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EFFECT OF DIFFERENT ORGANIC SOURCES AND SOWING DATES ON QUALITY OF BROCCOLI

Rakshanda Anayat[1], Shiffa Qadri[2], Shahnaz Mufti[2], Zahida Rashid[3*], Rehana Rasool[1], Shahnaz Parveen[2], Faisal Nabi[4], Mudasir Magrey[1] and Mehnaz Shakeel[1]

[1]Faculty of Agriculture (FoA), Wadura, SKUAST-Kashmir, India
[2]Faculty of Horticulture (FoH), Shalimar, SKUAST- Kashmir, India
[3]DARS Budgam, SKUAST-Kashmir, India
[4]KVK Kupwara SKUAST-Kashmir, India
*Corresponding author E-mail: zahida@skuastkashmir.ac.in
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ABSTRACT

The experiment was carried out in the experimental research farm of Vegetable Science, Faculty of Horticulture, SKUAST-Kashmir Srinagar Shalimar during *Kharif*-2022-2023. The geographical Shalimar is situated at an altitude of approximately 1,800 meters (5,900 feet) above sea level and the GPS coordinates of Shalimar are 34.05 31°N, 74.83 13°E. The experiment was laid out in a split plot design. The combinations of treatments including 4 organic manures *viz*., T1 (100% FYM + Biofertilizer @20 t ha^{-1}), T2 (100% Poultry manure + Biofertilizer @4.5 t ha^{-1}), T3(100% Vermicompost + Biofertilizer @5 t ha^{-1}) and T4 (100% Mustard Cake + Biofertilizer @1.9 t ha^{-1}) and 3 Dates of sowing, D1 (30th Standard Meteorological Week) D2 (32nd Standard Meteorological Week) and D3 (34th Standard Meteorological Week) were replicated thrice. Overall, this study highlights the importance of selecting appropriate organic source and date of sowing for improvement of quality of broccoli. The findings indicate that using a T3 (100% Vermicompost + Biofertilizer @5 t ha^{-1}) and D1 (30th Standard Meteorological Week) as a date of transplanting can boost the quality improvement of broccoli. These results will contribute to the advancement of efficient and sustainable organic cultivation practices, enabling growers to optimize production outcomes in broccoli cultivation.

***Key words*:** Broccoli, Environment modification, Organics, Quality, Sowing date

Introduction

Broccoli (Brassica oleracea var. italica) is a nutritious green vegetable belonging to the cabbage family (Brassicaceae), characterized by its sizable head and stalk, both of which are consumed as part of the meal. The word broccoli originates from the Italian broccolo plural, which means “a cabbage’s flowering crest” and is the diminutive form of brocco, which means “small nail” or “sprout” (Meena *et al*., 2020). Broccoli boasts sizable, dark green flower heads, forming a tree-like arrangement on a thick, light green stalk. The mass of flower heads is surrounded by leaves (Bhavnagri *et al*., 2015). Broccoli bears a striking resemblance to cauliflower, as both belong to distinct cultivars within the same species (Mukherjee and Mishra, 2012). Broccoli emerged through the selective breeding of Brassica crops in the northern Mediterranean around the sixth century. Its roots trace back to early cultivars cultivated in the Roman Empire, later refined through deliberate breeding in southern Italy or Sicily. By the 18th century, it had traversed to northern Europe, while Italian immigrants introduced it to North America during the 19th century (Dixon, 2007). Broccoli is also known as the Crown of jewel nutrition” because it is rich in vitamins and minerals (Singh *et al*., 2021). Broccoli stands out for its superior nutritional profile compared to cauliflower due to its higher content of various elements. It contains 5.5 g of carbohydrates, 3.3 g of protein, 3500 IU of vitamin-A, 0.05 mg of thiamine, 0.12 mg of riboflavin, 137 mg of ascorbic acid, 80 mg of calcium and 79 mg of phosphorus. Consequently, broccoli boasts 4 times more riboflavin, 2.5 times more calcium, and 2 times more vitamin-C

compared to cauliflower (Kaur *et al*., 2019). Additionally, broccoli serves as a rich source of sulforaphane, a compound linked to reducing the risk of cancer (Allen, 2007). Broccoli is recognized for its abundance in secondary metabolites like alkaloids, flavonoids, tannins, polyphenols, essential oils, and polypeptides (Sari *et al*., 2022).

