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Influence of integrated nutrient management on growth and root yield of beetroot (*Beta vulgaris* L.)

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Abstract

A study was conducted to evaluate the effect of different combinations of organic manures, inorganic fertilizers, and microbial consortium on the growth and root yield of beetroot (*Beta vulgaris* L.) cv. Detroit Dark Red during the rabi season under field conditions. The experiment was carried out during the academic year 2025-26 at the School of Agricultural Sciences, Malla Reddy University, Hyderabad, using a Randomized Block Design (RBD) with nine treatments and three replications. The treatments included sole and combined applications of farmyard manure (FYM), poultry manure, Recommended Dose of Fertilizers (RDF), and microbial consortium. The results revealed significant variation among treatments, indicating the positive effect of integrated nutrient management on growth and yield. Among the treatments, T₆ - 75% RDF + FYM (6 t ha⁻¹) + microbial consortium (10 kg ha⁻¹) showed superior performance in growth parameters, whereas T₈ - 75% RDF + FYM (3 t ha⁻¹) + poultry manure (1.5 t ha⁻¹) + microbial consortium (10 kg ha⁻¹) exhibited superior performance for yield parameters.

Keywords: Detroit Dark Red, Integrated Nutrient Management, Farmyard Manure (FYM), Poultry Manure, Microbial Consortium, Root Yield

Introduction

Beetroot (*Beta vulgaris* L.) is an important root vegetable crop belonging to the family Chenopodiaceae, with a diploid chromosome number of 2n = 18. It is cultivated mainly for its fleshy taproot and is botanically a biennial but grown as an annual crop. Beetroot is widely valued for its nutritional and medicinal properties, containing carbohydrates, proteins, vitamins, and minerals such as calcium, phosphorus, and iron. The presence of betalain pigments (betacyanins and betaxanthins) imparts its characteristic red colour and provides antioxidant and anti-inflammatory benefits, making it an important component of the human diet (Georgiev *et al.*, 2010) ^[1]. Due to these health-promoting properties, beetroot has gained considerable importance in recent years. In recent years, organic manures have gained importance due to their positive effects on soil health and crop productivity. Organic sources such as farmyard manure (FYM) and poultry manure play a crucial role in sustainable nutrient management. FYM improves soil structure, water-holding capacity, and microbial activity, while poultry manure, being rich in essential nutrients, enhances plant growth and yield (Jagadeesh *et al.*, 2018) ^[2]. Microbial consortium consisting of beneficial microorganisms further improves nutrient availability, soil biological activity, and overall crop performance.

The excessive and imbalanced use of chemical fertilizers has resulted in soil degradation, nutrient imbalance, and environmental concerns. Inorganic fertilizers such as urea, single super phosphate (SSP), and muriate of potash (MOP) are essential for supplying readily available nutrients required for crop growth. Urea promotes vegetative growth, SSP provides phosphorus and sulphur, and MOP enhances root development, sugar accumulation, and pigment formation in beetroot (Kumar *et al.*, 2013) ^[3]. However, sole dependence on chemical fertilizers may reduce soil fertility over time. (Rathore, S. S. *et al.*, 2025) ^[7].

Material and Methods

The experiment was conducted during the academic year 2025-2026 at the School of Agricultural Sciences, Malla Reddy

University and Hyderabad. The materials used and the methodology adopted for the present investigation are described in the following sections.

Table1: Treatment details

Treatments	Combinations
T ₁	100% Recommended Dose of NPK (70:110:70)
T ₂	50% RDF + FYM (12 t ha ⁻¹) + Microbial consortium (10 kg ha ⁻¹)
T ₃	50% RDF + Poultry manure (6 t ha ⁻¹) + Microbial consortium (10 kg ha ⁻¹)
T ₄	50% RDF + FYM (6 t ha ⁻¹) + Poultry manure (3 t ha ⁻¹) + Microbial consortium (10 kg ha ⁻¹)
T ₅	50% RDF + FYM (6 t ha ⁻¹) + Poultry manure (3 t ha ⁻¹)
T ₆	75% RDF + FYM (6 t ha ⁻¹) + Microbial consortium (10 kg ha ⁻¹)
T ₇	75% RDF + Poultry manure (3 t ha ⁻¹) + Microbial consortium (10 kg ha ⁻¹)
T ₈	75% RDF + FYM (3 t ha ⁻¹) + Poultry manure (1.5 t ha ⁻¹) + Microbial consortium (10 kg ha ⁻¹)
T ₉	75% RDF + FYM (3 t ha ⁻¹) + Poultry manure (1.5 t ha ⁻¹)

Experimental design

The experiment was conducted following a Randomized Block Design (RBD), a widely used experimental layout in agricultural research due to its ability to control field variability. This design was adopted to minimize the influence of inherent variations such as differences in soil fertility, moisture availability, temperature and other microclimatic factors that can affect plant growth. To achieve this, the experimental field was divided into uniform blocks so that each block provided similar growing conditions. Nine treatments (T₁-T₉) were evaluated, with each treatment appearing once in every block and the experiment was replicated three times, resulting in a total of 27 experimental units. The treatments were randomly allocated within each block to eliminate bias and ensure that the observed differences in crop performance were solely due to treatment effects rather than positional variation.

The RBD framework thus facilitated the following outcomes:

- Improved experimental accuracy by minimizing variability and reducing error.
- Enabled unbiased and effective comparison among different treatments.
- Provided a sound basis for valid statistical analysis and interpretation

- Enhanced reliability and reproducibility of the experimental results.
- Ensured better representation of treatment effects across varying field conditions.



