The Pharma Innovation Journal 2023; 12(3): 1149-1155

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(3): 1149-1155

www.thepharmajournal.com
Received: 02-12-2022
Accepted: 07-01-2023

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Effect of organic manures on growth, yield, quality and economics of beet root (*Beta vulgaris* L.) at Dehradun Valley of Uttarakhand

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Abstract
Present field experiment was carried out during the year 2021-22 at Horticulture Research Block, Department of Horticulture, School of Agriculture Sciences, SGRR University, Dehradun, Uttarakhand, India to investigate the "Effect of organic manures on growth, yield, quality and economics of beet root (*Beta vulgaris* L.) at Dehradun Valley of Uttarakhand". The experiment was laid out in randomized block design with three replications and nine treatments. The treatments comprised following levels of different organic manures with different concentrations viz., T_1 (Control), T_2 (FYM @10 t/ha), T_3 (Vermicompost @ 5 t/ha), T_4 (cow urine @ 50%), T_5 (FYM @ 5 t/ha + Vermicompost @2.5 t/ha + cow urine @ 25%), T_6 (FYM @ 5 t/ha + Vermicompost @ 2.5 t/ha), T_7 (FYM@ 5 t/ha + cow urine @ 25%), T_8 (Vermicompost @ 2.5 t/ha + cow urine @ 25%) and T_9 (FYM @10 t/ha + Vermicompost @ 5 t/ha + cow urine @ 50%). Observations on various attributes of growth, yield, quality and economics were recorded. Results revealed that among all the organic treatments T_9 (FYM@10 t/ha + Vermicompost @ 5 t/ha + cow urine @ 50%) reported the significant improvement in growth, yield and quality parameters than the other treatments. The treatment T_9 recorded the highest plant height (38.74 cm), number of leaves per plants (29.79), leaf length (28.70 cm), leaf width (18.72 cm), root weight (132.67 g), TSS (14.38 ^{0}Brix), net return (Rs. 7,02,324) and B:C ratio (1:8.56).

Keywords: Beet root, organic manures, growth, yield, quality, TSS, economics

Introduction
Beetroot (*Beta vulgaris* L.) is an herbaceous root vegetable, additionally called as garden beet, sugar beet or table beet and Chukander in Hindi. It is one of the major root vegetable which belongs to the family Chenopodiaceae and has chromosome number of 2n=18. It is originally from the Mediterranean Europe and North Africa. It is later spread all over the Europe to western India. It produces green tops and an enlarged root used both as vegetable and salad purpose. The popular varieties of beet root are Crimson Globe, Detroit Dark Red and Red Ball etc. The beet root is an excellent source of nutrients such as carbohydrates, fibre, minerals (potassium, calcium, iron, phosphorus and sodium) and vitamins (pro-vitamin A, niacin and Vitamin C). A natural pigment called betacyanin can also be produced which is used for obtaining a colouring matter at industrial level. It is further used as natural food colour in several products such as soups, liquors, ice creams, etc. Red colour of roots is due to presence of betanine pigment. Table beet is also a good source of sugar. It is sweet, healthy vegetables rich in antioxidants. These antioxidants in Beetroot help in protecting the heart and also prevent cancer. Organic farming was developed as a response to the environmental harm caused by the chemical pesticides and synthetic fertilizers in conventional farming. The important tenet of organic food movement is that it promotes ecological soundness and sustainable use of natural resources, also maintains crop diversity. The addition of organic manures to agricultural soil has beneficial effect on crop growth, yield and quality by improving soil physical and biological properties. The organic manuring has positive influence on soil texture and water holding capacity. Several attempts have been made to increase the production of root crops, but inorganic fertilizers are used as they give higher yield which leads to infertility of soil. Various organic manures such as farmyard manure, vermicompost, and cow urine are gaining more importance for getting higher yield and quality.