India is world's largest producer of vegetables next to China. The area and production of broccoli in India account of 6745 thousand hectares and 369 thousand tonnes (NHB, 2019). The pursuit of intensified and cost-effective agricultural production has led to widespread reliance on concentrated chemical fertilizers, often at high doses, while organic methods are underutilized, causing a decline in soil fertility and structure. Fertilizers aim to enhance fertility, yet excessive use of mineral variants raises environmental concerns. Agricultural chemicals, such as hormones and antibiotics, leave residues in food, posing potential risks like cancer or genetic damage. Other facets of food quality have also deteriorated. Thus, organic farming emerges as an alternative a sustainable, self-sufficient farming system. It stands among the fastest-growing sectors globally, focusing on establishing a harmonious balance within the interconnected system of soil organisms, plants, animals, and humans. Selection of appropriate fertilizers for crop growth is guided by local natural conditions, soil variations and climate suitability for cultivating crops.

Organic fertilizers derived from fermented and decomposed organic materials are typically rich in nutrients and considered safe. Microbial fertilizers appear to be eco- friendly, cost-effective, and compact agricultural inputs, playing a substantial role in plant nutrition as supplementary and complementary elements to mineral-based nutrition (Chinthapalli *et al*., 2015). Organic manures and biofertilizers serve as alternative and renewable nutrient sources. Organic manure not only consistently provides macro, micro, and secondary nutrients but also enhances the physical, chemical and biological characteristics of the soil (Chaterjee *et al*., 2005). Organic manures act as slow-release fertilizers, minimizing nutrient loss compared to inorganic fertilizers. This reduction in nutrient loss helps decrease soil, water and air pollution.

Numerous tests and experiences have shown that well decomposed farmyard manure contains 0.5% N, 0.3% P_2O_5 and 0.5% K_2O (Singh *et al*., 2018). When applied in appropriate proportions, it can effectively provide nearly all the essential elements of soil fertility required by crops. Vermicompost, an enriched "organic fertilizer," contains abundant NPK and essential micronutrients like Calcium (Ca), Magnesium (Mg), Zinc (Zn), and Manganese (Mn). Luishuxin *et al*., (1992) typically, vermicompost comprises an average of 3% N, 1% P_2O_5 and 1% K_2O. Vermicompost contains enzymes such as amylase, lipase, cellulase and chitinase, which persistently decompose organic matter within the soil (Yatoo *et al*., 2020).

Poultry manure provides an ample supply of both macro and micro nutrients essential for the growth, yield, and quality of horticultural crop production. Its significance has grown considerably in crop production practices due to its role in nourishing crops and preserving the physical and chemical properties of the soil (Akter, 2021). Poultry manure possesses higher nitrogen and phosphorus levels compared to other bulkier organic manures. On average, the nutrient content of poultry manure includes 1.5% N, 1.5% P_2O_5 and 1.8% K_2O (Barker, 1990).

Mustard cake is generated as a by-product during extraction of the oil from mustard. It contains 4.8% N, 2% P_2O_5 and 1.3% K_2O. It is also a good source of bioactive components including phenolics, glucosinolates and phytates (Ramachandran *et al*., 2007).

In recent years biofertilizers viz Azospirillium, Phosphate Solubilizing Bacteria and Potassium Solubilizing Bacteria that are eco-friendly and low-cost inputs have emerged as an important and integral component of integrated plant nutrient supply system for vegetable production (Sindhu *et al*., 2019).

Organic farming in vegetables is very limited and practiced in some cases for production of dehydrated vegetables and spices. Organic farming on commercial scale has been taken up by some farmers and agencies in Uttaranchal, Andhra Pradesh, Tamil Nadu, Karnataka, Kerala, Sikkim and Maharashtra. However due to one major constraint that is lack of organic production technologies, the organic vegetable production is still in infancy in our state. Many investigators have found that, addition of organic fertilizer had a major effect on vegetative growth, total yield and quality of broccoli (Sakhonwasee, 2015).