Fig 1: Overall experiment plot

Results and discussion

1. Growth parameters
2. Days to germination
3. Days to 50% germination

Table 2: Effect of different organic and inorganic fertilizers on the Days to germination and Days to (50%) germination

Treatment details	Days to germination	Days to 50% germination
T ₁ 100% Recommended dose of NPK (70:110:70)	7.00	23.00
T ₂ 50% RDF+12t ha ⁻¹ FYM +10kg ha ⁻¹ Microbial consortium	7.00	18.80
T ₃ 50% RDF+ 6t ha ⁻¹ Poultry manure + 10kg ha ⁻¹ Microbial consortium	7.00	17.76
T ₄ 50% RDF + 6t ha ⁻¹ FYM + 3t ha ⁻¹ Poultry manure + 10kg ha ⁻¹ Microbial consortium	6.66	17.30
T ₅ 50% RDF +6t ha ⁻¹ FYM +3t ha ⁻¹ Poultry manure	6.00	16.46
T ₆ 75% RDF +6t ha ⁻¹ FYM+ 10kg ha ⁻¹ Microbial consortium	4.33	15.46
T ₇ 75% RDF +3t ha ⁻¹ Poultry manure +10kg ha ⁻¹ Microbial consortium	6.00	16.30
T ₈ 75%RDF+3t ha ⁻¹ FYM +1.5t ha ⁻¹ Poultry manure + 10kg ha ⁻¹ Microbial consortium	6.00	16.80
T ₉ 75%RDF +3t ha ⁻¹ FYM +1.5t ha ⁻¹ Poultry manure	6.66	17.50
SEm (±)	0.512	0.589
CD (P=0.05)	1.549	1.780

Days to germination:

The data on days to germination revealed that the highest performance was recorded in T₆ (4.33 days). The lowest performance was observed in T₁, T₂ and T₃ (7.00 days). Treatments T₄ and T₉ (6.66 days) were found to be at par with each other.

Based on the data, the highest performance was recorded in T₆ (4.33 days) due to better nutrient availability and enhanced microbial activity from integrated nutrient management. The

lowest performance was observed in T₁, T₂ and T₃ (7.00 days) due to poor soil biological activity and less efficient nutrient use. Treatments T₄ and T₉ (6.66 days) were at par, while T₅, T₇ and T₈ (6.00 days) showed moderate performance due to partial integration of nutrients improving germination to some extent. (Verma *et al.*, 2016) ^[9].

Days to 50% germination

The data on days to 50% germination revealed that the highest

number of days was recorded in treatment T₁ (23.00 days), indicating the slowest germination, whereas the lowest number of days was observed in T₆ (15.467 days), showing the fastest germination. Based on the critical difference (CD = 1.780), treatments T₃ (17.767 days), T₄ (17.300 days) and T₉ (17.500 days) were found to be at par with each other, while another group comprising T₅ (16.467 days), T₇ (16.300 days) and T₈ (16.800 days) also showed statistically similar performance. Thus, T₆ performed significantly better by reducing the days to 50% germination, whereas T₁ recorded the poorest performance.

The highest days to 50% germination observed in T₁ may be due to the sole application of inorganic fertilizers, which do not improve soil physical properties and microbial activity, resulting in slower seed germination. In contrast, the lowest days recorded in T₆ could be attributed to the integrated use of organic manures and microbial consortium along with inorganic fertilizers, which enhances soil structure, nutrient availability and microbial activity, thereby promoting faster and uniform germination. (Vessey, J. K. 2003)^[10].

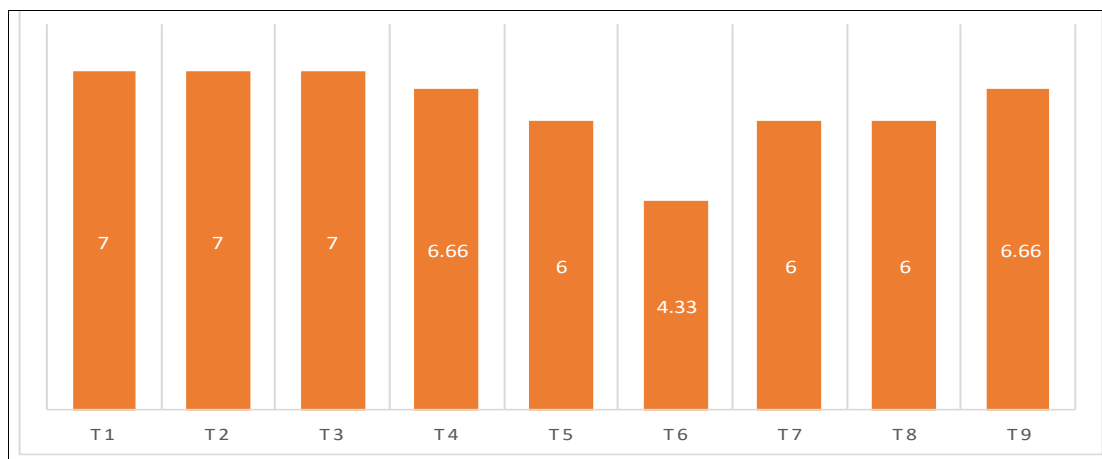


Fig 2: Graphical representation on Days to germination

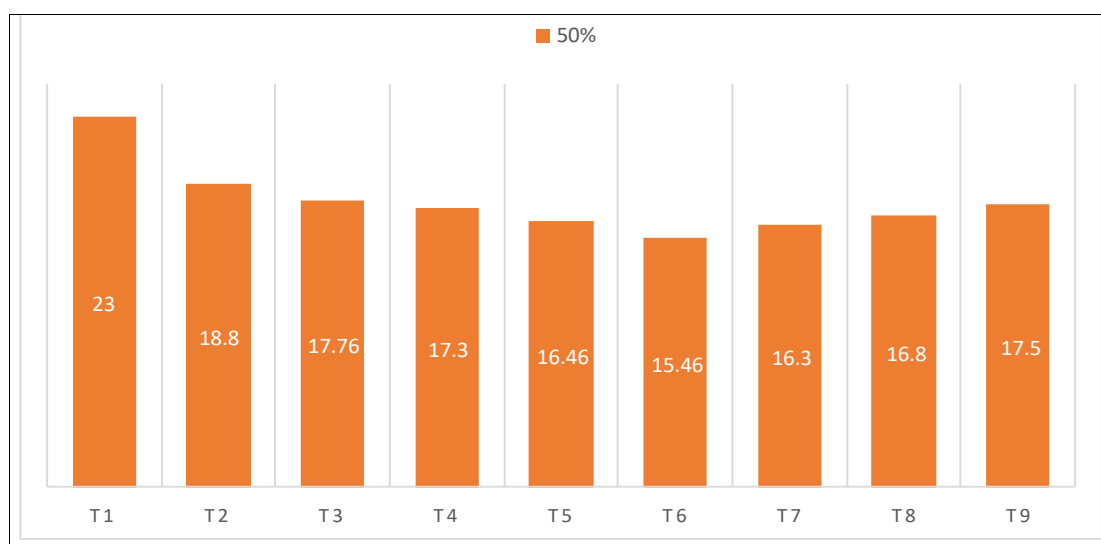


Fig 3: Graphical representation on Days to germination

Root to shoot ratio (g)

