Fundamental and Applied Agriculture
Vol. 8(1&2), pp. 377–389: 2023
doi: 10.5455/faa.93670

HORTICULTURE | ORIGINAL ARTICLE

Yield and quality performance of beetroot (*Beta vulgaris* L.) as influenced by organic manure management

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ARTICLE INFORMATION

Article History
Submitted: 11 Dec 2022
Accepted: 13 Feb 2023
First online: 22 Jun 2023

Academic Editor
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ABSTRACT

The experiment was carried out at the Horticulture Farm of the Department of Horticulture, Bangladesh Agricultural University, Mymensingh during the period from November 2020 to March 2021 to evaluate the performance of beetroot (*Beta vulgaris* L.) cultivars for higher yield and quality through organic manures. The experiment consisted of two varieties *viz.*, Beet Palong (V1), Red Ball (V2) and eight organic manures treatments viz., T0 (control), T1 (cow dung @ 15 t/ha), T2 (mustard oil cake @ 0.5 t/ha), T3 (vermicompost @ 10 t/ha), T4 (cow dung @ 7.5 t/ha + mustard oil cake @ 0.25 t/ha), T5 (cow dung @ 7.5 t/ha + vermicompost @ 0.5 t/ha), T6 (mustard oil cake @ 0.5 t/ha + vermicompost @ 10 t/ha), T7 (Cowdung @ 5 t/ha + Mustard oil cake @ 0.15 t/ha + vermicompost @ 3 t/ha). The experiment was laid out in a split-plot design with three replications. There was a significant effect of varieties and organic manures on beetroot growth, yield and quality. The highest plant height (35.21 cm) was recorded on the Red Ball variety with Cowdung @ 5 t/ha + Mustard oil cake @ 0.15 t/ha + vermicompost @ 3 t/ha (T7) treatment along with a large number of leaves (10.10), highest leaf length (24.33 cm) and breadth (16.03 cm). The root yield of the Red Ball variety was 35.82 t/ha, whereas the root yield of the Beet Palong variety was 25.68 t/ha. In case of organic manures, highest root yield (40.33 t/ha) was measured in T7 treatment whereas the lowest root yield (22.82 t/ha) was found in T2. In combination treatment, Red Ball variety with produced the maximum root yield (48.30 t/ha) in combination with T7 treatment whereas the Beet Palong variety produced the lowest root yield (15.37 t/ha) in combination with T0 treatment. Lower crack percentage (6.67%) and rotten percentage (3.33%) of beetroot were observed in the Red Ball variety (V2) in comparison to Beet Palong (V1). The maximum dry matter content (34.19%) was found in combination treatment V1T5 whereas the minimum dry matter content (16.08%) was observed in V2T0. Therefore, the study indicated that Red Ball variety (V2) in combination with Cowdung @ 5 t/ha + Mustard oil cake @ 0.15 t/ha + vermicompost @ 3 t/ha (T7) along with recommended chemical fertilizer may be recommended for better and better quality of beetroot.

Keywords: Beetroot cultivars, organic manures, yield, quality

Cite this article: Mia MN, Rashid MHA. 2023. Yield and quality performance of beetroot (*Beta vulgaris* L.) as influenced by organic manure management. Fundamental and Applied Agriculture 8(1&2): 377–389. doi: 10.5455/faa.93670

1 Introduction

Beetroot (*Beta vulgaris* L.), also called table beet, belongs to the family Chenopodiaceae, is a root vegetable, and it is consumed both raw and cooked. Beetroot is an immune-boosting food that acts as antioxidants, and antimicrobial and antiviral agents. Moreover, it has anti-cancer properties, lowers blood pressure, improves digestive health, supports energy levels and has an anti-inflammatory capability. For example, betalains of beetroot, comprised betacyanins and betaxanthins, can prevent as well as treat hypertension and cardiovascular diseases while the pro-

liferation of cells in human tumor cells can also be inhibited (Neha et al., 2018).

Beetroot is a very popular vegetable in eastern and central Europe but is much less important in Western Europe and the USA, where it is known as garden beet. It is grown for its swollen root and it is the horticultural form. The European countries especially England and France are the great producers and consumers of table beet. Beetroot plants prefer soil pH ranges from 6.5 to 7.5 and the ideal temperature for this crop is about 18-25 °C (Neelwarne and Halagur, 2012).

In Bangladesh, beetroot vegetable is a new crop that has lots of health benefits and becoming popular due to their colorful appearance. Most of the farmers (53%) are cultivating it just as a hobby. However, 32% of farmers grow it for commercial purposes. The farmers had to face different problems during the cultivation of this new crop, like seed and labor crisis, high labor costs, excessive rainfall, etc. It was shown that most of the farmers (46.7%) had faced seed crisis problems during the cultivation of beetroot. About 60% of farmers agreed to get technical assistance from the agricultural department during the cultivation to overcome all of these challenges and 95% of farmers still want to continue their cultivation of beetroots and increase their production if they can get adequate technical help during cultivation (Rashid et al.). Moreover, suitable and optimal fertilization methods and fertilizer types should be used on a larger scale. For achieving high growth parameters and bioactive metabolites, red beetroot should be cultivated using an integrated fertilization of 75% biofertilizer and 25% chemical fertilizer (Agic et al., 2018).

Organic manures can be used to increase the yield and quality of beetroot. In addition, it will conserve soil health and soil fertility, improve soil and crop quality and hence increases the yield and quality of crops in ways similar to inorganic fertilizers (Hlisnikovský et al., 2021). Soils of Bangladesh are low in organic matter, and conserving and maintaining it at moderate levels is one of the serious problems in soil management. This may be accomplished through the maximum return of crop and animal residues to soil; use of biofertilizers; green manuring in crop rotation and proper utilization of farm manure, night soil, composts and nitrogenous organic materials, such as crushed bones, fish wastes, mustard, sesame, castor cakes, etc. (Bhuiya, 1987).

Very limited research has been conducted on the productivity of beetroot in Bangladesh. Beetroot can be cultivated successfully in different areas of Bangladesh and its cultivation and selling seem to be profitable in terms of the country's perspective. Moreover, the cultivation of beetroot vegetables may also offer a new prospect for the food industry to produce phytonutrient-rich food products such as beetroot pickles, jam, cake, biscuits, pasta and so on. It is expected that the farmers of the country may come forward to cultivate more beet in the future if they can get proper help during cultivation and selling. Therefore, the current experiment was conducted to study the performance of beetroot cultivars for higher yield and quality through organic manures.

