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Efficient Utilization of Paddy Straw and Sugarcane Bagasse through Vermicomposting and its Impact on Growth, Yield and Quality of Broccoli [*Brassica oleracea* (var.) *italica*]

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ABSTRACT

Background: Broccoli [*Brassica oleracea* (var.) *italica*] is a cool season vegetable of family cruciferous, known as harigobi in Hindi. In modern agriculture, high doses of chemical fertilizers are used to maximize the crop production. Plenty of chemical fertilizers along with a small quantity of organic ones are being used to increase the yield which ultimately affects the health of soil. Due to excess use of chemical fertilizers a decline pattern is observed in soil fertility, therefore integrated nutrient management is an important demand of present era. Vermicompost application is an important forthcoming addition in this venture.

Methods: The research material comprised of seven treatments with three replications. Treatments included FYM (T1), Chemical fertilizer (T2), Paddy straw vermicompost (T3), Sugarcane bagasse vermicompost (T4), Paddy straw+Sugarcane bagasse vermicompost (T5), Vermicompost+Vermiwash (T6) and control (T7). The experiment was conducted considering the growth and yield parameters along with quality parameters.

Result: The results indicated that application of treatment T5 vermicompost was found to be the best treatment combination in terms of quality of broccoli. Thus, the study indicates that the vermicompost can be utilized effectively for sustainable crop production.

Key words: Broccoli, Fertilizer, Growth, Vermicompost, Quality, Yield.

INTRODUCTION

Broccoli is a cool season vegetable of family cruciferous, commonly known as harigobi in Hindi. It is either consumed raw as salad or cooked to prepare curries, soup and pickles. It is also known as “Crown of jewel nutrition” because it is rich in vitamins, proteins and minerals (Meena *et al.* 2017). Broccoli is of two types, heading and sprouting, sprouting broccoli is more popular in India. It was a rare cole crop in India but now gaining popularity in metropolitan’s cities, reputed hotels and restaurants (Maurya *et al.* 2008). Broccoli possesses both antioxidant and anticarcinogenic properties and reduces the risk of prostate cancer by 45% (Nurhidayati *et al.* 2017; Singh *et al.* 2018). In modern agriculture, high doses of chemical fertilizers are used to maximize crop production. Plenty of chemical fertilizers along with small quantity of organic ones are being used to increase the yield which ultimately affects the health of soil as well as human (Meena *et al.* 2017). Due to excess use of chemical fertilizers a decline pattern is observed in soil fertility, therefore integrated nutrient management is an important demand of present era (Attigah *et al.* 2013). Vermicompost application is an important forthcoming addition in this venture. It maintains soil fertility and productivity. Organic manure plays a direct role in plant growth as a source of all necessary macro and micronutrient in available forms during mineralization and improving physical and chemical properties of soils (Chaterjee *et al.* 2005). Therefore, utilization of locally produced manures by vegetable production operations may increase crop yield with less use of chemical fertilizer. Hence, there is a need to substitute the inorganic nutrient requirements with organic nutrient sources to enhance the production of plant with lower content of anti-nutritional factors.

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MATERIALS AND METHODS

An investigation was carried out to study the effect of vermicompost on growth, yield and quality of broccoli at Vegetable seed production farm, Department of Vegetable Science, Punjab Agricultural University, Ludhiana, India, during season 2016-17 and 2017-18. Broccoli was grown in earthen pots of size 12 inches and later harvested for growth, yield and quality attributes. The treatments consisted the use of Farmyard manure in 50:50 ratio (T1), Chemical fertilizer N(50):P(25):K(25) (T2), Paddy straw vermicompost

in 50:50 ratio (T3), Sugarcane bagasse vermicompost in 50:50 ratio (T4), Paddy straw+ Sugarcane bagasse vermicompost in 50:50 ratio (T5), Vermicompost+Vermiwash in 50:50+1:10 ratio respectively (T6) and Control (soil) (T7). Each treatment was replicated three times. Various growth parameters such as plant height, leaf size, head size, number of auxiliary sprouts and yield parameters as gram per plant along with the qualitative analysis such as dry matter content, iron content, carotene content, total minerals, ascorbic acid and total glucosinolates were studied. Analysis of variance (2-way ANOVA) with randomized block design (RBD) was used for the statistical interpretation of the results.

RESULTS AND DISCUSSION

Growth parameters

Plant height (cm) was recorded at 30, 60 and 90 days after transplanting (DAT) and at harvest only while other parameters were recorded at the harvest only.

