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Research Article

Effect of Different Organic Amendments on Growth, Yield and Quality of Broccoli (*Brassica oleracea* var. italica)

Rajkumari Asha Devi, Rupmalin Kropi, Avinash Kumar*, Tanuj Thakur, and Ankita

School of Agriculture, Lovely Professional University, Phagwara, Punjab, India

Abstract: To study the effect of different organic amendments on growth, yield and quality of broccoli a field experiment was conducted during 2021–2022 in the Agriculture Research Farm, Lovely Professional University, Punjab A Factorial Randomized Block Design (FRBD) with two factors was used. Factors 1 and 2 are varieties (V1: Palam Vichitra and V2: Palam Kanchan) and biofertilizers (T1: Phosphate Solubilizing Bacteria @ 2 % + Azotobacter @ 2 %, T2: Phosphate solubilizing @ 2 %, T3: Azotobacter @ 2 %, and T0: Control). A total of eight treatments were used, i.e., T1V1 (Palam Vichitra X Phosphate Solubilizing Bacteria @ 2 % + Azotobacter @ 2 %), T2V1 (Palam Vichitra X P.S.B @ 2 %), T3V1 (Palam Vichitra X Azotobacter @ 2 %), T0V1 (Palam Vichitra X Control), T1V1 (Palam Vichitra X Phosphate Solubilizing Bacteria @ 2% + Azotobacter @ 2 %), T0V1 (Palam Kanchan X Phosphate solubilizing bacteria @ 2 %), T3V2 (Palam Kanchan X Azotobacter @ 2 %), T0V2 (Palam Kanchan X Control). The experiment reveals that among all treatments like growth, quality and yield parameters T1 showed the best result for V1 and in V2, T3 showed the best result for almost all the parameters. Floral bud initiation was early when treated with T1 in both the varieties, i.e., V1 (63 DAT) and V2 (63.67 DAT). Days to harvest were the same for all the treatments in V1 (90 DAT) and in V2, T1 (90 DAT) took the least amount of time for harvesting. It can be concluded that, combination of Azotobacter @ 2 % with other organic amendments and treatment T1 give higher yield and better quality of broccoli.

Keywords: Broccoli, Azotobacter, Phosphate Solubilizing Bacteria, Yield, Growth and Quality

1. INTRODUCTION

Broccoli is a very well-known cole crop for its high nutritive content. It is a winter-season vegetable crop and requires an optimum temperature of 20-25 °C for proper growth. People mainly consume broccoli, as it has antioxidant properties and prevents certain cancer types. It is consumed either cooked or as a salad form but given the widespread use of chemical pesticides and insecticides, when eaten as a salad, the nutrient content is depleted, and it is also dangerous to human health. The crop contains a chemical compound called Sulforaphane that reduces the risk of cancer [1]. It is rich in ascorbic acid, protein, iron, fibre, and potassium content, respectively.

Most cruciferous vegetables, including broccoli, contain glucosinolates, which prevent chronic diseases. Fresh broccoli leaves are high in vitamins, an effective natural antioxidant and immune modulator that aids in the fight against flu, causing viruses. Broccoli leaves contain a sufficient amount of other antioxidant vitamins, vitamin-A, which helps in maintaining the integrity of skin and mucus membranes which is also required for vision [2]. Broccoli is similar to cauliflower but the difference is its relatively small flower heads which are green or purple in colour. There is commonly two type of broccoli – heading and purple or green broccoli. Green broccoli has a bunch of green, immature buds and a thick fleshy flower stalk that forms a head, whereas heading broccoli produces curd-like cauliflower. The purple type of broccoli is usually grown in Europe and North America. The crop is originated from Asia Minor and Eastern Mediterranean region. The ancestor is *Brassica oleracea* var. sylvestris.

It is observed that the use of different

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*Corresponding Author: Avinash Kumar <kumaravinash.12345689@gmail.com>

chemical fertilizers decreases the beneficial nutritional contents of the crop, while organic manures reduce the health hazards and the level of chemical residues. In recent years, bio-fertilizers application is gaining popularity among farmers, and environmentalists. They help N_2-fixing or P mobilization but also produce several vitamins and plant growth hormones needed for plant growth and hence, can be used as a bio-control agent by inhibiting many harmful pathogens and microbes. Bio-fertilizers like Azotobacter fix the nitrogen while PSB as phosphorous solubilizer. Broccoli is introduced newly to India, but it is quickly gaining popularity due to its low-fat, low-calorie but high vitamin C content, and also it is a good source of calcium, vitamin A and vitamin B2 [3]. In view of the negative effects of inorganic fertilizer on broccoli's nutritional quality, this study was conducted to analyze the effect of different organic amendments on growth, yield, and quality.

