.55
T_6 - Vermicompost (10 t ha^{-1})	6.82	2.63	107.50	4.28	4.70
T_7 - 50% NPK + 50% FYM	5.67	3.21	115.83	4.88	4.85
T_8 - 50% NPK + 50% Pig manure	5.95	3.31	117.50	4.90	4.95
T_9 - 50% NPK+ 50%Poultry Manure	6.14	3.27	115.83	4.90	4.83
T_{10}- 50 % NPK + 50 % Vermicompost	6.30	3.40	117.50	4.95	4.98
T_{11}- FYM + Biofertilizers (*Azospirillum* + Phosphotica)	5.72	2.92	107.50	4.65	4.38
T_{12}- Pig manure + Biofertilizers (*Azospirillum* + Phosphotica)	5.66	2.98	109.17	4.85	4.63
T_{13}-Poultry manure + Biofertilizers *(Azospirillum* + Phosphotica)	6.97	2.86	104.17	4.38	4.37
T_{14}- Vermicompost + Biofertilizers *(Azospirillum* + Phosphotica)	5.94	3.04	110.83	4.35	4.80
T_{15}- 50 % NPK + 50 % FYM + Biofertilizers *(Azospirillum* + Phosphotica)	5.79	3.69	127.50	4.97	5.03
T_{16}- 50 % NPK + 50 % Pig manure + Biofertilizers *(Azospirillum* + Phosphotica)	5.75	3.75	129.17	5.15	5.03
T_{17}- 50 % NPK + 50 % Poultry Manure + *Azospirillum* + Phosphotica	6.75	3.65	125.83	4.98	5.00
T_{18}- 50 % NPK + 50 % Vermicompost + *Azospirillum* + Phosphotica	6.00	3.77	132.50	5.52	5.12
SEm ±	0.73	0.06	4.68	0.19	0.24
CD(P=0.05)	2.09	0.16	13.45	0.54	0.69

vermicompost appeared to be the best soil additive in cabbage in terms of yield and net economic return with 50% RDF+ vermicompost treatment (5 t ha^{-1}). Application of vermicompost 2.5 t ha^{-1} + half NPK (75:60:60 kg ha^{-1}) recorded the maximum yield (183.16 q ha^{-1}) in broccoli as reported by Khan et al. (2009). Similarly, Kanwar et al. (2002) also reported that application of Vermicompost with 50% NPK level significantly increased head yield of cauliflower. Kumar *et al*. (2013) also observed that application of 50 kg N through vermicompost + 150:100:100 kg NPK ha^{-1} gave maximum yield of curd in sprouting broccoli. These findings are in agreement with Merentola et al. (2012) in cabbage.

Quality attributes: Pooled data on response of integrated nutrient management on quality attributes of broccoli at harvest is given in Table-4. As evident from the Table-4, the application of 50 % NPK + 50% vermicompost + biofertilizers (T_{18}) recorded the maximum head compactness (6.0) while minimum was recorded in control. Similarly, Ghuge *et al*. (2007) reported that the treatment with 50% RDF at 150:80:75 kg ha^{-1} NPK + 50% vermicompost of 2.5 t ha^{-1} gave the maximum head compactness (79.07%) in cabbage. The maximum protein content in head at harvest (3.37%) was recorded with application of 50% NPK + 50% vermicompost + biofertilizers (T_{18}) which was at par with application of 50% NPK + 50% pig manure + biofertilizers (T_{16}). The minimum value was recorded in case of control. Results indicated that, the maximum vitamin C content (132.50 mg 100 g^{-1}) was recorded with application of 50% NPK + 50% vermicompost + biofertilizers (T_{18}) which was at par with application of 50% NPK + 50% pig manure + biofertilizers (T_{18}). Ghuge et al. (2007) reported that the treatment with 50% RDF at 150:80:75 kg NPK ha^{-1} + 50% vermicompost at 2.5 t ha^{-1} gave the maximum chlorophyll content (652.1 µg g^{-1} of leaf) and ascorbic acid content (29.93 mg 100 g^{-1} head) in cabbage. The minimum vitamin C was recorded in case of control. The results inferred that application of 50% NPK + 50% vermicompost + biofertilizers (T_{18}) recorded the maximum total soluble solid (5.52 °brix). Mahendra and Kumar (1997) reported that highest TSS and ascorbic acid contents were produced by applying 75% of the recommended rate of NPK combined with vermicompost. The comparative higher level of both vitamin C and TSS with integration may be due to action of specific soil nutrients which may be made more readily available into soil for plant absorption as a result of mineral fertilizers + lone organic manure or with biofertilizers integrating effect which in turn may activate specific enzymes for the synthesis of these compounds. The maximum pH of head (5.12) at harvest was recorded with application of 50% NPK + 50% vermicompost + biofertilizers (T_{18}) which was significantly at par with application of 50% NPK + 50% pig manure + biofertilizers (T_{16}). The minimum value was recorded in case of control. These findings are in agreement with Merentola et al. (2012) in cabbage.

