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Studies on Various Levels of Organic Sources and Major Nutrients on Growth and Yield of Sprouting Broccoli (*Brassica oleracea var. italica Plenck*)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was carried out at the Vegetable Research Farm, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur (U.P.) during Rabi season 2021-22. The experiment consists of twenty-four treatment combinations of six sources of organic manure and four levels of major nutrients. The experiment was laid out in Factorial Randomized Block Design with replicated three times. Palam samridhi variety of broccoli was transplanted at spacing of 45x45 cm. Results of the experiment revealed that the growth characters of broccoli like plant height (cm), number of leaves plant^{-1}, plant spread, stem diameter and Yield attributes viz total head yield per plot(kg) and total head yield (q/ha) were significantly higher under M_6 (FYM 20t + Vermicompost 5 t + Poultry manure 5 t ha^{-1}) source of manure which was at par application of M_4 (Vermicompost 5 t ha^{-1}) whereas in case of major nutrients it was significantly higher under application of (140:80:80 kg NPK ha^{-1}) but it was at par with (120:60:60 kg NPK ha^{-1}) and significantly superior to rest sources of organic manure.

Keywords: Sprouting broccoli; nutrients; growth attributes; yield.

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1. INTRODUCTION

Broccoli (*Brassica oleracea* var. *italica* L.) is a popular vegetable which belongs to the family cruciferae. Broccoli is derived from the Latin word *brachium* and the Italian term brocco, both of which imply "arm" or "branch." It is often divided into three groups: white, purple, and green, with the green form being the most nutritious [1].

Broccoli is extremely healthy, with 130 times more vitamin A content than cauliflower and 22 times more vitamin A content than cabbage. It's also high in sulphoraphane, a substance that's linked to a lower risk of cancer. Broccoli is high in vitamins and minerals, with moisture 89.9 g, carbohydrate 5.5 g, fat 0.2 g, protein 3.3 g, vitamin-A 3500 IU,thiamine 0.05 mg, riboflavin 0.12 mg, phosphorous 79 mg, calcium 80 mg, iron mg, ascorbic acid 137 mg, and calories 37 g in each 100 g edible amount [2]. It contains indole-3-carbinol, a potent anti-cancer chemical that boosts DNA repair in cells and appears to inhibit cancer cell proliferation. Attempts might thus be made to establish methods for cultivating broccoli in order to increase its output and, if possible, add value.

Broccoli requires fertilizer management on a frequent basis throughout its development cycle. Because, it is a heavy feeder, it takes up a lot of macronutrients from the soil. Broccoli needed a lot of nitrogen fertiliser. For a quality crop that is impacted by nitrogenous fertiliser applications. The plant's early and quick vegetative development is required for a soft and succulent head as well as stem [3]. Nitrogen promotes vegetative growth, Phosphorus promotes root development and also supplying energy in the form of ATP, Potassium is crucial for glucose metabolism, enzyme activation, and osmotic control [2].

Nitrogen (N) has a significant impact on plant growth and development. Nitrogen is a vital component for cost-effective vegetable production, and it is especially crucial when growing in weak mineral soils. The increased nitrogen is expected to lower the overall risk of crop output. On vegetable farms, nitrogen management measures should be employed to reduce the amount of nitrogen lost to the environment [4].

Chlorophyll, protoplasm, proteins, and nucleic acids all include nitrogen. Its shortage affect growth and drastically lowers production [5,6]. Nitrogen is the most critical nutrient for plant development, production, and quality, and it is the most important nutrient among plant nutrients. More than half of the nitrogen in leaves is found through the process of photosynthesis-related components [7].

Phosphorus, on the other hand, aids in energy transmission, promotes early and abundant blooming, and promotes root, seed, and fruit development. Phosphorus serves to increase crop output by storing and transferring energy inside plants [7]. Phosphorus (P) is essential not just for floral initiation but also for plant growth. It is a necessary component of a variety of important chemicals [8,9]. A sufficient quantity of phosphorus tends to counteract the negative consequences of too much nitrogen. It promotes plant maturity, enhances fruit quality, promotes root development, and may boost disease resistance (Sharma et al. 2017).