Farm yard manure being bulky organic material, releases the soil compactness and improves the aeration in addition to the supply of essential plant nutrients and organic matter and increase soil microbial establishment along with accumulation of excess humus content.Bulk density, water holding capacity, humic substances, microbial activities and hormone concentration in optimum range also obtained by the application of FYM and vermicompost (Sharma and Garg, 2017) [16]. Vermicompost is created utilizing earthworms. They consume organic matter and discharge it as cast. Vermicompost stimulates to influence the microbial activity of soil, increases the availability of oxygen and maintains normal soil temperature, increases growth, yield and quality of the plant (Arora *et al.*, 2011) [2]. Application of cow urine besides improving the soil texture and working as a plant hormone also been reported to correct the micro nutrient deficiency being organic in nature it is also likely increase the fertilizer use efficiency. The uric acid in the urine acts as fertilizer and hormone. Cow urine is believed to provide nutrient at low cost and can be considered as alternative for plant nutrition, metabolic activities, pest and disease control. Keeping these in mind an experiment was carried out to study the effect of organic manures on growth, yield, quality and economics of beet root at Dehradun Valley.

Materials and Methods

The present investigation was carried out at Horticulture Research Block, Department of Horticulture, School of Agricultural Sciences, Shri Guru Ram Rai University, Dehradun, Uttarakhand during the *Rabi* season of 2021–22. The experiment was laid out in Randomized Block Design (RBD) and replicated thrice. Each replication consisted of nine treatments of organic manures viz., Control (T_1), Farmyard manure @ 10 t/ha (T_2), Vermicompost @ 5 t/ha (T_3), cow urine @ 50% (T_4), Farmyard manure @ 5 t/ha + Vermicompost @ 2.5 t/ha + cow urine @ 25% (T_5), Farmyard manure @ 5 t/ha + Vermicompost @ 2.5 t/ha (T_6), Farmyard manure @ 5 t/ha + Cow urine @ 25% (T_7), Vermicompost @ 2.5 t/ha + Cow urine @25% (T_8), and Farmyard manure @ 10 t/ha + Vermicompost @ 5 t/ha + cow urine @ 50% (T_9). The soil of the experimental field was sandy loam in texture having pH of 7.12 with available nitrogen (220.04%), available phosphorus (9.1 kg/ha) and available potassium (18.1 kg/ha). The cultivar "Suman" was taken for research purpose. The seeds of beet root were sown on 18th November, 2021. The organic manures i.e. Farmyard manure, vermin-compost and cow urine was incorporated in experimental field as per the treatments at the time of final plot preparation. All the cultural practices were done at regular intervals as per the requirement of crop during the course of investigation. During the experimentation, from each replication, randomly selected ten plants were used for recording various observations on growth, yield and quality promoting parameters during whole of the cropping period at 40, 80 days after sowing (DAS) and at Final harvest stage. The economics of beet root crop was calculated as per the fundamental market prices of the input and produced during the *Rabi* season 2022. The obtained data were statistically analyzed with using standard statistical method as suggested by Gomez and Gomez (1996).

Table 1: Treatment Details

Number of Treatment	Combinations	Concentration
T_1	Control	-
T_2	Farmyard Manure	10t/ha
T_3	Vermicompost	5t/ha
T_4	Cow urine	50%
T_5	Farmyard Manure + Vermicompost + Cow urine	5t/ha + 2.5 t/ha + 25%
T_6	Farmyard Manure + Vermicompost	5t/ha + 2.5 t/ha
T_7	Farmyard Manure + Cow urine	5t/ha+25%
T_8	Vermicompost + Cow urine	2.5t/ha + 25%
T_9	Farmyard Manure + Vermicompost + Cow urine	10t/ha +5t/ha+50%

Results and discussion

The data pertaining to various growth, yield as well as quality parameters like plant height, number of leaves, leaf length, leaf width, root weight, Total Soluble Solids and economics were significantly influenced by different organic manures as compared to control during the course of investigation. The data presented in Table-2, 3 and 4 were showed that the significant improvement was noticed when applied different combinations of organic manures on beet root economics as compared to control. The findings of the present investigation were recorded and are thoroughly discussed below.