Air temperature and solar radiation are major environmental factors affecting crop development (Mouraeo and Hadley, 1997). The proper time of sowing is one of the basic requirements for obtaining maximum yield and high return of any crop. Many experiments regarding sowing and transplanting time were conducted in different parts of the world which revealed that total yield of the crop is markedly influenced by different sowing and transplanting times. The timing of planting and the spacing between plants are crucial factors in the

Table 1: Initial soil properties of the experimental soil.

S. No.	Particulars	Observation	Analytical Method Employed
1.	pH	7.23	The pH of the soil was tested by mixing soil and water (1:2) in a glass-calomel electrode (Jackson, 1973)
2.	EC (ds/m)	0.19	EC of the soil samples was estimated by salt bridge conductivity meter (Jackson, 1973)
3.	BD (dSm^{-1})	1.33	Core sampler method as proposed by Black andHartge (1986)
4.	Organic carbon (%)	0.51	Rapid titration method, Walkley and Black's1934
5.	Available N (kg/ha)	298.73	Modified alkaline potassium permanganatemethod (Subbiah and Asija, 1956)
6.	Available P (kg/ha)	23.62	0.5 M Sodium bicarbonate extractable P method(Olsen *et al*., 1954)
7.	Available K (kg/ha)	199.37	Ammonium acetate extractable K method(Jackson, 1973)

production practices of broccoli. Previous studies have highlighted the impact of planting dates on broccoli's vegetative characteristics, yield, and the attributes of its heads (Singh *et al*., 2010 and Jayamanne *et al*., 2015).

Material And Methods

The present investigation was carried out at Research Farm of the Division of Vegetable Science, Faculty of Horticulture, SKUAST - Kashmir during the year of 2022. The details of materials used and methods applied in the experiment are mentioned below.

Experimental Site

Location and climatic condition

Shalimar, a village on the outskirts of Srinagar in Jammu and Kashmir, experiences a temperate climate with four distinct seasons. Summer months are mild with temperatures ranging from 10°C to 30°C, while winters are cold with temperatures dropping below freezing point. The average minimum and maximum temperature for each month are -5.7°C and 5.8°C in January, 14.4°C and 30.6°C in June, and -3.1°C and 7.8°C in December, respectively. Shalimar is situated at an altitude of approximately 1,800 meters (5,900 feet) above sea level and the GPS coordinates of Shalimar are 34.05 31°N,74.83 13°E

The experiment was carried out in the experimental research farm of Vegetable Science, Faculty of

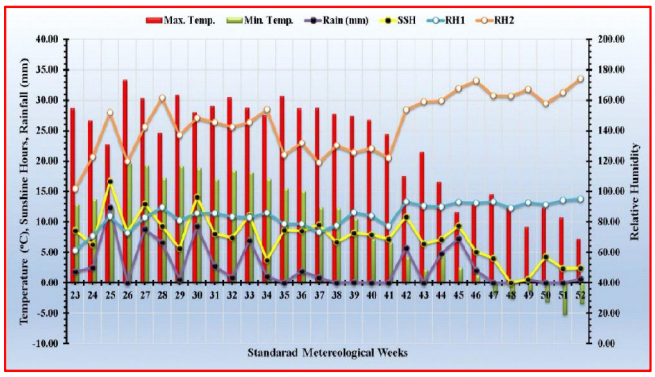

Fig. 1: Weather parameters observed during crop growing period of Broccoli, 2022.

Horticulture, SKUAST-Kashmir Srinagar the maximum and minimum temperature, bright sunshine hours, relative humidity and total weekly rainfall recorded during the period of investigation at Meteorological Observatory at the Department of Agro-Meteorology, SKUAST-Kashmir are presented in Fig. 1.

Soil conditions

Random soil samples of experimental field drawn from five places with auger up to 0-15 depth just before layout of experiment, after harvest of first year crop/ before transplanting of second crop and after harvest of second year crop were mixed thoroughly and composite samples are presented in Table 1.

