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Effect of organic nutrients on growth, yield and quality of beetroot (*Beta vulgaris* L.) var. crimson globe

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Abstract
The field experiment entitled "Effect of organic nutrients on growth, yield and quality of beetroot (*Beta vulgaris* L.) var. Crimson Globe" was conducted during the *rabi* season of the year 2023-24 at Horticulture Research Farm, B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat. The experiment was laid out in a Randomized Block Design with 3 replications. Among different treatments, the maximum number of leaves per plant (7.86 and 9.76), plant height (17.25 cm and 34.79 cm), plant width (29.57 cm and 42.57 cm), leaf area (105.14 cm^2 and 163.65 cm^2), leaf area index (0.234 and 0.363) were recorded at 25 and 50 DAS respectively as well as shoot weight at harvest (146.64 g) was recorded with treatment of 75% RDN through vermicompost + Bio-NPK (Drenching at 20 DAS). Maximum root length (17.21 cm), root diameter (78.77 mm), fresh weight of root (212.52 g), total plant biomass (340.53 g), dry weight of total biomass (21.85 g), root to shoot ratio (1.66), root yield (7.35 kg/plot), TSS (8.71 ^{0}Brix) and total sugar content (7.45%) were recorded with the treatment 50% RDN through FYM + 25% RDN through Vermicompost + Bio-NPK (Drenching at 20 DAS) + *Panchagavya* @ 3%.

Keywords: Beetroot, *Panchagavya*, Organic nutrients, Growth, Yield and Quality

Introduction
Beetroot (*Beta vulgaris* L.) is a crop belonging to the Chenopodiaceae family. It is the second most important sugar-producing crop after sugarcane, all over the world (Amr and Ghaffar, 2010) [1]. It is a native of North America. In many aspects, it is better than sugarcane as it has a short growth duration (5–6 months), higher sucrose contents and sugar recovery (Pathak and Kapur, 2013) [15]. It is the main crop for sugar production in temperate countries. Grown in 121 countries, the total production of beetroot in the world is 270 million tons from an area of 7.9 million hectares (FAO, 2019) [3]. Major beetroot crop-growing states in India are Haryana, Uttar Pradesh, Himachal Pradesh, West Bengal and Maharashtra.

Beetroot is one of the richest sources of folate. It contains vitamins A, B_1, B_2, B_6 and C. It is also a good source of calcium, magnesium, copper, phosphorus, sodium and iron (Neha *et al.*, 2018) [12]. Beetroot contains several highly bioactive phenolics, such as rutin, epicatechin and caffeic acid, also known to be excellent antioxidants (Georgiev *et al.*, 2010) [4]. The usually deep-red roots of beetroot can be baked, boiled, or steamed and often served hot as a cooked vegetable or cold as a salad vegetable. They are also pickled. Raw beets are added to salads. A large proportion of commercial production is processed into boiled and sterilized beets or pickles.

Organic nutrient sources are becoming more popular for vegetable production due to the high cost of chemical fertilizers and their long-term impact on soil health, ecology, and other natural resources. Farmyard manure, being a bulky organic substance, reduces soil compaction and increases aeration while also providing important plant nutrients and accumulating higher humus content. Vermicompost provides vital nutrients for plants, including nitrogen, phosphorous, potassium, and micronutrients. Biofertilizers are ready-to-use organic formulations that are inoculated with live effective and beneficial microorganisms that are added to soil to directly or indirectly make certain essential elements available to plants for their nutrition. *Panchagavya* means "mixture of five products (cow dung, cow urine, milk, ghee and curd) of cow". The three direct constituents are cow dung, cow urine and milk and the two derived products are curd and ghee. These liquid formulations compris

macronutrients, important micronutrients, numerous vitamins, essential amino acids, growth-stimulating hormones such as IAA and GA and beneficial microbes, which aid in crop development, yield and quality (Gore and Sreenivasa, 2011) [5].