2 Materials and Methods

2.1 Experimental site, soil and climate

The experiment was carried out at the Horticulture Farm of the Bangladesh Agricultural University, Mymensingh, during the period of November 2021 to March 2022. The experimental field was located at 24075′ N latitude and 90050′ E longitude at an average altitude of 18 m above sea level. The experimental field is part of the Old Brahmaputra floodplain AEZ-9, which has non-calcareous dark grey flood plain soil. The region occupied a large area of Brahmaputra sediments which are laid down before the river shifted into its present Jamuna Channel about 200 years ago (Brammer et al., 1988). The soil belongs to the sonata series of dark grey floodplain soil types. The soil was silty-loam in texture, having a pH of 5.5-6.8. The experimental area was located under a subtropical zone during the period of November to March which is comparatively cool, with less rainfall, plenty of sunshine and an average temperature range of 18-25 °C which is favorable for these exotic crops.

2.2 Planting material and treatments of the experiment

The experiment consisted of two varieties *viz.*, Beet Palong (V1), Red Ball (V2) and eight organic manures treatments viz., T0 (control), T1 (cow dung @ 15 t/ha), T2 (mustard oil cake @ 0.5 t/ha), T3 (vermicompost @ 10 t/ha), T4 (cow dung @ 7.5 t/ha + mustard oil cake @ 0.25 t/ha), T5 (cow dung @ 7.5 t/ha + vermicompost @ 0.5 t/ha), T6 (mustard oil cake @ 0.5 t/ha + vermicompost @ 10 t/ha), T7 (Cowdung @ 5 t/ha + Mustard oil cake @ 0.15 t/ha + vermicompost @ 3 t/ha). Organic manures were applied during the final land preparation according to the treatment doses. The inorganic fertilizers were applied following the recommended dose (Islam, 2008).

2.3 Experimental design and layout

The experiment was laid out in a split-plot design with three replications. The size of each plot was 1 square meter. The total number of plots was 48 and each replication was divided into 16-unit plots. The varieties were assigned to the main plot and the doses of organic manures were applied to the sub-plot. The

distance between plots was 0.30 m while the distance between two blocks was 0.50 m.

2.4 Land preparation

The experimental land was ploughed by a power tiller on 5 November 2021 The deep ploughing and cross ploughing were done four times and the land was leveled by laddering. The corners and levies were trimmed by spade and large colds were broken into small pieces with a wooden hammer. Weeds, stubbles and crop residues were removed.

2.5 Germination test

The rate of germination is an indicator of vigor. Rapid seed germination increases the chance of the seed establishing in the field. To measure the germination percentage, two separate petri dishes were taken and then disinfected with ethanol. Presoaked (in water) seeds were placed on the tissue paper in the petri dishes for 24 hours at the room temperature In the Beet Palong variety (V1) 61 seeds were germinated out of 80 seeds (rate of germination 76.25%) and in the Red Ball variety (V2) from 80 seeds, 73 seeds were germinated (rate of germination 91.25%).

2.6 Seed sowing and transplanting

Seeds were sown on 25 November 2021in a shaded seedbed of the Horticulture Farm, BAU. The seeds were sown in a separate line. The seedlings were transplanted on December 2021where plant-to-plant distance was 20 cm and row to row distance 25 cm. In 4 rows there were 20 seedlings in each plot.

2.7 Intercultural operations

Weeding was done as and when necessary. Gap filling was done after 3 weeks of planting to maintain the proper plant population and earthing up was done at 60 days after planting (DAP) to cover the root base and facilitate drainage and maximum root growth. It was reported that, depending on the soil types and the rainfall, the red beet crop requires 8-10 irrigations depending on the availability of soil moisture (Motiwale and Agnihotri, 1991). The soil of the experimental plot did not contain sufficient amount of moisture. For this reason, irrigation was done after every three alternate days in the first month, seven alternate days in the second month and 15 alternate days in the third month of transplanting by watering can. Some plots were infected by Rhizoctonia root rot disease. The fungicide Azoxystrobin was sprayed @ 2 mL/L of water by hand sprayer. There was no insect infestation found in the experimental plot.

2.8 Parameters measured

Data on various parameters such as number of leaves per plant, leaf length, leaf breadth, leaf area (cm2), plant height (cm), root length (cm), root diameter (cm), fresh weight of root per plant (g), root yield per plot (kg), root yield (tons per hectare), dry matter content of root (%), root crack percentage per plot (%), root rotten percentage per plot (%) were recorded from the sample plants during experimentation. The plant height, number of leaves per plant, leaf length and leaf breadth of five randomly selected plants from each plot were recorded using the unit in centimeters (cm) at 40, 55, 70, 85 and 100 days after planting (DAP). Leaf area was recorded from five randomly selected plants by using a leaf area index meter (LI-3100C area meter). Root length and root diameter of five randomly selected plants from each plot was recorded using the unit in centimeters (cm) 70, 85 and 100 days after planting (DAP). Fresh weight of the roots of five randomly selected plants was taken from each plot and expressed in grams (g). Fresh weight of root yield per plot was taken in kilograms (kg) and total root yield was converted to tons per hectare (t/ha). Root crack and rotten percentage per plot was measured in percentage (%). Dry matter content of the roots of five randomly selected plants from each plot was recorded after oven drying. The weight was expressed in grams (g). Root dry weight was obtained from total wet weight by root sample weight and multiplied by oven dry weight of sample.

2.9 Harvesting

Two times harvesting was done at 85 (first harvest where five plant samples were randomly selected from each plot to measure the fresh root weight and find the difference mean of root yield from 85 DAP to 100 DAP) and 100 DAP (final harvest). Five samples from each plot were separately uprooted from the plots. Then the dried and dead plant parts were removed from the plants and washed in water. After that, the plant samples were brought to the threshing floor for data recording.

2.10 Statistical analysis

All the collected data were analyzed statistically following the analysis of variance (ANOVA) technique and the significance of mean differences was measured by Least Significance Difference (LSD) at 5% and 1% levels of probability as described by Gomez and Gomez (1984).