Experimental details

The experiment was laid out in a split plot design. All 36 combinations involving two main plots including 4 organic manures (FYM, Vermicompost, Poultry manure and Mustard Cake) and 3 Dates of sowing (D1-24th August, D2-29th August and D3-2nd September) were replicated thrice. All the cultural practices were followed to raise a healthy crop. The harvesting of broccoli was done from 15th November onwards.

Treatment details

Treatment code	Treatments	Dosage
T1	100% FYM + Biofertilizer	20 t/ha
T2	100% Poultry Manure + Biofertilizer	4.5 t/ha
T3	100% Vermicompost + Biofertilizer	5 t/ha
T4	100% Mustard Cake + Biofertilizer	1.9 t/ha
Nutrient dosage was calculated on N equivalent basis. Soil application of biofertilizers *viz*., Azotobacter, Phosphate Solubilizing Bacteria and Potassium Solubilizing Bacteria was given @ 5 l/ha.		

Cultivation details

Preparation of nursery bed and sowing of seeds

Nursery bed of 3 m × 1 m × 0.15 m in size were prepared by mixing well rotten FYM in the soil at the rate of 15 kg per square meter. Seeds were sown at 25th

July, 8th August and 22nd August, respectively in shallow furrows 10 cm apart by dropping the seeds at 1-2 cm depth. A thin layer of fine FYM was spread over the seeds. Watering, hoeing and weeding were done according to crop requirement.

Field preparation

The experimental field was thoroughly ploughed and cross-ploughed thrice with the help of mould board plough and cross harrowing was done with tractor, followed by planking and leveling to bring the field to a good fine tilth. The FYM, vermicompost, poultry manure and mustard cake was applied at the rate of 20, 5, 4.5 and 1.9 t/ha, respectively and spread uniformly in the beds as per calculation

Transplanting and sowing

The seedlings were transplanted on 24th August, 29th August and 2nd September in 2022, respectively. When average height of seedlings was about 10-12 cm. The distance between row to row and plant to plant was kept 60 cm × 45 cm in a plot size of 3.6 × 3.6 m^2 area. Thus, 20 plants were transplanted in each plot. The transplanting was done in the morning hours followed by light irrigation.

Irrigation

The crop was irrigated immediately after transplanting and then at an interval of 2-3 days up to the establishment of seedlings. After this, the crop was irrigated at regular intervals of 7 to 8 days.

Gap filling

In place of dead seedlings, gap filling was done in early period to maintain the plant population.

Intercultural practices

First weeding and hoeing was done 25 days after transplanting and second weeding was done 40 days after transplanting.

Harvesting broccoli heads

Head were picked up before the bud opened when the bud clusters are compact. Harvesting was done with the help of sharp sickle and observations on ten tagged plants were recorded.

Observations recorded

The quality of broccoli was studied and recorded during the course of investigation. The following parameters were observed.

Dry matter content (%)

Five tagged plants were taken with the help of sharp sickle for fresh plant biomass by weighing machine in gram and oven dried for dry plant biomass by weighing machine and calculated by using the following formula.

$$\text{Dry matter content (\%)} = \frac{\text{Fresh weight - Dry weight}}{\text{Fresh weight}} \times 100$$

TSS (°Brix)

The Total Soluble Solids were estimated by hand refractometer (0-32 °brix) as per method described by Ranganna (2010).

Vitamin C (mg/100 g)

The A.O.A.C (1984) method of titration was used to titrate a known weight of sample using 2, 6-dichlorophenol indophenol dye and metaphosphoric acid as a stablising agent. Five gram of sample was ground with stabilising media (1:5) in a pestle and mortar Centrifuge was used to separate the homogenate. The supernatant was collected, and a volume of 50 ml was made with stabilising media and filtered. The dye 2, 6- dichlorophenol indophenols was used to titrate 10ml of the aliquot. The dye factor was calculated as; Five ml of 3% HPO_3 was added to standard ascorbic acid and titrated with the dye solution to a pink colour. The dye factor i.e. mg of ascorbic acid per ml of dye was determined by using the following formula:

$$\text{Dye factor} = \frac{0.5}{\text{titter value}}$$

The vitamin C content of the sample was calculated by using the following formula:

$$\text{Ascorbic acid (mg/100)} = \frac{\text{Titre value} \times \text{dye factor} \times \text{volume made up}}{\text{Total weight of the sample} \times \text{aliquot of sample}}$$