Potassium increases plant vigour and disease resistance, as well as regulating water loss from the plant by balancing anabolism, respiration, and transpiration [10,11]. As a result, the inclination to wilt is reduced, and available water is better utilised, which helps the creation of protein and chlorophyll, and improves the quality of the cabbage head in terms of flavour and preservation [12].

Depending on the species, soil, climate, plant density, and growth methods, the amount of ideal nutrients provided to broccoli might vary significantly. Appropriate fertilisation may ensure lucrative and high-quality crops, as well as the use of the right amount and combination of fertilisers to boost agricultural output. Keeping all of this in mind, the research investigates title “Studies on various levels of organic sources and major nutrients on growth, yield and quality attributes (*Brassica oleracea* var. *italica* Plenck)”.

2. MATERIALS AND METHODS

2.1 Experimental Site

The experiment was laid out at Kalyanpur Horticulture Farm Kanpur during Rabi season 2021-22. Kanpur is situated in sub-tropical zone at 25º26’ and 26º58’ N latitude, 79º 32’ and 80º 34’ E longitude with an altitude of 125.90 meters above mean sea level. The mean annual rainfall is about 816mm. It lies in the alluvial belt of gangetic plains of central Uttar Pradesh. This region falls under agroclimatic zone (Central Plain Zone) of the state.

2.2 Edaphic Condition

The soil of the experimental field was alluvial in origin, sandy loam in texture and slightly alkaline in reaction having pH 7.5 (1:2.5 soil: water suspension method given by Jackson, [13]), organic carbon percentage in soil is 0.47 per cent (Walkley and Black's rapid titration method given by Walkley and Black, [14]), with available nitrogen 220.0 kg ha^{-1} (Alkaline permanganate method given by Subbiah and Asija, [15]), available phosphorus as sodium bicarbonate-extractable P_2O_5 was 9.7 kg ha^{-1} (Olsen's calorimetrically method**,** Olsen et al. [16]) available potassium was 305.99 kg ha^{-1} (Flame photometer method given by Hanwey and Heidel, 1952).

2.3 Detail of Treatments and Design

The nine treatments combination of nutrient management practices having six sources of organic manure and four combinations of NPK. Experiment was laid out in factorial randomized block design with three replications.

2.4 Field Preparation

The experimental field was thoroughly ploughed and cross-ploughed with the help of mould board plough and cross-harrowing was done with tractor, followed by planking and levelling to bring the field to a good tilth. Beds of 1.8 × 1.8 m size and paths and channels were also prepared according to the layout of the experiment.

2.5 Transplanting

Six weeks old seedlings were transplanted on 3rd November, 2021, when average height of seedlings was about 10-12 cm. The distance between row to row and plant to plant was kept as 45 × 45 cm. Thus 16 plants were transplanted in each plot. The transplanting was done in the evening hours followed by light irrigation**.**

2.6 Economics of Treatments

The economics of the treatments is the most important consideration for making any recommendation to the farmer for its wide adoption. For calculating economics, the average treatment yield along with prevailing market rates of the produce and cost of inputs were used. B: C ratio was computed by dividing gross return with cost of cultivation for each treatment. The details of economics for each treatment are given in table.

2.7 Statistical Analysis

The growth parameters and yields were recorded and analyzed as per Gomez and Gomez [17] the tested at 5% level of significance to interpret the significant differences.