Table 3: Effect of different organic manures and inorganic fertilizers on root to shoot ratio (g)

Treatment details		Root to shoot ratio (g)
T ₁	100% Recommended dose of NPK (70:110:70)	1.30
T ₂	50% RDF+12t ha ⁻¹ FYM +10kg ha ⁻¹ Microbial consortium	1.46
T ₃	50% RDF+ 6t ha ⁻¹ Poultry manure + 10kg ha ⁻¹ Microbial consortium	1.56
T ₄	50% RDF + 6t ha ⁻¹ FYM + 3t ha ⁻¹ Poultry manure + 10kg ha ⁻¹ Microbial consortium	1.56
T ₅	50% RDF +6t ha ⁻¹ FYM +3t ha ⁻¹ Poultry manure	1.66
T ₆	75% RDF +6t ha ⁻¹ FYM+ 10kg ha ⁻¹ Microbial consortium	2.40
T ₇	75% RDF +3t ha ⁻¹ Poultry manure +10kg ha ⁻¹ Microbial consortium	1.71
T ₈	75%RDF+3t ha ⁻¹ FYM +1.5t ha ⁻¹ Poultry manure + 10kg ha ⁻¹ Microbial consortium	1.69
T ₉	75%RDF +3t ha ⁻¹ FYM +1.5t ha ⁻¹ Poultry manure	1.63
SEm (±)		0.156
CD (P=0.05)		0.471

Root to shoot ratio is an important parameter which indicates the balance between below-ground and above-ground growth of the plant. The results revealed that treatment T₆ (75% RDF + 6 t ha⁻¹ FYM + 10 kg ha⁻¹ microbial consortium) recorded the highest root to shoot ratio (2.40). Treatments T₇ (1.71), T₈ (1.69) and T₅ (1.66) were found to be statistically on par with each other, showing better performance next to the highest treatment. Treatments T₉ (1.63), T₃ (1.56) and T₄ (1.56) exhibited moderate performance, indicating balanced root and shoot growth. In contrast, the lowest root to shoot ratio was observed in T₁ (100% recommended dose of NPK) with a value of 1.30, which was on par with T₂ (1.46), indicating comparatively lower root development.

The highest root to shoot ratio observed in treatment T₆ may be attributed to the combined application of FYM and microbial consortium along with reduced inorganic fertilizers, which

improves soil structure, aeration, and microbial activity, thereby promoting better root proliferation and efficient nutrient and water uptake; this enhanced root growth relative to shoot growth results in a higher root to shoot ratio and overall better plant balance. Organic manures also encourage deeper and more extensive root systems by gradually releasing nutrients and improving soil physical conditions. Higher root to shoot ratios under integrated nutrient management practices. In contrast, the lowest root to shoot ratio recorded in T₁ may be due to the sole application of chemical fertilizers, which often leads to rapid shoot growth but comparatively poor root development due to lack of improvement in soil structure and microbial activity, resulting in an imbalanced growth pattern; who reported reduced root growth and lower root to shoot ratios under exclusive inorganic fertilization. (Meena *et al.* 2019) ^[4].

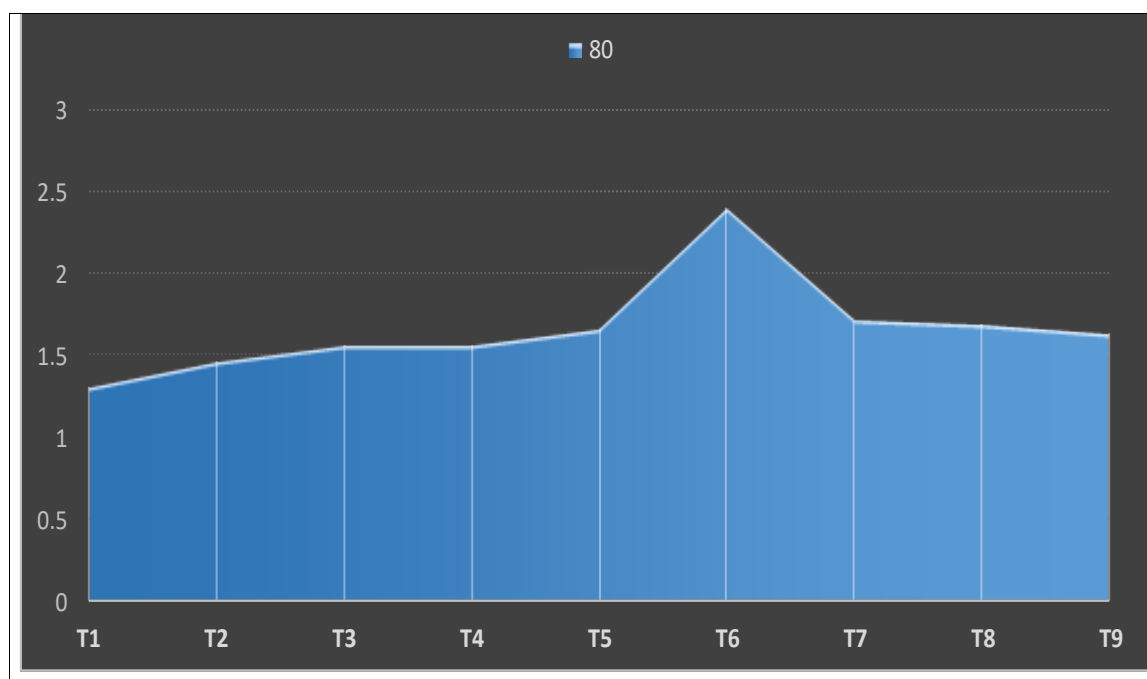


Fig 4: Graphical representation on Root to shoot ratio

Leaf area (cm²)

Table 4: Effect of different organic manures and inorganic fertilizers on Leaf area (cm²)