Table 2: Effect of different organic manures on plant height (cm), number of leaves per plant, leaf length (cm) and leaf width (cm) of beet root at various stages of harvesting

Treatment	Plant height (cm)				Number of leaves per plant				Leaf length (cm)				Leaf width (cm)			
	40 DAS	80 DAS	At Final Harvest	Mean	40 DAS	80 DAS	At Final Harvest	Mean	40 DAS	80 DAS	At Final Harvest	Mean	40 DAS	80 DAS	At Final Harvest	Mean
T_1	8.39	16.57	27.31	17.42	9.67	16.78	22.29	16.25	7.15	11.67	21.85	13.56	3.85	8.95	13.26	8.69
T_2	11.78	20.34	31.78	21.30	10.82	18.36	25.18	18.12	9.26	14.19	24.81	16.09	4.70	10.12	15.04	9.95
T_3	11.24	19.60	30.12	20.32	10.53	18.15	25.07	17.92	9.38	14.38	24.32	16.03	3.92	10.53	15.21	9.89
T_4	10.19	18.09	29.36	19.21	10.16	17.32	23.43	16.97	8.39	13.12	23.07	14.86	3.89	9.47	14.88	9.41
T_5	13.36	23.87	34.48	23.90	11.74	19.28	27.18	19.40	11.17	16.21	25.39	17.59	5.58	11.25	16.27	11.03
T_6	14.78	24.64	36.81	25.41	12.38	19.76	28.45	20.20	11.55	17.76	27.92	19.08	5.67	12.08	17.43	11.73
T_7	12.84	22.74	33.59	23.06	11.27	18.73	25.78	18.59	10.56	15.69	25.64	17.30	5.44	10.50	16.85	10.93
T_8	12.14	21.17	32.12	21.81	11.15	18.52	25.39	18.35	10.47	15.33	25.41	17.07	4.89	10.28	16.59	10.59
T_9	15.61	27.58	38.74	27.31	12.79	20.61	29.79	21.06	12.67	18.57	28.70	19.98	6.79	13.89	18.72	13.13
C.D (P=0.05)	1.45				1.28				0.68				0.92			
SE(m) ±	0.48				0.42				0.23				0.30			
SE(d) ±	0.68				0.60				0.32				0.43			
C.V.	3.74				3.96				2.33				4.96			

Table 3: Effect of different organic manures on root weight (g) and TSS (^{0}Brix) of beet root

Treatment	Root weight (g)	TSS (^{0}Brix)
T_1	92.33	10.17
T_2	115.33	11.52
T_3	102.32	11.31
T_4	95.36	10.73
T_5	123.23	13.05
T_6	126.40	13.85
T_7	118.20	12.57
T_8	110.45	12.26
T_9	132.67	14.38
CD $_{(5\%)}$	0.062	0.029
SE (d)	0.021	0.010
SE (m)	0.029	0.014
C.V. (%)	0.031	0.138

Table 4: Effect of different organic manures on net return and B:C ratio of beet root

Treatment	Net return (Rs ha^{-1})	B:C ratio
T_1	3,45,130	1:6.29
T_2	4,46,280	1:6.49
T_3	4,19,500	1:6.60
T_4	4,07,604	1:7.60
T_5	5,96,726	1:7.42
T_6	6,54,250	1:8.19
T_7	4,95,554	1:6.95
T_8	4,91,974	1:7.40
T_9	7,02,324	1:8.56

Plant Height

The observation of plants height was recorded at 40 DAS, 80 DAS and at final harvest and the result were significantly differs among the treatments. At 40 DAS, the highest plant height (15.61 cm) was recorded in T_9 (FYM @ 10t/ha + VC @ 5t/ha + CU 50%) which was at par with T_6 (14.78 cm) with FYM @ 5t/ha + VC @ 2.5t/ha and T_5 (13.36 cm) with FYM @ 5t/ha + VC @ 2.5t/ha + CU @ 25%. However significant differences were observed with treatment T_7 (12.84 cm) and T_4 (10.19 cm). The minimum plant height was recorded in T_1 (8.39 cm) under control condition. At 80 DAS, the highest plant height (27.58 cm) was recorded in T_9.The significant difference was recorded with treatment T_7 (22.74 cm), T_8 (21.17 cm), T_4 (18.09 cm), T_3 (19.60 cm) and T_2 (20.34 cm). The minimum plant height was recorded in T_1 (16.57 cm) under control condition. At final harvest, the highest plant height was recorded in T_9 (38.74 cm) which was at par with T_6 (36.81 cm). However, significant difference were observed with treatment T_7 (33.59 cm), T_3 (30.12cm), T_8 (32.12 cm), T_4 (29.36 cm) and T_2 (31.78 cm). While, the minimum plant height was recorded in T_1 (27.31 cm). The significant increase in plant height may be due to application of major and minor nutrients, through different organic manure in various levels, which increased the photosynthetic activity, chlorophyll formation, nitrogen metabolism and auxin contents in the plants which ultimately resulted into improving the plant height. The findings are in agreement with the findings of Mbithi *et al*., (2015) [12] in beet root; Sunandarani and Mallareddy (2007) [17]; Vijayakumari *et al*., (2009) [19]; Kirad *et al*., (2010) [8] in carrot; Uddain *et al*., (2010) [18]; Kumar *et al*., (2014) [9] in radish and Yanthan *et al*., (2012) [21] in turnip.

