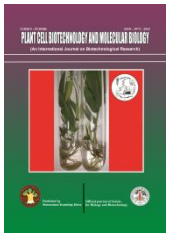

Plant Cell Biotechnology and Molecular Biology

Volume 25, Issue 5-6, Page 12-18, 2024; Article no.PCBMB.12078
ISSN: 0972-2025

Performance of Enriched Organic Manures on Head Quality, Yield, Nutrient Uptake and Economics of Sprouting Broccoli (*Brassica oleracea* Var. *italica*)

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Authors' contributions

This work was carried out in collaboration among all authors. Author SV designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author RC is the major guide and chairman of the advisory committee of the author SV. Authors SGM and ER managed the literature searches and helped in the data analysis. All authors read and approved the final manuscript.

Article Information

DOI: 10.56557/PCBMB/2024/v25i5-68676

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://prh.ikprress.org/review-history/12078

Original Research Article

Received: 25/02/2024
Accepted: 27/04/2024
Published: 02/05/2024

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ABSTRACT

The present field experiment was carried out to study the performance of enriched organic manures containing farmyard manure, vermicompost and poultry manure on head quality, nutrient uptake and economics of sprouting broccoli during 2018-19 and 2019-20 at UBKV, West Bengal, India, which comprised of 8 treatment combinations in randomized block design with 3 replications. The results of the field experiment showed that the use of *Azophos* biofertilizer enriched vermicompost @ 2.5 t/ha along with *Azophos* biofertilizer enriched poultry manure @ 2.5 t/ha as basal + top dressing of *Azophos* biofertilizer enriched vermicompost @ 0.5 t/ha along with *Azophos* biofertilizer enriched poultry manure @ 0.5 t/ha each (T_7) significantly improved the head yield (20.47 t/ha) and superior head quality in terms of the maximum TSS (8.14˚Brix), vitamin A (288.97 IU/100 g) and vitamin C (90.00 mg/100 g) of organic broccoli. The greatest benefit to cost ratio (1.93) was also obtained from the treatment T_7. Hence, the treatment T_7 can be recommended for sustainable production of organic sprouting broccoli under terai region of West Bengal.

Keywords: Azospirillum; biofertilizers; enriched organic manure; sprouting broccoli; yield.

1. INTRODUCTION

Sprouting broccoli is more nutritious cole group vegetable, belonging to the family Brassicaceae and has chromosome number 2n= 18 [1]. Broccoli contains 22 times more vitamin A than cabbage and 130 times more than cauliflower. It is also rich in vitamin B1, vitamin B2, vitamin C and minerals [2]. "The use of organic manures such as farmyard manure, vermicompost and poultry manure enhance the availability of nutrients resulting in good yields and better quality of produce" [3,4]. Apart from these organic manures, biofertilizers played vital role in maintaining sustainable soil health and quality [5,6]. Biofertilizers reduce the use of external inputs and increase the quantity and quality of vegetable crops [7,8]. They fulfill the gap between nutrient demand and supply [9]. *Azotobacter* spp. improve germination of seeds, plant vigor, thereby improving the crop plants. They can produce antifungal compounds that fight against plant pathogens [10]. Few research studies have also proved the role of *Azotobacter* in nitrogen fixation. *Azospirillum* spp. provides nutrients to the crop plants through supplementation with inorganic fertilizers [11,12,13]. The use of *Azotobacter* spp. and *Azospirillum* spp. have increased plant height, biomass yield, number of sprouts per head, number of slips per sprout and yield of sprouting broccoli plants [14]. Phosphate-solubilizing bacteria solubilizes both native and applied phosphorus and synthesizes vitamins and growth-promoting substances (auxin, IAA, GA, cytokinin) which improve the plant growth [15,16,17]. In addition, VAM (Vesicular Arbuscular Mycorrhizae) enhance the availability of copper and zinc to the plant parts [18].

