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Effect of Manures and Bio Fertilizers on Growth, Yield and Quality of Sweet Orange cv. Hamlin

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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 study was carried out to determine the effect of manures and bio fertilizers on growth, yield and quality of three years old sweet orange cv. Hamlin during the year 2022-23 and 2023-24 with four replications under randomized block design. Different treatments were applied i.e. T1 : RDN through FYM, T2 : RDN through Vermicompost, T3 : RDN through FYM + *Azotobacter sp.* + *Pseudomonas sp*., T4 : RDN through Vermicompost + *Azotobacter sp.* + *Pseudomonas sp.*, T5 : Cow based bio formulation (Liquid formulation 5 liter/plant/month + Solid formulation 1.5 kg/plant at 3 months interval) and T6 : Control. The results of the study revealed significant increase in growth, yield and quality of sweet orange fruit crop. However, application of RDN through FYM + *Azotobacter sp.* + *Pseudomonas sp.* and application of RDN through Vermicompost + *Azotobacter sp.* + *Pseudomonas sp.* proved to be the best treatments in increasing the plant height (cm), plant

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spread (cm), stem girth (cm), fruit length (mm), fruit breadth (mm), average fruit weight (g), number of fruits per plant, yield (kg/plant), TSS (°Brix), decreasing acidity (%), TSS:Acid, Initial soil pH, EC (dS/m), SOC (%), Available N (kg/ha), P (kg/ha), K (kg/ha), bacterial count and fungal count. Thus, it can be concluded that effect of manures and bio fertilizers increases the growth, yield and quality of sweet orange.

Keywords: Citrus sinensis; hamlin; FYM; vermicompost; bio fertilizers; yield.

1. Introduction

Citrus constitutes one of the most economically significant groups of fruit crops worldwide. It belongs to the family *Rutaceae* and is widely regarded as having originated in China. Among the cultivated species, sweet orange (*Citrus sinensis* (L.) Osbeck) is believed to have arisen in southern China, where it has been grown for many centuries (Nicolosi, 2007; Lindsay & Norvell, 1978; Mahendra et al., 2009; Tatar & Pant, 2008). At present, sweet orange is cultivated commercially across tropical, subtropical and certain temperate regions, and it has become the most extensively planted fruit tree globally due to its high consumer demand and wide adaptability.

The chemical composition of sweet orange fruit reflects its substantial nutritional value. It typically contains 86–92% water, 5–8% sugars, 1–2% pectin, 0.1–1.5% glycosides, 0.8–1.2% pentosans, and 0.4–1.5% citric acid. In addition, the fruit comprises 0.6–0.9% fibre, 0.6–0.8% proteins, 0.2–0.5% lipids, 0.5–0.9% minerals, and 0.2–0.5% essential oils. The total soluble solids (TSS) content generally ranges from 10 to 12 °Brix (Syed *et al.*, 2012). This compositional profile underpins its nutritional, organoleptic and processing qualities.

Sweet orange cv. ‘Hamlin’ is a widely recognised and commercially important cultivar of *Citrus sinensis*. It originated as a chance seedling discovered in Florida, USA, in the late nineteenth century and was subsequently named after A. G. Hamlin, the grower in whose orchard it was first identified (University of Florida, IFAS Extension, 2025). The cultivar has since gained prominence in citrus production systems owing to its adaptability and fruit quality attributes.

Farmyard manure (FYM), widely acknowledged as a vital and extensively utilised organic amendment, plays a pivotal role in improving sweet orange productivity through the amelioration of soil physicochemical properties and the gradual release of essential macro- and micronutrients. The incorporation of FYM enhances soil structure, aggregation and moisture-holding capacity, while simultaneously stimulating microbial activity and nutrient mineralisation. On average, FYM contains approximately 0.5–1.5% nitrogen (N), 0.5–0.9% phosphorus (P), and 0.5–1.4% potassium (K), in addition to trace quantities of secondary and micronutrients, thereby contributing to balanced plant nutrition. Vermicompost, produced through the synergistic action of earthworms and microorganisms during the decomposition and stabilisation of organic residues, constitutes a finely fragmented, peat-like material with favourable agronomic characteristics. It is distinguished by improved soil permeability, aeration and drainage, enhanced water-holding capacity, and increased microbial activity. These attributes collectively promote root proliferation, nutrient availability and overall plant growth, making vermicompost a valuable component of integrated nutrient management strategies in perennial fruit crops. Biofertilisers, also referred to as microbial inoculants, are formulations containing viable or dormant cells of efficient strains of beneficial microorganisms. These preparations facilitate nutrient mobilisation and biological nitrogen fixation, thereby improving nutrient uptake efficiency. As cost-effective and renewable inputs, biofertilisers contribute to the reduction of inorganic fertiliser requirements while enhancing flowering, fruit quality and yield, alongside sustaining long-term soil fertility (Kumari *et al.*, 2015). Their integration into nutrient management programmes is increasingly advocated as part of sustainable horticultural production systems.