2. MATERIALS AND METHODS

The Department of Vegetable Science, School of Agriculture, Lovely Professional University, Phagwara, is where the trial was carried out. The experiment was carried out in Factorial Randomized Block Design with two factors, factor 1 consists of varieties (V1: Palam Vichitra and V2: Palam Kanchan) and factor 2 consists of biofertilizers (T1: Phosphate Solubilising Bacteria @ 2 % + Azotobacter @ 2 %, T2: Phosphate solubilizing bacteria @ 2 %, T3: Azotobacter @ 2 % and T0: Control). 3 replications with a total of 8 treatment combinations were used. Spacing of 45 x 45cm was adopted and transplanting was done on the 11th of November, 2021. The total area was 184.26 m^2. Seeds were treated with Phosphate Solubilizing Bacteria @ 2 % + Azotobacter @ 2 %, Phosphate Solubilizing Bacteria @ 2 % and Azotobacter @ 2 %. After 30 DAT for insect management, a 2 L mixture of neem oil was applied on the leaves and after sometime go for nutrition management, 3 L of Panchagavya were applied at 45 days after transplanting (DAT). Observations on the number of leaves per plant DAT, plant spread (cm^2), plant height(cm), days to flower bud initiation DAT, days to harvesting, the weight of the floral bud (g), floral bud diameter (mm), chlorophyll index (SPAD value), dry matter content (%), vitamin C (mg/100 g) and TSS (°Bx) were recorded.

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

The growth parameter of broccoli was considered with regard to plant height (60 days after transplanting), Number of leaves per plant (60 days after transplanting), plant spread (N-S and E-W) (cm^2), floral bud initiation (DAT) and days to harvesting (DAT). As per Table 1, it is observed that T1 i.e. (Phosphate Solubilizing Bacteria @ 2 % + Azotobacter @2 %) showed the maximum plant height for both V1 (166.6 cm) and V2 (172.5) Number of leaves was found to be similar for all the treatments in V_1 i.e. (45 DAT) and also in V2 (46 DAT) Except for control, T0V1 (44.7 DAT) and T0V2 (46.7 DAT) [4]. It has been reported that an effective and healthy Azotobacter strain in the rhizosphere resulted in increased atmospheric nitrogen fixation to be used by the plant, resulting in strong plant development [5].

Plant spread (cm^2) was observed with the help of scale and statistical significance was found (Table 2). In plant spread (N-S) it is seen that V1 treated with T1 (60.95 cm^2) showed the highest plant spread and V2 treated with T3 (64.87 cm^2) showed the maximum plant spread. For plant spread (E-W) it is observed that the combination for T1V1 (57.4 cm^2) showed the maximum plant spread for V1 and the V2 combination for T3V2 (63.3 cm^2) showed the maximum plant height.

The level of significance is determined as shown in Table 3. It is observed that the application of T1 (63 days) and T3 (63 days) gave the shortest number of days for the initiation of floral bud in V1 and for V2 combination of T1V2 (63.67 days) gave the shortest number of days for the initiation of floral bud. Control treatment took the longest days for floral bud initiation in both the varieties T0V1 (63.33 days), and T0V2 (74.57 days). Days to harvesting were the same for all the treatments in V1 (90 days) and in V2, T1 (90 days) showed the least days to harvest followed by T2 (96.67 days). Early maturity from sowing might be due to the reason that appropriate balance in the levels of nitrogen and phosphorus maintained through the application of Azotobacter, PSB and FYM helps early maturity [6].

Table 1. Effect of different organic amendments on plant height and Number of leaves per plant in broccoli.

Varieties/ Treatments	Plant height (cm) at 60 DAT			Number of leaves 60 DAT		
	V_1	V_2	MEAN (Treatment)	V_1	V_2	MEAN (Treatment)
T1	166.6	172.5	169.55	45	46	45.5
T2	166.4	171.5	168.95	45	46	45.5
T3	166.2	172.1	169.15	45	46	45.5
T0	166	171.1	168.55	44.7	45.7	45.2
MEAN (Variety)	166.3	171.8		44.9	45.9	
	C.D.	**SE(d)**	**SE(m)**	**C.D.**	**SE(d)**	**SE(m)**
Treatment	1.247	0.576	0.407	0.306	0.141	0.100
Variety	1.764	0.814	0.576	0.432	0.200	0.141

Note: T_1: Phosphate Solubilizing Bacteria @2 % + Azotobacter @2 %. T_2: Phosphate Solubilizing Bacteria @2 %. T_3: Azotobacter 2 %. T_0: Control. V_1: Palam Vichitra V_2: Palam Kanchan.