Treatment details		Leaf area (cm ²)	
		25 DAT	50 DAT
T ₁	100% Recommended dose of NPK (70:110:70)	29.71	182.00
T ₂	50% RDF+12t ha ⁻¹ FYM +10kg ha ⁻¹ Microbial consortium	36.55	199.48
T ₃	50% RDF+ 6t ha ⁻¹ Poultry manure + 10kg ha ⁻¹ Microbial consortium	36.70	212.80
T ₄	50% RDF + 6t ha ⁻¹ FYM + 3t ha ⁻¹ Poultry manure + 10kg ha ⁻¹ Microbial consortium	38.16	221.15
T ₅	50% RDF +6t ha ⁻¹ FYM +3t ha ⁻¹ Poultry manure	53.95	253.93
T ₆	75% RDF +6t ha ⁻¹ FYM+ 10kg ha ⁻¹ Microbial consortium	74.79	318.10
T ₇	75% RDF +3t ha ⁻¹ Poultry manure +10kg ha ⁻¹ Microbial consortium	63.16	300.23
T ₈	75%RDF+3t ha ⁻¹ FYM +1.5t ha ⁻¹ Poultry manure + 10kg ha ⁻¹ Microbial consortium	56.03	262.56
T ₉	75%RDF +3t ha ⁻¹ FYM +1.5t ha ⁻¹ Poultry manure	50.26	248.30
SEm (±)		6.074	13.697
CD (P=0.05)		18.367	41.418

It was recorded at 25 and 50 days after transplanting. The results revealed that at both stages of observation, treatment T₆ (75% RDF + 6 t ha⁻¹ FYM + 10 kg ha⁻¹ microbial consortium) recorded the highest leaf area with values of 74.79 cm² and 318.10 cm², respectively, while treatment T₇ (75% RDF + 3 t ha⁻¹ poultry manure + 10 kg ha⁻¹ microbial consortium) was

found to be on par with it, recording 63.16 cm² and 300.23 cm². This was followed by T₈ (75% RDF + 3 t ha⁻¹ FYM + 1.5 t ha⁻¹ poultry manure + 10 kg ha⁻¹ microbial consortium) with values of 56.03 cm² and 262.56 cm², and T₅ (50% RDF + 6 t ha⁻¹ FYM + 3 t ha⁻¹ poultry manure) with 53.95 cm² and 253.93 cm². In contrast, the lowest leaf area was recorded in treatment T₁

(100% recommended dose of NPK) with values of 29.71 cm² and 182.00 cm², indicating comparatively reduced leaf expansion and growth. The highest leaf area recorded in treatment T₆ may be due to the integrated application of inorganic fertilizers along with FYM and microbial consortium, which ensures a sustained and balanced nutrient supply, improves soil structure, enhances microbial activity, and promotes efficient nutrient uptake, ultimately leading to increased cell division, cell elongation, and

leaf expansion; the presence of organic manures also enhances moisture retention and nutrient availability, which are critical for leaf development. The lowest leaf area observed in T₁ may be attributed to the sole application of chemical fertilizers, which, although supplying nutrients, lack the ability to improve soil physical properties and microbial activity, who found that exclusive inorganic fertilization led to reduced vegetative growth and leaf development. Yadav *et al.* (2016) ^[11].

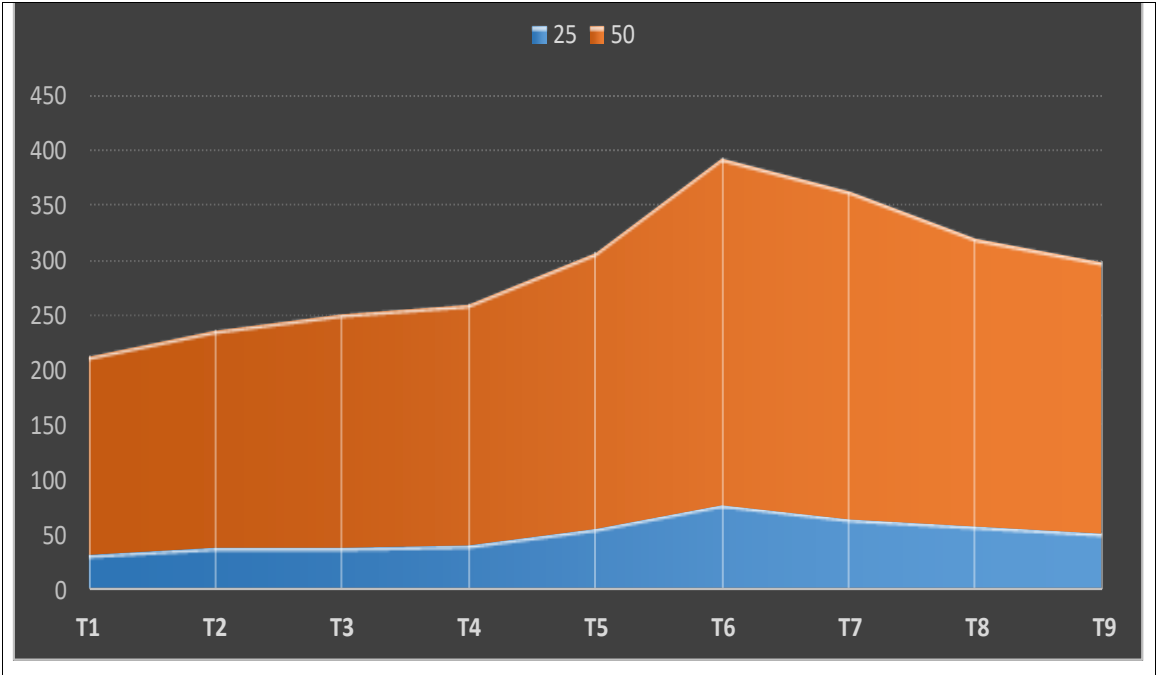


Fig 5: Graphical representation on Leaf area

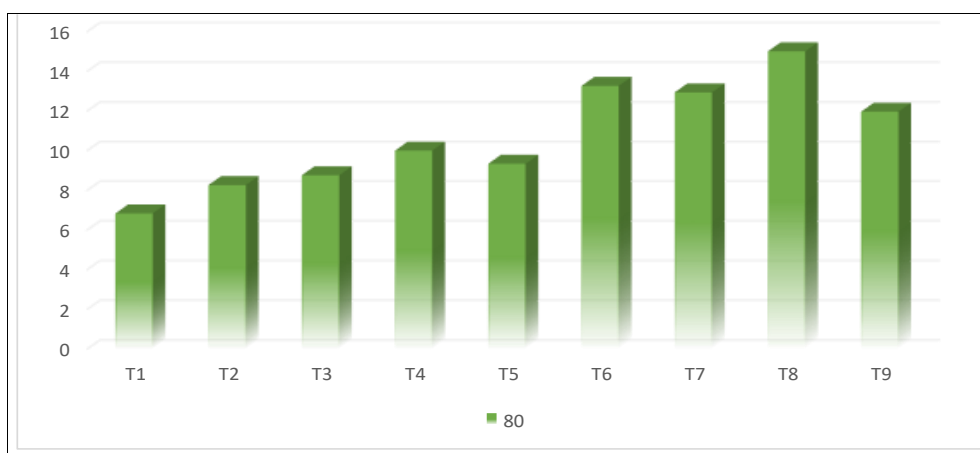
Yield parameters Root length (mm)