Plate 1. Seed germination test of two beetroot varieties

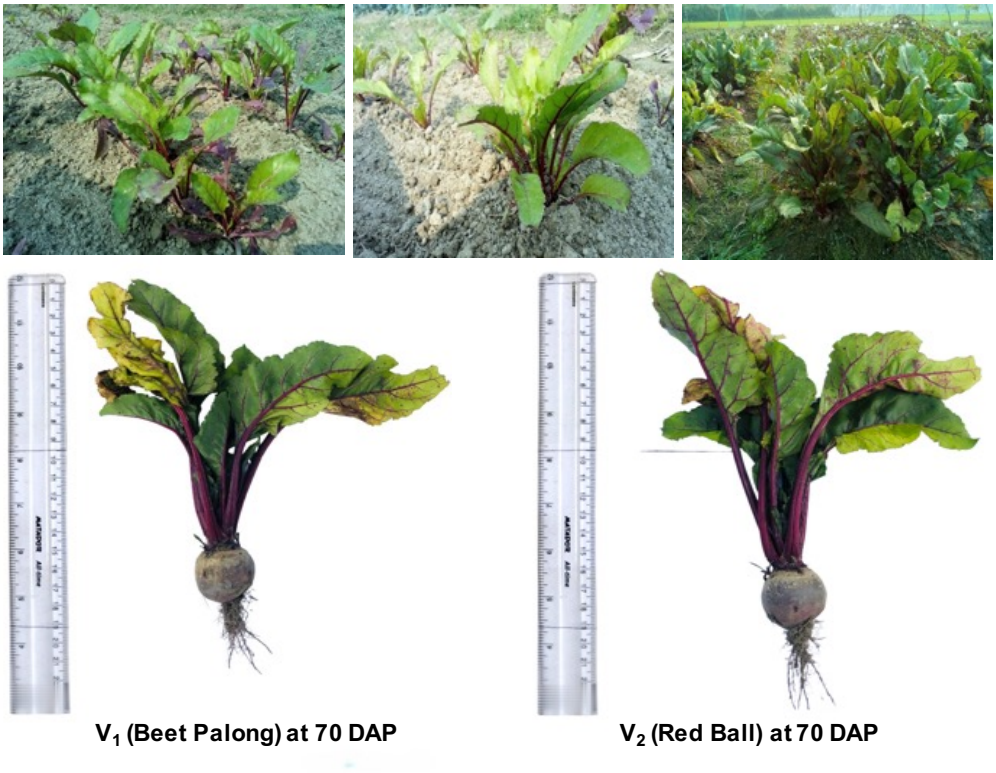
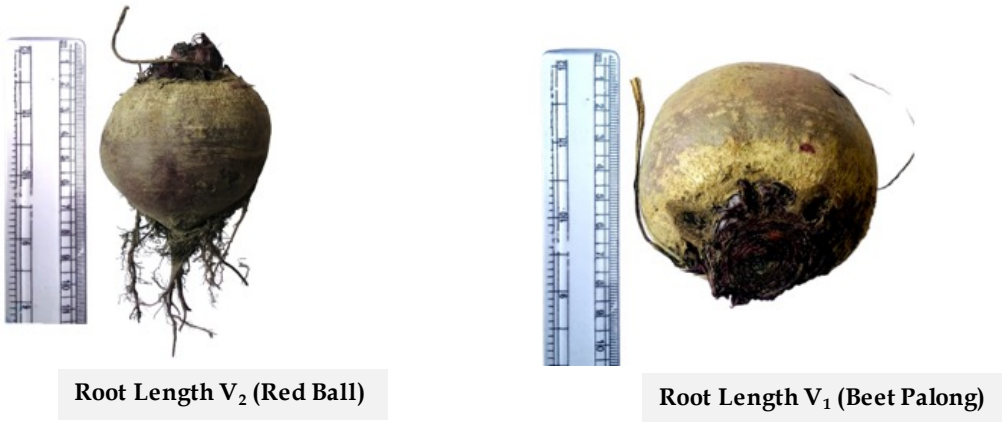


Plate 2. Various growth and development stages of beetroot

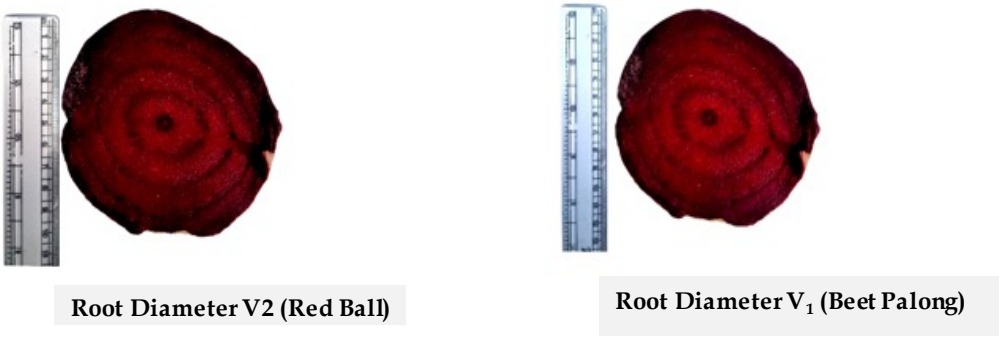
Plate 3. Harvested beetroot and measurement of weigh using table top balance

Leaf length V_1 (Beet Palong) **Leaf length V_2 (Red Ball)**

Plate 4. Measurements of leaf length of two beetroot varieties



Root Length V_2 (Red Ball) **Root Length V_1 (Beet Palong)**



Root Diameter V2 (Red Ball) **Root Diameter V_1 (Beet Palong)**

Plate 5. Measurements of root length and root diameter of two beetroot varieties

3 Results and Discussion

3.1 Plant height

Plant height showed a significant response to variety. Plant height was recorded at 40, 55, 70, 85, and 100 DAP.

The plant height increased gradually up to 70 DAP and then reduced slowly up to 100 DAP. The result showed that higher plant height (29.45 cm) was recorded on Red Ball variety at 70 DAP than Beet Palong variety 26.50 cm) (Fig. 1).