Material and Methods

The present experiment was carried out during the *rabi* season of the year 2023-24 at Horticulture Research Farm, Department of Horticulture, B. A. College of Agriculture, Anand Agricultural University, Anand.The experimental field, referred to locally as "Goradu," has sandy loam soil. Belonging to the Entisol class, it has an alluvial origin. The experiment was laid out in a Randomized Block Design with 3 replications. The experiment was comprised of fourteen treatments *viz*., T_1: Absolute control, T_2: 100% RDN through FYM, T_3: 100% RDN through vermicompost, T_4: 75% RDN through FYM + 25% RDN through vermicompost, T_5: 50% RDN through FYM + 50% RDN through vermicompost, T_6: 25% RDN through FYM + 75% RDN through vermicompost, T_7: 75% RDN through FYM + Bio-NPK (Drenching at 20 DAS), T_8: 75% RDN through FYM + Bio-NPK (Drenching at 20 DAS) + *Panchagavya* @ 3%, T_9: 75% RDN through vermicompost + Bio-NPK (Drenching at 20 DAS), T_{10}: 75% RDN through Vermicompost + Bio-NPK (Drenching at 20 DAS) + *Panchagavya* @ 3%, T_{11}: 50% RDN through FYM + 25% RDN through Vermicompost + Bio-NPK (Drenching at 20 DAS) T_{12}: 50% RDN through FYM + 25% RDN through Vermicompost + Bio-NPK (Drenching at 20 DAS) + *Panchagavya* @ 3% T_{13}: 50% RDN through Vermicompost + 25% RDN through FYM + Bio-NPK (Drenching at 20 DAS) and T_{14}: 50% RDN through Vermicompost + 25% RDN through FYM + Bio-NPK (Drenching at 20 DAS) + *Panchagavya* @ 3% to study the effect of organic nutrients on growth, yield and quality parameter *viz*. No. of leaves per plant at 25 & 50 DAS, Plant height (cm) at 25 & 50 DAS, Plant spread (cm) at 25 & 50 DAS, Leaf area (cm^2) at 25 & 50 DAS, Leaf area index at 25 & 50 DAS, Root length at harvest (cm), Root diameter at harvest (mm), Fresh weight of root at harvest (g), Shoot weight at harvest (g), Root to shoot ratio at harvest, Total plant biomass at harvest (g), Dry weight of total biomass at harvest (g), Root yield per plot at harvest (kg), TSS (°Brix) and Total Sugar (%).

The beetroot variety under study was "Crimson Globe". Seeds were sown at a spacing of 30 cm × 15 cm. All the recommended agronomic practices were followed to raise a good crop. A blanket application of FYM @ 10 t/ha was applied at the time of soil preparation and different doses of organic manures (FYM and Vermicompost) according to treatments were applied in all the treatments and replications. Beetroot fertilizer dose is 100:60:60 NPK (kg/ha). FYM and vermicompost were applied equivalent to RDF of nitrogen in beetroot treatment. Bio NPK was given as a drenching (1 lit./ha) after 20 days of sowing and drenching of *Panchagavya* @ 3% (30 ml/lit.) after 20 and 40 days of sowing. Five plants were selected randomly from each net plot. The data recorded on different parameters during the year of the investigation were statically analyzed as per the statistical methods described by (Panse and Sukhatme, 1985) [14].

Results and Discussion

1. Effect of organic nutrient treatments on growth attributes

The study results revealed that the maximum number of leaves per plant (7.86 and 9.76), plant height (17.25 cm and 34.79 cm), plant width (29.57 cm and 42.57 cm), leaf area (105.14 cm2 and 163.65 cm2), leaf area index (0.234 and 0.363) were recorded at 25 and 50 DAS respectively with the application of T_9: 75% RDN through vermicompost + Bio-NPK (Drenching at 20 DAS) which was at par with treatment of T_{13}: 50% RDN through Vermicompost + 25% RDN through FYM + Bio-NPK (Drenching at 20 DAS), whereas the minimum growth parameters observed with treatment T_1: Absolute control. It might be due to the vermicompost, which can be ascribed to the increased availability of essential macro and micronutrients, such as zinc, copper, iron, and manganese, to the plant in sufficient amounts (Bhattarai and Maharjan, 2013) [2]. Biofertilizers produce plant hormones such as auxins, cytokinins and gibberellins and improves crop productivity by protecting the plants against soil-borne pathogens. it improved growth at all the growth stages, which might be due to vermicompost nitrification inhibitory properties, improved soil structure and enhanced photosynthetic activity, cell division and cell elongation that are facilitated by the applications of biofertilizer and organic manures. Biofertilizers can produce growth-promoting compounds and modify metabolic processes, which may have increased cell division and elongation, increased uptake of water and nutrients, and ultimately result in the vegetative development of the plant. The results are in close agreement with the findings of Mali *et al*. (2018) [11], Kumar *et al*. (2018) [9], Kaur *et al*. (2023) [8] in radish.