Table 5: Effect of different organic manures and inorganic fertilizers on Root length (mm)

Treatment details		Root length(mm)
T ₁	100% Recommended dose of NPK (70:110:70)	6.83
T ₂	50% RDF+12t ha ⁻¹ FYM +10kg ha ⁻¹ Microbial consortium	8.26
T ₃	50% RDF+ 6t ha ⁻¹ Poultry manure + 10kg ha ⁻¹ Microbial consortium	8.75
T ₄	50% RDF + 6t ha ⁻¹ FYM + 3t ha ⁻¹ Poultry manure + 10kg ha ⁻¹ Microbial consortium	10.00
T ₅	50% RDF +6t ha ⁻¹ FYM +3t ha ⁻¹ Poultry manure	9.33
T ₆	75% RDF +6t ha ⁻¹ FYM+ 10kg ha ⁻¹ Microbial consortium	13.26
T ₇	75% RDF +3t ha ⁻¹ Poultry manure +10kg ha ⁻¹ Microbial consortium	12.93
T ₈	75%RDF+3t ha ⁻¹ FYM +1.5t ha ⁻¹ Poultry manure + 10kg ha ⁻¹ Microbial consortium	15.00
T ₉	75%RDF +3t ha ⁻¹ FYM +1.5t ha ⁻¹ Poultry manure	11.96
SEm (±)		0.334
CD (P=0.05)		1.008

Among the treatments, T₈ recorded the highest root length (15.00 cm). The treatments T₆ (13.26 cm) and T₇ (12.93 cm) were found to be on par with each other as the difference between them was less than the CD value (CD = 1.008). The next best performance was observed in T₉ (11.96 cm). Moderate root length was recorded in T₄ (10.00 cm) and T₅ (9.33 cm), followed by T₃ (8.75 cm) and T₂ (8.26 cm). The lowest root length was observed in T₁ (6.83 cm). The differences among treatments were significant at 5% level with SE(m) ± 0.334. The highest root length recorded in T₈ may be attributed to the combined effect of organic manures and microbial consortium along with reduced RDF, which improved soil structure, aeration, and microbial activity, thereby promoting better root

proliferation and elongation. Organic inputs enhance soil porosity and moisture retention, while biofertilizers increase nutrient availability especially phosphorus leading to enhanced root growth and development. These conditions favor deeper and more extensive root systems. These root growth under integrated nutrient management practices. In contrast, the lowest root length in T₁ (100% RDF) may be due to the sole application of inorganic fertilizers, which can lead to poor soil physical properties, reduced microbial activity, and limited nutrient use efficiency, thereby restricting root development. He reported reduced root growth under exclusive chemical fertilization due to degraded soil health and lower biological activity. Rathore *et al.* (2025) ^[7].

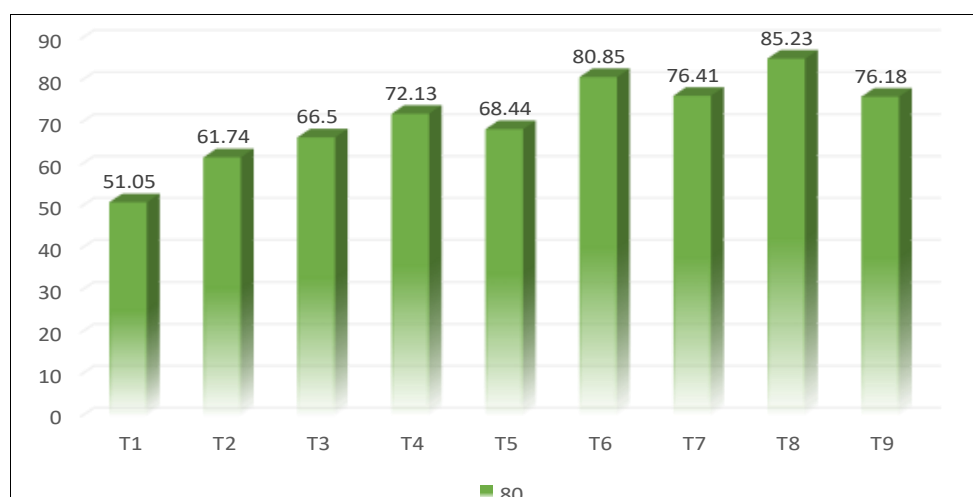
**Fig 6:** Graphical representation on Root length**Root diameter (mm)****Table 6:** Effect of different organic manures and inorganic fertilizers on Root diameter (mm)

Treatment details		Root diameter(mm)
T ₁	100% Recommended dose of NPK (70:110:70)	51.05
T ₂	50% RDF+12t ha ⁻¹ FYM +10kg ha ⁻¹ Microbial consortium	61.74
T ₃	50% RDF+ 6t ha ⁻¹ Poultry manure + 10kg ha ⁻¹ Microbial consortium	66.50
T ₄	50% RDF + 6t ha ⁻¹ FYM + 3t ha ⁻¹ Poultry manure + 10kg ha ⁻¹ Microbial consortium	72.13
T ₅	50% RDF +6t ha ⁻¹ FYM +3t ha ⁻¹ Poultry manure	68.44
T ₆	75% RDF +6t ha ⁻¹ FYM+ 10kg ha ⁻¹ Microbial consortium	80.85
T ₇	75% RDF +3t ha ⁻¹ Poultry manure +10kg ha ⁻¹ Microbial consortium	76.41
T ₈	75%RDF+3t ha ⁻¹ FYM +1.5t ha ⁻¹ Poultry manure + 10kg ha ⁻¹ Microbial consortium	85.23
T ₉	75%RDF +3t ha ⁻¹ FYM +1.5t ha ⁻¹ Poultry manure	76.18
SEm (±)		0.644
CD (P=0.05)		1.948

Root diameter is an important yield parameter which indicates the thickness and quality of the root. Among all the treatments, T₈ recorded the highest root diameter (85.23 mm). The treatments T₆ (80.85 mm), T₇ (76.41 mm) and T₉ (76.18 mm) were found to be on par with each other. The next best performance was observed in T₄ (72.13 mm). Moderate root diameter was recorded in T₅ (68.44 mm) and T₃ (66.50 mm), followed by T₂ (61.74 mm). The lowest root diameter was observed in T₁ (51.05 mm).