Table 3: Response of integrated nutrient management on economics of broccoli

Treatments	Cost of cultivation (Rs ha^{-1})			Yield (t ha^{-1})	Gross income (? ha^{-1})	Net income (? ha^{-1})	Cost benefit ratio
	Fixed cost	Treatment cost	Total				
T_1 - Control	65000	-	65000	3.27	98100	33100	1:0.51
T_2 - 100% NPK (120:60:60 kg ha^{-1})	65000	4500	69500	5.72	171600	106600	1:1.64
T_3 - FYM (30 t ha^{-1})	65000	15000	80000	3.77	113100	33100	1:0.41
T_4 - Pig manure (20 t ha^{-1})	65000	14000	79000	4.04	121200	42200	1:0.86
T_5 - Poultry Manure (15 t ha^{-1})	65000	15000	80000	4.94	148800	68800	1:1.74
T_6 - Vermicompost (10 t ha^{-1})	65000	100000	165000	4.08	122400	-42600	1:-0.25
T_7 - 50% NPK + 50% FYM	65000	9750	74750	6.85	205500	130750	1:1.74
T_8 - 50% NPK + 50% Pig manure	65000	9250	74250	7.81	243300	160050	1:2.15
T_9 - 50% NPK+ 50%Poultry Manure	65000	9750	74750	7.63	228900	154150	1:2.06
T_{10}- 50 % NPK + 50 % Vermicompost	65000	52250	117250	8.7	261000	143750	1:1.22
T_{11}- FYM + Biofertilizers (*Azospirillum* + Phosphotica)	65000	15400	80400	3.98	119400	39000	1:0.48
T_{12}- Pig manure + Biofertilizers (*Azospirillum* + Phosphotica)	65000	14400	79400	4.40	132000	52600	1:0.66
T_{13}-Poultry manure + Biofertilizers *(Azospirillum* + Phosphotica)	65000	15400	80400	4.05	121500	41100	1:0.51
T_{14}- Vermicompost + Biofertilizers *(Azospirillum* + Phosphotica)	65000	100400	165400	4.96	148800	-16600	1:-0.10
T_{15}- 50 % NPK + 50 % FYM + Biofertilizers *(Azospirillum* + Phosphotica)	65000	10150	75150	9.95	298500	223350	1:2.97
T_{16}- 50 % NPK + 50 % Pig manure + Biofertilizers *(Azospirillum* + Phosphotica)	65000	9650	74650	11.17	335100	260450	1:3.48
T_{17}- 50 % NPK + 50 % Poultry Manure + *Azospirillum* + Phosphotica	65000	10150	75150	8.31	249300	174150	1:2.31
T_{18}- 50 % NPK + 50 % Vermicompost + *Azospirillum* + Phosphotica	65000	52650	117650	11.96	358800	241150	1:2.05