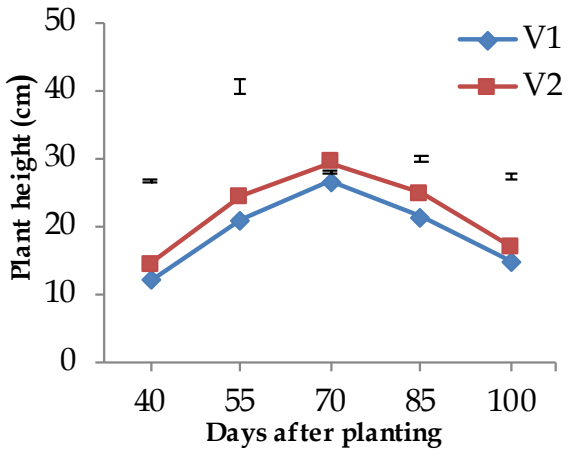


Figure 1. Effect of variety on plant height at different DAP. The vertical bars represent LSD at 1% level of probability. V1=Beet Palong and V2= Red Ball

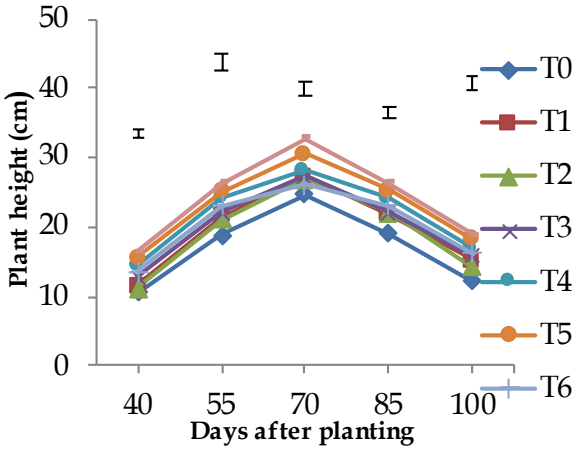


Figure 2. Effect of organic manures on plant height at different DAP. The vertical bars represent LSD at 1% level of probability. Here, T0= Control, T1=Cow dung, T2=Mustard oil cake, T3= Vermicompost, T4=Cow dung +mustard oil cake, T5= Cow dung + vermicompost, T6=Mustard oil cake + vermicompost, T7=Cow dung + mustard oil cake+ vermicompost

The results showed that the highest plant height (32.76 cm) was recorded in T7 treatment at 70 DAP followed by T5 (25.24 cm) whereas the lowest value was observed in T0 treatment (24.77 cm) preceded by T2 (26.83) (Fig. 2). Plant height showed a significant response due to the combined effect of variety and organic manures. The highest plant height (35.21 cm) was recorded on the Red Ball variety with T7 treatment (V2T7) followed by V2T5 (33.27 cm) and the lowest value (24.17 cm) was observed on the Beet Palong variety with T0 treatment (V1T0) preceded by (V1T2) (26.33 cm). A study conducted by Raab and Terry (1994) described that nitrogen helps foliage grow strong by affecting the plant's leaf and height development. It is also responsible for giving plants their green coloring by helping with chlorophyll production. In treatment T7 cow dung comprises 0.85% N, Vermicompost comprises 1.6 N% and mustard oil cake comprises 4.7% N. T7 treatment contains the highest amount of nitrogen in comparison with other organic treatments which affects vigorous plant height, leaf number, leaf length, leaf breadth and leaf area.

3.2 Number of leaves per plant

The result indicates that higher number of leaves (9.59) was recorded on the Red Ball variety (V2) at 70 DAP and lower number of leaves (8.29) was recorded on the Beet Palong (V1) (Fig. 3).

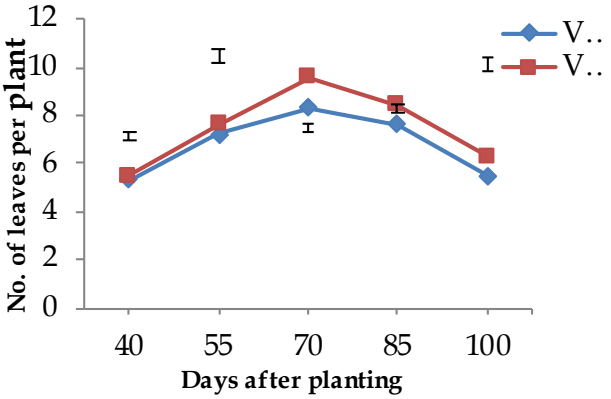


Figure 3. Effect of variety on no. of leaves per plant at different DAP. The vertical bars represent LSD at 1% level of probability. V1=Beet Palong and V2= Red Ball

Number of leaves responded significantly to organic manures. The result indicated that the highest number of leaves (10.10) was recorded on T7 treatment at 70 DAP followed by T5 (9.17) and the lowest value (8.33) was recorded on T0 treatment preceded by T2 (8.53) (Fig. 4). Variety and organic manures had a significant impact on leaf count (Table 1). The outcome showed that the Red Ball variety with T7 treatment (V2T7) at 70 DAP had the largest number of

leaves (10.10) followed by V2T5 (9.93) and the Beet Palong variety with T0 treatment (V1T0) had the lowest value (7.60) preceded by V1T2 (7.93). Hybrid variety contains superior genes and some quality of vigorous growing which advances its stronger seasonal hardiness, deep color of leaves, shapes, pattern and leaf number.

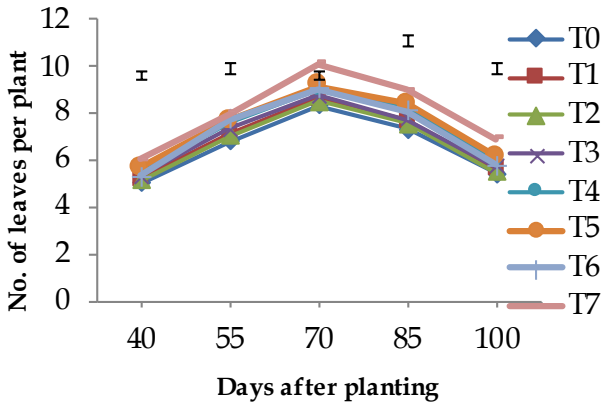


Figure 4. Effect of organic manures on no. of leaves per plant at different DAP. The vertical bars represent LSD at 1% level of probability. Here, T0= Control, T1=Cow dung, T2=Mustard oil cake, T3= Vermicompost, T4=Cow dung +mustard oil cake, T5= Cow dung + vermicompost, T6=Mustard oil cake + vermicompost, T7=Cow dung + mustard oil cake+ vermicompost

According to the study of Sapkota et al. (2021) organic and inorganic integrated fertilization gave significantly higher plant height (41.84 cm), number of leaves per plant (14.68), leaf length (34.56 cm) and leaf width (11.38 cm).

