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EFFECT OF ORGANIC MANURES AND BIO-FERTILIZERS ON GROWTH, YIELD, QUALITY AND ECONOMICS OF BROCCOLI (*Brassica Oleracea* L. *var. italica* PLENCK) cv. GREEN HEAD UNDER HIGH-HILL CONDITIONS OF UTTARAKHAND

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ABSTRACT
Global awareness of human & soil health and environmental issues has attracted the vegetable growers to adopt alternate farm practices. Therefore, an experiment was conducted at the Organic and Dairy Block, College of Horticulture, VCSG Uttarakhand University of Horticulture and Forestry, Bharsar, Uttarakhand during the year 2015. The experiment was laid out in a randomized complete block design (RCBD) at a spacing of 45 cm × 45 cm with three replications having 10 treatments comprised of farmyard manure, neem cake, biovita granules, vermicompost and biofertilizers (azotobacter and phosphate solubilizing bacteria). The observations were recorded on different growth, yield, and quality attributes. Further, economics of different treatments was also worked out. The analysis of variance revealed significant differences among the treatments for all the characters under study. The treatment T_6 (Farmyard manure + Biofertilizer) due to its persistent performance for yield (39.25 t/ha), gross income (Rs. 314561.23/ha), net returns (Rs. 252982.41/ha) and higher benefit: cost ratio (1:4.10) along with balanced application of nutrients to maintain soil health was rated as best treatment. Hence, treatment T_6 can be recommended for commercial cultivation in long run for sustainable broccoli production in hilly region of the country.

KEYWORDS: Biofertilizers, Broccoli, FYM, Growth, Organic, Vermicompost and Yield.

INTRODUCTION

Sprouting broccoli (*Brassica oleracea* L. var *italica*) is one of the most nutritious vegetable amongst the cole crops grown for its tender heads. It is regarded as important functional food due to its high nutritional value i.e. vitamin A, protein and anticarcinogenic compounds. It is richest source of sulphoraphane, a compound associated with reducing risk of cancer in human beings (Thamburaj and Singh, 2001). In the last few decades, production of vegetable crops has been enhanced manifolds by the excessive use of chemical fertilizers and pesticides (Sharma *et al*., 2008). Nutrient management is the key factor, which influences the productivity and quality of any crop. Organic manures are considered helpful in improving the physical and nutritional status of the soil and also enhance the activity of soil microflora. They also add considerable amount of major nutrients in the soil besides improving the soil properties. Further, decomposition of organics in the soil leads to different types of biological reactions which are helpful in preventing various disease causing pathogens (Ramesh *et al*., 2010). Biofertilizers offer an economically attractive and ecologically sound means of reducing external inputs and improving quality and quantity of vegetable produce. They contain microorganisms which are capable of mobilizing nutrient elements from unavailable form to available form through different biological processes. Hence, the present investigation was aimed to study the response of various organic manures and bio-fertilizers on growth, yield, quality and economics of broccoli under high-hill conditions of Uttarakhand.

MATERIALS & METHODS

The present investigation was carried out at the Organic and Dairy Block, College of Horticulture, VCSG Uttarakhand University of Horticulture and Forestry, Bharsar, Uttarakhand during the year 2015 in 'Green Head' cultivar of broccoli. The experiment was laid out in a randomized complete block design (RCBD) at a spacing of 45 cm × 45 cm with three replications and 10 treatments, which consisted of sole application of organic sources (vermicompost, neem cake, biovita granule and farmyard), biofertilizers (azotobacter and phosphate solubilizing bacteria) and their combinations (Table 1). All forms of bio-fertilizers were inoculated as root dip of seedlings for 15-20 minutes just before transplanting. After dipping, seedlings were immediately transplanted in the main field. Five plants were randomly tagged in each treatment per replication and data were recorded with respect to various growth, yield and

quality attributes *viz.* days taken to 50 % heading, days to marketable maturity, plant height at maturity (cm), number of leaves per plant, polar diameter of head (cm), equatorial diameter of head (cm), terminal head weight (g), number of spear, average spear weight (g), average plant yield (g), yield per hectare (q), ascorbic acid content (mg/100g), total soluble solids (^{o}Brix), and shelf life (days) and mean data were subjected to statistical analysis as per Gomez and Gomez (1984). Further, economic analysis of different treatments was tested depending upon the locally existing fixed and variable costs of different inputs. The cost of cultivation under different treatments was calculated by following Sharma *et al*. (2008). The net return was worked out for all the treatments by subtracting the cost of cultivation from the gross returns. The benefit: cost ratio as return per rupee invested was calculated by dividing net return with total cost of cultivation for each treatment under study.