Carotenoids (mg/100 g)

5 g of sample was extracted in acetone to which few crystals of Na_2SO_4 were added and centrifuged. The supernatant was taken in a beaker, 50 ml of 10% alcoholic KOH was added and heated on water bath for 30 minutes. Material was taken in separating funnel and 50ml of petroleum ether was added. The upper layer of petroleum ether containing pigments was removed in 100 ml volumetric flask and volume made up to 100 ml with petroleum ether. O.D was recorded at 452 nm and total carotenoids were calculated using formula (Datta *et al.*, 2016):

$$\text{Carotenoids (mg/100g)} = \frac{\text{O.D.} \times 13.9 \times 10^{-4} \times \text{volume made up}}{\text{Weight of sample} \times 560 \times 1000}$$

Antioxidant activity (%DPPH)

Antioxidative activity was determined spectrophotometrically according to Yen and Chen (1995), as the percent of DPPH (2, 2-diphenyl-1-picrylhydrazyl) inhibition in plant methanol extract. Samples were grounded and extracted, using ultrasounds, for 30 min in

methanol. Measurements were done after 10 minutes of reaction, using the light wavelength of 517 nm.

Head compactness (g/cm3)

The five tagged plants from each plot were estimated as per the formula. The average of five plants was computed to get the mean Head Compactness (Pearson, 1931).

$$Z = \frac{C \times 100}{W3}$$

Where,

Z = Index of compactness

C = Net weight of head

W = Average lateral and polar diameter of head

Result and Discussion

Effect of different sowing dates and organic sources on quality of broccoli

The quality of broccoli is influenced by a range of factors, including the choice of organic sources and sowing dates. These variables have a direct impact on critical quality parameters such as Total Soluble Solids (TSS), Vitamin C, Carotenoid levels, Antioxidant activity and Head compactness. Optimal selection of organic sources and sowing dates can result in broccoli with superior nutritional value and taste, enhancing its market desirability. Broccoli rich in essential nutrients, antioxidants and compact form head is more likely to meet consumer preferences and expectations. Therefore, understanding and carefully managing these factors in broccoli cultivation is vital for both producer success and the satisfaction of health- conscious consumers in the market.

The data presented in Table 2 & 3 revealed that treatment combinations had significant variation on quality attributes of broccoli, the maximum dry matter content (10.45%), TSS (9.57 ^{o}Brix), Vitamin C (105.98 mg/100 g), Carotenoid content (2.15 mg/100 g), Antioxidant activity (75.88) and Head Compactness (14.05 g/cm^3) were recorded in T3 (100% Vermicompost + Biofertilizer @5 t ha^{-1}) and D1 (30th Standard Meteorological Week) followed by T3 (100% Vermicompost + Biofertilizer @5 t ha^{-1}) and D2 (32th Standard Meteorological Week). While the minimum dry matter content (8.69%), TSS (8.74 ^{0}Brix), Vitamin C (92.22 mg/100 g), Carotenoid