3.3 Leaf length

The leaf length increased gradually and attained maximum up to 70 DAP. At 70 DAP, the highest leaf length (21.73 cm) was recorded on the Red Ball variety (V2) and the lowest leaf length (20.90 cm) was recorded on the Beet Palong variety (V1) (Fig. 5). In T7 treatment the longest leaf length (23.68 cm) was measured at 70 DAP followed by T5 (22.52 cm) (Fig. 6). The shortest leaf length (18.51 cm) was measured in T0 treatment preceded by T2 (20.21 cm) (Fig. 6). The Red Ball variety with T7 treatment (V2T7) was measured to have the longest leaf length (24.33 cm) at 70 DAP followed by V2T5 (23.01 cm) whereas the Beet Palong variety with T0 treatment (V1T0) observed the shortest leaf length (18.02 cm) preceded by V1T2 (20.02 cm) (Table 2). Findings stated by Sapkota et al. (2019) that organic manures with synthetic N2 fertilizer favor the growth of vegetative parts of the beetroot plants.

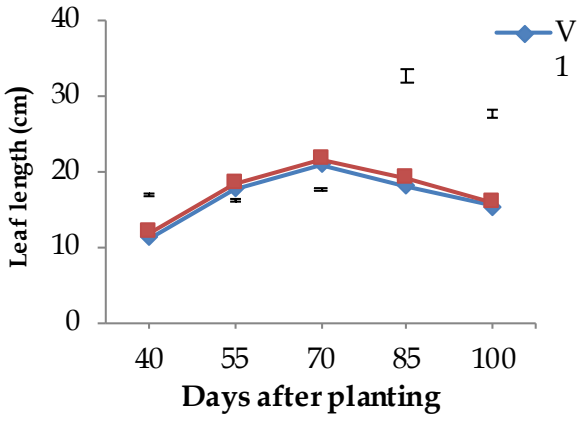


Figure 5. Effect of variety on leaf length at different DAP. The vertical bars represent LSD at 1% level of probability. V1=Beet Palong and V2= Red Ball

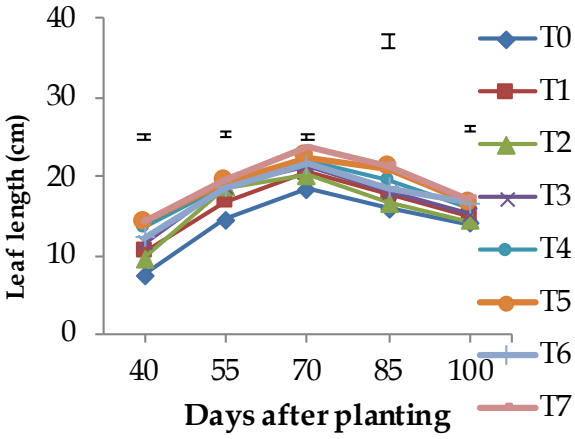


Figure 6. Effect of organic manures on leaf length at different DAP. The vertical bars represent LSD at 1% level of probability. Here, T0= Control, T1=Cow dung, T2=Mustard oil cake, T3= Vermicompost, T4=Cow dung +mustard oil cake, T5= Cow dung + vermicompost, T6=Mustard oil cake + vermicompost, T7=Cow dung + mustard oil cake+ vermicompost

3.4 Leaf breadth

Leaf breadth of plants was measured at 40, 55, 70, 85, and 100 DAP. The plants leaf breadth increased gradually up to 70 DAP and then reduced slowly up to 100 DAP. At 70 DAP, higher leaf breadth (12.27 cm) was recorded on the Red Ball variety than Beet Palong variety (11.30 cm) ((Fig. 7)). On T7 treatment the longest leaf breadth (15.52 cm) was measured at 70 DAP followed by T5 (14.02 cm) while on T0 treatment the shortest leaf breadth (8.51 cm) was measured preceded by T2 (10.35 cm) ((Fig. 8)). On the Red Ball variety with T7 treatment (V2T7), the longest leaf breadth (16.03 cm) was measured at 70 DAP followed

by in V2T5 (15.01 cm). Beet Palong variety with T0 treatment (V1T0) recorded the shortest leaf breadth (7.99 cm) preceded by V1T1 (10.02 cm) (Table 2).

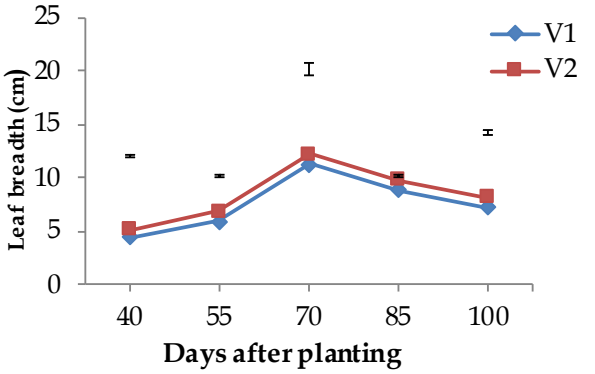


Figure 7. Effect of variety on leaf breadth at different DAP. The vertical bars represent LSD at 1% level of probability. V1=Beet Palong and V2= Red Ball

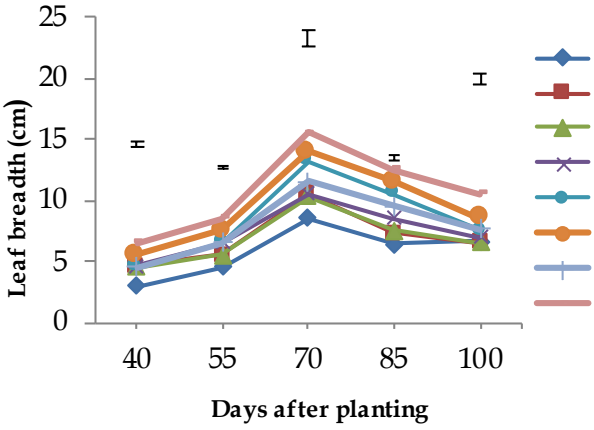


Figure 8. Effect of organic manures on leaf breadth at different DAP. The vertical bars represent LSD at 1% level of probability. Here, T0= Control, T1=Cow dung, T2=Mustard oil cake, T3= Vermicompost, T4=Cow dung +mustard oil cake, T5= Cow dung + vermicompost, T6=Mustard oil cake + vermicompost, T7=Cow dung + mustard oil cake+ vermicompost

3.5 Leaf area

The leaf area differed significantly between varieties. At 85 DAP, Red Ball variety (V2) had larger leaf area (155.81 cm^2) than Beet Palong variety (V1) (137.06 cm^2) (Table 3). The longest leaf area (185.15 cm^2) was measured on T7 treatment at 85 DAP followed by T5 (172.69 cm^2) whereas on T0 treatment the shortest leaf area was measured (110.17 cm^2) preceded by T2 (131.12 cm^2) (Table 4). Red Ball variety with T7 treatment (V2T7), the longest leaf area (190.21 cm^2) was measured at 85 DAP followed by V1T7 (180.09 cm^2) whereas on the Beet Palong variety with T0 treatment (V1T0) measured the shortest leaf area (105.15 cm^2) preceded by V2T0 (115.18 cm^2) (**??**).