Number of leaves per plant

The numbers of leaves per plant counted at different stages of harvesting are presented in Table 2 and Fig. 2. At 40 DAS, number of leaves per plant ranged from 9.67 to 12.79. On the basis of mean the maximum number of leaves per plant was counted in T_9 (12.79) which was at par with T_6 (12.38). However, significant differences were observed with rest of all treatments. The minimum number of leaves per plant was recoded in the treatment T_1 (9.67). In the case of 80 DAS, the mean value ofr number of leaves per plant were found maximum in T_9 (20.61) which were at par with T_6 (19.76) and T_5 (19.28). However, significant differences were found with rest of the treatments. The minimum number of leaves per plant was recorded in the treatment T_1 (16.78). At final harvest after sowing showed significant differences and on the basis of mean the maximum number of leaves per plant were counted in the treatment T_9 (29.79) which were at par with T_6 (28.45) and T_5 (27.18).However, significant difference were found with rest of the treatment T_7 (25.78), T_4 (23.43), T_3 (25.07), T_8 (25.39) and T_2 (25.18).The minimum number of leaves per plant were recorded in the treatment T_1 (22.29). The probable reasons for enchanced more number of leaves, may be due to promotive effect of macro and micro nutrients on vegetative growth ultimately lead to more photosynthetic activities. The findings are in agreement with Jagadeesh (2015) [6] in beetroot, Jabeen *et al*., (2017) [5] in spinach beet and Pawar (2010) [15], Chauhan (2015) [3], Mehwish *et al*., (2016) [13] in carrot.

Leaf length

The observation of leaf length was recorded at 40 DAS, 80 DAS and at final harvest and the results shows significant differences between the treatments. At 40 DAS, the highest value of leaf length was recorded in treatment T_9 (12.67 cm) and the lowest value (7.15 cm) of leaf length was recorded under the treatment T_1 control. In 80DAS, the maximum number of leaf length was recorded in treatments T_9 (18.57 cm), which was at par with the treatments T_6 (17.76 cm) and T_5 (16.21 cm). The significant difference was observed with treatment T_2 (14.19 cm), T_4 (13.12 cm), T_3 (14.38 cm), T_7

(15.69 cm) and T_8 (15.33 cm). The minimum leaf length (11.67 cm) was recorded under the treatment T_1.At final harvest DAS, the leaf length was maximum in T_9 (28.70 cm) which was at par with T_6 (27.92 cm). However significant difference was observed with treatment T_3 (24.32 cm), T_7 (25.64 cm), T_8 (25.41 cm), T_2 (24.81 cm), T_4 (23.32 cm), and T_5 (25.39 cm).While minimum leaf length was recorded in the treatment T_1 (21.85 cm). It may be due to application of major and minor nutrients, through different organic manures in various levels, increased the photosynthetic activity, chlorophyll formation, nitrogen metabolism and auxin contents in the plants which ultimately increase the plant height. The findings is also in agreement with the findings of Yanthan *et al*. (2012) [21].