The enrichment of organic manures with biofertilizers enhances the essential nutrient content, microbial load, enzymatic activity, decomposition and mineralization, which improve the availability of nutrients for a longer period. The use of farmyard manure and seed inoculation with biofertilizer (VAM) significantly improved the yield of broccoli [19]. Considering the demand for organic sprouting broccoli, there is an urgent need to standardize the nutrient management schedules for organic cultivation of broccoli. Therefore, an attempt was made to evaluate different enriched organic manures and examine their effects on the yield and quality of sprouting broccoli.

2. MATERIALS AND METHODS

The field experiment was carried out at Instructional Farm, Uttar Banga Krishi Viswavidyalaya, West Bengal, India (26°19' N latitude and 89°23′ E longitude at 43 m above MSL) during 2018-19 and 2019-20. The soil was sandy loamy with acidic pH, organic carbon content 0.76%, available N, P_2O_5 and K_2O contents were117.60, 14.98 and 104.26 kg/ha, respectively.

The field experiment consisted of eight treatments viz., T_1- farmyard manure @ 20 t/ha (basal) + farmyard manure @ 5 t/ha (top dressing) as control; T_2- enriched farmyard manure @ 20 t/ha (basal) + enriched farmyard manure @ 5 t/ha (top dressing); T_3- enriched vermicompost @ 5 t/ha (basal) + enriched vermicompost @ 1 t/ha (top dressing); T_4- enriched poultry manure @ 5 t/ha (basal) + enriched poultry manure @ 1 t/ha (top dressing); T_5- enriched farmyard manure @ 10 t/ha and enriched vermicompost @ 2.5 t/ha (basal) +

enriched farmyard manure @ 2.5 t/ha and enriched vermicompost @ 0.5 t/ha (top dressing); T_6- enriched farmyard manure @ 10 t/ha and enriched poultry manure @ 2.5 t/ha (basal) + enriched farmyard manure @ 2.5 t/ha and enriched poultry manure @ 0.5 t/ha (top dressing); T_7- enriched vermicompost @ 2.5 t/ha along with enriched poultry manure @ 2.5 t/ha (basal) + enriched vermicompost @ 0.5 t/ha along with enriched poultry manure @ 0.5 t/ha each (top dressing); T_8- enriched farmyard manure @ 7 t/ha, enriched poultry manure @ 2 t/ha and enriched vermicompost @ 2 t/ha (basal) + enriched farmyard manure @ 2 t/ha, enriched vermicompost @ 0.25 t/ha and enriched poultry manure @ 0.25 t/ha (top dressing), were laid out in Randomized Block Design which were replicated thrice.

Sprouting broccoli seedlings (var. Green Magic) were transplanted in 3 m × 3 m plots with a spacing of 60 cm × 60 cm during winter season for both the years. The organic manures were enriched by mixing well decomposed organic manures (farmyard manure, vermicompost and poultry manure) with *Azophos* containing *Azotobacter chroococcum* and phosphate-solubilizing bacteria (*Acinetobacter sp*.) with a standard microbial population (5×10^8) at 10g/ kg of organic manure and kept under shade for about 20 days before field application. The crop was raised by adopting standard cultural practices.

Five plants were randomly selected in each replication in each treatment and data were recorded with respect to yield and quality attributes and mean data were statistically analyzed with the help of OPSTAT statistical package [20]. Further, economics of different treatments was tested based on fixed and variable costs of different inputs used. The cost of cultivation was calculated as suggested by Sharma et al. [21]. The net return was worked out by subtracting the cost of cultivation from gross returns. The benefit: cost ratio under different treatments was calculated by dividing net return with total cost of cultivation.

3. RESULTS AND DISCUSSION

3.1 Yield and Quality Attributes of Sprouting Broccoli

The maximum head yield per plot was recorded in T_7 (23.03 kg), followed by T_4 (22.66 kg), and the minimum head yield per plot was observed in T_1 (18.93 kg). The average highest head yield per hectare was recorded in T_7 (20.47 t), followed by T_4 (20.15 t), and the lowest head yield per hectare from T_1 (16.83 t) is presented in Table 1 and Fig. 1. The greatest amount of head dry matter was recorded in T_3 (11.44%), followed by T_4 (10.89%) and T_7 (10.65%). The findings of the data presented in Table 2 and Fig. 1 showed significant effects of enriched organic manures on total soluble solids (TSS) content in broccoli. Among the treatments, the maximum TSS content was recorded in T_7 (8.14°Brix) and minimum was observed in T_1 (5.90°Brix). There was a significant effect of enriched organic manure on the vitamin- A content in broccoli heads. Among the treatments, T_7 had recorded the highest vitamin-A content (288.97 IU/100 g), and the lowest was observed in T_1 (189.67 IU/100 g). The vitamin-C content of broccoli heads was highest in the T_7 treatment (90.00 mg/100g) and the lowest was recorded in the T_1 treatment (66.01 mg/100 g).