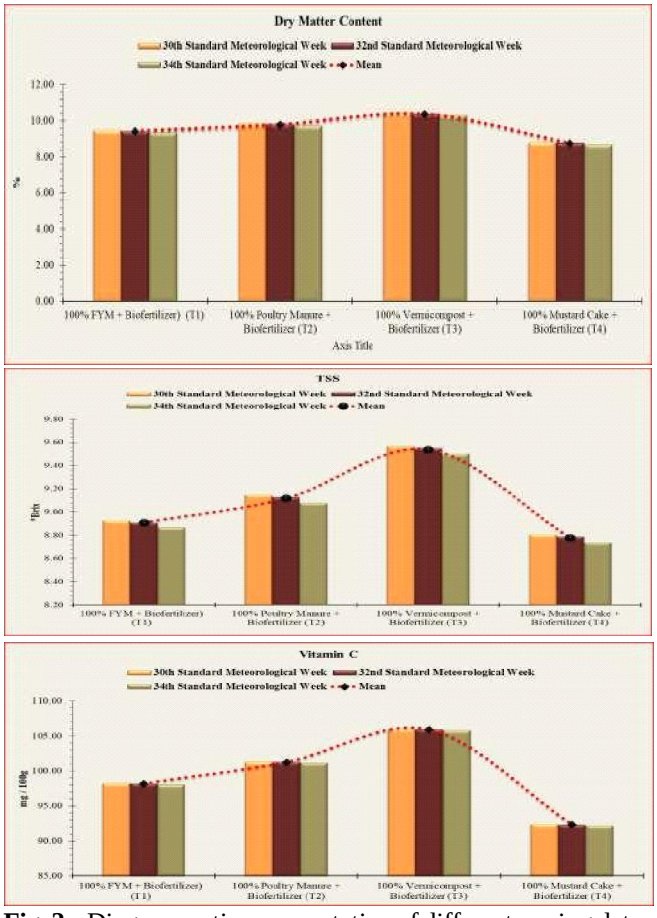

Fig. 2: Diagrammatic representation of different sowing dates and organic sources on Dry Matter Content (%), TSS (0Brix) and Vitamin C (mg/100g) of (cm^2) of Broccoli.

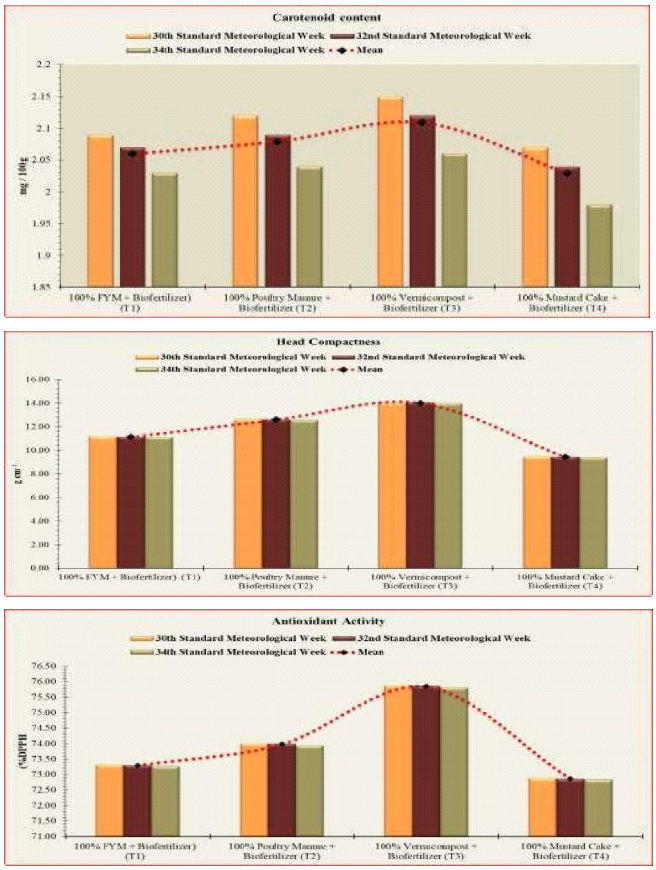

Fig. 3: Diagrammatic representation of different sowing dates and organic sources on Carotenoids(mg/100g), Antioxidant activity (%DPPH) and Head Compactness (g/cm^3) of Broccoli.

Table 2: Effect of different Sowing dates and Organic sources on Dry Matter Content (%), TSS (0Brix) and Vitamin C (mg/100g) content of Broccoli.

