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Goutam Kumar
Department of Horticulture, College of Agriculture, Dharwad, University of Agricultural Sciences, Dharwad, Karnataka, India

MS Biradar
Department of Horticulture, College of Agriculture, Dharwad, University of Agricultural Sciences, Dharwad, Karnataka, India

Correspondence
Goutam Kumar
Department of Horticulture, College of Agriculture, Dharwad, University of Agricultural Sciences, Dharwad, Karnataka, India

Integrated nutrient management studies for protected cultivation of broccoli (*Brassica oleracea* var. *italica* L.)

Goutam Kumar and MS Biradar

Abstract
Experiment was conducted under protected condition (Shade house) at Main Agriculture Research Station, University of Agriculture Sciences, Dharwad during 2015-2016 to find the response of integrated nutrient management (INM) on growth and yield of broccoli (*Brassica oleracea* var. *italica* L.). Observation during investigation for plant height, plant spread, stalk length, number of leaves per plant, chlorophyll content, average weight of primary head, diameter of primary curd, days for curd initiation, yield per m2 and yield per hectare were recorded. Higher yield of curd of 19.5 t ha-1 was obtained in treatment T11-75% RDF + FYM and VC (1:1) equivalent to 25% RDN +AZT + PSB. However, minimum value for all the characters studied were recorded by sole application of different organic manure and biofertilizers. It was concluded that integration of biofertilizers, organic manures and reduced level of inorganic fertilizers gave better results and hence, there is a great scope of improvement in growth, and yield of broccoli.

Keywords: Shade house, organic manure, biofertilizers, inorganic fertilizers

Introduction
Sprouting broccoli (*Brassica oleracea* var. *italica* L.) is an important cole crop which belongs to the family cruciferae. The native place of broccoli is Italy.

Integrated nutrient management (INM) consists of improvement and maintenance of soil fertility for sustainable crop productivity through optimization of all available organic, inorganic and biotic resources in an integrated manner, appropriate to each cropping system and farming situations with its ecological, social and economic ramifications. Recent energy crisis and consequent price hike of chemical fertilizers due to withdrawal of relevant subsidies coupled with low purchasing power of farming community have generated renewed interest in organic recycling throughout the world for sustainable crop production.

As such protected cultivation is highly intensive cultivation, with high dose of chemical fertilizers are leads to degradation of soil physical, chemical and biological property. Hence integrated nutrient management is judicious application of chemical fertilizers along with organic manure and biofertilizers helps in improving soil health and crop productivity under protected cultivation.

Material method
Experiment was carried out at Main Agriculture Research Station, University of Agriculture Sciences, Dharwad. The treatments were laid out in Randomized Block Design with 14 treatments rand 2 replicated. FYM and vermicompost were used as organic source of nutrients. Bioagents used in the experiment were *Azotobacter* and PSB. Urea, MOP and DAP was used as chemical fertilizer. The treatments were selected for sole and combined application of varied levels of vermicompost and farmyard manure along with 100%, 75% and 50% of recommended dose of inorganic fertilizers in presence and absence of biofertilizer and thus 14 treatment combinations were laid out in randomized block design (RBD) with two replications. The crop was transplanted on raise beds at a spacing of 45 X 45 cm. Organic (FYM and Vermicompost), inorganic (NPK) and bioinoculant (Azatobacter, 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 treatments were T1-100% recommended fertilizer dose (R.F.D) of 150 N:100 P:125 K kg/ha + FYM 25 t/ha, T2-75% RDF + FYM equivalent to 25% RDN, T3-75% RDF + FYM equivalent to 25% RDN +AZT + PSB, T4-75% RDF + VC equivalent to 25% RDN; T5 -75% RDF + VC equivalent to 25% RDN +AZT + PSB T6 -50% RDF +
FYM equivalent to 50% RDN T7 -50% RDF + FYM equivalent to 50% RDN +AZT + PSB T8 -50% RDF + VC equivalent to 50% RDN T9-50% RDF + VC equivalent to 50% RDN +AZT + PSB, T10 75% RDF + FYM and VC (1:1) equivalent to 25% RDN, T11-75% RDF + FYM and VC (1:1) equivalent to 25% RDN +AZT + PSB, T12 -50%
RDF + FYM and VC (1:1)equivalent to 50% RDN, T13-50% RDF + FYM and VC (1:1)equivalent to 50% RDN +AZT + PSB and T14 - Each FYM and VC (1:1) equivalent to 100% RDN +AZT + PSB.