TABLE 1: Detail of treatments used in the present study

Sr. No.	Treatment code	Treatment Detail
1.	T_1	Farmyard manure (FYM) @20t/ha
2.	T_2	Vermicompost @5t/ha
3.	T_3	Neem cake @ 2t/ha
4.	T_4	Biovita granules @50 kg/ha
5.	T_5	Biofertilizers (Azotobacter +PSB) each @5kg/ ha
6.	T_6	Farmyard manure + Biofertilizers
7.	T_7	Vermicompost + Biofertilizers
8.	T_8	Neem cake + Biofertilizers
9.	T_9	Biovita granules + Biofertilizers
10.	T_{10}	Control

RESULTS & DISCUSSION

Growth characters

The data pertaining to different growth characters revealed significant variations among the different treatments under study (Table 2). The minimum number of days to 50 % heading (63.40) and days to marketable maturity (91.13) were recorded in the treatment T_6 (Farmyard manure + Biofertilizers). This might be attributed to increased availability of nitrogen due to the action of *Azotobacter* which is an important constituent of chlorophyll and protein thus causing more growth. Farmyard manure helps in improving soil health and it ensures proper aeration in soil and improves water holding capacity of soil. The present findings are in line with the results of Chaterjee *et al.* (2005), Kumar *et al.* (2013) and Mal *et al.* (2015) in broccoli. Further, different treatments showed significant variations with respect to plant height at maturity and number of leaves per plant. The maximum plant height at maturity (35.45 cm) and number of leaves per plant (15.66) were again recorded in the treatment T_6 (Farmyard manure + Biofertilizers). This may be attributed to better water holding capacity, supply of micro-nutrient and availability of major nutrients due to favourable soil conditions offered by the farmyard manure (Chaudhary *et al*., 2012). The present findings are in line with the results of Chatterjee *et al.* (2005) and Pandey *et al.* (2008) in broccoli. Bhardwaj *et al*. (2007) also stated that application of biofertilizers help in secretion of growth promoting substances, which lead to better root development, transportation of water, uptake and decomposition of nutrients. The present results are also in agreement with the findings of Sharma (2002) in cabbage and Magd *et al.* (2006) in broccoli.

TABLE 2: Effect of organic manures and bio-fertilizers on growth characters in broccoli

Treatment code	Days of 50% heading ± SE (m)	Days to marketable Maturity ± SE (m)	Plant height at maturity (cm) ± SE (m)	No of leaves per plant ± SE (m)
T_1	63.60 ± 0.83	93.26 ± 0.88	31.60 ± 0.57	14.73 ± 1.33
T_2	66.73 ± 0.78	100.06 ± 1.38	32.32 ± 0.57	14.86 ± 0.46
T_3	65.73 ± 2.25	101.13 ± 1.16	31.86 ± 0.57	13.80 ± 0.52
T_4	68.93 ± 1.57	99.06 ± 4.83	31.75 ± 0.57	13.40 ± 1.15
T_5	70.73 ± 0.83	100.26 ± 0.96	31.62 ± 0.57	14.13 ± 0.96
T_6	63.40 ± 0.11	91.13 ± 0.78	35.45 ± 0.57	15.66 ± 0.70
T_7	65.13 ± 0.83	94.06 ± 0.93	35.41 ± 0.57	14.46 ± 0.83
T_8	74.93 ± 0.37	110.86 ± 0.73	30.28 ± 0.57	13.60 ± 1.21
T_9	70.73 ± 3.1	103.06 ± 3.15	30.83 ± 0.57	14.46 ± 0.43
T_{10}	69.50 ± 4.09	101.65 ± 6.62	27.38 ± 0.59	12.26 ± 1.18
± SE(d)	2.391	3.91	0.84	1.32
$CD_{(0.05)}$	5.02	8.22	1.79	2.77