The application of organic manures along with biofertilizers helped in root proliferation, which led to increased water and nutrient uptake, higher leaf area which might have increased the photosynthesis and accumulation of food in plants. Vermicompost and poultry manure has higher level of plant growth hormones, soil enzymes and greater microbial load, that led to hold nutrients over a longer period. With increasing plant growth and dry matter accumulation, plants develop better heads and ultimately have higher head yield. These results are in accordance with those of Sharma [22], Magd et al. [23], Bhardwaj et al. [24], Choudhary et al. [18], Mohapatra et al. [25] and Sarker et al. [26]. The increase in the TSS, vitamin-A and vitamin- C content of broccoli heads may have been due to the increase in soil microbial activity, which might have added vitamins, hormones and growth regulators to the soil and subsequently to the plants. These results are in accordance with those of Mohapatra et al. [25] for broccoli, Chatterjee et al. [27] for cabbage and Chatterjee et al. [28] for tomato.

3.2 Available N, P and K Content of Broccoli Field

It is clear from the data given in Table 3 and Fig. 1 that N, P, and K were significantly affected by different organic nutrient sources. Among the various treatments, T_7 (109.48 kg/ha) had the highest maximum nitrogen content. The highest available phosphorous and potassium contents were recorded in T_2 (26.11 kg/ha and 121.77 kg/ha, respectively).

The superior characteristics of available N, P and K content might be due to the ability of the growing organic nutrient sources to provide good aeration to plants to sustain the growth and development of roots and shoots. Enriched FYM, vermicompost and poultry manure resulted in maximum growth because of the favourable physico-chemical properties of the soil. Furthermore, the nutritional value of organic manures for supplying nitrogen, phosphorous and potassium in addition to micronutrients would favour better growth. The availability of N, P and K in the soil led to an increase in cell number and cell size [29].

Table 1. Effects of different organic nutrient sources on yield and yield attributes of broccoli

Treatments*	Head dry matter (%)	Head yield/ 9m^2 plot (kg)	Head yield/ hectare (ton)
T_1	7.17	18.93	16.83
T_2	8.12	19.68	17.49
T_3	11.44	22.29	19.81
T_4	10.89	22.66	20.15
T_5	10.50	20.31	18.05
T_6	8.30	20.67	18.38
T_7	10.65	23.03	20.47
T_8	9.74	21.65	19.24
S.Em.±	**0.44**	**0.36**	**0.32**
CD (0.05)	**1.50**	**1.24**	**1.10**

**Treatment details are in materials and methods*
S.Em. = standard error of mean; CD = critical difference

Table 2. Effects of different organic nutrient sources on quality of broccoli head

Treatments*	TSS (ºBrix)	Vitamin A (IU/100g)	Vitamin C (mg/100g)
T_1	5.90	189.67	66.01
T_2	6.20	196.02	69.59
T_3	7.87	244.32	81.95
T_4	8.02	249.64	86.05
T_5	6.42	206.98	71.34
T_6	6.81	221.38	77.16
T_7	8.14	288.97	90.00
T_8	7.49	227.17	79.31
S.Em.±	**0.08**	**1.19**	**0.66**
CD (0.05)	**0.25**	**4.04**	**2.24**

**Treatment details are in materials and methods*
S.Em. = standard error of mean; CD = critical difference

Table 3. Effects of different organic nutrient sources on residual nutrient status of broccoli field

