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Effect of integrated nutrient management on growth, yield and economics of broccoli (*Brassica oleracea* L. Var. *italica* plenck.)

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Abstract: The present investigation was undertaken to study the effect of integrated nutrient management on growth, yield and economics of broccoli during 2008-09 and 2009-10 cropping years at Regional Research and Technology Transfer Station, OUAT, Keonjhar, Odisha. It was concluded that biometrical parameters of the broccoli like plant height, number of leaves per plant and leaf area were influenced by the combined application of NPK and bio-fertilizers along with different organic sources. Curd diameter as well as curd weight were significantly influenced by the application of 100% NPK + Bio-fertilizers (*Azatobacter* + *Azospirillum* + PSB @ 2 kg each/ha) + FYM @ 5t ha^{-1} + Vermicopost@ 2.5t ha^{-1}. In the present study the highest cost of cultivation (Rs. 43508.00 ha^{-1}) was worked out under the treatment VC@5t ha^{-1} + 100% RDF (150:45:80 kg ha^{-1}) + BF (*Azatobacter* + *Azospirillum* + PSB@ 2 kg each/ha). Maximum gross income of Rs. 209235.00 ha^{-1} and cost benefit ratio of 5.1 were recorded when broccoli crop was grown by applying 150:45:80 kg ha^{-1} N: P: K + biofertilizers (*Azatobacter* + *Azospirillum* +PSB @ 2 kg each/ha) + FYM@5t ha^{-1} + Vermicompost@ 2.5 t ha^{-1} by spending Rs. 41188.00.

Keywords: Broccoli, FYM, vermicompost, inorganic fertilizers

Introduction

Broccoli (*Brassica oleracea* L. var. *italica* Plenck.) is a winter vegetable that has high nutritional and good commercial value (Yoldas *et al*., 2008). It is a recent introduction to India but is becoming popular among the rich people because of its low fat content, low in calories, high vitamin C and good source of vitamin A, vitamin B_2 and calcium (Decoteau, 2000). Like other vegetable crops of the family, it removes large quantity of major nutrients from the soil. However, continuous application of huge amount of chemical fertilizers hampers the soil health and generates pollution. The integrated nutrient management paves the way to overcome these problems, which involves conjunctive use of chemical fertilizers and organic manures to sustain crop production as well as maintenance of soil health (Nanjappa *et al*., 2001). However, biofertilizers offer an alternative to chemical fertilizers, which have a ability to mobilize the nutritionally important elements from non-useable form to useable from through chemical processes and are known to increase yield in several other vegetables (Purkayastha *et al*.,1998). The use of biofertilizers in combination with chemical fertilizers and organic manures offer a great opportunity to increase the production of broccoli with less cost. Hence, the present study was undertaken to develop a suitable integrated nutrient management module for improving productivity and quality of broccoli.

Materials and Methods

The experiments were carried out at Regional Research and Technology Transfer Station, Keonjhar, Odisha for two consecutive cropping years i.e., 2008-09 and 2009-10. The soil was loamy with pH 6.06 and contained 4.6g kg^{-1} organic carbon, 125 kg ha^{-1} available N, 137 kg ha^{-1} available P and 212 kg ha^{-1} of available K. The experiment was laid out in Randomized Block Design (Factorial) with three replications. There were twenty four treatment combinations, which included various combinations of inorganic fertilizers with various sources of organic manures *viz*., FYM and Vermicompost. These organic manures were spread uniformly in the respective plots and incorporated in the soil up to a depth of 8-10 cm before transplanting.

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The crop was transplanted in the field at a spacing of 50 X 40 cm. Organic (FYM and Vermicompost), inorganic (NPK) and bioinoculant (*Azatobacter*, *Azospirillum* and PSB) were applied according to the treatment. Half of nitrogen and full doses of phosphorus and potassium were added at the time of transplanting. The remaining dose of nitrogen was applied 30 days after transplanting. The source of N, P, and K used were urea, single super phosphate & muriate of potash respectively. The data recorded on growth and yield during both the years were pooled and analysed (Panse and Sukhatme, 1985).