Cow based bioformulation is an organic liquid manure made from cow dung, urine, pulse flour, water, jaggery and soil. Organic farming using organic sources like farmyard manure, crop residue, oil cakes and animal’s excreta is slowly regaining its importance. There is no use of synthetic agrochemicals in organic farming. As compared to fertilizers, manures contain a small amount of plant nutrients but they help in enhancing the organic matter, permeability of the soil, good soil aggregation, supply several macro and micronutrients and also increasing the density of microbes in the soil. The use of manures along with bio fertilizers and crop residues has a positive effect on the yield and quality of crops and also a cheap source of available nutrients to plants. Keeping in view, this experiment was planned to study the "Effect of manures and bio fertilizers on growth, yield and quality of sweet orange cv. Hamlin" with the objective to study the effect of manures on growth, yield and quality of sweet orange.

2. Materials and Methods

The present investigation was conducted at Experimental orchard of Deendayal Upadhyay Centre of Excellence for Organic Farming, CCS Haryana Agricultural University, Hisar on three and three year old sweet orange trees during the year 2022-23 and 2023-24. Hamlin variety was selected as an experimental material to examine the effect of manures and bio fertilizers on growth, yield and quality of sweet orange. The experiment comprised of total 6 treatments i.e. T1 : RDN through FYM, T2 : RDN through Vermicompost, T3 : RDN through FYM + *Azotobacter sp.* + *Pseudomonas sp*., T4 : RDN through Vermicompost + *Azotobacter sp.* + *Pseudomonas sp.*, T5 : Cow based bio formulation (Liquid formulation 5 liter /plant/month + Solid formulation 1.5 kg/plant at 3 months interval) and T6 : Control with four replications under randomized block design. After application of manures and bio fertilizers, the fruits were analyzed for plant height (cm), plant spread (cm), stem girth (cm), fruit length (mm), fruit breadth (mm), average fruit weight (g), number of fruits per plant, yield (kg/plant), TSS (°Brix), acidity (%), TSS:Acid, Initial soil pH, EC (dS/m), SOC (%), Available N (kg/ha), P (kg/ha), K (kg/ha), bacterial count and fungal count.

Plant Height (cm): The plant height of the trees were measured with the help of measuring pole, upto maximum point of height.

Plant Spread (cm): The plant spread of the trees was measured with the help of measuring tape.

Stem Girth (cm): The stem girth of the trees was measured with the help of measuring tape.

Fruit Length and Breadth (mm): The observations on size of fruits in terms of their length (mm) and breadth (mm) were taken with the help of Vernier Caliper, at the time of fruit harvesting. Then the average length and breadth were calculated and expressed in millimeter (mm).

Number of Fruits/Plant: Numbers of fruits per plant were counted for different treatments.

Average Fruit Weight (g): Ten randomly selected fruits from the tagged branch of the tree were picked and weighed on top pan electric balance. To calculate the average fruit weight the total fruit weight was divided by total number of fruits taken and expressed in grams (g).

Yield (kg/plant): To calculate total fruit yield, the total number of fruits per tree was multiplied with average fruit weight and the value was expressed in kilograms (kg/tree).

TSS (ºBrix): The total soluble solids (TSS) was measured by hand refractometer.

Acidity (%): Acidity was estimated by using the method given in A.O.A.C. (1990).

TSS/Acid Ratio: The TSS/acid ratio was obtained by dividing the corresponding value of total soluble solids to the acid content of the fruit juice.

2.1 Soil Analysis

Collection of Soil Samples: Soil samples were collected at the start as well as at the end of experiment from the area under tree canopy in all four directions and were mixed. Trowel was used for this purpose and kept in clean polythene bags.

Processing of Soil Samples: Soil samples were air dried in shade for three to four days. These were grinded using wooden mortar and pestle and passed through 2mm sieve to separate out the coarse fragments. Coarse fragments were discarded and fine earth samples were used for analysis.