The highest root diameter observed in T₈ may be due to the integrated application of organic manures and microbial consortium along with reduced RDF, which improved soil fertility, structure, and microbial activity, thereby enhancing nutrient uptake and cell expansion in roots. Adequate

availability of nutrients, especially potassium and phosphorus, plays a key role in cell division, enlargement, and translocation of photosynthates, resulting in thicker and well-developed roots. Organic amendments also improve soil moisture retention and aeration, which further supports root bulking and quality. Increased root diameter under integrated nutrient management practices. In contrast, the lowest root diameter in T₁ (100% RDF) may be attributed to the sole use of inorganic fertilizers, which can deteriorate soil structure, reduce microbial activity, and limit balanced nutrient availability, thereby restricting proper root development and thickening. who reported reduced root thickness under exclusive chemical fertilization due to poor soil health and inefficient nutrient utilization. Rawat *et al.* (2021) [8].

**Fig 7:** Graphical representation on Root diameter

Fresh weight of beetroot (g) and Dry weight of beetroot (g)**Table 7:** Effect of different organic manures and inorganic fertilizers on fresh and dry weight of beetroot (g)

Treatment details		Fresh weight of beetroot (g)	Dry weight of beetroot (g)
T ₁	100% Recommended dose of NPK (70:110:70)	117.50	46.40
T ₂	50% RDF+12t ha ⁻¹ FYM +10kg ha ⁻¹ Microbial consortium	128.33	48.60
T ₃	50% RDF+ 6t ha ⁻¹ Poultry manure + 10kg ha ⁻¹ Microbial consortium	135.06	49.53
T ₄	50% RDF + 6t ha ⁻¹ FYM + 3t ha ⁻¹ Poultry manure + 10kg ha ⁻¹ Microbial consortium	162.26	51.60
T ₅	50% RDF +6t ha ⁻¹ FYM +3t ha ⁻¹ Poultry manure	141.40	51.36
T ₆	75% RDF +6t ha ⁻¹ FYM+ 10kg ha ⁻¹ Microbial consortium	216.93	60.43
T ₇	75% RDF +3t ha ⁻¹ Poultry manure +10kg ha ⁻¹ Microbial consortium	193.00	57.56
T ₈	75%RDF+3t ha ⁻¹ FYM +1.5t ha ⁻¹ Poultry manure + 10kg ha ⁻¹ Microbial consortium	231.03	63.43
T ₉	75%RDF +3t ha ⁻¹ FYM +1.5t ha ⁻¹ Poultry manure	183.00	54.30
SEm (±)		1.374	0.402
CD (P=0.05)		4.153	1.217

Fresh weight of beetroot

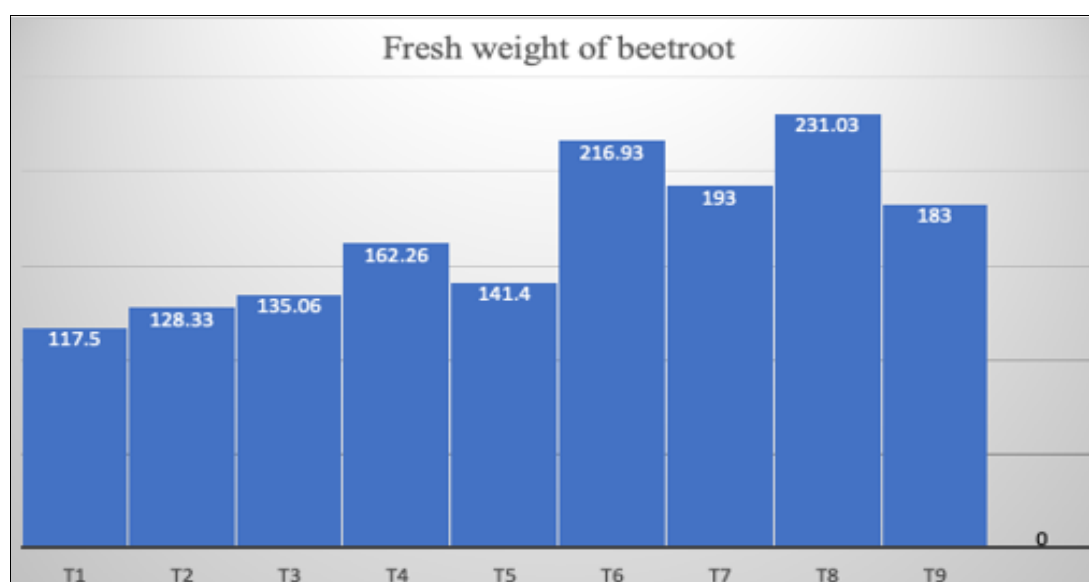
Among all the treatments, T₈ recorded the highest fresh weight (231.03 g). The treatment T₆ (216.93 g) was found to be on par with it as the difference was less than the CD value (CD = 4.153). This was followed by T₇ (193.00 g) and T₉ (183.00 g). Moderate fresh weight was recorded in T₄ (162.26 g), T₅ (141.40 g) and T₃ (135.06 g), followed by T₂ (128.33 g). The lowest fresh weight was observed in T₁ (117.50 g).

The highest fresh weight observed in T₈ may be attributed to the integrated use of organic manures, microbial consortium, and reduced RDF, which improved soil fertility, structure, and microbial activity, thereby enhancing nutrient availability and uptake. This leads to increased photosynthetic activity, better translocation of assimilates, and higher accumulation of water and nutrients in the roots, resulting in greater biomass and fresh weight. Organic inputs also improve soil moisture retention, which supports continuous growth and root enlargement. Observed higher fresh weight in root crops under integrated nutrient management practices. In contrast, the lowest fresh weight in T₁ (100% RDF) may be due to the sole reliance on inorganic fertilizers, which can reduce soil organic matter, microbial activity, and nutrient use efficiency, thereby limiting plant growth and biomass accumulation. This reduced fresh weight under exclusive chemical fertilization due to poor soil health and imbalance in nutrient supply. Marajan, S. *et al.*, (2020) [5].