Date of Sowings / Organic Source	Dry Matter Content (%)			TSS (°Brix)			Vitamin C (mg/100g)		
	30th SMW	32nd SMW	34th SMW	30th SMW	32nd SMW	34th SMW	30th SMW	32nd SMW	34th SMW
T1 (100% FYM + Biofertilizer) 20 t/ha	9.49	9.43	9.35	8.93	8.91	8.87	98.28	98.20	98.09
T2 (100% Poultry Manure + Biofertilizer) 4.5 t/ha	9.87	9.81	9.73	9.15	9.13	9.08	101.34	101.28	101.20
T3 (100% Vermicompost + Biofertilizer) 5 t/ha	10.45	10.39	10.1	9.57	9.55	9.50	105.98	105.92	105.84
T4 (100% Mustard Cake + Biofertilizer) 1.9 t/ha	8.81	8.79	8.69	8.81	8.79	8.74	92.44	92.34	92.22
Factor									
Organic Source	0.22			0.11			0.94		
Date of Sowings	0.05			0.02			0.03		
Organic Source × Date of Sowings	0.27			0.13			0.97		

content (1.98 mg/100 g), Antioxidant activity (72.85) and Head compactness (9.40 g/cm^3) were observed in T4 (100% Mustard Cake + Biofertilizer @1.9 t ha^{-1}) and D3 (34th Standard Meteorological Week). The enhanced in Vitamin C content in broccoli could potentially be attributed to increased soil microbial activity, which might have contributed growth regulators, vitamins, and hormones to the plants. Similar findings have also been observed by Gupta *et al.,* (2009), Sharma *et al.,* (2011), Tanwar *et al.,* (2003) and Mohapatra *et al.,* (2013). Total soluble solids (TSS) content stands as a critical quality parameter in the processing industry, signifying the cumulative non-water and volatile components within fruits. Mishra *et al.,* (2014), in their study on knol khol, noted an increase in TSS content with higher nutrient levels in the treatments, supplemented by organic nutrients. Similarly, comparable findings were reported by Kandil and Gad (2009) in broccoli and Chatterjee *et al*., (2012) in cabbage.

Continuous availability of nutrients at shorter and frequent intervals making the plants photo synthetically active resulting in higher assimilation of primary and secondary metabolites viz., ascorbic acid, sugars, Vitamin C etc. Significantly higher concentration of total soluble solids and vitamin C was reported at higher levels of nutrients provided by vermicompost and also due to the biofertilizers direct impact on mobilization of nutrients (Dhotre *et al.*, 2018). This phenomenon could be attributed to the heightened accumulation of carbohydrates and the conversion of more organic acids into sugars, which occurs with an increase in fertilizer levels (Aminifard *et al.*, 2012). This clearly indicates the importance of vermicompost and biofertilizers in enhancing quality attributes and their requirement in crop.

There is a common observation that organically managed crops tend to contain higher levels of vitamin C compared to conventionally fertilized crops. This difference arises because when plants are exposed to higher nitrogen levels, there's an increase in protein production but a reduction in carbohydrate synthesis. Vitamin C is synthesized from carbohydrates, so its levels are consequently reduced. In the case of organically managed soil, plants are typically exposed to relatively lower amounts of nitrogen, and various plant nutrients are released slowly over time. Therefore, organic crops would be expected to maintain higher levels of vitamin C

Table 3: Effect of different Sowing dates and Organic sources on Carotenoids(mg/100g), Antioxidant activity (%DPPH) and Head Compactness (g/cm^3) of Broccoli.

Date of Sowings / Organic Source	Carotenoids (mg/100g)			Antioxidant activity (%DPPH)			Head compactness (g/cm^3)		
	30th SMW	32nd SMW	34th SMW	30th SMW	32nd SMW	34th SMW	30th SMW	32nd SMW	34th SMW
T1 (100% FYM + Biofertilizer) 20 t/ha	2.09	2.07	2.03	73.33	73.31	73.27	11.18	11.16	11.12
T2 (100% Poultry Manure + Biofertilizer) 4.5 t/ha	2.12	2.09	2.04	74.02	74.00	73.95	12.64	12.62	12.57
T3 (100% Vermicompost + Biofertilizer) 5 t/ha	2.15	2.12	2.06	75.88	75.86	75.81	14.05	14.03	13.98
T4 (100% Mustard Cake + Biofertilizer) 1.9 t/ha	2.07	2.04	1.98	72.89	72.87	72.85	9.47	9.45	9.40
Factor									
Organic Source	0.02			0.07			0.41		
Date of Sowings	0.03			0.02			0.02		
Organic Source × Date of Sowings	0.05			0.09			0.43		

and carbohydrates while having less protein, as reported by Bahadur *et al*., (2003) in their study on broccoli. Chaterjee *et al.*, (2005) studied that the effect of organic nutrition in sprouting broccoli var. Green Country with different treatments of biofertilizers *viz.*, *Azotobacter*, Phosphate Solubilizers, Potash mobilizers and Vesicular-Arbuscular- Mycorrhizae and recoded that the organic sources of nutrition produced significantly better quality of curd parameters than inorganic sources.