2. Effect of organic nutrient treatments on yield attributes and yield

The yield attributes *viz*. root length (17.21 cm), root diameter (78.77 mm), fresh weight of root (212.52 g), total plant biomass (340.53 g), dry weight of total biomass (21.85 g), root to shoot ratio (1.66) and root yield (7.35 kg/plot and 27.21 t/ha) were recorded higher with the treatment 50% RDN through FYM + 25% RDN through Vermicompost + Bio-NPK (Drenching at 20 DAS) + *Panchagavya* @ 3% and which was significantly at par with T_{14} (50% RDN through Vermicompost + 25% RDN through FYM + Bio-NPK (Drenching at 20 DAS) + *Panchagavya* @ 3%), whereas the minimum yield parameters recorded with treatment of T_1: Absolute control.

The positive effect of integrated organic nutrients had resulted in increased yield attributes, which had responded to higher yield. The effect of biofertilizer, *panchgavya* along with organic manure application on root size may be attributed active role of bacteria released from biofertilizer. Release of certain growth regulators and stimulation compounds, like GA_3 and IAA, by the bacteria from the biofertilizer. Additionally, the availability of sufficient amounts of nitrogen and phosphorus from organic manures of the natural status of soil nutrients may also contribute to increased nutrient uptake Similar results were suggested by Jabeen *et al.* (2018) [7]. The presence of organic manures may have triggered an increase in root length and diameter by encouraging the production of polysaccharides by soil microorganisms and improving soil structure, which is important for root development and growth. The increased root parameters of the plants may have resulted from improved aggregation, an overall reduction in bulk density, an increase in porosity and an improvement in the capacity of the soil to store water due to organic manures. Similar results of root parameters were also found by Singh *et al*. (2016) [18] in radish, Subedi *et al*. (2018) [19] in radish and Gyewali *et al*. (2020) [6] in radish.

However on the other hand, the maximum shoot weight at harvest (146.64 g) was noted in application with the T_9: 75% RDN through vermicompost + Bio-NPK (Drenching at 20 DAS) which was at par with treatment of T_{13}: 50% RDN through Vermicompost + 25% RDN through FYM + Bio-NPK (Drenching at 20 DAS), whereas the minimum growth parameters observed with treatment T_1: Absolute control. It might be due to the combination of organic manures and biofertilizers that may have improved the physical-chemical characteristics, drainage, porosity and aeration of the soil, which has given plants the nutrients they need to develop properly. The results were accorded with Gyewali *et al.* (2020) [6] in radish.

3. Effect of organic nutrient treatments on quality parameters

The data from the investigation revealed that the application of organic nutrients to be influence on quality parameters *viz*. TSS (˚Brix) and Total sugar (%).

The maximum TSS (8.71 ˚Brix) and total sugar content (7.45 %) were found significantly superior in the treatment 50 % RDN through FYM + 25 % RDN through Vermicompost + Bio-NPK (Drenching at 20 DAS) + *Panchagavya* @ 3 % which was significantly at par with T_{14} (50 % RDN through Vermicompost + 25 % RDN through FYM + Bio-NPK (Drenching at 20 DAS) + *Panchagavya* @ 3%). This might be due to the accumulation of more reserved compounds in beetroot. Better availability and uptake of nitrogen and other nutrients with the application of manures which might have led to a balanced C/N ratio and increased activity of plant metabolism. Similar findings were made by and Rani et al. (2006) in beetroot, Sunandarani and Mallareddy (2007) [20] in beetroot, Sarma et al. (2015) [17] in carrot, Pandey *et al*. (2017) [13] in carrot and Kushwah *et al.* (2020) [10] in radish.