3. RESULTS AND DISCUSSION

3.1 Growth and Yield Attributes

Data recorded on growth and yield attributes viz; plant height, plant spread, stem diameter, number of leaves per plant as influenced by different levels of organic sources and major nutrients clearly indicated that increase significantly by the application of organic sources of FYM 20 t/ha + Vermi-compost 5t/ha + 5t/ha Poultry manure and 140:80:80 kg NPK/ha as compared to other doses of application. Maximum number of leaves i.e. 14.15 per plant was noted treatment M_6 (FYM 20 t ha^{-} + Vermicompost 5 t ha^{-1} + Poultry manure 5 t ha^{-1}) which was on par with treatment M_4 (FYM 20 t ha^{-} + Vermicompost 5 t $ha^{-\ 1}$) and significantly superior to rest organic sources. Among organic sources M_6 (FYM 20 t ha^{-} + Vermicompost 5 t ha^{-1} + Poultry manure 5 t ha^{-1}) being at par with M_4 (FYM 20 t ha^{-} + Vermicompost 5 t ha^{-1}) produced significantly taller plant than rest of organic sources. Minimum height was noted under M_1 (FYM 20 tha^{-1}) treatment. Maximum stem diameter i.e. 5.13 cm was noted treatment M_6 (FYM 20 t ha^{-} + Vermicompost 5 t ha^{-1} + Poultry manure 5 t ha^{-1}) which was on par with treatment M_4 (FYM 20 t ha^{-} + Vermicompost 5 t ha^{-1}) and significantly superior to rest organic sources. Least diameter of stem was associated with M_1 (FYM @ 20t ha^{-1}). Lowest diameter of stem was associated with M_1 (FYM 20 tha^{-1}). The highest plant spread of 61.20cm was obtained with M_6 (FYM 20 t ha^{-} + Vermicompost 5 t ha^{-1} + Poultry manure 5 t ha^{-1}) which was at par with treatment M_4 (FYM 20 t ha^{-} + Vermicompost 5 t ha^{-1}) and significantly superior to other organic sources. However, the plant spread was recorded with M_1 FYM (20 tha^{-1}) which was 54.78 cm. The maximum spread was obtained of 60.27 cm with F_3 (140+80+80 kg NPK ha^{-1}) which was at par with F_2 (120+60+60 kg NPK ha^{-1}) and significantly superior to over rest treatments. However, the lowest plant spread of 54.37 cm was recorded with F_0 (0+0+0 kg NPK ha^{-1}) nutrient level. The role of appropriate combination of organic sources *viz*., FYM 210t/ha + Vermi compost 5t/ha + Poultry manure 5t/ha + Poultry manure 5t/ha and 140 kg + 80 kg NPK/ha on increase of plant height, plant spread and stem diameter have been confirmed by Renand et al. [18], Mehdi et al. 2018, Burhan and Al-Taey [19] and Hamzaand Al-Taey [20].