Results and Discussion

The biometrical characters of broccoli crop like plant height, number of leaves per plant and leaf area was influenced by the combined application of NPK and bio-fertilizers along with different organic sources. Application of only biofertilizers or 100% chemical fertilizers alone could not influence the characters significantly as compared to combined application. However, they individually differ significantly over control in all the above characters. Highest values for above characters were obtained by the application of 100% NPK with bio-fertilizers among the inorganic treatments (Table 1, 2 & 3). Similarly, with organic treatments, combined application of FYM and Vermicompost (50% each) gave the highest values than the control as well as single application. The notable improvement with respect to growth parameters with the use of biofertilizers, organic manures and inorganic fertilizers may be attributed to longer and sustained supply of nutrients during the entire growth period. Biofertilizers might attribute to production of different phyto hormones like IAA,GA, Cytokines which could have led to better root development, better uptake and translocation of nutrients ultimately resulted in increased growth.

Curd diameter as well as curd weight were found be significantly influenced by the combined effect of 100% NPK + Biofertilizers (*Azatobacter* + *Azospirillum* + PSB @ 2 kg each/ha) + FYM @ 5t ha^{-1} + Vermicopost @ 2.5t ha^{-1} (Table 4). There was highest in curd diameter (25.4 cm) & curd weight (289.2 g) with increasing dose of NPK along with bio-fertilizers and organic manures which might have favoured the production as well as accumulation of prepared food. Similar results were also observed by Sing and Naik (1993) in cauliflower, Maurya *et al*. (2008) in broccoli.

Table 1: Plant height (cm) of broccoli as influenced by integrated use of organic manures, bioinoculation and chemical fertilizers.(Pooled)

Inorganic + BI / Organic	F_0 Control	F_1 BI	F_2 75% NPK	F_3 100% NPK	F_4 75% NPK + BI	F_5 100% NPK + BI	Mean
M_0 - No-manure	11.9	13.8	25.9	31.7	32.5	35.3	25.2
M_1 - FYM	14.6	16.8	27.6	32.8	34.3	35.9	27.0
M_2 - VC	15.6	17.2	32.1	33.3	35.4	36.2	28.3
M_3 - FYM + VC	16.0	17.5	33.7	34.5	36.7	40.7	29.8
Mean	14.5	16.3	29.8	33.1	34.7	37.0	
	Manure	Fertilizer	M x F				
SEm (±)	0.2	0.3	0.6				
CD(0.05)	0.7	0.8	1.7				

Table 2: Number of leaves per plant of broccoli as influenced by integrated use of organic manures, bioinoculation and chemical fertilizers (Pooled)

Inorganic + BI / Organic	F_0 Control	F_1 BI	F_2 75% NPK	F_3 100% NPK	F_4 75% NPK + BI	F_5 100% NPK + BI	Mean
M_0 - No-manure	15.6	18.6	20.1	24.0	24.3	24.9	21.2
M_1 - FYM	19.8	22.0	23.5	24.2	24.7	25.1	23.2
M_2 - VC	19.9	22.1	23.8	24.4	24.7	25.4	23.4
M_3 - FYM + VC	20.9	22.8	24.6	25.6	25.8	28.8	24.7
Mean	19.1	21.3	23.0	24.5	24.9	26.0	
	Manure	Fertilizer	M x F				
SEm (±)	0.2	0.3	0.5				
CD(0.05)	0.6	0.7	1.4				

Table 3: Leaf area (cm2) of broccoli as influenced by integrated use of organic manures, bioinoculation and chemical fertilizers (Pooled)

Inorganic + BI / Organic	F_0 Control	F_1 BI	F_2 75% NPK	F_3 100% NPK	F_4 75% NPK + BI	F_5 100% NPK + BI	Mean
M_0 - No-manure	48. 6	51.8	101.3	127.5	133.0	143.3	100.9
M_1 - FYM	56.7	64.1	112.9	133.1	140.1	146.3	108.9
M_2 - VC	60.7	65.5	128.5	136.7	141.4	147.1	113.3
M_3 - FYM + VC	63.2	68.7	134.1	137.8	146.7	165.2	119.3
Mean	57.3	62.5	119.2	133.8	140.3	150.5	
	Manure	Fertilizer	M x F				
SEm (±)	1.0	1.2	2.4				
CD(0.05)	2.8	3.4	6.8				

Table 4: Curd diameter (cm) of broccoli as influenced by integrated use of organic manures, bioinoculation and chemical fertilizers (Pooled)

