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Full Research Article

Effect of Vermi-compost and Inorganic Fertilizers on Growth, Yield and Quality of Sprouting Broccoli (*Brassica oleracea* L. var. *italica* Plenck)

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Abstract

The response of vermi-compost and inorganic fertilizers on growth, yield and quality of sprouting broccoli was studied during 2011-13 at UBKV, Pundibari, West Bengal, India. The treatments comprised of five levels of vermi-compost (0, 2.5, 5, 7.5 and 10 t ha^{-1}) and four levels of inorganic fertilizers (0, 50, 75 and 100% of recommended dose) were evaluated in two factor factorial RBD with three replications. The result revealed that successive increase in vermi-compost level significantly increased the growth and yield attributes and application of highest level of vermi-compost (10 t ha^{-1}) registered 38% and 43% improvement of central head weight and total head yield respectively over control, whereas application of 100% recommended fertilizers enhanced the head weight and total head yield by 32% and 35% respectively over control. The nutrient schedule comprising of higher level of vermi-compost (10 t ha^{-1}) and 100% of recommended inorganic fertilizers emerged as potential nutrient source and resulted in many fold improvement in the form of vigorous growth, early head initiation, advanced head maturity and higher yield as well as superior quality of head as compared other nutrient combination.

1. Introduction

Sprouting broccoli or broccoli is a high value exotic vegetable cultivated for its tender flowering head and the secondary heads (spears). Apart from anti-cancerous properties, heads are rich sources of protein, minerals, vitamin and antioxidant (Keck, 2004).The crop attract very high price in urban market and can be exported to abroad. Realizing the tremendous potential of sprouting broccoli in domestic and foreign market, the cauliflower growers are gradually adopting the broccoli cultivation. To get higher head yield the farmers are indiscriminately using the straight fertilizers without addition of sufficient quantities of organic manures. Alarmed with declined soil health and chemicalization of modern day crop production renewed emphasis is given on liberal application of organic manures along with chemical fertilizers for optimum crop growth and sustainable soil health. Traditionally cow dung is used as organic manure, which has become scared due to sharp reduction in livestock population and diverse domestic use. Vermi-compost is gradually gaining popularity as an alternate source of organic manure in vegetable production. Vermi-compost is the product of ingested biomass by earthworm after undergoing physical, chemical and microbial transformations and available in the form of cast. Besides macro and micronutrients it also contains humic acids, plant growth promoting substances like auxins, gibberellins and cytokinins (Lazcanoa and Dominguezb, 2011; Trevisan et al., 2010), N-fixing and P-solubilizing bacteria, enzymes and vitamins (Ismail, 1997), which increases the availability of essential plant nutrients in plants (Dominguez et al., 2010). Sometimes it exhibited similar effects as of inorganic fertilizers on different growth and yield attributes of plants (Gopinath et al., 2008). Research works suggested that vermi-compost in combination with inorganic fertilizers influenced the growth, yield and nutritional quality in cabbage (Zhenyu and Yongliang 2012; Ghuje et al., 2007), chinese cabbage (Wang et al., 2010) and lettuce (Coria-Cayupan et al., 2009). However information regarding the optimum dose as well as the interaction effect in combination with inorganic fertilizers on growth, yield and quality attributes of broccoli are scanty under moist humid climate of eastern Himalayan region. Keeping in view the tremendous potential of broccoli the present study was formulated to evaluate the impact of vermi-compost and inorganic fertilizers on broccoli growth and yield under eastern Himalayan region.

2. Materials and Methods

The field experiment was conducted at the Instructional Farm of UBKV, Pundibari, Coochbehar, West Bengal, India during winter season (November to February) of 2010-11 and 2011-2012 (consecutive two years). The site is located at 89°23′53″ E longitude and 26°19′86″ N latitude and at 43 m above mean sea level. The soil was sandy loam (63%, 22% and 19% sand, silt and clay respectively) in texture and slight acidic in reaction (pH 5.78). The initial soil organic carbon was 0.82% and available N, P and K contents were 172.12, 20.11 and 122.80 kg ha^{-1} respectively. Five levels of vermi-compost (0, 2.5, 5, 7.5 and 10 t ha^{-1}) and four inorganic fertilizers levels (0, 50, 75 and 100% of recommended dose) thus 20 treatment combinations (Table 1) were laid out in two factor factorial Randomized Block Design with three replications. Broccoli seedlings of the cultivar Nok Guk were transplanted on 4th November for both the years in 4.2×3.6 m^2 plots with both ways spacing of 60 cm. Vermi-compost (N:P:K-1.88:0.63:0.96 on % dry weight) was applied to the respective plots at the time of transplanting. The recommended doses of inorganic fertilizers (120 kg N, 60 kg P and 60 kg K ha^{-1}) were applied in the form of urea (N-46%), single super phosphate (P-16%) and muriate of potash (K-60%). Full dose of P and K along with half N were applied as basal and rest N was top dressed in two equal splits at 30 and 45 days after transplanting. The crop was raised adopting standard cultural practices. The observation were recorded for plant height (cm), number of leaves plant^{-1}, days to central head formation and maturity, central head weight (g), number of secondary heads plant^{-1}, secondary head weight (g), total yield (g plant^{-1} and t ha^{-1}) and economics of production. The chlorophyll content of the head was measured by portable chlorophyll meter (SPAD 502; Minolta, Japan). The ascorbic acid content was determined titrimetrically, using 2, 6 dichlorophenol indophenol dye as per method suggested by Ranganna (1986). Two years data collected on various parameters were pooled and statistically analyzed as per method suggested by Panse and Sukhatme (2000).