Soil Electric Conductivity (dS/m): Electric conductivity was estimated in 1:2 soil: water suspension. 20 g soil sample was taken in 100 ml beaker and 40 ml distilled water was added to it and a glass rod was used to stir intermittently for 30 minutes. It was allowed to stand until a clear supernatant liquid was acquired. This clear extract was used for EC measurement with the help of EC meter.

Soil pH: Soil pH was measured in 1:2 soil: water suspension. 20 g soil of sample was taken in 100 ml beaker and 40 ml distilled water was added to it and a glass rod was used to stir intermittently for 30 minutes. It was allowed to stand until a clear supernatant liquid was acquired. This clear extract was used for pH estimation with the help of pH meter.

Organic Carbon: The organic C in soil was determined by method given by Kalembasa and Jenkinson (1973).

Available Nitrogen (kg/ha): The alkaline permanganate method proposed by Subbiah and Asija (1956) was used for the determination of available nitrigen in soil sample.

Available Phosphorus (kg/ha): For the determination of available phosphorus, Olsen's method (Olsen *et al.*, 1954) was used.

Available Potassium (kg/ha): Available Potassium was determined by neutral normal NH_4OAC solution using flame photometer (Hanway and Heidal, 1952).

Statistical Analysis: The OPSTAT statistical software was used for all the statistical analysis.

3. Results and Discussion

Application of manures and bio fertilizers was found effective in influencing the growth, yield and quality of sweet orange. During 2022-23, the effect of manures and bio fertilizers on growth, yield and quality of sweet orange cv. Hamlin revealed that the maximum stem girth (38.1 cm) was recorded in T3 (RDN through FYM + *Azotobacter* sp. + *Pseudomonas* sp.) which was statistically at par with T1 (RDN through FYM) and minimum (35.6 cm) in control. The maximum plant height (387.2 cm), plant spread (370.0 cm) was recorded in T3 (RDN through FYM + *Azotobacter* sp. + *Pseudomonas* sp.) and minimum plant height (356.2 cm), plant spread (328.7 cm) was recorded in control. Similarly during 2023-24, The maximum stem girth (42.1 cm) and plant height (426.2 cm) were recorded in T4 (RDN through Vermicompost + *Azotobacter* sp + *Pseudomonas* sp.) which remained at par with T2 (RDN through Vermicompost), T3 (RDN through FYM + *Azotobacter* sp. + *Pseudomonas* sp.) and T1 (RDN through FYM). The maximum plant spread (409.2 cm) was recorded in T4 (RDN through Vermicompost + *Azotobacter* sp + *Pseudomonas* sp.) which was at par with T2 (RDN through Vermicompost) and T3 (RDN through FYM + *Azotobacter* sp. + *Pseudomonas* sp.) followed by T1 i.e. RDN through FYM and minimum stem girth (39.1 cm), plant height (396.2 cm), plant spread (357.7 cm) was recorded in control (Table 1). Optimum dose of FYM may be attributed to increased metabolic uses of nutrients in plants which promotes meristematic activities resulting in higher growth and expansion of photosynthetic surface. Vermicompost is a protein builder and the main constituent of protoplasm in plants; thus, an increase in nitrogen supply accelerates synthesis of amino acids, which may have indirectly exhibited an increase in plant height. *Azotobacter* and PSB are also helpful in cell elongation and cell division in the meristmatic region of the plant, which was due to the production of plant growth substances (IAA and GA). Similar results are in accordance with the findings of Ingle *et al*. (2008) in okra, Yadav *et al*. (2011) in papaya, Mishra and Tripathi (2012), Gupta and Tripathi (2012) and Singh *et al*. (2008) in strawberry.

In the year 2022-23, the maximum fruit length (71.7 mm) and fruit breadth (72.5 mm) was recorded in T3 (RDN through FYM + *Azotobacter* sp. + *Pseudomonas* sp.) which was statistically at par with T1 (RDN through FYM) and T4 (RDN through Vermicompost + *Azotobacter* sp + *Pseudomonas* sp.) and minimum fruit length (68.3 mm) and fruit breadth (68.7 mm) was recorded in control. Whereas during 2023-24, the maximum fruit length (66.7 mm) and fruit breadth (67.5 mm) were recorded in T4 (RDN through Vermicompost + *Azotobacter* sp + *Pseudomonas* sp.) which was at par with T2 (RDN through Vermicompost), T3 (RDN through FYM + *Azotobacter* sp. + *Pseudomonas* sp.) and T1 (RDN through FYM) whereas minimum fruit length (63.3 mm) and fruit breadth (63.7 mm) was recorded under control (Table 2). The observed increase in fruit size (length and breadth) and weight can be attributed to the plants that were fertilized with FYM + *Azotobacter* and vermicompost + *Azotobacter*, as they exhibited a higher photosynthetic ability. This enhanced photosynthetic capacity likely facilitated increased dry matter accumulation in the fruits. Fruit size (length and breadth) and weight are closely associated with the content of dry matter and the balanced levels of hormones. These findings align with the studies conducted by Shukla *et al*. (2009) in tomato, Gupta and Tripathi (2012), Verma and Rao (2013) and Soni *et al*. (2018) in strawberry.