Data were recorded in broccoli for plant height (cm), plant spread (cm2), stalk length (cm), number of leaves per plant, chlorophyll content (SPAD unit), average weight of primary head (g), diameter of primary curd (cm), days for curd initiation, yield per m2 (kg) and yield per hectare (ton) were recorded. The data recorded was then statistically analyzed to get CD.

Result and discussion

The biometrical characters of broccoli crop like plant height, plant spread, stalk length, number of leaves per plant and chlorophyll content, was influenced by the combined application of NPK and bio-fertilizers along with different organic sources. Application of only organic manure and biofertilizers (T14) or 100% chemical fertilizers (T1) alone could not influence the characters significantly as compared to combined application.

Marked effect in height of plant was observed due to application of different treatments. Application of 75% RDF + FYM and VC (1:1) equivalent to 25% RDN +AZT + PSB T11 which was on par with T9-50% RDF + VC equivalent to 50% RDN +AZT + PSB produced significantly taller plants i.e. 35.45 cm and 31.4 cm respectively at harvesting. The increased height might be due to better water holding capacity, supply of micro- nutrient and availability of major nutrient due to favorable soil condition offered by the farmyard manure and vermicompost. The present finding are in line with the results of Singh *et al.* (1970) [9] in cauliflower, Khudair *et al.* (1989) [5] and Rathauskiene and Foderys (1999) [6] in cabbage.

There was a significant increase in plant spread due to different treatments. Higher plant spread (83.4 cm2) was noted with the application of 75% RDF + FYM and VC (1:1) equivalent to 25% RDN +AZT + PSB T11. This better growth might be due to the abundance of the free-living nitrogen fixing bacteria which help in improving the root development, fertility, mineral uptake and synthesis of growth hormone. Similar results are also observed by Singh and Singh (2005) [11] in cauliflower.

The number of leaves per plant at harvesting stage was highest (17.5) with application of 75 % recommended dose of NPK, FYM and vermicompost along with biofertilizers (T11). This is probably due to the facts that nitrogen might have contributed towards an increase in leaf buds and growth promoting substance secreted by microbes and increase availability of atmospheric nitrogen due to fixation by *Azotobacter* and PSB help in more plant growth.

The number of days taken to curd initiation was significantly affected by different treatments as shown in Table. The treatment having 75% RDF + FYM and VC (1:1) equivalent to 25% RDN +AZT + PSB T11. reached first to curd initiation (54.6) and while treatments T14 Each FYM and VC (1:1) equivalent to 100% RDN +AZT + PSB. significantly delayed (59.8) to curd initiation. This might be due to the more availability of available nitrogen throughout the growing season. Present finding are in line with those reported by Jana and Mukhopadhyay (2001) [4] in cauliflower.

The maximum curd diameter (18.0 cm) and curd weight (398 g) were obtained with application of 75% RDF + FYM and VC (1:1) equivalent to 25% RDN +AZT + PSB T11 which was on par with T9-50% RDF + VC equivalent to 50% RDN +AZT + PSB. It is probably due to the fact that biofertilizers in combination with organic manure and inorganic fertilizers helps in better root proliferation, more uptake of nutrient and water, higher leaf number and more area responsible for effective photosynthesis and enhanced food accumulation. Similar results are found by Wani *et al.* (2010) [12] in cauliflower and choudhary *et al.* (2012) [2] in broccoli.