3.2 Marketable Head Yield

The data assembled on total marketable head yield kg plot^{-1} of broccoli was recorded. The sources was noted on marketable head yield kg plot^{-1} of broccoli and maximum marketable head yield kg plot^{-1} of broccoli i.e. 6.46 kg was obtained with M_6 (FYM 20 t ha^{-} + Vermicompost 5 t ha^{-1} + Poultry manure 5 t ha^{-1}) which was at par with treatment M_4 (FYM 20 t ha^{-} + Vermicompost 5 t ha^{-1}) which recoded 6.33 kg plant weight and these were significantly superior to other organic sources. However, minimum marketable head yield kg plot^{-1} was recorded with M_1 FYM (20 tha^{-1}) which was 5.80 kg. Application of different doses of major nutrient showed significant effect on the marketable head yield kg plot^{-1} of broccoli. Maximum marketable head yield kg plot^{-1} of 6.40 kg was obtained with F_3 (140+80+80 kg NPK ha^{-1}) which was at par with F_2 (120+60+60 kg NPK ha^{-1}) and significantly superior to over rest treatments. However, the lowest marketable head yield kg plot^{-1} of 5.78 kg was recorded with F_0 (0+0+0 kg NPK ha^{-1}) nutrient level. Marked influence of organic sources was noted on marketable head yield of broccoli and maximum marketable head yield of broccoli i.e. 199.36 q ha^{-1} g was obtained with M_6 (FYM 20 t ha^{-} + Vermicompost 5 t ha^{-1} + Poultry manure 5 t ha^{-1}) which was on par with treatment M_4 (FYM 20 t ha^{-} + Vermicompost 5 t ha^{-1}) which recoded 195.51 q yield and these were significantly superior to other organic sources. However, minimum marketable head yield was recorded with M_1 FYM (20 tha^{-1}) which was 178.89 q ha^{-1}. Application of different doses of major nutrient showed significant effect on the marketable yield of broccoli. Maximum marketable yield of 197.38qha^{-1} was obtained with F_3 (140+80+80 kg NPK ha^{-1}) which was at par with F_2 (120+60+60 kg NPK ha^{-1}) and significantly superior to over rest treatments. However, the lowest marketable yield of 177.54 q ha^{-1} was recorded with F_0 (0+0+0 kg NPK ha^{-1}) nutrient level. The production of significantly higher level of marketable head yield has been achieved by the cumulative combination of average head weight size of head and head compactness. The significant effect of higher level of application of FYM 210t/ha + Vermi compost 5t/ha + Poultry manure 5t/ha + Poultry manure 5t/ha and 140 kg + 80 kg NPK/ha in achieving higher level of marketable head yield (190q/ha) which might be obtained due to higher yield attributing characters *viz.,* average head weight, head size and head compactness. Similar observations were also recorded by Biswas et al. [21], Singh et al. [22] and Tarafder et al. [23].

Table 1. Details of treatments

S. No.	Treatment	Levels	Symbols
1.	Organic Sources	(i) Farm yard manure (20 t ha^{-1})	M_1
		(ii) Vermicompost (5 t ha^{-1})	M_2
		(iii) Poultry manure (5 t ha^{-1})	M_3
		(iv) Farm yard manure (20 t ha^{-1}) + Vermicompost (5 t ha^{-1})	M_4
		(v) Farm yard manure (20 t ha^{-1}) + Poultry manure (5 t ha^{-1})	M_5
		(vi) Farm yard manure (20 t ha^{-1}) + Vermicompost (5 t ha^{-1}) + Poultry manure (5 t ha^{-1})	M_6
2.	Inorganic Sources	(i) Control	F_0
		(ii) 80 N + 40 P_2O_5 + 40 K_2O	F_1
		(iii) 120 N + 60 P_2O_5 + 60 K_2O	F_2
		(iv) 140 N + 80 P_2O_5 + 80 K_2O	F_3

Table 2. Effect of organic sources and major nutrients on plant growthparameters

Treatments	Numberof leaf Plant^{-1}	Plantheight (cm)	Diameterof stem(cm)	Plant spread
Organic sources				
M_1 FYM (20 tha^{-1})	12.30	48.93	4.43	54.23
M_2 Vermicompost (5 t ha^{-1})	13.10	52.38	4.73	57.78

Treatments	**Numberof leaf Plant^{-1}**	**Plantheight (cm)**	**Diameterof stem(cm)**	**Plant spread**
M_3 Poultry manure(5 t ha$^{- 1}$)	12.50	49.70	4.45	54.78
M_4 (FYM 20 t ha^{-} +Vermicompost 5 t ha^{-1})	13.90	55.53	5.03	60.43
M_5 (FYM 20 t ha^{-} + Poultry manure 5t ha^{-1})	13.40	53.48	4.83	59.23
M_6 (FYM 20 t ha^{-} + Vermicompost 5 t ha^{-1} + Poultrymanure 5 t ha^{-1})	14.15	56.68	5.13	61.20
SEm(±)	**0.26**	**1.13**	**0.09**	**1.18**
CD (P=0.05)	**0.74**	**3.23**	**0.27**	**3.36**
Major nutrients				
F_0 (0+0+0 kg NPK ha^{-1}) Control	12.32	49.25	4.45	54.37
F_1 (80+40+40 kg NPK ha^{-1})	12.90	51.38	4.63	57.55
F_2 (120+60+60 kg NPK ha^{-1})	13.75	54.97	4.93	59.57
F_3 (140+80+80 kg NPK ha^{-1})	13.93	55.52	5.03	60.27
SEm(±)	**0.21**	**0.92**	**0.08**	**0.96**
CD (P=0.05)	**0.61**	**2.63**	**0.22**	**2.74**