Treatments*	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)
T_1	93.85	20.45	112.45
T_2	96.32	26.11	121.77
T_3	105.98	22.59	116.50
T_4	107.16	19.74	109.97
T_5	96.80	25.39	120.09
T_6	102.09	24.36	119.01
T_7	109.48	21.57	114.01
T_8	105.25	23.59	117.99
S.Em.±	**2.19**	**0.20**	**0.40**
CD (0.05)	**0.63**	**0.67**	**1.35**

**Treatment details are in materials and methods*
S.Em. = standard error of mean; CD = critical difference

Table 4. Effects of different organic nutrient sources on economics of broccoli cultivation

Treatments*	Head yield (t/ha)	Cost of cultivation (Rs.)	Gross return (Rs.)	Net return (Rs.)	Benefit: cost ratio
T_1	16.83	80300	218785	138485	1.72
T_2	17.49	85800	227413	141613	1.65
T_3	19.81	90800	257516	166716	1.84
T_4	20.15	90800	261895	171095	1.88
T_5	18.05	88300	234636	146336	1.66
T_6	18.38	88300	238892	150592	1.71
T_7	20.47	90800	266105	175305	1.93
T_8	19.24	86300	250120	163820	1.90

**Treatment details are in materials and methods*

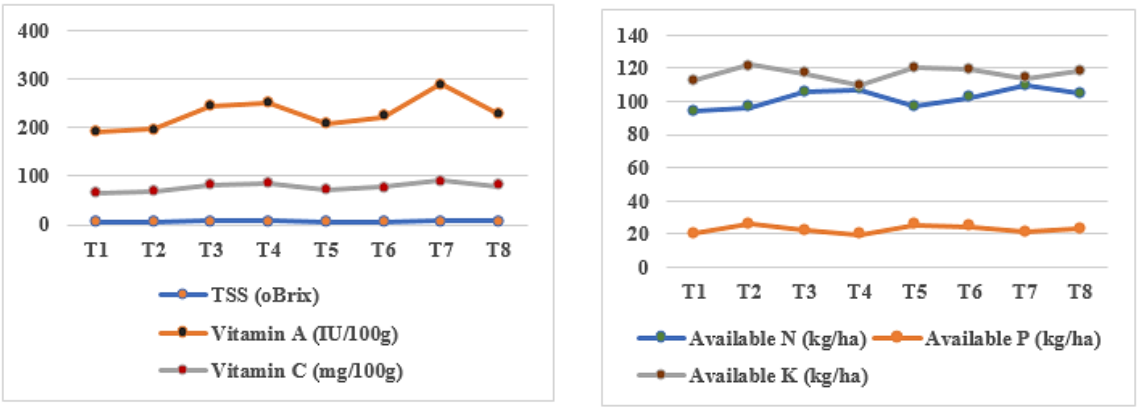

Fig. 1. Effects of different organic nutrient sources on yield, and quality attributes and residual nutrient status of broccoli

3.3 Economics of Broccoli Cultivation

The cost of cultivation of broccoli under enriched organic manures is presented in Table 4. The highest gross return (Rs. 266105.00), the maximum net return (Rs.175305.00) and the highest benefit- cost ratio (1.93) was obtained from T_7. The higher net return value under these treatments could be attributed to the higher head yield of broccoli. These results are in accordance with those of Chaudhary et al. [30], Dass et al. [31] Maurya et al. [32], Chaterjee et al. [33] and Bhardwaj et al. [34]. Hence, the treatment T_7 (basal application of enriched vermicompost @ 2.5 t/ha along with enriched poultry manure @ 2.5 t/ha + top dressing of enriched vermicompost @ 0.5 t/ha along with enriched poultry manure @ 0.5 t/ha each) can be recommended for sustainable production of organic sprouting broccoli under terai region of West Bengal.

4. CONCLUSION

Based on the present field experiment, it can be concluded that basal application of *Azophos* biofertilizer- enriched vermicompost (2.5 t/ha) and poultry manure (2.5 t/ha) along with top dressing of enriched vermicompost (0.5 t/ha) and poultry manure (0.5 t/ha) at 30 and 45 days after transplanting exerted maximum head yield along with superior head quality of organic broccoli. The greatest benefit to cost ratio was also obtained from the same treatment. Hence, this can be recommended for sustainable production of organic sprouting broccoli under terai region of West Bengal.