Table (1) indicates that the maximum height of plant was observed in treatment T2 *i.e.* 26.67 cm, 39.00 cm and 47.33 cm followed by treatment T5 *i.e.* 26.05 cm, 37.15 cm and 46.03 cm at 30, 60 and 90 (DAT) and at harvest whereas the least plant height values were noted in treatment T7 *i.e.* 20.53 cm, 30.27 cm and 38.28 cm. The increase in the plant height due to application of chemical fertilizer can be attributed to enhanced photosynthesis which resulted in more production of photosynthates and ultimately increases the plant height (Neethu *et al.* 2015; Dhakal *et al.* 2016; Singh *et al.* 2015; Singh *et al.* 2018).

The maximum increase in the leaf size was observed in T2 (361.56 cm^2) followed by treatment T5 (360.78cm^2), T4 (360.03 cm^2), T3 (354.01 cm^2), T6 (347.78 cm^2), T1 (320.76 cm^2) and T7 (314.53 cm^2) (Table 2). The present increase in the mean leaf size might be due to the application of organic fertilizer. The present increase in the leaf size due to the application of chemical fertilizer causes more production of cytokinin in the roots which is carried to leaves resulting in more cell division. Due to increase in number of cells, leaf expansion takes place and as a result the size of leaf increases (El-Helaly, 2012; Neethu *et al.* 2015; Singh *et al.* 2015; Dhakal *et al.* 2016).

The findings of the present study indicated that the head size of broccoli significantly increased with the addition of chemical fertilizer. Maximum head size was obtained in the treatment T2 (15.11 cm) followed by treatment T5 (14.61 cm), treatment T4 (14.43 cm), T3 (13.74 cm), T6 (12.21 cm), T1 (10.70 cm) while the minimum head size was observed in T7 (9.53 cm) respectively (Table 2). Increment in the head diameter was due to the reason that application of chemical fertilizer significantly increased the growth parameters and produced more plant metabolites which showed an obvious increase in head size (Singh *et al.* 2015; Dhakal *et al.* 2016; Singh *et al.* 2018).

The maximum numbers of sprouts were observed in the treatment T2 (10.00) followed by the T5 (8.66), T4 (8.17), T3 (7.87), T6 (7.00), T1 (6.00) as compared to T7 (4.67) (Table 2). The enhancing effect of fertilizer on number of auxialiary sprouts is supported by the findings of Yoldas *et al.* (2008) and Giri *et al.* (2013). Increase in number of auxiliary sprouts is related to increase in photosynthesis which stimulates leaf area increment, photosynthates production, meristemic activity, reflecting on the production of more organs (sprouts).

The maximum yield gram per plant *i.e.* 289.99g was recorded in the treatment T2 followed by treatment T5 (288.31 g), treatment T4 (287.04 g), treatment T3 (281.35 g), treatment T6 (270.05 g) and treatment T1 (237.75 g) respectively (Table 3). However, the minimum yield gram per plant was recorded in treatment T7 *i.e.* 217.98 g. According to Quda and Mahadeen (2008) application of organic manures seemed to be less effective in increasing the yield than chemical fertilizers. The increase in yield attributes could be due to optimum vegetative growth of broccoli under application of chemical fertilizer which might assisted in more accumulation of nitrogen in the leaves, elevating the photosynthetic rate, resulting in more production of carbohydrates and thus increased the yield (Yoldas *et al.* 2008; El-Helaly, 2012; Neethu *et al.* 2015; Singh *et al.* 2015; Dhakal *et al.* 2016; Singh *et al.* 2018).

Table 1: Effect of vermicompost and vermiwash on height (cm) of Broccoli.

Treatments	Plant height (cm)								
	30 DAT			60 DAT			90 DAT		
	2016-17	2017-18	Mean	2016-17	2017-18	Mean	2016-17	2017-18	Mean
T1- FYM	21.17	22.37	22.27	31.13	32.03	31.58	39.23	40.00	39.62
T2- Chemical fertilizer	26.10	27.23	26.67	37.20	40.80	39.00	45.43	49.23	47.33
T3- Paddy straw Vermicompost	23.53	23.80	23.67	35.00	35.60	35.30	42.77	43.43	43.10
T4- Sugarcane bagasse Vermicompost	24.20	25.07	24.64	36.13	36.37	36.25	43.00	45.47	44.24
T5- Paddy straw+sugarcane bagasse Vermicompost	25.27	26.83	26.05	36.43	37.86	37.15	44.40	47.67	46.03
T6- Vermicompost +Vermiwash	22.27	22.37	22.32	33.27	34.00	33.63	41.73	40.97	41.35
T7- Control	20.47	20.60	20.53	30.13	30.40	30.27	38.80	37.77	38.28
LSD (p=0.05)	NS	NS	NS	NS	5.50	3.93	NS	4.52	3.51

(DAT-Days after transplanting).