3. Results and Discussion

3.1. Effect of vermi-compost

Soil amended with vermi-compost showed significant effect on growth and yield characters of sprouting broccoli over unamended plots (Table 1). Successive increase in vermi-compost levels significantly increased the plant height and number of leaves while reducing the days for central head formation and maturity. The maximum central head weight (411.56 g), secondary head yield (184.04 g) and subsequently greatest total head yield (595.11g) was registered by the plants grown with highest level of vermi-compost (10 t ha^{-1}). Application of vermi-compost had distinctly improved the number of secondary heads and secondary head yield which in turn increased the total head yield. The result revealed that vermi-compost amended plot (10 t ha^{-1}) produced 38% greater

Table 1: Effect of vermi-compost and inorganic fertilizers on growth and yield of broccoli

Treatment	Plant height (cm)	No. of leaves plant^{-1}	Days to central head formation	Days to central head maturity	Central head weight (g)	No. of secondary head	Secondary head yield (g) plant^{-1}	Total yield(g) plant^{-1}	Total yield t ha^{-1}
Vermi-compost level									
V_0	40.29	11.15	61.29	83.38	256.25	1.74	84.33	340.58	6.76
V_1	42.49	12.39	59.90	80.77	323.48	2.14	108.81	432.29	8.27
V_2	45.44	13.75	58.18	78.47	362.88	2.65	142.74	505.62	9.53
V_3	48.25	14.76	56.60	75.56	402.66	3.05	166.74	569.40	11.30
V_4	50.79	16.65	55.41	73.88	411.56	3.32	184.04	595.60	12.66
SEm±	0.43	0.25	0.35	0.38	0.58	0.07	0.54	1.91	0.08
CD (*p*=0.05)	1.12	0.71	0.99	1.08	1.63	0.20	1.51	5.37	0.23
Recommended fertilizers dose									
F_0	41.49	12.04	60.62	82.06	282.58	1.83	99.06	381.64	7.74
F_1	43.96	12.96	59.10	79.29	328.32	2.49	132.00	460.32	9.09
F_2	46.76	14.39	57.35	76.97	379.99	2.74	148.54	528.53	10.49
F_3	49.60	15.58	56.03	75.32	414.57	3.25	169.73	584.30	11.49
SEm±	0.38	0.23	0.31	0.34	0.52	0.06	0.48	1.21	0.07
CD (*p*=0.05)	1.07	0.64	0.88	0.96	1.45	0.17	1.35	3.39	0.21

V_0: No vermi-compost; V_1: Vermi-compost (2.5 t ha^{-1}); V_2: Vermi-compost (5 t ha^{-1}); V_3: Vermi-compost (7.5 t ha^{-1});V_4: Vermi-compost (10 t ha^{-1}); F_0: Control (0% RDF); F_1: 50% RDF; F_2: 75% RDF; F_3: 100% RDF

central head weight and 43% higher total head yield over the control. Vermi-compost levels also showed a marked effect on the quality attributes of broccoli. The chlorophyll content and ascorbic acid content of head (Table 3) were progressively increased with the increasing level of vermi-compost. The increase in growth and yield attributes with highest level of vermi-compost may be due to better uptake and assimilation of essential elements (Atiyeh et al., 2002). Vermi-compost contains a well balanced composition of nutrients. Again the humic acid and humic substances of vermi-compost might have enhanced the soil physical condition and favoured the growth of soil micro flora and helped in solubilizing the reserved mineral substances which subsequently resulted in greater uptake of plant nutrients and make them available throughout the growth period of the plant (Chatterjee et al., 2006).