Leaf width

The leaf width on 40 days after sowing differs significantly and was ranging from 6.70 cm to 11.49 cm. The maximum leaf width was recorded in T_5 (11.49cm) which was statistically at par with T_8 (10.72cm) and T_9 (10.01cm). However, significant difference were observed with treatment T_7 (8.70cm), T_4 (7.66cm), T_3 (8.20cm), T_2 (8.16cm) and T_6 (8.47cm). The minimum leaf width was recorded in the treatment T_1 (6.70cm).In 80 days after sowing, the maximum leaf width was recorded in T_5 (16.47cm) which was at par with treatment T_8 (15.63cm) and T_9 (15.39cm). However, significant differences were observed with treatments T_7 (13.96cm), T_4 (12.72cm), T_3 (13.65cm), T_2 (13.39cm) and T_6 (13.73cm). While, minimum leaf length was obtained in the treatment T_1 (11.32cm). At final harvest, the data showed that leaf width of different treatments ranged from 13.96 cm to 20.15 cm. The maximum leaf width was recorded in T_5 (20.15 cm), which was found at par with treatments T_8 (18.85cm) and T_9 (18.69cm). However significant difference was observed with rest of the treatments. The minimum leaf width was recorded in the treatment T_1 (13.96cm). This might be due to the continuous nutrient availability by the use of organics. The findings are found to be in accordance with Hasan and Solaiman (2012) [4] who reported that the use of organics in cauliflower results in the continuous availability of nutrients to the plants and increased the growth and development.

Root weight

The root weight of beet root (132.67 g) was recorded in T_9 with the application of FYM @ 10t/ha + VC @ 5t/ha + CU 50% and significantly superior to all other treatments. The lowest root weight of beet root was recorded in control T_1 (92.33 g). The organic manures play a direct role in plant growth as a source of all necessary macro and micro-nutrients in available forms during mineralization, improving physical and physiological properties of soil. The similar findings have been reported by Kushwah (2015) [10] in carrot.

Total Soluble Solids (^{0}Brix)

The highest TSS content of (14.38 ^{0}Brix) was recorded in T_9 with the application of FYM @ 10t/ha + VC @ 5t/ha + CU 50% which was at par with T_6 (13.85 ^{0}Brix) and T_5 (13.05 ^{0}Brix) which were significantly superior to all the other treatments. The lowest TSS content of (10.17 ^{0}Brix) was recorded in control T_1. This might be due to accumulation of more reserve substances in beet root. The similar findings have been reported by Panday (2017) in carrot and Kushwah (2016) [11] in radish.

Economics

The maximum net profit per hectare (Rs. 7,02,324) was recorded under the treatment T_9 with the application of FYM @ 10t/ha + VC @ 5t/ha + CU 50%. While minimum net profit per hectare was obtained in the treatment T_1 (Rs. 3,45,400). The B:C ratio was found to be highest (1:9.16) under the treatments T_9 with the application of FYM @ 10t/ha + VC @ 5t/ha + CU 50% and lowest (1:6.29) under the treatment T_1 i.e. control.

Conclusion

On the basis of present research on "Effect of organic manure on growth, yield, quality and economics of Beet root (*Beta vulgaris* L.) at Dehradun Valley" in cultivar Suman, it can be concluded that among different organic manures treatments, the combination of FYM (@ 5 t/ha^{-1}) + VC (@ 2.5 t/ha^{-1}) + Cow urine (@ 50%) i.e. T_9 was found to be most efficient for increasing plant height, number of leaves/plant, leaf length, leaf width, root weight, Total Soluble Solids and in terms of economics also.