Quality parameters

The data analysis revealed that maximum dry matter (9.29%) was recorded in the treatment T5 which was statistically at par with the treatment T4 (9.09%) respectively. However, the dry matter of 8.69% was recorded in the treatment T3 followed by treatment T6 (7.96%), treatment T2 (7.88%) and treatment T1 (5.62%) whereas the minimum dry matter was noticed in the treatment T7 (4.62%) respectively (Table 4). The increase in dry matter weight could be due to more vegetative growth of plant. Application of vermicompost stimulates the leaf size, expansion in leaf size promotes the process of photosynthesis and accumulates more photosythates which in turn increases the dry matter content of plants (Singh *et al.* 2018). Similar finding has been reported by Azarmi *et al.* (2008) in tomato with increase in dry matter via application of vermicompost.

However, the results of the present study revealed that the carotene content were in the order PS+SBVC (14.60 mg/100g) > SBVC (14.01 mg/100g) > VCVW (13.04 mg/100g) > PSVC (13.02 mg/100g) > CF (10.89 mg/100 g) > FYM (10.25 mg/100 g) as compare to control (Table 4). The result is in consistence with the findings of Yadav *et al.* (2016); Mauriya *et al.* (2018) and Singh *et al.* (2018).

In addition, the maximum ascorbic acid content (107.14 mg/100g) was recorded in the treatment T5 followed by the treatment T4 (106.06 mg/100 g), treatment T3 (102.96 mg/100 g), treatment T6 (101.25 mg/100 g), treatment T2 (100.15 mg/100 g) and treatment T1 (95.95 mg/100 g) respectively while the minimum ascorbic acid level of 94.16 mg/100 g was recorded in treatment T7 (Table 5). The increase in ascorbic acid content by the application of vermicompost may be attributed to increased availability of nutrients in the soil that might lead to synthesis and accumulation of more photosynthates which mobilized the biosynthesis of ascorbic acid (Mal *et al.* 2015). Dhakal *et al.* (2016) reported that the application of vermicompost and farm yard manure increases the ascorbic acid content in broccoli. The results are in consistence with the finding of Meena *et al.* (2017) who reported an increase in ascorbic acid content with the application of organic manures and biofertlizer on quality of broccoli.

Glucosinolates are known for their health benefits especially due to anticarcinogenic properties and therefore its higher content in broccoli is desirable. The present findings showed that vermicompost had significant effect on glucosinolates concentrations. The maximum total glucosinolate content (57.71 µmol/g) was noted with application of treatment T5 which was statistically at par with the treatment T4 (57.34 µmol/g). The application of the treatment T3 showed total glucosinolate content of 55.66 µmol/g followed by treatment T6 (54.17 µmol/g), treatment T2 (52.49 µmol/g), treatment T1 (49.95 µmol/g) and treatment T7 (47.46 µmol/g) respectively (Table 5). These results supported the findings of Naguib *et al.* (2012); Rosa and Rodrigues, (2001) who reported an increase in the total glucosinolates content with the application of organic fertilizer in broccoli.

Table 2: Effect of vermicompost and vermiwash on leaf size (cm^2), head size (cm) and no. of sprouts of Broccoli.

Treatments	Leaf size (cm^2)			Head size (cm)			No. of sprouts		
	2016-17	2017-18	Mean	2016-17	2017-18	Mean	2016-17	2017-18	Mean
T1- FYM	321.76	319.76	320.76	11.22	10.18	10.70	5.67	6.33	6.00
T2- Chemical fertilizer	360.86	362.27	361.56	14.90	15.31	15.11	10.66	9.33	10.00
T3- Paddy straw vermicompost	354.16	353.87	354.01	13.17	14.31	13.74	7.67	8.07	7.87
T4- Sugarcane bagasse vermicompost	359.86	360.20	360.03	13.92	14.95	14.43	8.33	8.00	8.17
T5- Paddy straw+sugarcane bagasse Vermicompost	360.53	361.03	360.78	14.10	15.11	14.61	8.67	8.66	8.66
T6- Vermicompost+vermiwash	348.16	346.80	347.48	12.07	12.34	12.21	7.33	6.66	7.00
T7- Control	315.26	313.80	314.53	10.18	8.88	9.53	5.33	4.00	4.67
LSD (p=0.05)				NS	3.72	2.36	3.03	2.14	1.84

Table 3: Effect of vermicompost and vermiwash on yield gram/plant of broccoli.