3.2. Effect of inorganic fertilizers

A perusal data indicated that increasing levels of inorganic fertilizers significantly influenced the growth and yield attributes of broccoli (Table 1). Plants received 100% recommended fertilizers had maximum plant height (49.60 cm) and number of leaves (15.58) as well as minimum days for central head formation (56.03) and maturity (75.32). The same treatment not only improved the growth attributes but also increased the central head weight (414.57 g), secondary head yield (169.73 g plant^{-1}) and finally total yield (582.34 g plant^{-1}). The chlorophyll content and ascorbic acid content of head (Table 3) also showed positive effect and increased with the increasing level of inorganic fertilizers. The maximum values were observed for the 100% recommended fertilizers containing treatment. The enhancement of head weight, head yield and quality attributes with higher doses of inorganic fertilizers could be attributed to greater movement and availability of essential nutrients for better development of head resulted in higher head weight and finally led to highest total yield.

3.3. Effect of interaction of vermi-compost and inorganic fertilizers

The result indicated a significant interaction between vermi-compost and inorganic fertilizers for the growth and yield attributes of sprouting broccoli (Table 2). The highest amount of vermi-compost (10 t ha^{-1}) in combination with 100% of recommended inorganic fertilizers had recorded the maximum

Table 2: Effect of interaction of vermi-compost and inorganic fertilizers on growth and yield of broccoli

Treatment*	Plant height (cm)	Leaves no. Plant^{-1}	Days to central head formation	Days to central head maturity	Central head weight (g)	No. of secondary head	Secondary head yield (g) plant^{-1}	Total yield (g) plant^{-1}	Total yield t ha^{-1}
$V_0 F_0$	36.38	9.17	63.94	86.18	157.78	1.13	61.22	219.00	4.92
$V_1 F_0$	39.55	11.05	61.93	83.97	245.31	1.31	76.67	321.98	6.81
$V_2 F_0$	41.86	11.95	60.30	82.43	295.42	1.88	94.77	390.19	7.68
$V_3 F_0$	43.83	12.98	59.12	79.75	341.99	2.37	125.22	467.21	8.92
$V_4 F_0$	45.83	15.07	57.81	77.99	372.42	2.48	137.43	509.85	10.38
$V_0 F_1$	39.30	10.70	61.89	84.35	218.27	1.64	80.12	298.39	6.32
$V_1 F_1$	40.84	11.32	60.33	81.72	314.79	1.98	100.23	415.02	7.57
$V_2 F_1$	43.94	12.83	58.97	79.21	348.32	2.64	144.66	492.98	9.12
$V_3 F_1$	46.32	13.76	57.68	76.30	372.42	2.93	160.73	533.15	10.48
$V_4 F_1$	49.42	16.17	56.64	74.89	387.83	3.29	174.27	562.10	11.97
$V_0 F_2$	41.31	12.01	60.36	82.17	311.29	1.99	91.25	402.54	7.41
$V_1 F_2$	43.25	13.12	59.23	79.65	353.93	2.49	119.76	473.69	8.82
$V_2 F_2$	46.63	14.48	57.31	76.94	384.12	2.82	158.73	542.85	10.27
$V_3 F_2$	50.06	15.32	55.44	73.78	421.36	3.13	180.22	601.58	12.38
$V_4 F_2$	52.55	17.01	54.41	72.33	429.26	3.29	192.74	622.00	12.56
$V_0 F_3$	44.18	12.74	58.97	80.84	337.65	2.22	104.73	442.38	8.40
$V_1 F_3$	46.34	14.09	58.11	77.75	379.91	2.77	138.57	518.48	9.86
$V_2 F_3$	49.33	15.72	56.13	75.30	423.68	3.26	172.82	596.50	11.03
$V_3 F_3$	52.79	16.97	54.18	72.41	474.86	3.79	200.80	675.66	13.41
$V_4 F_3$	55.36	18.38	52.80	70.33	456.74	4.21	231.72	688.46	14.73
SEm±	0.85	0.51	0.70	0.76	1.15	0.14	1.07	3.81	0.16
CD (p=0.05)	2.39	1.42	1.97	2.15	3.25	0.39	3.03	10.73	0.46