ACKNOWLEDGEMENTS

The authors are grateful to the Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal, India for providing resources to complete the current work.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Yoldas F, Ceylan S, Yagmur B, Mordogan N. Effects of nitrogen fertilizer on yield,

quality and nutrient content in broccoli. Journal of Plant Nutrition. 2008;31:1333-1343.
2. Acharya U, Thapa S, Sharma N. Study on the growth, yield and soil nutrient status of broccoli under organic nutrient management. International Journal of Current Research. 2015;7(2):13029-13032.
3. Atiyeh RM, Lee SS, Edwards CA, Arancon NQ, Metzger J. The influence of humic acid derived from earthworm processed organic waste on plant growth. Bioresource Technology. 2002;84:7-14.
4. Sen A, Khade SD, Das SS, Chatterjee R. Comparing effects of different trellis systems for organically grown ridge gourd (*Luffa acutangula*). Biological Agriculture & Horticulture. 2023.
DOI: 10.1080/01448765.2023.2249855
5. Bhattacharya P, Jain RK, Paliwal MK. Biofertilizers for vegetables. Indian Horticulture (July-September issue) ICAR Publication, New Delhi, India; 2000.
6. El-Yazeid AA, Abou-Aly HA, Mady MA, Moussa SAM Enhancing growth, productivity and quality of squash plants using phosphate dissolving microorganisms (bio phosphor) combined with boron foliar spray. Research Journal of Agriculture and Biological Sciences. 2007;3(4):274-286.
7. Yadav LP, Kavita A, Maurya IB. Effect of nitrogen and biofertilizers on growth of cabbage (*Brassica oleracea var. capitata* L.) var. Pride of India. Progressive Horticulture. 2012;44(2):318-320.
8. Ruiz JL, Sanjuan MDCS. The use of plant growth promoting bacteria for biofertigation; effects on concentrations of nutrients in inoculated aqueous vermicompost extract and on the yield and quality of tomatoes. Biological Agriculture & Horticulture. 2022;38(3):145–161.
9. Meena K, Ram RB, Meena ML, Meena JK, Meena DC. Effect of Organic Manures and Bio-Fertilizers on Growth, Yield and Quality of Broccoli (*Brassica oleracea* var. *italica* Plenck.) cv. KTS-1. Chemical Science Review and Letters. 2017;6(24):2153-2158.
10. Siddique AK, Shivle R, Mangodia N. Possible role of biofertilizer inorganic agriculture. International Journal of Innovative Research and Studies. 2014; 3(9):719-725.
11. Bhattacharjee R, Dey U. Biofertilizer, a way towards organic agriculture: A review. African Journal of Microbiology Research. 2014;8:2332–2343.
12. Chauhan H, Bagyaraj DJ, Selvakumar G, Sundaram SP. Novel plant growth promoting rhizobacteria-prospects and potential. Applied Soil Ecology. 2015;95: 38-53.
13. Geddes BA, Ryu M, Mus F, Costas AG, Peters JW, Voigt CA, Poole P. Use of plant colonizing bacteria as chassis for transfer of N 2 -fixation to cereals. Current Opinion in Biotechnology. 2015; 32:216-222.
14. Manivannan MI, Singh JP. Effect of biofertilizers on the growth and yield of sprouting broccoli (*Brassica oleracea* var. *Italica* Plenck) under Allahabad agro climatic conditions. Bioved. 2004;15(1/2): 33-36.
15. Ponmurugan K, Sankaranarayanan A, Al-Dhabi NA. Biological activities of plant growth promoting *Azotobacter* sp. isolated from vegetable crops rhizosphere soils. J Journal of Pure and Applied Microbiology. 2012;6:1689-1698.
16. Ahemad M, Kibret M. Mechanisms and applications of plant growth promoting rhizobacteria: Current perspective. Journal of King Saud University - Science. 2014; 26:1–20.
17. Joseph MH, Dhargave TS, Deshpane CP, Shrivastava AK. Microbial solubilization of phosphate: Pseudomonas versus Trichoderma. Annals of Plant and Soil Research. 2015;17(3):227-232.
18. Choudhary S, Soni AK, Jat NK. Effect of organic and inorganic sources of nutrients on growth, yield and quality of sprouting broccoli cv. Cbh-1. Indian Journal of Horticulture. 2012;69(4):550-554.
19. Bahadur A, Singh J, Upadhyay AK, Singh KP. Effect of organic manure and biofertilizer on growth, yield and quality attributes of broccoli. Vegetable Science. 2003;30(2):192-194.
20. Panse VG, Sukhatme PV. Statistical methods for agricultural workers. Indian Council for Agricultural Research (ICAR), New Delhi, India; 1985.
21. Sharma R, Negi YS, Vaidya M. Analysis for Forestry and Horticultural Crops: Theory with Application. Dr. Y S Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh. 2008;32-35.