Treatments	Yield (g/plant)		
	2016-17	2017-18	Mean
T1- FYM	237.63	237.88	237.75
T2- Chemical fertilizer	288.59	291.39	289.99
T3- Paddy straw vermicompost	279.13	283.56	281.35
T4- Sugarcane bagasse vermicompost	268.87	287.21	287.04
T5- Paddy straw+sugarcane bagasse vermicompost	287.41	289.21	288.31
T6- Vermicompost+vermiwash	272.10	268.01	270.05
T7- Control	218.72	217.24	217.98
LSD (p=0.05)	11.49	11.82	7.60

Table 4: Effect of vermicompost and vermiwash on dry matter (%) and carotene content (mg/100 gm) of Broccoli.

Treatments	Dry matter %			Carotene content (mg/100 gm)		
	2016-17	2017-18	Mean	2016-17	2017-18	Mean
T1- FYM	6.03	5.20	5.62	11.10	9.39	10.25
T2- Chemical fertilizer	7.36	8.39	7.88	12.32	9.46	10.89
T3- Paddy straw vermicompost	8.10	9.28	8.69	13.50	12.53	13.02
T4- Sugarcane bagasse vermicompost	8.63	9.54	9.09	14.02	13.99	14.01
T5- Paddy straw+sugarcane bagasse vermicompost	8.77	9.82	9.29	14.14	15.05	14.60
T6- Vermicompost+vermiwash	7.79	8.13	7.96	13.03	13.04	13.04
T7- Control	5.45	3.78	4.62	10.19	8.10	9.15
LSD (p=0.05)	NS	1.94	1.48	NS	2.84	1.86

Table 5: Effect of vermicompost and vermiwash on ascorbic acid (mg/100 gm) and total glucosinolate content (µmol/g) of Broccoli.

Treatments	Ascorbic acid (mg/100 g)			Total glucosinolate content (µmol/g)		
	2016-17	2017-18	Mean	2016-17	2017-18	Mean
T1-FYM	95.92	96.03	95.98	49.59	50.31	49.95
T2-Chemical fertilizer	99.24	101.06	100.15	51.55	53.42	52.49
T3-Paddy straw vermicompost	102.58	103.35	102.96	55.18	56.13	55.66
T4-Sugarcane bagasse vermicompost	105.15	106.97	106.06	56.49	58.18	57.34
T5-Paddy straw+sugarcane vermicompost	106.07	108.20	107.14	56.89	58.53	57.71
T6-Vermicompost+vermiwash	100.36	102.13	101.25	53.32	55.01	54.17
T7-Control	95.34	92.97	94.16	48.65	46.27	47.46
LSD (p=0.05)	NS	NS	NS	NS	NS	NS

Thus, the present study revealed that the broccoli plants when grown in soil amended with vermicompost showed better results in terms of quality parameters. Variations in plant growth, yield and quality might be due to the availability of nutrients through application of inorganic fertilizers and organic manure enhances soil aggregation, aeration, water holding capacity (Arisha *et al* 2003, Devi *et al* 2003, Shapla *et al* 2014). Meena *et al* (2017) reported that the quality of broccoli crop improved with the effect of organic manures and bio fertilizer and noted the maximum ascorbic acid content (90.50 mg/100 g) in T8 (RDF25%+Vermicompost 50%+azotobacter 50%+azotobecter 25%). Effect of vermicompost and other organic fertilizers due to the better availability of soil nutrients improved the soil chemical and physical properties thereby producing healthy plants (Stewart *et al.* 2005; Ouda and Mahadeen (2008); Maurya *et al.* 2008 and Singh and Pandey, 2010). Thus, our results are in correlation with the findings of many researchers (Ahirwar and Hussain, 2015 in vegetable crops**;** Mal *et al.* 2015 on sprouting broccoli; Dhakal *et al.* 2016 on broccoli; Esakkaimmal *et al.* 2015 on *dolichous lab lab.*; Yadav *et al.* 2016 on broccoli; Mauriya *et al.* 2018 on broccoli; Meena *et al.* 2017 on okra; Singh *et al.* 2018 on [*Brassica oleracea* (var.) *italica*]. Moreover, broccoli prepared by the application of vermicompost is expected to be healthier compared to those prepared with chemical fertilizers.

CONCLUSION

The study revealed that the integration of chemical fertilizers had shown an enhancing effect on growth and yield of broccoli whereas the vermicompost enhanced the overall quality of broccoli. On the basis of results, it is concluded that the vermicompost prepared from the test substrates *viz.* paddy straw + sugarcane bagasse (PS+SB) revealed beneficial outcomes with improved effects on the quality attributes of Broccoli. Thus, the study indicates that the vermicompost can be utilized effectively for sustainable crop production.

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