*Treatment details are given in Table 1

plant height (55.36 cm), early initiation of central head (52.80 days) and earliest maturity of central head (70.33 days). Earliness in head formation and maturity in vermi-compost (10 t ha^{-1}) and 100% of inorganic fertilizers loaded treatment could be attributed to enhanced vegetative growth coupled with adequate reserved food material which facilitated early differentiation of vegetative buds and results in advance head formation and subsequently early maturity of head (Chatterjee, 2009). The central head weight was found highest (474.86 g) for the plants received 7.5 t ha^{-1} vermi-compost and 100% of inorganic fertilizers. However owing to higher secondary head number and secondary head yield the maximum total head yield (686.65 g $plant^{-1}$) was found for the highest level of vermi-compost and inorganic fertilizers. The combined application of optimum levels of inorganic fertilizers and higher vermi-compost in deficient soil might have improved the physicochemical and biological characteristics of the growth medium and increased the concentration of essential nutrients in soil solution resulted in steady uptake of major nutrients, sturdy plant growth and improvement of head weight and total yield. While at control, treatment plants remain stunted for the want of other essential nutrients including micronutrients resulting in lowest head weight and yield. Increased head yield with the balance application of inorganic fertilizers and vermi-compost was previously reported by Sharma et al., (2012) in broccoli and Zhenyu and Yongliang (2012) in cabbage. The findings further showed that performance of inorganic fertilizers was also influenced by the levels of vermi-compost.

Table 3: Effect of vermi-compost and inorganic fertilizers on quality attributes of broccoli

Treatment*	Head chlorophyll content (SPAD 502 value)	Ascorbic acid content (mg 100 g fresh $head^{-1}$)
Vermi-compost level		
V_0	29.02	51.43
V_1	36.22	59.42
V_2	40.76	63.06
V_3	45.23	67.80
V_4	49.05	70.48
SEm±	0.32	0.31
CD (*p*=0.05)	0.90	0.88
Recommended fertilizers dose		
F_0	31.02	51.77
F_1	38.98	62.29
F_2	43.78	66.14
F_3	46.43	69.56
SEm±	0.29	0.28
CD (*p*=0.05)	0.81	0.79

*Treatment details are given in Table 1

In case of 75% recommended fertilizers in presence of 10 t ha^{-1} vermi-compost (V_4F_2) resulted in 66% more head yield $plant^{-1}$ over the control, whereas 100% recommended fertilizers in presence of 10 t ha^{-1} vermi-compost (V_4F_3) resulted in 69% improvement in head yield $plant^{-1}$ over the control. Presence of vermi-compost had pronounced the efficiency of the inorganic fertilizers and better inorganic nutrient utilization may be due to quick decomposition of organic substances results more supply of N, P, K and micro nutrients to the crop that enhanced plant growth, results in higher metabolic activities and higher carbohydrate synthesis and ultimately resulted in higher yield (Barani and Anburani, 2004). Improvement of bulb yield in onion with the combination with vermi-compost and inorganic fertilizers was earlier reported by Mandal et al., (2013). The quality attributes of broccoli head were also influenced significantly in presence of vermi-compost and inorganic fertilizers. The chlorophyll content of head was increased with the increasing levels of both the nutrient sources (Figure 1). The highest chlorophyll content of head (53.67 SPAD 502 value) was recorded for the plants received highest amount of vermi-compost (10 t ha^{-1}) and 100% recommended fertilizers. Increase in chlorophyll content by these heads might be due to stimulation of chlorophyll synthesis by the combined effect of highest vermi-compost level and 100% chemical fertilizers. The ascorbic acid content of head also followed similar pattern (Figure 2) and the highest ascorbic acid 76.29 mg 100 g fresh $head^{-1}$) was recorded for the combined use of highest level of both sources of nutrients (V_4F_2). The increase in ascorbic acid content in the higher level of inorganic fertilizers and vermi-compost combination may be attributed to increased availability of nutrients in the soil that might lead to synthesis and accumulation of more photosynthetes which could have mobilized the biosynthesis of ascorbic acid. Improvement in ascorbic acid content with the application of higher amount of organic manures was reported earlier by Bahadur et al., (2003) in broccoli and Wang et al., (2010) in chinese cabbage.

3.4. Economics of production

The economics of broccoli production (Table 4) revealed that the gross return and net return of broccoli was influenced to a great extend by the combination of different nutrient sources. The highest amount of vermi-compost (10 t ha^{-1}) in combination with 100% of recommended inorganic fertilizers (V_4F_3) recorded the maximum gross return (₹ 220875 ha^{-1}) and net return (₹ 166256 ha^{-1}). The treatment comprising of 7.5 t ha^{-1} vermi-compost and 100% of recommended inorganic fertilizers (V_3F_3) although recorded second highest net return (₹ 152156 ha^{-1}) but showed the maximum benefit cost ratio (3.11) followed by V_4F_3 (3.04). The higher benefit cost ratio by the treatment V_3F_3 may be due to reduction in total cost of production due lower amount of vermi-compost used.