3.6 Root length

A measurement of the root length of the plants was conducted at 85 DAP and 100 DAP. At 100 DAP, the Red Ball variety (V2) had the larger root length (7.96 cm) compared to Beet Palong variety (5.95 cm) (Table 3). On T7 treatment the longest root length (9.75 cm) was measured at 100 DAP followed by T5 (5.82 cm) while on T0 treatment the shortest root length (4.08 cm) was measured preceded by T2 (5.46 cm) (Table 4). Red Ball variety with T7 treatment (V2T7), the longest root length (11.26 cm) was measured at 100 DAP followed by V2T5 (9.99 cm). In Beet Palong variety with treatment T0 (V1T0) the shortest root length (4.03 cm) was measured preceded by V1T3 (4.78 cm) (**??**). Study conducted by Zhang et al. (2020) showed that biochar based organic nitrogen source had great effect on root length of beet. In this study T7 contained the highest amount of nitrogen from mixed organic sources.

3.7 Root diameter

Red Ball variety (V2) had the larger root diameter (6.75 cm) compared to Beet Palong variety (5.15 cm) (Table 3). Largest root diameter (7.06 cm) was measured in T5 treatment at 100 DAP followed by T7 (7.02 cm) and shortest root diameter (4.52 cm) was observed T0 treatment preceded by T2 (5.02 cm) (Table 4). In combined treatment, root diameter differed significantly for different varieties and organic manures. Red Ball variety with T7 treatment (V2T7) the largest root diameter (8.51 cm) was measured at 100 DAP followed by V2T5 (8.06 cm) while on the Beet Palong variety with T0 (V1T0) the shortest root diameter (4.03 cm) was observed preceded by V1T3 (4.53 cm) (**??**). In comparison to variety, the Red Ball extracts the highest amount of nutrients from the soil (we know HYV – high-yielding varieties have the capability to consume more nutrient contents from the soil). For this reason, V2 (Red Ball) had a larger root diameter than V1 (Beet Palong).

3.8 Root fresh weight

To measure the root fresh weight of the plants, measurements were conducted at 85 DAP and 100 DAP. The Red Ball variety (V2) had higher fresh weight of root at 100 DAP (214.14 g) compared to the Beet Palong variety (V1) (145.27 g) (Table 3). On T7 treatment the highest root fresh weight (221.56 g) was measured at 100 DAP followed by T5 (200.68 g) whereas in T0 smallest root fresh weight (91.52 g) was measured preceded by T2 treatment (173.23g) (Table 4). The

Table 1. Combined effects of variety and organic manures on plant height and number of leaves at different days after planting (DAP) of beetroot

Treatment	Plant height (cm) at different DAP					Number of leaves per plant at different DAP				
	40	55	70	85	100	40	55	70	85	100
V1T0	10.17	18.05	24.17	17.99	11.14	4.93	6.73	7.6	6.93	4.93
V1T1	10.27	20.33	26.67	20.21	14.33	5.2	7.2	8.07	7.33	5.2
V1T2	10.37	19.05	26.33	21.11	13.12	5.13	7.13	7.93	7.2	5.07
V1T3	11.33	20.23	26.43	20.1	14.3	5.27	7.33	8.13	7.4	5.4
V1T4	13.03	22.12	26.23	22.24	15.33	5.4	7.07	8.2	7.8	5.6
V1T5	14.12	22.98	27.67	23.13	17.69	5.6	7.13	8.4	7.93	5.93
V1T6	12.02	21.05	24.2	21.29	14.18	5.27	7.6	8.4	7.6	5.47
V1T7	15.03	24.33	30.31	24.33	18.12	5.73	7.6	9.6	8.8	6.47
V2T0	10.97	19.7	25.38	20.23	13.16	5.13	6.87	9.07	7.8	5.93
V2T1	13.07	22.67	28.13	23.67	16.15	5.27	7.13	9.2	8	6.07
V2T2	11.93	23.23	27.33	23.2	15.15	5.2	6.93	9.13	7.93	6
V2T3	14.1	24.02	28.2	24.15	17.33	5.33	7.4	9.4	8.13	6.13
V2T4	15.73	26.02	29.98	26.16	18.17	5.67	8.07	9.73	8.8	6.27
V2T5	17.05	27.17	33.27	27.35	18.82	5.8	8.27	9.93	8.93	6.4
V2T6	15.08	25.2	28.11	25.02	18.33	5.4	7.87	9.67	8.6	6.2
V2T7	17.98	28.1	35.21	28.33	19.67	6.33	8.4	10.6	9.2	7.33
LSD0.05	0.42	0.77	0.65	0.54	0.68	0.2	0.21	0.2	0.27	0.21
LSD0.01	0.57	1.04	0.88	0.72	0.92	0.27	0.29	0.26	0.37	0.29
Sig. level	**	**	**	**	**	**	**	**	*	*

** = Significant at 1% level of probability. (V1 = Beet Palong and V2 = Red Ball). Here, T0= Control, T1=Cow dung, T2=Mustard oil cake, T3= Vermicompost, T4=Cow dung +mustard oil cake, T5= Cow dung + vermicompost, T6=Mustard oil cake + vermicompost, T7=Cow dung + mustard oil cake+ vermicompost

Table 2. Combined effects of variety and organic manures on leaf length and leaf breadth at different days after planting (DAP) of beetroot