The highest curd yield in kg per m2 (1.95) and per hectare in ton/ha (19.5) was obtained with application 75% RDF + FYM and VC (1:1) equivalent to 25% RDN +AZT + PSB T11 which was on par with T9-50% RDF + VC equivalent to 50% RDN +AZT + PSB. It might be due to application of NPK in conjunction with biofertilizers and organic manure might have favored the effective utilization of nutrient availability in the soil, which ultimately increased auxin activity, growth and activity of microbial saprophytes, which ultimately influenced the yield per m2 and per hectare. The present finding are in agreement with the results of Verma *et al*., (1997) [11] in cabbage, Bambal *et al.* (1998) [1] and Das *et al.* (2000) [3] in cauliflower, Singh and Singh (2000) [8] and Sharma *et al.* (2002) [7] in broccoli.

Table 1: Different treatment combinations used in experiment.

Treatment number	Treatment details
T1	100%RDF + FYM (control)
T2	75% RDF + FYM equivalent to 25% RDN
T3	75% RDF + FYM equivalent to 25% RDN + AZT + PSB
T4	75% RDF + VC equivalent to 25% RDN
T5	75% RDF + VC equivalent to 25% RDN + AZT + PSB
T6	50% RDF + FYM equivalent to 50% RDN
T7	50% RDF + FYM equivalent to 50% RDN + AZT + PSB
T8	50% RDF + VC equivalent to 50% RDN
T9	50% RDF + VC equivalent to 50% RDN + AZT + PSB
T10	75% RDF + FYM and VC (1:1) equivalent to 25% RDN
T11	75% RDF + FYM and VC (1:1) equivalent to 25% RDN + AZT + PSB
T12	50% RDF + FYM and VC (1:1) equivalent to 50% RDN
T13	50% RDF + FYM and VC (1:1) equivalent to 50% RDN + AZT + PSB
T14	Each FYM and VC (1:1) equivalent to 100% RDN + AZT + PSB

Table 2: Growth character as influenced by integrated nutrient management in broccoli under shade house.

Treatment	Plant height (cm)	Plant spread (cm2)	Stalk length (cm)	Number of leaves	SPAD reading
T1	29.3	74.665	20.6	15.8	73.0
T2	23.3	66.5	19.5	14.1	62.2
T3	25.4	66.5	19.6	19.6	65.6
T4	26.8	65.545	19.6	15.8	66.7
T5	29.7	76.82	21.0	16	73.9
T6	23.7	64.15	19.6	13.7	64.7
T7	27.2	73.775	20.1	15.6	68.5
T8	27.1	72.2	20.0	14.4	67.6
T9	31.4	82.4	23.1	16.7	75.5
T10	28.9	74.56	20.9	15.3	71.0
T11	35.4	83.4	23.4	17.5	76.7
T12	28.2	74.51	20.3	15.4	70.0
T13	31.2	76.82	21.1	16.1	74.2
T14	22.9	63.3	19.0	13	60.5
S.Em±	1.7	3.2	0.12	0.52	0.51
CD (p=0.05)	5.3	10.0	0.39	1.59	1.58

Table 3: Yield character as influenced by integrated nutrient management in broccoli under shade house.

Treatment	Curd weight (g)	Curd diameter (cm)	Curd initiation (Days)	Curd yield/m2 (kg)	Curd yield/ha (t)
T1	322	16.0	58.6	1.58	15.8
T2	233	13.9	61	1.14	11.4
T3	263	14.8	61.3	1.29	12.9
T4	269	14.9	59.4	1.32	13.2
T5	339	16.1	56.7	1.46	16.6
T6	241	14.5	59.1	1.18	11.8
T7	288	15.2	56.5	1.41	14.1
T8	278	15.0	59.6	1.36	13.6
T9	365	17.2	55.5	1.79	17.9
T10	318	15.6	58.7	1.56	15.6
T11	398	18.0	54.6	1.95	19.5
T12	300	15.6	58.6	1.47	14.7
T13	345	16.7	57.8	1.69	16.9
T14	229	13.6	59.8	1.12	11.2
S.Em±	21.8	0.9	1.0	0.10	1.0
CD (p=0.05)	66.6	2.7	3.3	0.33	3.2

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