Table 1. Effect of manures and bio fertilizers on stem girth, plant height and plant spread of sweet orange cv. Hamlin during the year 2022-23 and 2023-24

Treatments	Stem girth (cm)		Plant height (cm)		Plant spread (cm)	
	2022-23	**2023-24**	**2022-23**	**2023-24**	**2022-23**	**2023-24**
T_1 - RDN through FYM	37.7	41.5	382.7	420.7	363.7	400.8
T_2 - RDN through Vermicompost	36.5	41.7	377.7	422.7	358.8	407.6
T_3 - RDN through FYM + *Azotobacter* sp. + *Pseudomonas* sp.	38.1	41.7	387.2	422.3	370.0	406.7
T_4 - RDN through Vermicompost +*Azotobacter* sp. + *Pseudomonas* sp.	36.7	42.1	380.3	426.2	362.2	409.2
T_5 - Cow based bio formulation	35.1	39.6	366.6	406.6	348.5	376.5
T_6 - Control	35.6	39.1	356.2	396.2	328.7	357.7
CD at 5%	0.9	0.9	6.4	6.6	6.6	6.4

Table 2. Effect of manures and bio fertilizers on fruit length and fruit breadth of sweet orange cv. Hamlin during the year 2022-23 and 2023-24

Treatments	Fruit length (mm)		Fruit breadth (mm)	
	2022-23	**2023-24**	**2022-23**	**2023-24**
T_1 - RDN through FYM	70.7	65.5	72.2	66.6
T_2 - RDN through Vermicompost	70.4	65.7	71.6	67.2
T_3 - RDN through FYM + *Azotobacter* sp. + *Pseudomonas* sp.	71.7	65.5	72.5	66.9
T_4 - RDN through Vermicompost +*Azotobacter* sp. + *Pseudomonas* sp.	70.5	66.7	71.9	67.5
T_5 - Cow based bio formulation	69.5	64.4	70.8	65.8
T_6 - Control	68.3	63.3	68.7	63.7
CD at 5%	1.2	1.2	1.2	1.3

Table 3. Effect of manures and bio fertilizers on average fruit weight, number of fruits per plant and yield of sweet orange cv. Hamlin during the year 2022-23 and 2023-24

Treatments	Average fruit weight (g)		Number of fruits per plant		Yield (kg/plant)	
	2022-23	**2023-24**	**2022-23**	**2023-24**	**2022-23**	**2023-24**
T_1 - RDN through FYM	184.5	174.4	150.3	159.4	27.7	27.7
T_2 - RDN through Vermicompost	181.4	174.5	144.4	165.3	26.2	28.8
T_3 - RDN through FYM + *Azotobacter* sp. + *Pseudomonas* sp.	185.4	174.1	154.3	161.5	28.6	28.1
T_4 - RDN through Vermicompost +*Azotobacter* sp. + *Pseudomonas* sp.	183.1	175.6	146.5	169.3	26.8	29.7
T_5 - Cow based bio formulation	179.3	169.3	138.8	153.8	24.9	26.0
T_6 - Control	171.7	164.7	131.6	146.6	22.6	24.1
CD at 5%	2.3	2.3	5.5	5.6	1.9	2.1

Table 4. Effect of manures and bio fertilizers on TSS, acidity and TSS: Acid of sweet orange cv. Hamlin during the year 2022-23 and 2023-24