Treatment	Leaf length (cm) at different DAP					Leaf breadth (cm) at different DAP				
	40	55	70	85	100	40	55	70	85	100
V1T0	7.03	14.03	18.02	16.07	14.02	3.03	4.04	7.99	6.07	6.06
V1T1	9.97	16.7	20.05	17.01	15.09	5.3	5.03	10.02	7	6.01
V1T2	9.03	18.33	20.02	16.03	14.27	4.01	5.03	10.04	7.01	6.04
V1T3	11.23	18.68	21.02	17.99	15.07	4.03	6.04	10.17	8.04	7.03
V1T4	13.17	18.68	22.03	19	15.89	4.08	6.05	13.13	10.07	7.04
V1T5	14.12	18.72	22.03	20.17	16.27	5.02	7.03	13.04	11	8.12
V1T6	12.02	18.33	21.02	18.05	16.17	3.98	6.04	11.01	9.11	7.07
V1T7	14.03	19.03	23.02	20.33	17.02	6.07	8.02	15.01	12.03	10.09
V2T0	7.93	15.03	19.01	15.7	14.13	3.09	5.06	9.02	6.77	7.27
V2T1	10.97	17.05	21.04	18.33	15.21	4.01	6.03	11.03	7.67	7.01
V2T2	10.12	18.7	20.4	17.2	14.36	5.03	6.04	10.67	8.15	7.03
V2T3	12	18.98	21.68	18.17	15.41	5.37	7.06	10.94	9.04	6.99
V2T4	13.85	19	22.32	20.01	16.25	5.07	7.04	13.41	11.03	8.07
V2T5	14.27	19.83	23.01	22	17.02	6.05	8.02	15.01	12.05	9.03
V2T6	12.7	19.03	22.03	19.03	17.33	5.05	7.04	12.03	10.02	8.33
V2T7	14.68	20.01	24.33	22.35	17.5	7.07	9.07	16.03	13.02	11.14
LSD0.05	0.27	0.29	0.27	0.74	0.31	0.21	0.11	0.62	0.15	0.47
LSD0.01	0.36	0.39	0.36	0.99	0.42	0.28	0.15	0.83	0.2	0.63
Sig. level	**	**	**	**	**	**	NS	*	**	**

** = Significant at 1% level of probability. (V1 = Beet Palong and V2 = Red Ball). Here, T0= Control, T1=Cow dung, T2=Mustard oil cake, T3= Vermicompost, T4=Cow dung +mustard oil cake, T5= Cow dung + vermicompost, T6=Mustard oil cake + vermicompost, T7=Cow dung + mustard oil cake+ vermicompost

highest root fresh weight (273.16 g) was measured on the Red Ball variety with T7 treatment (V2T7) at 100 DAP, followed by V2T5 (250.70 g) whereas the smallest root fresh weight (81.67 g) was measured on the Beet Palong variety with T0 (V1T0) preceded by V1T3 (Table 4). Varietal superiority (traits that developed by combining two species' higher qualities in the first filial generation F1-hybrid) was also a significant factor in the Red Ball variety's longest root length. One of the most important intercultural operations is singling was done with 40 DAP and 55 DAP. That helps the root to grow bigger in size and max root length and diameter of root was obtained and thus the fresh weight of root. Due to varietal genetic variability and different doses of organic manures application the difference was made. According to Garg and Mudgal (2007) study, cow dung provides 0.12% of phosphorous, 1.49% of potassium and 1.57% of calcium to the soil. Vermicompost supplies 0.7% of phosphorous, 0.8% potassium and 0.5% of calcium to the soil. On the other hand, mustard oil cake come up with 1.06% of phosphorous, 0.91% of potassium and 0.93% of sulfur. The N-P-K-S nutrient contents of these organic manures affect the vigorous growth of the plant's vegetative and reproductive part.

3.9 Root yield tons per hectare

Between cultivars, a considerable difference in root yield tons per hectare was found. Measurements were made at 100 DAP to calculate the plants root production in tons per hectare. The higher root yield (35.82 tons per hectare) was measured on the Red Ball variety (V2), whereas the lower root yield (25.68 t/ha) was observed for the Beet Palong variety (V1) (Fig. 9). Treatment indicated some notable changes in the root yield ton per hectare 100 days following planting, a fresh weight measurement of root yield tons per hectare was undertaken. The highest root yield (40.33 tons per hectare) was measured in T7 treatment followed by T5 (38.53 tons per hectare) whereas the smallest root yield (16.97 tons per hectare) was found in T0 (Fig. 10). In combined treatment, root production ton per hectare differed significantly for different kinds of organic manures and varieties. The Red Ball variety with T7 treatment (V2T7) produced the maximum root yield (48.30 tons per hectare) whereas the Beet Palong variety with T0 (V1T0) produced the lowest root yield (15.37 tons per hectare) preceded by V1T2 (20.50 tons per hectare) (Fig. 11). Magro et al. (2015) stated that by using only compost 49 t/ha resulted in the maximum root yield estimated in 43 t/ha of roots.

3.10 Crack percentage

Measurements were made at harvesting to calculate the crack percentage. At harvesting, the minimum crack percentage (8.75%) was observed on the Red Ball variety (V2) whereas the higher crack percentage (12.08%) was recorded in Beet Palong variety (V1) (Table 3). The lowest crack percentage (7.50%) was measured in the T7 treatment followed by T1 and T5 (8.33%) whereas the highest root crack percentage (18.33%) was found in T0 treatment preceded by T2 (11.67%) (Table 4). The Red Ball variety with T1 treatment (V2T1) produced the minimum root crack percentage (3.33%), whereas the Beet Palong variety with T0 (V1T0) produced the maximum root crack percentage (18.33%) preceded by V1T3 (13.33%) (Table 4). Manure generally contains 0.03–0.08 pounds boron per ton. Boron is one of the essential nutrients, which is responsible for checking root crake and rotten percentage. The Red Ball variety with T5 and T7 treatment produced the minimum crack and rotten percentage of root. T5 treatment contained vermicompost and cow dung which offered a smaller amount of boron to check the cracks and rotten of beet. Timely irrigation provides adequate moisture to the soil that reduces cracks in beet.