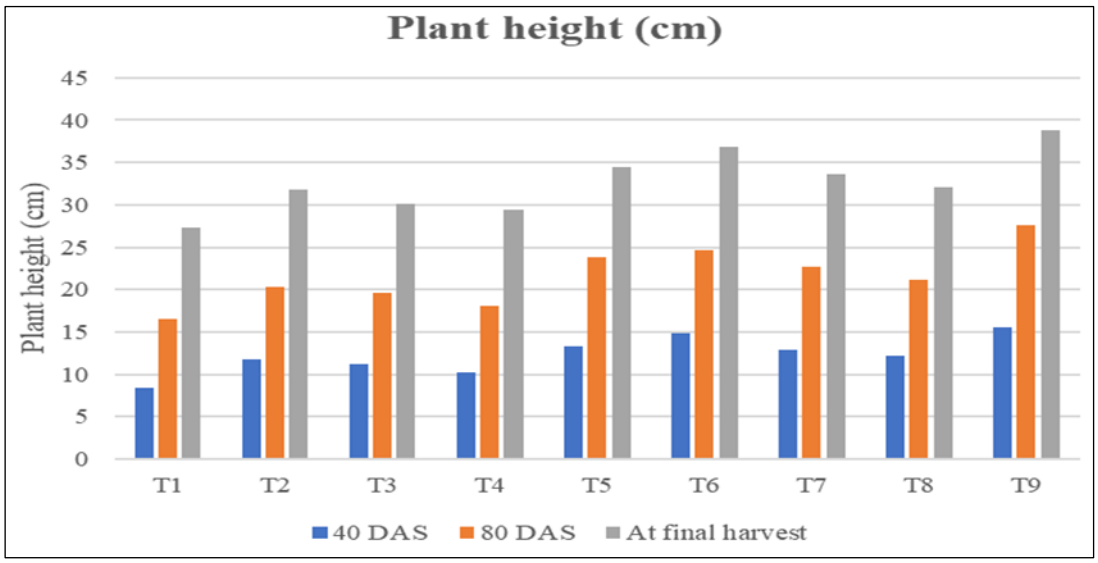

Fig 1: Effect of different organic manures on plant height (cm) of beet root at different stages of harvesting

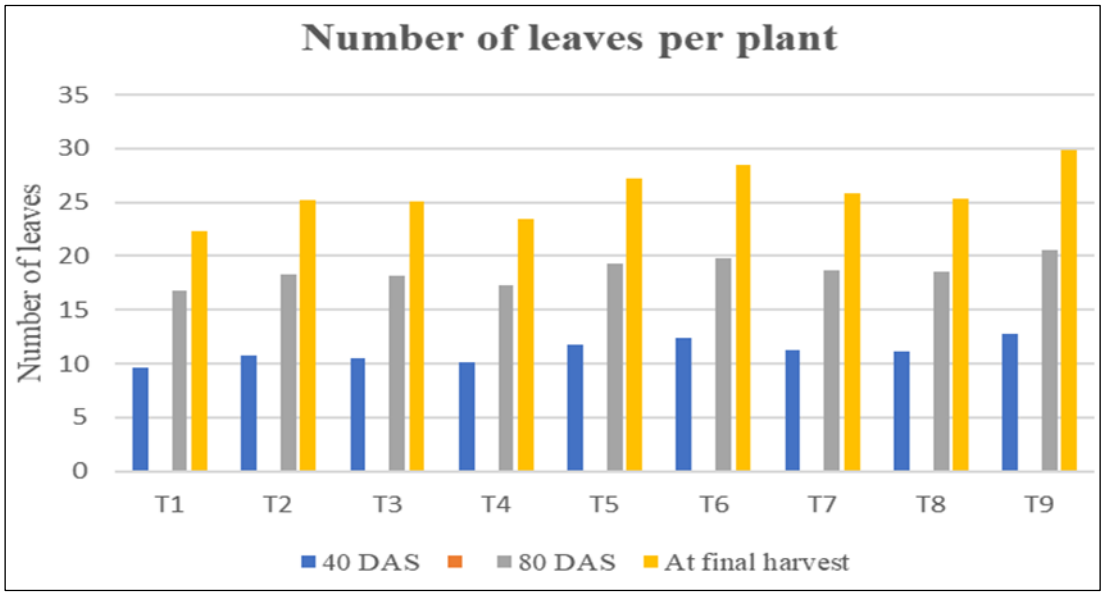

Fig 2: Effect of different organic manures on number of leaves per plant of beet root at different stages of harvesting