Table 1: Effect of organic nutrients on number of leaves plant height and plant spread of beetroot.

Tr. No.	Treatment details	Number of leaves/ plant		Plant height (cm)		Plant spread (cm)	
		At 25 DAS	At 50 DAS	At 25 DAS	At 50 DAS	At 25 DAS	At 50 DAS
T_1	Absolute control	5.07	7.66	13.94	28.29	22.57	30.82
T_2	100% RDN through FYM	5.37	7.80	15.45	31.04	23.94	33.86
T_3	100% RDN through Vermicompost	5.67	7.89	15.27	30.93	24.35	34.69
T_4	75% RDN through FYM + 25% RDN through Vermicompost	5.82	7.97	15.51	31.17	24.62	34.72
T_5	50% RDN through FYM + 50% RDN through Vermicompost	6.13	8.17	15.59	31.37	24.71	35.23
T_6	25% RDN through FYM + 75% RDN through Vermicompost	6.40	8.28	15.62	31.44	24.76	35.50
T_7	75% RDN through FYM + Bio-NPK (Drenching at 20 DAS)	6.47	8.35	15.66	31.48	24.85	36.37
T_8	75% RDN through FYM + Bio-NPK (Drenching at 20 DAS) + *Panchagavya* @ 3%	6.50	8.39	15.69	31.90	25.31	36.93
T_9	75% RDN through Vermicompost + Bio-NPK (Drenching at 20 DAS)	7.86	9.76	17.25	34.79	29.57	42.57
T_{10}	75% RDN through Vermicompost + Bio-NPK (Drenching at 20 DAS) + *Panchagavya* @ 3%	6.53	8.48	15.78	31.99	25.72	37.25
T_{11}	50% RDN through FYM + 25% RDN through Vermicompost + Bio-NPK (Drenching at 20 DAS)	7.08	8.78	16.03	32.42	26.70	38.44
T_{12}	50% RDN through FYM + 25% RDN through Vermicompost + Bio-NPK (Drenching at 20 DAS) + *Panchagavya* @ 3%	6.83	8.71	15.96	32.25	26.18	38.15
T_{13}	50% RDN through Vermicompost + 25% RDN through FYM + Bio-NPK (Drenching at 20 DAS)	7.23	9.10	16.59	33.67	27.15	39.55
T_{14}	50% RDN through Vermicompost + 25% RDN through FYM + Bio-NPK (Drenching at 20 DAS) + *Panchagavya* @ 3%	6.73	8.52	15.82	32.22	25.98	37.32
SEm ±		0.26	0.32	0.38	0.73	0.91	1.21
CD at 5%		0.77	0.93	1.12	2.14	2.66	3.53
CV%		7.23	6.61	4.24	4.00	6.20	5.75

Table 2: Effect of organic nutrients leaf area and leaf area index of beetroot

Tr. No.	Treatment details	Leaf area (cm^2)		Leaf area index	
		At 25 DAS	At 50 DAS	At 25 DAS	At 50 DAS
T_1	Absolute control	72.84	117.38	0.162	0.263
T_2	100% RDN through FYM	79.54	122.26	0.177	0.270
T_3	100% RDN through Vermicompost	82.24	125.12	0.183	0.280
T_4	75% RDN through FYM + 25% RDN through Vermicompost	84.25	127.25	0.187	0.282
T_5	50% RDN through FYM + 50% RDN through Vermicompost	84.54	130.62	0.188	0.290
T_6	25% RDN through FYM + 75% RDN through Vermicompost	85.11	132.67	0.189	0.293
T_7	75% RDN through FYM + Bio-NPK (Drenching at 20 DAS)	85.83	133.58	0.191	0.297
T_8	75% RDN through FYM + Bio-NPK (Drenching at 20 DAS) + *Panchagavya* @ 3%	86.33	135.52	0.192	0.300
T_9	75% RDN through Vermicompost + Bio-NPK (Drenching at 20 DAS)	105.14	163.65	0.234	0.363
T_{10}	75% RDN through Vermicompost + Bio-NPK (Drenching at 20 DAS) + *Panchagavya* @ 3%	86.58	139.52	0.192	0.313