Yield attributing characters

Significant variations were recorded among different treatment combinations for yield and its attributing traits (Table 3). In the present investigation, maximum polar (11.68 cm) and equatorial diameter (10.45 cm) of head was recorded in treatment T_6 (Farmyard manure + Biofertilizers). This might be due to additional supply of N through FYM, which increased the synthesis of chlorophyll and amino acid,

which in turn enhanced the head size (Sharma *et al*., 2002). Almost identical results have also been reported earlier by Bahadur *et al.* (2003) and Kandil and Gad (2009) in broccoli**.** Maximum terminal head weight (51.96 g) and highest number of spears (6.56) were obtained with the treatment T_7 (Vermicompost + Biofertilizers). It is probably due to the fact that biofertilizers in combination with organic fertilizers help in better root proliferation, which facilitate more uptake of nutrients and water, higher leaf number and more area responsible for effective photosynthesis and enhanced food accumulation. Vermicompost is considered as an excellent product since it is homogenous, has desirable aesthetics, reduced level of contaminates, plant growth hormones, higher level of soil enzymes, greater microbial population and tends to hold more nutrients over a longer period without adverse impact on environment. The present findings are in line with those of Sharma (2002) and Bhardwaj *et al*. (2007) in broccoli. On the other hand, maximum average spear weight (32.12 g) was recorded in treatment T_6 (Farmyard manure + Biofertilizers). Increase in secondary head weight might be due to higher and continuous nutrient availability from different sources like organic manures and biofertilizers at different stages of growth. It might have resulted in better translocation of carbohydrates to storage organs, which influenced the weight of lateral heads. Similar findings have also been reported by Bhardwaj *et al*. (2007) and Kumar *et al*. (2012) in sprouting broccoli. The maximum average plant yield (999.45 g) and per hectare yield (41.13 q) was registered with the treatment T_7 (Vermicompost + Biofertilizers). This might be because of appropriate levels of nitrogen, which acts as an integral component of many compounds including chlorophyll and enzymes that are critical for carbohydrate use within plants**.** Improvement in this growth attribute with the application of vermicompost might be due to more availability of water, micro-nutrients and major nutrients because of favourable soil condition (Chaudhary *et al*., 2012). Similar results were also recorded earlier by the Magd *et al*. (2006) in sprouting broccoli.

TABLE 3: Effect of organic manures and bio-fertilizers on yield and its contributing characters in broccoli

Treatment code	Polar diameter of head (cm) ± SE(m)	Equatorial diameter of head (cm) ± SE (m)	Terminal head weight (g) ± SE (m)	Number of spear ± SE (m)	Average spear weight (g) ± SE (m)	Average plant yield (g) ± SE (m)	Yield per hectare (q) ± SE (m)
T_1	11.16 ± 0.34	9.84 ± 1.71	38.57 ± 0.00	5.50 ± 0.57	28.61 ± 1.48	903.63 ± 0.19	37.18 ± 1.97
T_2	9.69 ± 0.35	7.40 ± 0.54	31.68 ± 0.57	4.83 ± 0.57	24.57 ± 0.70	654.32 ± 0.57	26.92 ± 1.37
T_3	9.74 ± 0.44	8.17 ± 0.92	42.51 ± 0.57	4.96 ± 0.57	25.97 ± 1.06	842.51 ± 0.57	34.67 ± 0.67
T_4	9.90 ± 1.24	8.38 ± 1.28	34.98 ± 1.15	5.46 ± 0.57	23.74 ± 2.02	708.44 ± 0.57	29.15 ± 3.42
T_5	10.08 ± 0.23	7.88 ± 0.24	43.30 ± 0.57	5.53 ± 0.57	25.03 ± 1.35	774.67 ± 0.57	31.88 ± 4.11
T_6	11.68 ± 0.83	10.45 ± 0.99	49.42 ± 0.57	6.26 ± 0.57	32.12 ± 1.50	953.92 ± 0.57	39.25 ± 2.45
T_7	11.37 ± 0.95	10.03 ± 0.29	51.96 ± 0.57	6.56 ± 0.57	29.15 ± 0.54	999.45 ± 0.57	41.13 ± 2.32
T_8	8.47 ± 0.46	6.84 ± 0.32	29.76 ± 0.57	4.63 ± 0.57	23.29 ± 0.43	636.12 ± 0.57	26.18 ± 0.77
T_9	9.46 ± 1.10	8.52 ± 1.47	40.01 ± 0.57	5.56 ± 0.57	27.75 ± 1.14	828.80 ± 0.57	34.11 ± 2.92
T_{10}	8.13 ± 0.68	6.51 ± 0.55	20.09 ± 0.57	3.63 ± 0.57	20.08 ± 1.03	479.44 ± 0.57	19.71 ± 1.02
± SE(d)	0.98	1.11	0.93	0.74	1.23	0.33	3.17
$CD_{(0.05)}$	2.06	2.34	1.95	1.73	3.65	0.58	6.72

TABLE 4: Effect of organic manures and bio-fertilizers on quality characters in broccoli