Plants from later plantings exhibited lower levels of ascorbic acid, likely due to reduced sunlight intensity. This positive relationship between light intensity and ascorbic acid levels in plants was also highlighted by Lee and Kader (2000) and Acikgoz (2011). Gajewski *et al.*, (2007) reavealed that high antioxidant activity of broccoli can be related to high carotenoids and vitamin C. These compounds are believed to be very active antioxidants (Wu *et al*., 2004).

The increased compactness of broccoli heads could be attributed to the greater availability of nitrogen, achieved through the amalgamation of inorganic and organic sources of nitrogen, along with atmospheric N-fixation by biofertilizers (Ranjeet and Ravi, 2004). Additionally, the supply of growth regulators such as enzymes from manures and biofertilizers may facilitate enhanced protein synthesis (Vasanti and Subramanian, 2004). The positive impact of organic matter on protein content, leading to increased nitrogen content in seeds, has also been documented by Kumar *et al*., (2012). Furthermore, the heightened activity of nitrate reductase enzymes might aid in the synthesis of amino acids and protein (Yadav and Vijaya Kumari, 2004; Choudhary *et al*., 2012). Chatterjee *et al*., (2012) in cabbage also observed that the higher shelf life in the treatments containing 75% in combination with higher amount of organic manure and biofertilizer could be due to slower rate of respiration and transpiration which might have prevented the moisture loss from the head surface resulted in delay in loosening of head therefore retained the head freshness for the longer period.

Conclusion

Effect of organic sources

Among the organic sources, the highest quality parameters were recorded in T3 (100% Vermicompost + Biofertilizer @5 t ha^{-1}). This finding indicates that vermicompost improved water holding capacity of the soil, supply of balanced nutrients due to favourable soil condition during the entire growth period and especially at critical stages of growth. Biofertilizers results in production of different phytohormones like IAA, GA, Cytokines which could have led to better root development, better uptake and translocation of nutrients ultimately resulted in better growth attributes and was reflected in the quality of plant. Vermicompost + Biofertilizers helps in better availability of N throughout the growth period of plant and functional role of N is the plant body that is in multiplication, cell elongation, tissue differentiation for the better nourishment of the crop for longer period. On the other hand, the lowest quality parameters were observed in T4 (100% Mustard Cake + Biofertilizer @1.9 t ha^{-1}). This suggests that nutrient concentration in the organic source significantly impacted on qualityof broccoli.

Effect of date of sowing

Among the date of Sowing, D1 (30^{th} Standard Meteorological Week) exhibited the highest quality parameters, indicating its suitability as a medium for broccoli cultivation. These results suggest this might be attributed to favorable climatic conditions during the vegetative growth and curd development period. In contrast, the D3 (34^{th} Standard Meteorological Week) showed the lowest growth parameters, highlighting the advantages of early transplanting.

The interaction of D1 (30^{th} Standard Meteorological Week) and T3 (100% Vermicompost + Biofertilizer @5 t ha^{-1}) resulted in significantly highest quality parameters. This suggests a synergistic effect between the organic source and the favourable climatic conditions during D1 (30^{th} Standard Meteorological Week) crop growing period. The presence of vermicompost enhanced the nutrient availability and root development, contributing to improved plant performance. Conversely, the combination of D3 (34^{th} Standard Meteorological Week) and T4 (100% Mustard Cake + Biofertilizer @1.9 t ha^{-1}) showed the lowest quality parameters. This emphasizes that the quality observed in late planting was a consequence of the gradual decrease in temperatures during the curd development stage. Hence, the timing of transplantation becomes significantly important, as delayed transplantation negatively impacts quality and overall production.

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