T_{11}	50% RDN through FYM + 25% RDN through Vermicompost + Bio-NPK (Drenching at 20 DAS)	90.70	144.96	0.202	0.323
T_{12}	50% RDN through FYM + 25% RDN through Vermicompost + Bio-NPK (Drenching at 20 DAS) + *Panchagavya* @ 3%	89.36	142.32	0.199	0.313
T_{13}	50% RDN through Vermicompost + 25% RDN through FYM + Bio-NPK (Drenching at 20 DAS)	101.74	159.00	0.226	0.353
T_{14}	50% RDN through Vermicompost + 25% RDN through FYM + Bio-NPK (Drenching at 20 DAS) + *Panchagavya* @ 3%	88.20	141.21	0.196	0.313
SEm ±		3.37	5.24	0.007	0.01
CD at 5%		9.80	15.25	0.021	0.03
CV%		6.69	6.72	6.69	6.72

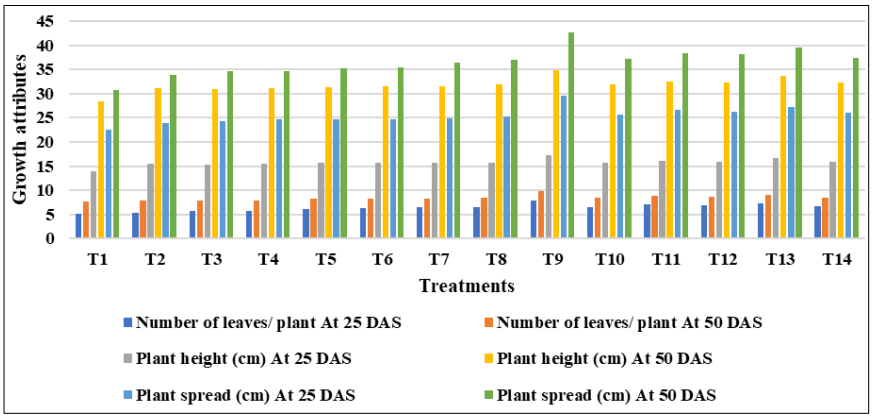

Fig 1: Effect of organic nutrients on number of leaves, plant height and plant spread of beetroot