Inorganic + BI / Organic	F_0 Control	F_1 BI	F_2 75% NPK	F_3 100% NPK	F_4 75% NPK + BI	F_5 100% NPK + BI	Mean
M_0 - No-manure	6.6	7.2	13.6	16.6	17.5	19.0	13.4
M_1 - FYM	8.5	9.5	16.0	17.7	19.1	21.7	15.4
M_2 - VC	9.6	9.9	19.2	19.5	20.5	23.3	17.0
M_3 - FYM + VC	9.8	10.1	20.5	20.8	22.1	25.4	18.1
Mean	8.6	9.2	17.3	18.7	19.8	22.3	
	Manure	Fertilizer	M x F				
SEm (±)	0.16	0.20	0.39				
CD(0.05)	0.45	0.55	1.10				

Table 5: Curd yield (q/ha) of broccoli as influenced by integrated use of organic manures, bioinoculation and chemical fertilizers (Pooled)

Inorganic + BI / Organic	F_0 Control	F_1 BI	F_2 75% NPK	F_3 100% NPK	F_4 75% NPK + BI	F_5 100% NPK + BI	Mean
M_0 - No-manure	8.7	11.6	61.1	72.3	87.3	92.9	55.6
M_1 - FYM	13.5	16.8	93.0	119.1	125.3	129.3	82.8
M_2 - VC	17.7	22.2	107.9	124.3	128.6	131.9	88.7
M_3 - FYM + VC	29.5	33.6	111.0	128.8	131.9	139.5	95.7
Mean	17.3	21.1	93.2	111.1	118.3	123.4	
	Manure	Fertilizer	M x F				
SEm (±)	0.7	0.9	1.8				
CD(0.05)	2.0	2.5	4.9				

Table 6: Influence of INM on benefit cost ratio of broccoli

Inorganic + BI / Organic	F_0 Control	F_1 BI	F_2 75% NPK	F_3 100% NPK	F_4 75% NPK + BI	F_5 100% NPK + BI	Mean
M_0 - No-manure	0.5	0.7	3.4	3.9	4.8	4.9	3.0
M_1 - FYM	0.6	0.7	3.8	4.7	5.0	5.0	3.3
M_2 - VC	0.7	0.8	3.9	4.4	4.5	4.6	3.1
M_3 - FYM + VC	1.2	1.3	4.2	4.8	4.9	5.1	3.6
Mean	0.75	0.9	3.8	4.4	4.8	4.9	

Application of different levels of NPK in combination with biofertilizers and organic manures increase the unit curd weight and ultimately yield per hectare. Maximum yield (139.5 q ha^{-1}) was obtained by using N: P: K 150:45:80 kg ha^{-1} + biofertilizers (*Azatobacter* + *Azospirillum* +PSB @ 2 kg each/ha) + FYM@5t ha^{-1} + vermicompost@ 2.5 t ha^{-1}(Table 5) which was significantly higher than other treatments including control. The increase in yield might have been due to the performance of the vegetative growth which might have influenced the production of more amount of carbohydrates ultimately accumulated in the form of curd and thereby increase the yield. The increase in yield might be due to the solubilizing effect of the nutrients as well as chelating effect of biofertilizers on metal, thereby, the availability of essential nutrients get increased. The result is in confirmation with the findings of Feller and Fink (2005) and (Ranawat *et al*., 2008) in broccoli.

The adoption of any technology in modern agriculture can only be feasible and acceptable to farmers if it is economically viable. In the present investigation the highest cost of cultivation (Rs. 43508.00 ha^{-1}) was worked out under the treatment VC@ 5 t ha^{-1} + 100% RDF (150:45:80 kg ha^{-1}) + BF (*Azatobacter* + *Azospirillum* +PSB @ 2 kg each/ha). Maximum gross income (Rs. 209235.00 ha^{-1}) and cost benefit ratio (5.1) were recorded when broccoli crop was grown by applying N: P: K 150:45:80 kg ha^{-1} + biofertilizers (*Azatobacter* + *Azospirillum* +PSB @ 2 kg each/ha) + FYM@5t ha^{-1} + Vermicompost@ 2.5 t ha^{-1} by spending Rs. 41188.00 (Table 6), however, the lowest value of these parameters was recorded in control, where plots were deprived of any fertilizer application.

Thus, N: P: K 150:45:80 kg ha^{-1} + bio- fertilizers (*Azatobacter* + *Azospirillum* +PSB @ 2 kg each/ha) + FYM@5t ha^{-1} + vermicompost@ 2.5 t ha^{-1} may be recommended for optimum growth, yield and profit of broccoli cultivation under Odisha condition.

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