Table 3. Effect of organic sources and major nutrients on yield attributes of Broccoli

Treatments	**Marketable head yield (kg plot^{-1})**	**Marketable head yield (q ha^{-1})**
Organic sources		
M_1 FYM (20 tha^{-1})	5.80	178.89
M_2 Vermicompost (5 t ha^{-1})	6.21	191.69
M_3 Poultry manure(5 t ha$^{- 1}$)	5.91	182.54
M_4 (FYM 20 t ha^{-} + Vermicompost 5 t ha^{-1})	6.33	195.51
M_5 (FYM 20 t ha^{-} + Poultry manure 5 t ha^{-1})	6.03	186.19
M_6 (FYM 20 t ha^{-} + Vermicompost 5 t ha^{-1} + Poultry manure 5 t ha^{-1})	6.46	199.36
SEm(±)	**0.12**	**3.71**
CD (P=0.05)	**0.34**	**10.57**
Major nutrients		
F_0 (0+0+0 kg NPK ha^{-1}) Control	5.78	177.54
F_1 (80+40+40 kg NPK ha^{-1})	6.01	185.42
F_2 (120+60+60 kg NPK ha^{-1})	6.21	191.77
F_3 (140+80+80 kg NPK ha^{-1})	6.40	197.38
SEm(±)	**0.10**	**3.03**
CD (P=0.05)	**0.28**	**8.63**

Table 4. Effect of nutrients on yield attributes of Broccoli with B:C ratio

Treatments	**B:C ratio**
Organic sources	
M_1 FYM (20 tha^{-1})	7.90
M_2 Vermicompost (5 t ha^{-1})	6.82
M_3 Poultry manure(5 t ha$^{- 1}$)	9.22
M_4 (FYM 20 t ha^{-} + Vermicompost 5 t ha^{-1})	5.77
M_5 (FYM 20 t ha^{-} + Poultry manure 5 t ha^{-1})	7.52
M_6 (FYM 20 t ha^{-} + Vermicompost 5 t ha^{-1} + Poultry manure 5 t ha^{-1})	5.60
SEm(±)	**0.136**
CD (P=0.05)	**0.386**
Major nutrients	
F_0 (0+0+0 kg NPK ha^{-1}) Control	7.29
F_1 (80+40+40 kg NPK ha^{-1})	6.90

Treatments	B:C ratio
F_2 (120+60+60 kg NPK ha^{-1})	7.47
F_3 (140+80+80 kg NPK ha^{-1})	6.89
SEm(±)	**0.111**
CD (P=0.05)	**0.316**

3.3 B:C Ratio

Data on account of net return Rs ha^{-1} have been presented in Table 4. Summary of data given in above table revealed that maximum B:C ratio of 9.22 was recorded under M_3 (Poultry manure 5 t ha^{-1}). It was contrary to net return and gross return due to heavy input cost. Variation in values of net return was also noted due to Major nutrients. Maximum B:C ratio of 7.47 was noted under F_2 (120+60+60 kg NPK ha^{-1}) followed by F_3, F_1 and control. These results are in agreement with results of Singh et al. [22].

4. CONCLUSION

On the basis of results obtained from the present investigation, it can be concluded that among organic sources, M_6 (FYM 20 t ha^{-} + Vermicompost 5 t ha^{-1} + Poultry manure 5 t ha^{-1}) and a dose of F_3 (140+80+80 kg NPK ha^{-1}) major nutrients proved to be the most suitable for commercial cultivation under Kanpur conditions.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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