Table 3: Effect of organic nutrients on yield attributes and yield of beetroot

Tr. No.	Treatment details	Root length (cm)	Root diameter (mm)	Fresh weight of root (g)	Shoot weight (g)	Root-to-shoot ratio	Total plant biomass (g)	Dry weight of total biomass (g)	Root yield per plot (kg/ plot)
T_1	Absolute control	13.71	60.06	111.39	116.91	0.97	228.30	14.52	4.21
T_2	100% RDN through FYM	14.63	68.09	148.64	123.48	1.20	272.12	18.42	4.90
T_3	100% RDN through Vermicompost	14.44	67.32	141.20	127.60	1.11	268.80	17.94	4.83
T_4	75% RDN through FYM + 25% RDN through Vermicompost	14.87	68.67	153.19	124.26	1.23	277.45	18.51	5.20
T_5	50% RDN through FYM + 50% RDN through Vermicompost	15.13	69.34	157.24	131.23	1.20	288.47	18.85	5.62
T_6	25% RDN through FYM + 75% RDN through Vermicompost	15.06	68.85	161.61	131.53	1.23	293.14	18.76	5.76
T_7	75% RDN through FYM + Bio-NPK (Drenching at 20 DAS)	15.33	69.60	163.64	133.27	1.23	296.90	19.16	6.10
T_8	75% RDN through FYM + Bio-NPK (Drenching at 20 DAS) + *Panchagavya* @ 3%	15.74	71.76	187.80	131.04	1.43	318.84	19.96	6.41
T_9	75% RDN through Vermicompost + Bio-NPK (Drenching at 20 DAS)	15.38	70.78	168.33	146.64	1.15	314.98	19.23	6.18
T_{10}	75% RDN through Vermicompost + Bio-NPK (Drenching at 20 DAS) + *Panchagavya* @ 3%	15.90	72.19	191.36	129.59	1.48	320.96	20.05	6.53
T_{11}	50% RDN through FYM + 25% RDN through Vermicompost + Bio-NPK (Drenching at 20 DAS)	15.52	71.25	179.44	135.03	1.33	314.47	19.78	6.28
T_{12}	50% RDN through FYM + 25% RDN through Vermicompost + Bio-NPK (Drenching at 20 DAS) + *Panchagavya* @ 3%	17.21	78.77	212.52	128.01	1.66	340.53	21.85	7.35
T_{13}	50% RDN through Vermicompost + 25% RDN through FYM + Bio-NPK (Drenching at 20 DAS)	15.49	70.93	173.64	140.36	1.24	314.00	19.69	6.24
T_{14}	50% RDN through Vermicompost + 25% RDN through FYM + Bio-NPK (Drenching at 20 DAS) + *Panchagavya* @ 3%	16.51	74.21	207.65	128.31	1.62	335.96	20.10	7.14
SEm ±		0.38	1.94	6.05	3.37	0.06	6.14	0.60	0.25
CD at 5%		1.11	5.65	17. 62	9.81	0.18	17.85	1.75	0.72
CV%		4.32	4.80	6.24	4.48	8.74	3.56	5.48	7.27

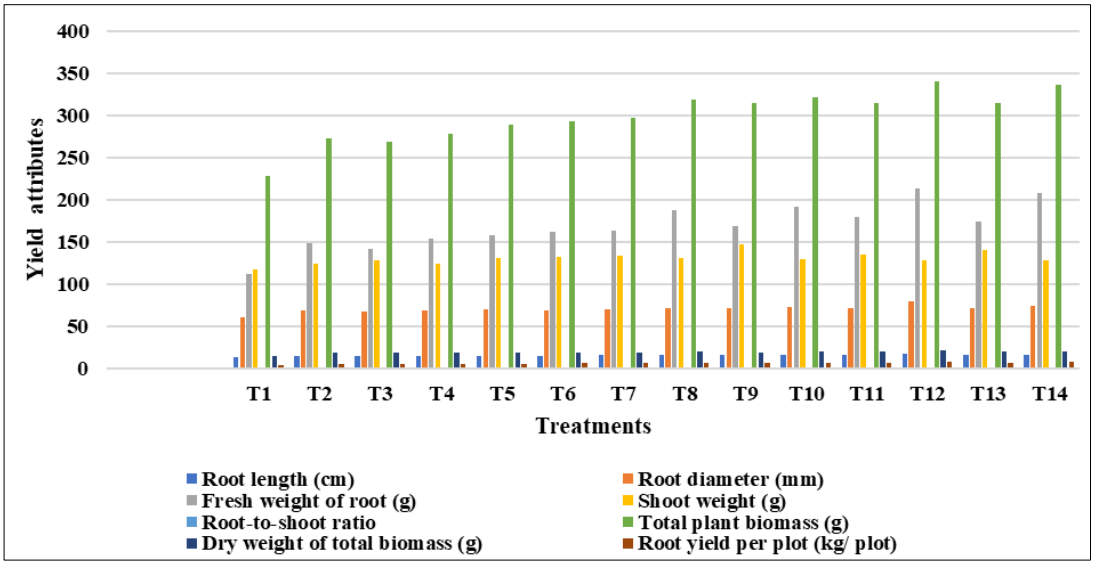

Fig 2: Effect of organic nutrients on yield attributes of beetroot.