Table 2. Effect of different organic amendments on plant spread (cm²) in broccoli (*Brassica oleracea* var. italica).

Varieties/ Treatments	Plant spread (N-S) (cm^2)			Plant spread (E-W) (cm^2)		
	V1	V2	MEAN (Treatment)	V1	V2	MEAN (Treatment)
T1	60.95	64.43	62.69	57.4	63.2	60.3
T2	60.85	64.29	62.57	56.8	62.2	59.5
T3	60.83	64.87	62.85	56.5	63.3	59.9
T0	59.83	63.58	61.84	56.2	60.8	58.5
MEAN (Variety)	60.6	64.3		56.7	62.4	
	C.D.	**SE(d)**	**SE(m)**	**C.D**	**SE(d)**	**SE(m)**
Treatment	0.809	0.374	0.264	1.311	0.605	0.428
Variety	1.144	0.528	0.374	1.854	0.856	0.605

Note: T_1: Phosphate Solubilizing Bacteria @2 % + Azotobacter @2 %. T_2: Phosphate Solubilizing Bacteria @2 %. T_3: Azotobacter 2 %. T_0: Control. V_1: Palam Vichitra V_2: Palam Kanchan.

3.2 Quality Parameters

Chlorophyll index was determined with the help SPAD meter by putting the SPAD meter in the leaves. As per Table 4, T_1 showed the best results in both V_1 (56.8) and V_2 (67.2) compared to the other treatments. In terms of interactions between treatments and varieties, $T1V_2$ had the highest Chlorophyll index (67.2), which was statistically significant as compared to the other interactions. These findings are very similar to those of Patidar *et al.* [7]. Variations were noted in the dry matter content samples, In V1, T1V1 (70.87 %) had the highest dry matter content amongst different interactions and in V2, T3V2 (72 %) recorded the highest dry matter content.

Table 3. Effect of different organic amendments on floral bud initiation (DAT) and days to harvesting (DAT) in broccoli (*Brassica oleracea* var. italica).

Varieties/ Treatments	Floral bud initiation (DAT)			Days to harvesting (DAT)		
	V1	V2	MEAN (Treatment)	V1	V2	MEAN (Treatment)
T1	63	63.67	63.34	90	90	90
T2	63.11	70.90	67.01	90	96.67	93.33
T3	63	74.44	68.72	90	100	95
T0	63.33	74.57	68.95	90	104.45	97.22
MEAN (Variety)	63.11	70.90		90	97.78	
	C.D.	**SE(d)**	**SE(m)**	**C.D**	**SE(d)**	**SE(m)**
Treatment	1.546	0.714	0.505	2.562	1.183	0.837
Variety	2.186	1.009	0.714	3.623	1.673	1.183

Note: T_1: Phosphate Solubilizing Bacteria @2 % + Azotobacter @2 %. T_2: Phosphate Solubilizing Bacteria @2 %. T_3: Azotobacter 2 %. T_0: Control. V_1: Palam Vichitra V_2: Palam Kanchan.

Floral buds were analyzed and recorded for vitamin C. According to Table 5, T1 showed the best results in both V1 (85.76 mg/100 g) and V2 (70.83 g/100 g) compared to the other treatments. After harvest, each sample's total soluble solids (TSS) were analyzed, and variations across treatments, and varieties, including their combinations were discovered. In V1, treating with T1 (39.7 °Bx) resulted in maximum TSS and in V2, (42 °Bx) combination of both T1V2 and T3V2 resulted in the highest TSS. The combined inoculation with Azotobacter + PSB was more helpful in improving all the above metrics due to increased solubility of phosphorus and higher nitrogen fixation, leading to increased availability of nitrogen and phosphorus [8].

Table 4. Effect of different organic amendments on chlorophyll index (SPAD value) and dry matter content (%) in broccoli.