Treatments	TSS (°Brix)		Acidity (%)		TSS: Acid	
	2022-23	**2023-24**	**2022-23**	**2023-24**	**2022-23**	**2023-24**
T_1 - RDN through FYM	9.82	9.70	0.73	0.75	13.45	12.93
T_2 - RDN through Vermicompost	9.80	9.72	0.74	0.74	13.24	13.13
T_3 - RDN through FYM + *Azotobacter* sp. + *Pseudomonas* sp.	9.86	9.74	0.70	0.72	14.09	13.52
T_4 - RDN through Vermicompost +*Azotobacter* sp. + *Pseudomonas* sp.	9.84	9.76	0.71	0.71	13.85	13.74
T_5 - Cow based bio formulation	9.56	9.56	0.75	0.76	12.74	12.57
T_6 - Control	9.56	9.56	0.76	0.77	12.58	12.41
CD at 5%	0.20	0.18	0.03	0.03	0.40	0.38

Table 5. Effect of FYM, Vermicompost and bio fertilizers on soil properties of sweet orange cv. Hamlin during the year 2022-23

Treatments	Soil properties					
	pH (1:2)	EC 1:2 (ds/m)	SOC (%)	Avail. N (kg/ha)	Avail. P (kg/ha)	Avail. K (kg/ha)
T_1 - RDN through FYM	8.08	0.31	0.65	159.00	12.83	288.00
T_2 - RDN through Vermicompost	8.09	0.31	0.66	160.33	13.03	292.00
T_3 - RDN through FYM + *Azotobacter* sp. + *Pseudomonas* sp.	8.08	0.33	0.66	162.00	13.13	292.67
T_4 - RDN through Vermicompost +*Azotobacter* sp. + *Pseudomonas* sp.	8.09	0.32	0.68	163.00	13.30	294.33
T_5 - Cow based bio formulation	8.09	0.31	0.62	153.00	12.70	285.00
T_6 - Control	8.08	0.32	0.61	151.00	12.60	280.33
CD at 5%	NS	NS	0.01	0.93	0.14	3.11
Initial	7.65	0.38	0.66	158.00	13.50	305.00

Table 6. Effect of FYM, Vermicompost and bio fertilizers on soil properties of sweet orange cv. Hamlin during the year 2023-24

Treatments	Soil properties							
	pH (1:2)	EC 1:2 (ds/m)	SOC(%)	Avail. N (kg/ha)	Avail. P (kg/ha)	Avail. K (kg/ha)	BacterialCount	Fungal Count
T_1 - RDN through FYM	7.83	0.39	0.63	156.00	12.95	279.00	$2.3x10^4$	$4.6 x10^2$
T_2 - RDN through Vermicompost	7.81	0.38	0.64	158.33	13.05	281.05	$7.2 x10^5$	$2.5 x10^3$
T_3 - RDN through FYM + *Azotobacter* sp. + *Pseudomonas* sp.	7.79	0.37	0.65	159.00	13.19	282.17	$6.8 x10^5$	$5.6 x10^3$
T_4 - RDN through Vermicompost +*Azotobacter* sp. + *Pseudomonas* sp.	7.73	0.36	0.66	160.00	13.25	284.15	$3.6 x10^6$	$1.5 x10^4$
T_5 - Cow based bio formulation	7.80	0.39	0.62	154.00	12.90	276.00	$4.9x10^7$	$7.3 x10^4$
T_6 - Control	7.89	0.41	0.61	153.00	12.82	270.33	$7.3 x10^3$	$3.1 x10^3$
CD at 5%	NS	NS	0.02	0.76	0.12	3.45	-	-
Initial	7.65	0.38	0.66	158.00	13.50	305.00	$5.6 x10^5$	

However in 2022-23, the maximum average fruit weight (185.4 g) was recorded under T3 (RDN through FYM + *Azotobacter sp.* + *Pseudomonas sp*.) which was statistically at par with T1 (RDN through FYM) and T4 (RDN through Vermicompost + *Azotobacter sp.* + *Pseudomonas sp.*) whereas minimum average fruit weight (171.7 g) was recorded under control. The maximum number of fruits per plant (154.3) and yield (28.6 kg/plant) were also recorded in T3 (RDN through FYM + *Azotobacter sp.* + *Pseudomonas sp*.) which was statistically at par with T1 (RDN through FYM) whereas, minimum number of fruits (131.6) and yield (22.6 kg/plant) was recorded in control. Similarly during 2023-24, the maximum average fruit weight (176.5 g) was recorded under T4 (RDN through Vermicompost + *Azotobacter sp.* + *Pseudomonas sp.*) which was statistically at par with T2 (RDN through Vermicompost) whereas minimum average fruit weight (164.7 g) was recorded under control. The maximum number of fruits per plant (169.3) and yield (29.7 kg/plant) were also recorded in T4 (RDN through Vermicompost + *Azotobacter sp.* + *Pseudomonas sp.*) whereas, minimum number of fruits (146.6) and yield (24.1 kg/plant) was recorded in control (Table 3). The presence of bio fertilizers, particularly *Azotobacter* inoculation, which subsequently led to flower initiation and the number of flowers per plant, may be responsible for an increase in the number of fruits per plant. Similar results were observed by Yadav *et al*. (2010) and Verma and Rao (2013) in strawberry.