Table 4: Effect of organic nutrients on quality parameters of beetroot

Tr. No.	Treatment details	TSS (^{0}Brix)	Total sugar content (%)
T_1	Absolute control	7.03	6.04
T_2	100% RDN through FYM	7.75	6.30
T_3	100% RDN through Vermicompost	7.94	6.23
T_4	75% RDN through FYM + 25% RDN through Vermicompost	7.98	6.33
T_5	50% RDN through FYM + 50% RDN through Vermicompost	8.11	6.39
T_6	25% RDN through FYM + 75% RDN through Vermicompost	8.18	6.52
T_7	75% RDN through FYM + Bio-NPK (Drenching at 20 DAS)	8.20	6.59
T_8	75% RDN through FYM + Bio-NPK (Drenching at 20 DAS) + *Panchagavya* @ 3%	8.25	6.79
T_9	75% RDN through Vermicompost + Bio-NPK (Drenching at 20 DAS)	8.21	6.60
T_{10}	75% RDN through Vermicompost + Bio-NPK (Drenching at 20 DAS) + *Panchagavya* @ 3%	8.30	6.82
T_{11}	50% RDN through FYM + 25% RDN through Vermicompost + Bio-NPK (Drenching at 20 DAS)	8.24	6.78
T_{12}	50% RDN through FYM + 25% RDN through Vermicompost + Bio-NPK (Drenching at 20 DAS) + *Panchagavya* @ 3%	8.71	7.45
T_{13}	50% RDN through Vermicompost + 25% RDN through FYM + Bio-NPK (Drenching at 20 DAS)	8.23	6.68
T_{14}	50% RDN through Vermicompost + 25% RDN through FYM + Bio-NPK (Drenching at 20 DAS) + *Panchagavya* @ 3%	8.38	7.14
SEm $\pm$		0.11	0.18
CD at 5%		0.33	0.53
CV%		2.42	4.82

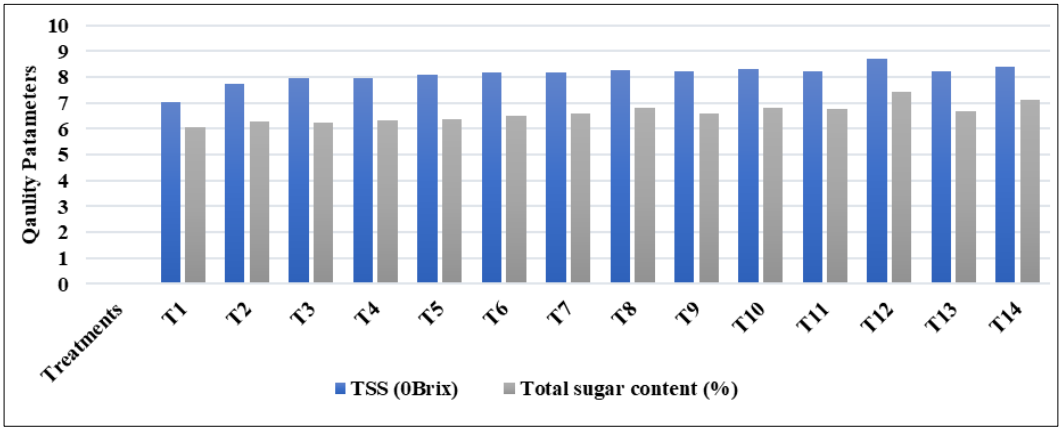

Fig 3: Effect of organic nutrients on TSS and total sugar of beetroot

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Conclusion
It is summarized, that with respect to growth attributes maximum with treatment T_9 [75 % RDN through vermicompost + Bio-NPK (Drenching at 20 DAS)] and it was

at par with T_{13} [50 % RDN through Vermicompost + 25 % RDN through FYM + Bio-NPK (Drenching at 20 DAS)]. While the yield attributes and quality parameters maximum with treatment T_{12} [50 % RDN through FYM + 25 % RDN through Vermicompost + Bio-NPK (Drenching at 20 DAS) + Panchagavya @ 3 %] and it was at par with T_{14} [50 % RDN through Vermicompost + 25 % RDN through FYM + Bio-NPK (Drenching at 20 DAS) + Panchagavya @ 3 %].

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