Treatment code	Ascorbic acid content (mg/100g) ± SE(m)	Total soluble solids (^oBrix) ± SE(m)	Shelf life (days) ± SE (m)
T_1	19.20 ± 3.69	10.53 ± 0.26	12.73 ± 0.13
T_2	18.37 ± 2.59	8.56 ± 0.29	12.00 ± 0.40
T_3	22.46 ± 2.82	10.43 ± 0.17	9.93 ± 0.24
T_4	19.20 ± 3.69	11.56 ± 0.29	11.00 ± 0.20
T_5	19.10 ± 1.88	11.56 ± 0.74	10.66 ± 0.06
T_6	23.23 ± 1.70	11.26 ± 0.12	13.80 ± 0.11
T_7	21.33 ± 3.84	10.76 ± 0.17	12.46 ± 0.40
T_8	16.13 ± 1.73	10.90 ± 0.30	10.60 ± 0.11
T_9	19.43 ± 3.49	10.96 ± 0.59	11.53 ± 0.17
T_{10}	12.26 ± 0.58	8.43 ± 0.17	8.93 ± 0.17
± SE(d)	3.97	0.46	0.31
$CD_{(0.05)}$	8.34	0.96	0.65

Quality characters

In the present study, substantial variations were recorded for different quality traits under study (Table 4). The highest ascorbic acid content (23.23 mg/100g) was recorded with the treatment T_6 (Farmyard manure + Biofertilizers). It means that combined application of different biofertilizers and vermicompost played a significant role for higher ascorbic acid accumulation in the broccoli heads. Maximum total

soluble solids (11.56 ^{o}Brix) was recorded in treatment T_4 (Biovita granules) and T_5 (Biofertilizers). Mishra *et al*. (2014) in knolkhol, reported that the TSS content was increased with the increase in the nutrient level in the soil. However, maximum self-life (13.80 days) was recorded in treatment T_6 (Farmyard manure + Biofertilizers). Application of organic manures influenced broccoli longevity due to the increased nutrient uptake by the plants and greater development of water conducting tissue. These findings are in agreement with Chatterjee *et al*. (2013) in tomato and Chatterjee *et al*. (2014) in cabbage.

Economics of treatments

The perusal of data pertaining to benefit: cost (B:C) ratio revealed that maximum B:C ratio (1:4.16) was obtained with the treatment combination T_9 (Biovita granules + Biofertilizers) followed by T_6 (Farmyard manure + Biofertilizer), due to higher yield and lower cost of cultivation (Table 5). On the other hand, minimum B:C ratio (1:1.01) was obtained with the T_{10} (Control). These results are in line with the findings of Bhardwaj *et al*. (2000) in cauliflower and Chaterjee *et al*. (2005) in broccoli, who had also reported minimum benefit: cost ratio with the control, due to reduced yield, lesser gross income and ultimately lesser net returns. Hence, taking into consideration all aspects, treatment T_6 (Farmyard manure + Biofertilizer) due to its persistent performance for yield (39.25 t/ha), gross income (Rs. 314561.23/ha), net returns (Rs. 252982.41/ha) and higher benefit: cost ratio (1:4.10) along with balanced application of nutrients to maintain the soil health was rated as best treatment. Dass *et al*. (2008) and Maurya *et al*. (2008) had also realized the production potential of balanced nutrition for higher benefit: cost ratio in broccoli. Hence, treatment T_6 (Farmyard manure + Biofertilizer) can be recommended for commercial cultivation in long run for sustainable broccoli production in hilly region of the country.

TABLE 5: Economics of various treatments for yield per hectare in broccoli

Treatments	Yield (kg)/ha	Total Cost of Cultivation (Rs./ ha)	Gross Income (Rs. / ha)	Net Return (Rs. / ha)	B:C Ratio
T_1	3718.66	60654.82	297959.27	237304.45	1: 3.91
T_2	2692.67	71892.25	215806.77	143914.52	1:2.00
T_3	3467.13	64119.82	277785.97	213666.15	1: 3.33
T_4	2915.42	51992.32	233613.51	181621.19	1: 3.49
T_5	3187.95	50028.28	255436.54	205407.72	1: 4.09
T_6	3925.59	61578.82	314561.23	252982.41	1: 4.10
T_7	4112.98	72812.25	329496.21	256683.96	1: 3.52
T_8	2617.78	65043.82	209795.04	144751.23	1:2.22
T_9	3410.70	52916.32	273300.05	220383.73	1:4.16
T_{10}	1971.35	49104.82	98888.89	49784.07	1:1.01

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