Dry weight of beetroot

Among all the treatments, T₈ recorded the highest dry weight (63.43 g). The treatment T₆ (60.43 g) was found to be on par with it as the difference was less than the CD value (CD = 1.217). This was followed by T₇ (57.56 g) and T₉ (54.30 g). Moderate dry weight was recorded in T₄ (51.60 g) and T₅ (51.36 g), followed by T₃ (49.53 g) and T₂ (48.60 g). The lowest dry weight was observed in T₁ (46.40 g).

The highest dry weight observed in T₈ may be attributed to the integrated application of organic manures, microbial consortium, and reduced RDF, which enhanced nutrient availability, soil biological activity, and efficient photosynthesis, leading to greater accumulation of assimilates and dry matter in the roots. Organic inputs improve soil structure, moisture retention, and nutrient release, while biofertilizers enhance nutrient solubilization and uptake, resulting in increased biomass production and dry matter accumulation. Similar results were observed higher dry matter production under integrated nutrient management practices. In contrast, the lowest dry weight in T₁ (100% RDF) may be due to the sole application of inorganic fertilizers, which can reduce soil organic carbon, microbial population, and nutrient use efficiency, thereby limiting photosynthesis and accumulation of dry matter. Who reported lower dry weight under exclusive chemical fertilization due to poor soil health and reduced metabolic efficiency. Nargave *et al.*, (2018) [6].