22. Sharma SK, Sharma R, Korla BN. Response of N and P on growth and yield of sprouting broccoli (*Brassica oleracea* var. *Italica*). Indian Journal of Horticulture. 2002;59(3):313-315.
23. Magd MA, Bassiony AM, Fawzy ZF. Effect of organic manure with or without chemical fertilizers on growth, yield and quality of some varieties of broccoli plants. Journal of Applied Sciences Research. 2006; 2(10):791- 798.
24. Bhardwaj AK, Kumar P, Singh RK. Response of nitrogen and pre-planting treatment of seedlings with the *Azotobacter* on growth and productivity of broccoli (*Brassica oleracea* var. *Italica*). The Asian Journal of Horticulture. 2007; 2(1):15-17.
25. Mohapatra SK, Munsi PS, Mohapatra PN. Effect of Integrated Nutrient Management on growth, yield and economics of broccoli (*Brassica oleracea* var. *italica* Plenck). Vegetable Science. 2013;40(1):69-72.
26. Sarker MMHS, Kashem MA, Ali S. Role of Vermicomposts Quality on Zinc and Boron Nutrition and Growth of Cauliflower. Agric Res. 2021;10(2):205–214.
27. Chatterjee R, Bandhopadhyay S, Jana JC. Organic amendments influencing growth, head yield and nitrogen use efficiency in cabbage (*Brassica oleracea* var. *capitata* L.). American International Journal of Research in Formal, Applied & Natural Sciences. 2014;5(1):90-95.
28. Chatterjee R, Jana JC, Paul PK. Vermicompost substitution influences shelf life and fruit quality of tomato (*Lycopersicon esculentum* Mill.). American Journal of Agricultural Science and Technology. 2013;1:69-76.
29. Kaur K. Effect of biofertilizers and nitrogen on the yield and quality of pearl millet folder. Annals of Biological Research. 1992;8:29-32.
30. Chaudhary MM, Bhanvadia AS, Parmar PN. Effect of integrated nutrient management on growth, yield attributes and yield of cabbage (*Brassica oleracea* var. *capitata* L.) under middle Gujarat conditions. Trends in Biosciences. 2015; 8(8):2164-2168.
31. Dass A, Lenka NK, Patnaik US, Sudhishri S. Integarted nutrient management for production, economics and soil improvement in winter vegetables. International Journal of Vegetable Science. 2008;14(2):104-120.
32. Maurya AK, Singh MP, Srivastava BK, Singh YV, Singh DK, Singh S, Singh PK. Effect of organic manures and inorganic fertilizers on growth characters, yield and economics of sprouting broccoli cv. Fiesta. Indian Journal of Horticulture. 2008;65 (1):116-118.
33. Chaterjee B, Ghanti P, Thapa U, Tripathy P. Effect of organic nutrition in sprouting broccoli (*Brassica oleracea* L. var. *italica* Plenck). Vegetable Science. 2005;32 (1):51-54.
34. Bhardwaj ML, Harender R, Koul BL. Yield response and economics of organic sources of nutrients as substitute to inorganic sources in tomato (*Lycopersicon esculentum*), okra (*Abelmoschus esculentus*), cabbage (*Brassica oleracea* var. *capitata*) and cauliflower (*B. oleracea* var. *botrytis*). Indian Journal of Agricultural Sciences. 2000;70(10):653-656.

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