In the year 2022-23, the quality parameters like maximum TSS (9.86°Brix), minimum acidity (0.70%) and maximum TSS: Acid (14.09) were recorded in T3 (RDN through FYM + *Azotobacter sp.* + *Pseudomonas sp*.) which was statistically at par with T1 (RDN through FYM) and T4 (RDN through Vermicompost + *Azotobacter sp.* + *Pseudomonas sp.*) whereas, minimum TSS (9.56°Brix) and maximum acidity (0.76) were recorded under control. During 2023-24, quality parameters like maximum TSS (9.76°Brix), minimum acidity (0.71%) and maximum TSS: Acid (13.74) were recorded in T4 (RDN through Vermicompost + *Azotobacter sp.* + *Pseudomonas sp.*) which was statistically at par with T2 (RDN through Vermicompost) and T3 (RDN through FYM + *Azotobacter sp.* + *Pseudomonas sp*.) whereas, minimum TSS (9.56°Brix) and maximum acidity (0.77) were recorded under control (Table 4). FYM contains micronutrients which help in proper development of fruits and improves their quality. The observed increase in TSS (Total Soluble Solids) is due to the application of bio fertilizers and vermicompost which can be attributed to the rapid conversion of starch and pectin into soluble compounds and the efficient transportation of sugars from leaves to developing fruits. Similar findings were reported by Singh & Singh (2009) in ber, Baksh *et al*. (2008) in guava, Rathi and Bilst (2004) in pear, Attia *et al*. (2009) in banana, Gupta and Tripathi (2012) and Jain *et al*. (2017) in strawberry.

The results presented in Tables 5 and 6 showed that the effect of FYM, vermicompost and bio fertilizers was found significant on soil organic carbon, nitrogen, phosphorus and potash. The highest available soil organic carbon (0.68%) during 2022-23 and (0.66%) during 2023-24 were observed under treatment T4 - RDN through Vermicompost + *Azotobacter* sp + *Pseudomonas* sp. which was at par with treatment T3 - RDN through FYM + *Azotobacter* sp +*Pseudomonas* sp. and T1 - RDN through FYM. Soil Organic carbon and available NPK were significantly superior over control and cow based bioformulations under sweet orange cultivation. Whereas, the bacterial count and fungal count were found maximum in T5 - Cow based bio formulation. The increased soil nutrient status may also be attributed to the fact that bio fertilizers in combination with manures improved the physical condition of soil, root development and more soil moisture retention. The increased bacterial population might be due to role of manures incorporated in the soil which proved essential organic carbon source and also because of soil being the natural habitat of these microorganisms. Similar results were reported by Mitra *et al*. (2012), Trivedi *et al*. (2012), Kumar *et al*. (2014) in guava and Marathe and Bharambe (2007) in sweet orange.

4. Conclusion

Manures and bio fertilizers play an important role in growth, fruit retention and development and cause efficient yield improvement. Results revealed that during 2022-23, the maximum stem girth (38.1 cm), plant height (387.2 cm), plant spread (370.0 cm), fruit length (71.7 mm), fruit breadth (72.5 mm), average fruit weight (185.4 g), number of fruits per plant (154.3), yield (28.6 kg/plant), TSS (9.86°Brix), minimum acidity (0.70%), TSS: Acid (14.09) and available soil organic carbon (0.68%) of sweet orange cv. Hamlin were recorded in RDN through FYM +

Azotobacter sp + *Pseudomonas* sp. Similarly, during 2023-24, the maximum stem girth (42.1 cm), plant height (426.2 cm), plant spread (409.2 cm), fruit length (66.7 mm), fruit breadth (67.5 mm), average fruit weight (175.6 g), number of fruits per plant (169.3), yield (29.7 kg/plant), TSS (9.76°Brix), minimum acidity (0.71%), TSS: Acid (13.74) and available soil organic carbon (0.66%) of sweet orange cv. Hamlin were recorded in RDN through Vermicompost + *Azotobacter* sp + *Pseudomonas* sp.

Disclaimer (Artificial Intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

Competing Interests

Authors have declared that no competing interests exist.

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