**Fig 8:** Graphical representation on Fresh weight of beetroot

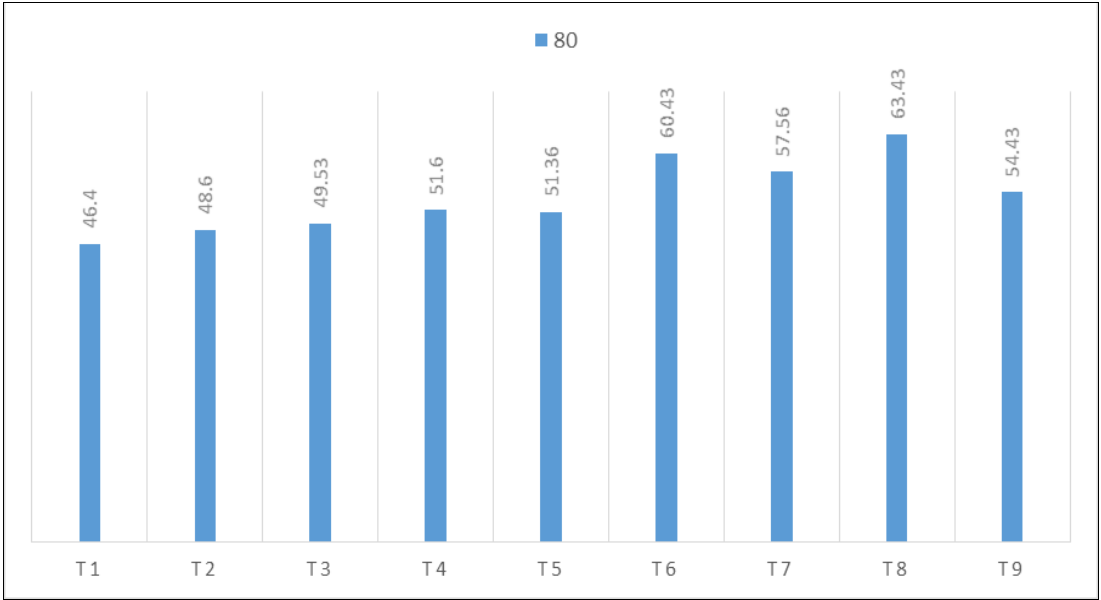


Fig 9: Graphical representation on Dry weight of beetroot

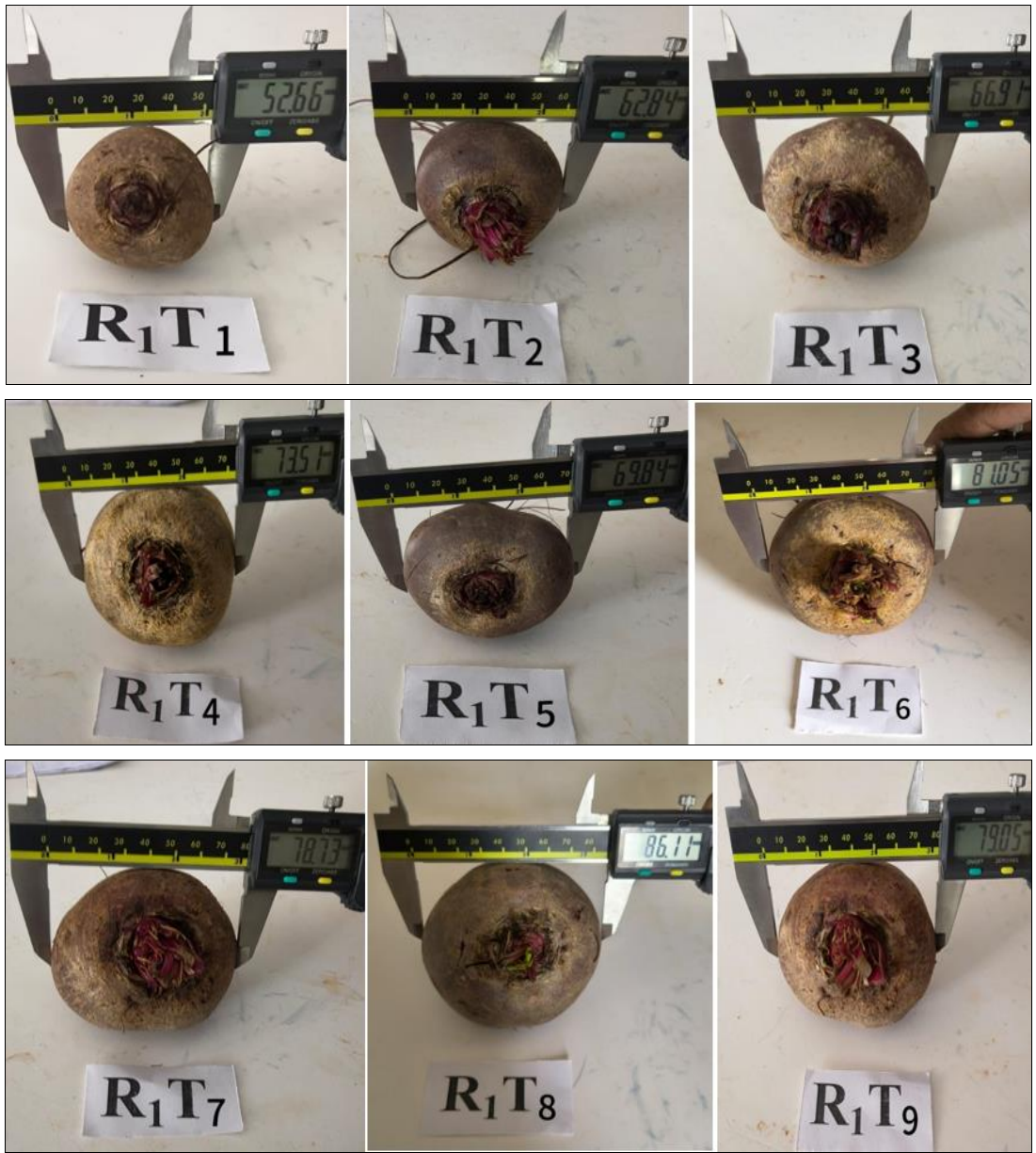


Fig 10: Root diameter grown under different organic manures and inorganic fertilizers

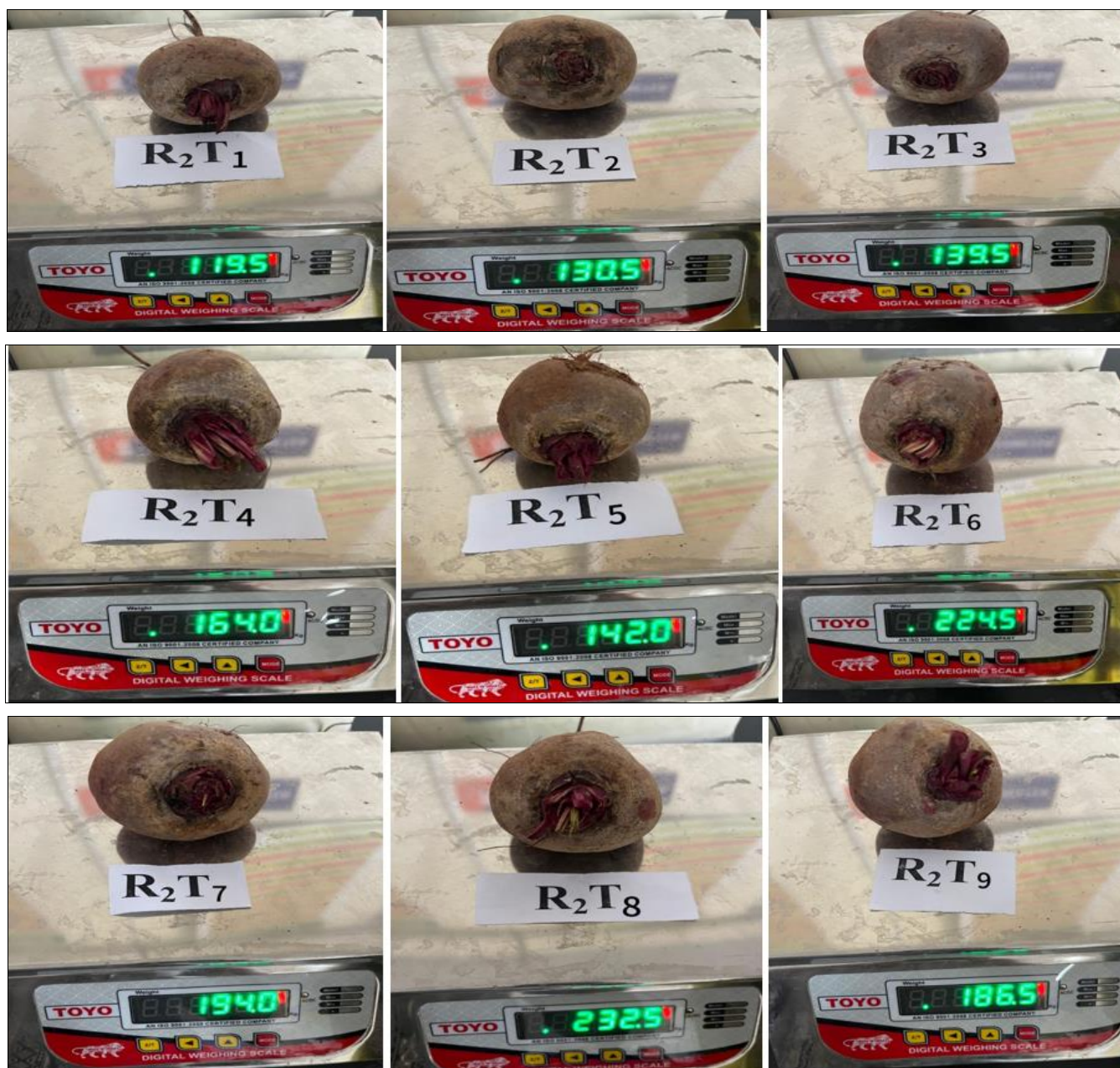


Fig 11: Fresh weight grown under different organic manures and inorganic fertilizers

Conclusion

In conclusion, the findings of the study revealed that Treatment T₆ - 75% RDF + FYM (6 t ha⁻¹) + Microbial consortium (10 kg ha⁻¹), T₈ - 75% RDF + FYM (3 t ha⁻¹) + Poultry manure (1.5 t ha⁻¹) + Microbial consortium (10 kg ha⁻¹), were most effective for beetroot cultivation. These treatments recorded superior performance in terms of growth and yield when compared to other treatment combinations. The enhanced performance can be attributed to improved soil-plant interactions, increased microbial activity, and efficient nutrient cycling under integrated nutrient management. This combination ensured a balanced and sustained nutrient supply, improved root development, and better nutrient use efficiency. Furthermore, the integration of organic manures with microbial consortium likely enhanced physiological processes, resulting in improved overall plant performance and higher productivity. Hence, the application of 75% RDF in combination with FYM, poultry manure, and microbial consortium at specified levels is recommended for achieving enhanced growth and yield in beetroot cultivation.

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