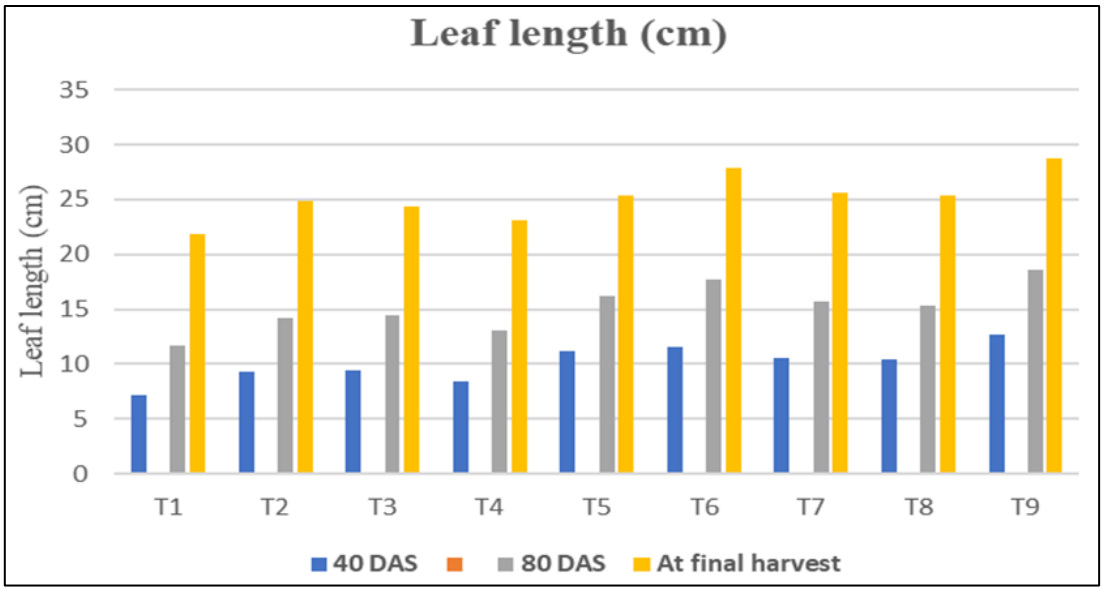

Fig 3: Effect of different organic manures on leaf length (cm) of beet root at different stages of harvesting

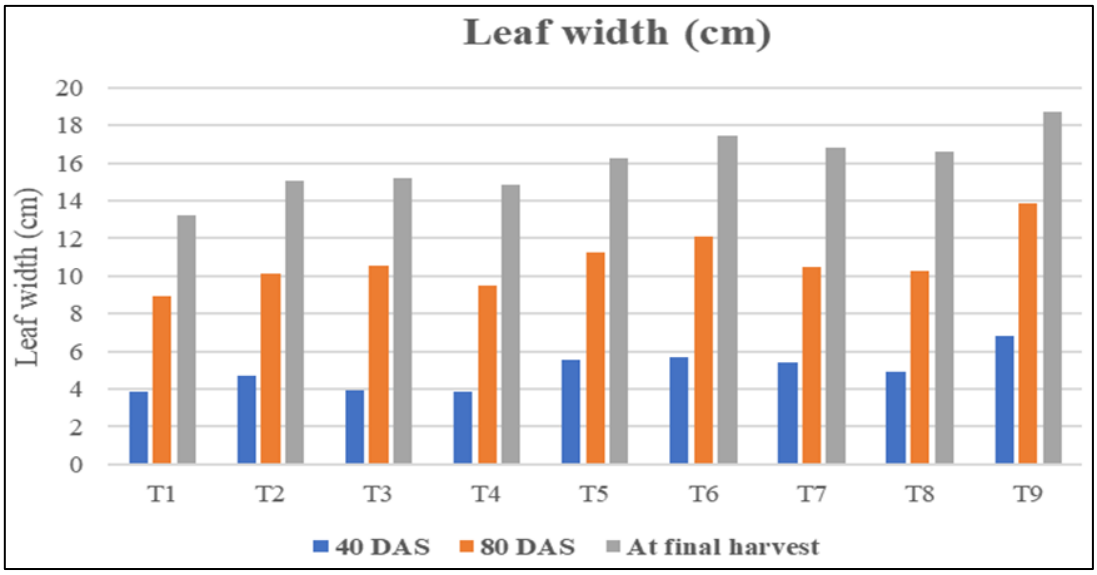

Fig 4: Effect of different organic manures on leaf width (cm) of beet root at different stages of harvesting