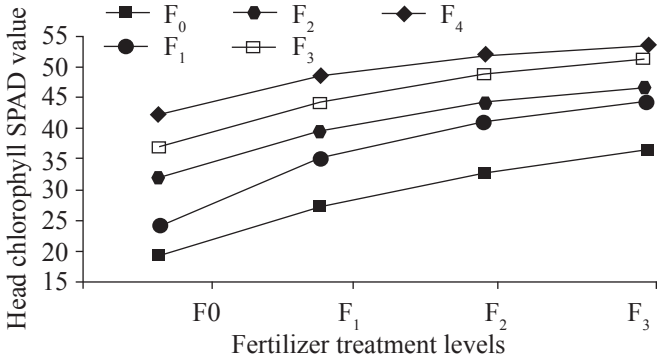

Figure 1: Effect vermi-compost and inorganic fertilizers on head chlorophyll of broccoli

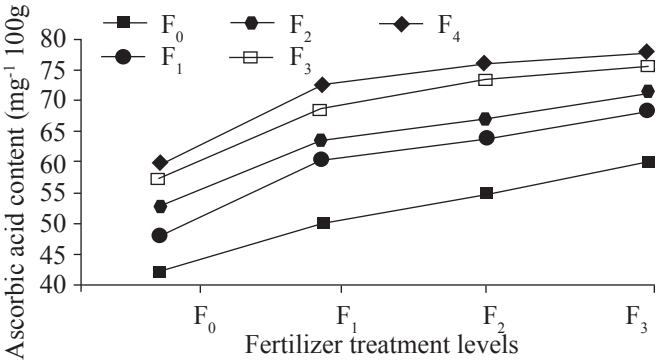

Figure 2: Effect of vermi-compost and inorganic fertilizers on ascorbic acid content of broccoli head

Table 4: Effect of vermi-compost and inorganic fertilizers on economics of broccoli cultivation

Treatment*	Head yield (t ha^{-1})	Gross return (₹)*	Treatment cost (₹)			Net return (₹)	Benefit : cost ratio
			Fixed cost	Variable cost	Total cost		
$V_0 F_0$	4.92	73800	29784	0	29784	44016	1.48
$V_1 F_0$	6.81	102150	29784	6024	35808	66342	1.85
$V_2 F_0$	7.68	115200	29784	11915	41699	73501	1.76
$V_3 F_0$	8.92	133800	29784	17806	47590	86210	1.81
$V_4 F_0$	10.38	155700	29784	23697	53481	102219	1.91
$V_0 F_1$	6.32	94800	29784	1505	31289	63511	2.03
$V_1 F_1$	7.57	113550	29784	7130	36914	76636	2.08
$V_2 F_1$	9.12	136800	29784	12755	42539	94261	2.22
$V_3 F_1$	10.48	157125	29784	18380	48164	108961	2.26
$V_4 F_1$	11.97	179550	29784	24005	53789	125761	2.34
$V_0 F_2$	7.41	111150	29784	2191	31975	79175	2.48
$V_1 F_2$	8.82	132300	29784	7550	37334	94966	2.54
$V_2 F_2$	10.27	154050	29784	13175	42959	111091	2.59
$V_3 F_2$	12.03	180450	29784	18800	48584	131866	2.71
$V_4 F_2$	12.56	188400	29784	24425	54209	134191	2.48
$V_0 F_3$	8.40	126000	29784	2611	32395	93605	2.89
$V_1 F_3$	9.86	147900	29784	7960	37744	110156	2.92
$V_2 F_3$	11.53	172950	29784	13585	43369	129581	2.99
$V_3 F_3$	13.41	201150	29784	19210	48994	152156	3.11
$V_4 F_3$	14.73	220875	29784	24835	54619	166256	3.04

*Treatment details are given in Table 1; *Sale price of broccoli head @ 15.00 kg ha^{-1} of fresh head; 1US$= 45.3494 and 49.055 (as on 7th February, 2011 and 2012, respectively)

5. Conclusion

Vermi-compost offers great potential as organic amendment and it can be used beneficially in combination with inorganic fertilizers for broccoli cultivation. Combined application of 10 t ha^{-1} vermi-compost and 100% recommended inorganic fertilizers proved its superiority in enhancing the growth, yield and quality attributes of broccoli. A judicious integration of vermi-compost and recommended inorganic fertilizers seems to be appropriate for sustainable production of sprouting broccoli under eastern Himalayan region.

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