Varieties/ Treatments	Chlorophyll index (SPAD value)			dry matter content (%)		
	V1	V2	MEAN (Treatment)	V1	V2	MEAN (Treatment)
T1	56.8	67.2	62	70.87	71.767	71.317
T2	56.6	66.6	61.9	70.70	71.433	71.067
T3	56.1	67	61.55	70.57	72.000	71.283
T0	55.87	64.1	59.98	70.47	70.033	70.25
MEAN (Variety)	56.34	66.3		70.65	71.308	
	C.D.	**SE(d)**	**SE(m)**	**C.D**	**SE(d)**	**SE(m)**
Treatment	2.047	0.945	0.668	0.412	0.190	0.135
Variety	2.895	1.337	0.945	0.583	0.269	0.190

Note: T1: Phosphate Solubilizing Bacteria @2 % + Azotobacter @2 %. T2: Phosphate Solubilizing Bacteria @2 %. T3: Azotobacter 2 %. T0: Control. V1: Palam Vichitra V2: Palam Kanchan.

Table 5. Effect of different organic amendments on Vitamin-C (mg/100 g) content and TSS (°Bx) in broccoli.

Varieties/ Treatments	Ascorbic acid (mg/100 g)			TSS (°Bx)		
	V1	V2	MEAN (Treatment)	V1	V2	MEAN (Treatment)
T1	85.76	70.83	78.3	39.7	42	40.85
T2	85.42	70.68	78.05	39	41	40.15
T3	85.46	70.71	78.1	39	42	40.4
T0	84.8	70.52	77.66	37	41	39
MEAN (Variety)	85.35	70.69		38.8	41.5	
	C.D.	**SE(d)**	**SE(m)**	**C.D**	**SE(d)**	**SE(m)**
Treatment	2.551	1.178	0.833	0.865	0.400	0.283
Variety	3.607	1.666	1.178	1.224	0.565	0.400

Note: T_1: Phosphate Solubilizing Bacteria @2 % + Azotobacter @2 %. T_2: Phosphate Solubilizing Bacteria @2 %. T_3: Azotobacter 2 %. T0: Control. V_1: Palam Vichitra V_2: Palam Kanchan.

3.3 Yield Parameters

According to Table 6 Fresh weight of the floral bud for V1 was shown to be better when treated with T1 (663.0 g) and we can observe that in V2 treated with T3 (974.2 g) showing the maximum fresh weight of floral bud T0 showed the lowest Fresh weight of floral bud in both varieties V1T0 (646.2 g) and V2T0 (819.7 g). Floral bud diameter was observed at the time of harvesting V_1, T1(49.06 mm) recorded the highest floral bud diameter and T_0 (47.98 mm) recorded the lowest floral bud diameter and in V_2, T_3 (57.83 mm) showed the highest floral bud diameter whereas, T_0 (57.15 mm) showed lowest floral bub diameter. Different combinations of Nitrogen doses applied directly and Azotobacter inoculated in the seedlings yielded meaningful outcomes for nearly all growth and yield attributes [9].

Table 6. Effect of different organic amendments on Fresh weight of floral bud (g) and floral bud diameter (mm) in broccoli (*Brassica oleracea* var. italica).

Varieties/ Treatments	Fresh weight of floral bud			Floral bud diameter		
	V1	V2	MEAN (Treatment)	V1	V2	MEAN (Treatment)
T1	663.0	954.6	808.8	49.06	57.78	53.42
T2	655.7	895.6	775.65	48.3	57.32	52.81
T3	656.53	974.2	815.36	48.07	57.83	52.95
T0	646.2	819.7	732.95	47.98	57.15	52.565
MEAN (Variety)	655.4	911.0		48.35	57.52	
	C.D.	**SE(d)**	**SE(m)**	**C.D**	**SE(d)**	**SE(m)**
Treatment	61.845	28.558	20.194	1.747	0.807	0.570
Variety	87.461	40.387	28.558	2.470	1.141	0.807

Note: T_1: Phosphate Solubilising Bacteria @2 % + Azotobacter @2 %. T_2: Phosphate Solubilising Bacteria @2 %. T_3: Azotobacter 2 %. T_0: Control. V_1: Palam Vichitra V_2: Palam Kanchan.

4. CONCLUSION

It can be concluded from this experiment that, in the province of Punjab use of Azotobacter @ 2 % in combination with some other organic amendments such as FYM, vermicomposting, neem oil, and Panchagavya give higher yield and better quality and treatment T1 (P.S.B @ 2 % + azotobacter @ 2 %) generated better outcomes in Palam Vichitra. For getting continuous yield Palam Kanchan can be grown, which can compensate for the high perishability problem in broccoli broccoli (Brassica oleracea var. italica).

5. CONFLICT OF INTEREST

The authors declared no conflict of interest

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