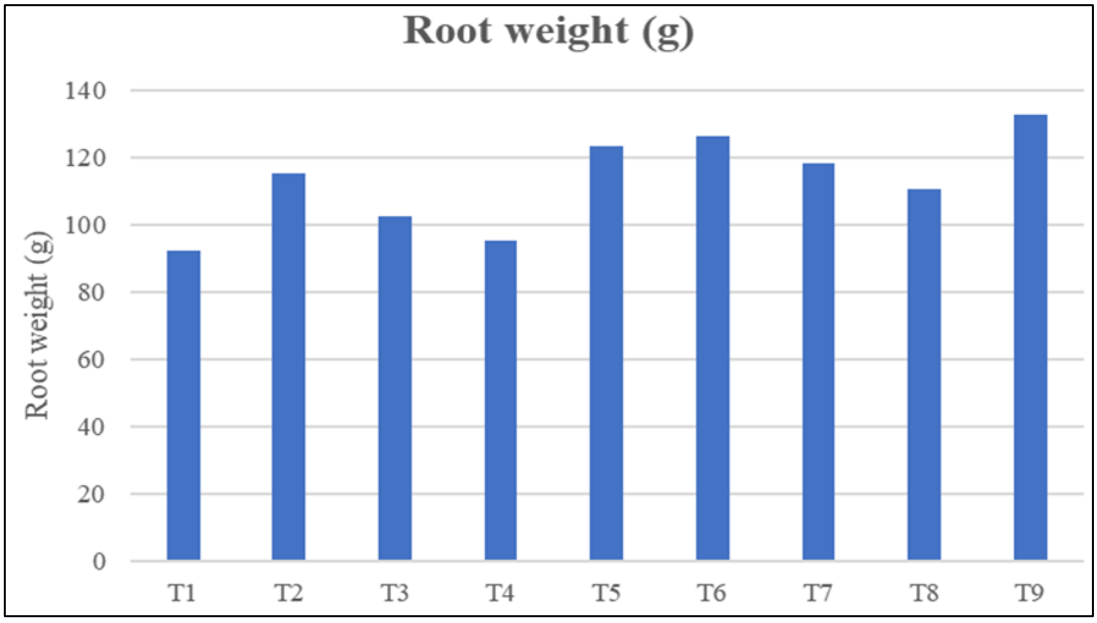

Fig 5: Effect of different organic manures on root weight (g) of beet root

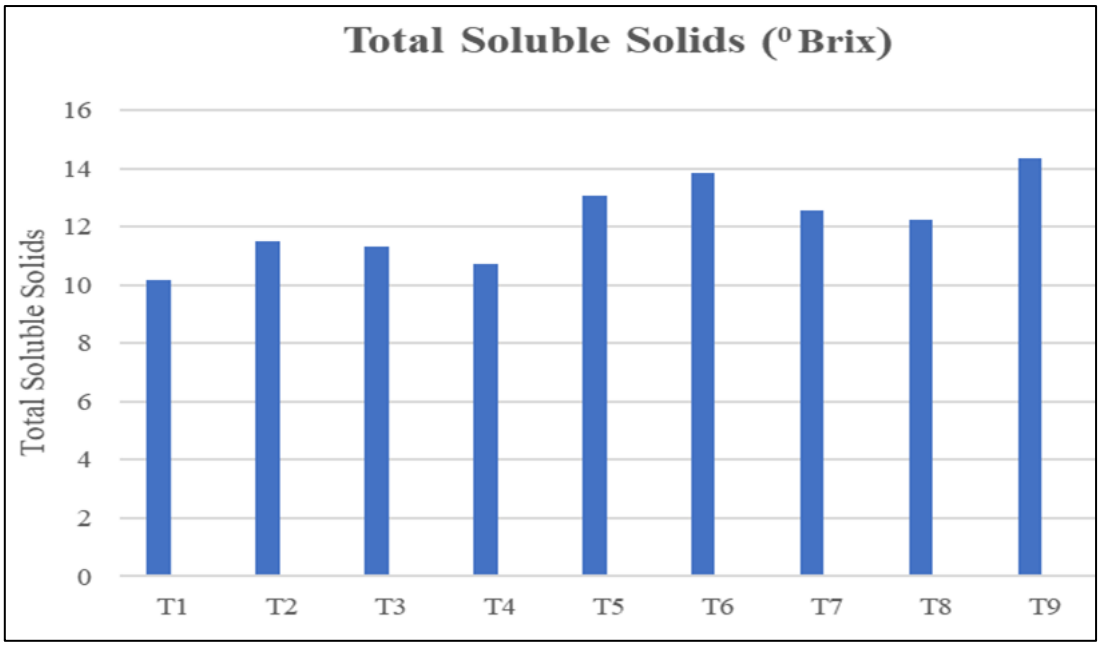

Fig 6: Effect of different organic manures on Total Soluble Solids (^{0}Brix) of beet root

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