Economics: Pooled data on response of integrated nutrient management on economics of broccoli at harvest is given in Table-5. It clearly indicates that the most profitable treatment was T_{16} (50% NPK + 50% pig manure + biofertilizers) which also showed highest cost benefit ratio 1:3.48 which was very much in par with T_{18} (50% NPK + 50% vermicompost + biofertilizers). T_{16} (50% NPK + 50% pig manure + biofertilizers) gave the highest net income of ¹ 2, 60, 450 followed by ¹ 2, 41, 150 in T_{18} (50% NPK + 50% vermicompost + biofertilizers). Integrated application of chemical fertilizers, organic manures and biofertilizers alone or in combination has appreciable effect in the altering of head yield and economics of broccoli. It is evident from the findings that the most profitable way for cultivating broccoli could be achieved by application of 50% NPK + 50% pig manure + biofertilizers which gave the highest net return of Rs. 2,60,450 along with cost benefit ratio of 1:3.48 followed by Rs. 2,41,150 with the application of 50% NPK + 50% vermicompost + biofertilizers. The reason of high net economic return (profit) in the treatment of 50% NPK + 50% pig manure + biofertilizers was due to low input cost and high yield. Negative net return of Rs. 42,600 was obtained in the treatment of T_6 (vermicompost 10 t ha^{-1}) due to high cost of vermicompost (Rs. 10,000 t^{-1}). Application of 50% pig manure (20 t ha^{-1}) +50% NPK (40:20:20 kg ha^{-1}) can be recommended for cultivation of turnip in foot hill condition of Nagaland, which was found to be the better source of manuring in sustaining the soil fertility with better cost benefit ratio (Subenthung et al. 2012). Further, Khate et al. (2012) observed that treatment 50% NPK + 50% pig manure obtained maximum profit (Rs. 1,22,480) in cucumber. Similar results were also reported by Merentola et al. (2012) in cabbage as they found highest net return with combined application of 50% NPK + 50% pig manure + biofertilizers.

It can be concluded from the results that treatment comprising of 50% NPK + 50% vermicompost + biofertilizers was found optimum for growth, yield and quality of broccoli. This treatment reduced 50% chemical fertilizers without any reduction in yield and quality. While treatment T_{16}- 50% NPK + 50% pig manure + biofertilizers gave the highest net return and cost benefit ratio, and was found to be significantly *at par* for all growth, yield and quality parameters with treatment T_{18} (50% NPK + 50% vermicompost + biofertilizers). Therefore, two treatment combinations (i) 50 % NPK (60: 30: 30 kg ha^{-1}) + 50 % vermicompost (5 t ha^{-1}) + biofertilizers, and (ii) 50 % NPK (60: 30: 30 kg ha^{-1}) + 50 % pig manure (10 t ha^{-1}) + biofertilizers may be recommended for better production of broccoli and to sustain the soil fertility under the foothill conditions of Nagaland.

सारांश

नागालैण्ड के पहाड़ी तलहटी में ब्रोकली के पौध वृद्धि, उपज व गुणवत्ता पर समन्वित पोषक तत्व प्रबंधन के प्रभाव के अध्ययन हेतु वर्ष 2012–13 व 2013–14 में प्रक्षेत्र अध्ययन प्रायोगिक प्रक्षेत्र, उद्यान विज्ञान विभाग, स्कूल आफ एग्रीकल्चरल साइंसेज एण्ड रूरल डेवलपमेन्ट, नागालैण्ड विश्वविद्यालय, मेडजीफेमा में किया गया। यादृक्षिक प्रखण्ड योजना में 18 उपचारों को 3 बार प्रतिकृति किया गया। परिणाम से स्पष्ट हुआ कि 50 प्रतिशत एन.पी.के. + 50 प्रतिशत वर्मीकम्पोस्ट + बायोर्टिलाइजर के समन्वित उपयोग से पौध ा ऊँचाई (70.33 सेन्टीमीटर), पत्तियों की संख्या (20.45), तना व्यास (3.25 सेन्टी मीटर), पौध फैलाव (74.25 सेन्टी मीटर), समबाहू शीर्ष व्यास (16.97 सेन्टीमीटर), ध्रुवीय शीर्ष व्यास (18.37 सेन्टी मीटर), शीर्ष आकार (310.59 वर्ग सेमी), सम्पूर्ण शीर्ष भार (956 ग्राम), शुद्ध शीर्ष वजन (330.86 ग्राम), उपज/हे. (11.96टन), प्रोटीन की मात्रा (3.77 प्रतिशत), विटामिन सी की मात्रा (132.50 मिलीग्राम/100), कुल विलेय ठोस (5.52) तथा शीर्ष के पी.एच.मान (5.12) में सार्थक वृद्धि होती है। जबकि उपचार टी.–16 में 50 प्रतिशत एन.पी.के. + 50 प्रतिशत सुअर की खाद + बायोफर्टिलाइजर से अधिकतम लाभ (रू. 260450) एवं लागत लाभ अनुपात (1:3.48) तथा वृद्धि, उपज व गुणवत्ता मापदंडो हेतु उपचार टी.–18 (50 प्रतिशत एन.पी.के. + 50 प्रतिशत वर्मीकम्पोस्ट + बायोफर्टिलाइजर) सार्थक रूप से समतुल्य पाया गया।

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