3.11 Rotten percentage

There was a considerable difference in the rotten percentage between cultivars. Measurements were taken at harvest to determine the percentage of rotting produce. At harvest, the lower rotten percentage (6.42%) was recorded in Red Ball variety (V2), while the higher rotten percentage (9.38%) was measured with Beet Palong variety (V1) (Table 3). The lowest rotten percentage (3.33%) was measured in T5 (Treatment 5) followed by T7 (5.0%) whereas the highest rotten (16.67%) was found in treatment T0 preceded by T1 (10.0%) (Table 4). The Red Ball variety with T4, T5 and T7 (V2T4, V2T5 and V2T7) produced the minimum rotten percentage (3.33 %), followed by V2T2 and V2T3 (5.67%) whereas the Beet Palong variety with T0 treatment (V1T0) produced the maximum root rotten percentage (21.67%) preceded by V1T2 (11.67%) (Table 4). T5 treatment contained vermicompost and cowdung which offered a smaller amount of boron to check rotten of beet. The boron essentiality on horticulture crops stated by Greenhill (1938).

3.12 Root dry matter content in percentage

There was a considerable difference in the dry matter content percentage between cultivars (Table 3). To determine the dry matter content percentage of root measurements were taken at harvest. The Red Ball variety (V2) had lower dry matter content (22.95%), while the Beet Palong variety (V1) had the higher dry matter content (24.93%) (Table 3). The lowest dry matter content percentage (17.07%) was measured in T0 treatment followed by T2 (18.66%) whereas the

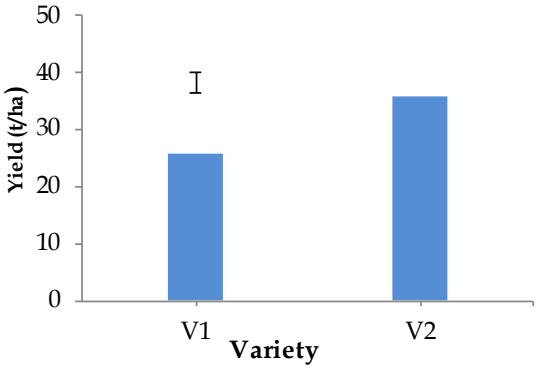


Figure 9. Effect of variety on root yield at different DAP. The vertical bars represent LSD at 1% level of probability. V1=Beet Palong and V2= Red Ball

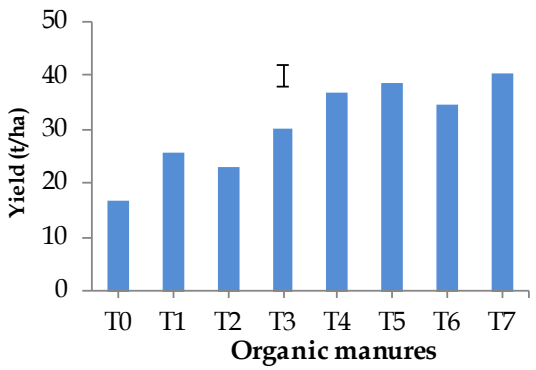


Figure 10. Effect of organic manures on root yield at different DAP. The vertical bars represent LSD at 1% level of probability. Here, T0= Control, T1=Cow dung, T2=Mustard oil cake, T3= Vermicompost, T4=Cow dung +mustard oil cake, T5= Cow dung + vermicompost, T6=Mustard oil cake + vermicompost, T7=Cow dung + mustard oil cake+ vermicompost

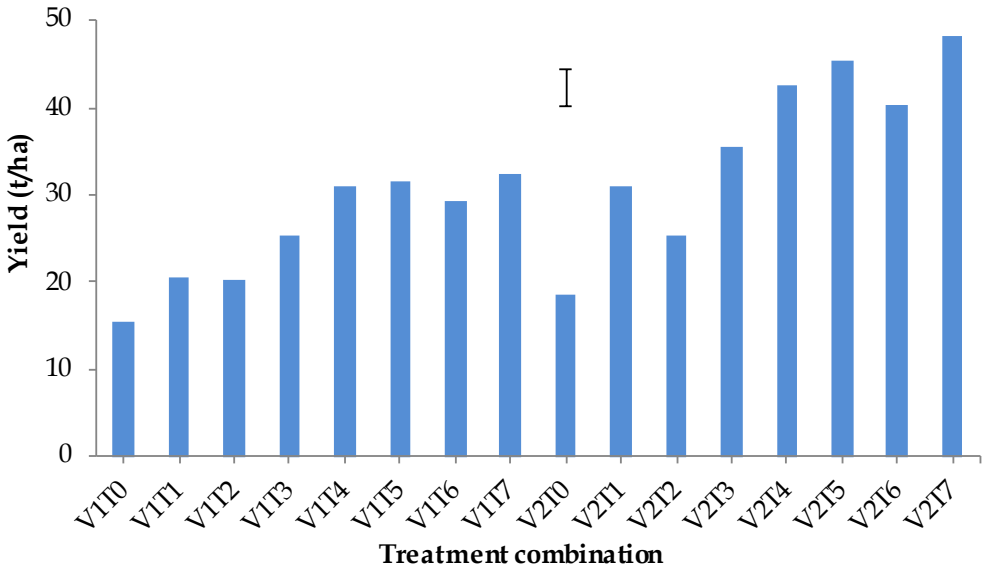


Figure 11. Combined effect of variety and organic manures on root yield. The vertical bars represent LSD at 1% level of probability. Here, T0= Control, T1=Cow dung, T2=Mustard oil cake, T3= Vermicompost, T4=Cow dung +mustard oil cake, T5= Cow dung + vermicompost, T6=Mustard oil cake + vermicompost, T7=Cow dung + mustard oil cake+ vermicompost

Table 3. Effects of variety on yield and quality characters of beetroot at different days after planting (DAP)

Variety	LA (cm^2)		RL (cm)		RD (cm)		RFW (g)		Yield (kg)	Crack%	Rotten%	DM%
	85 DAP	100 DAP	85 DAP	100 DAP	85 DAP	100 DAP	85 DAP	100 DAP				
V1	137.1	120.9	4.87	5.95	4.58	5.15	103.9	145.3	2.57	12.08	9.38	24.93
V2	155.9	138.6	6.1	7.96	5.72	6.75	144.6	214.1	3.58	8.75	6.42	22.95
LSD0.05	3.69	0.3	4.87	5.95	4.58	5.15	103.9	145.3	0.09	0.3	1.13	0.21
LSD0.01	4.98	0.4	0.4	0.28	0.08	0.34	4.64	4.4	0.12	0.4	1.52	0.28
Sig. level	**	**	*	**	**	**	**	**	**	**	*	**

DAP: days after planting; ** = Significant at 1% level of probability V1=Beet Palong and V2= Red Ball; LA: leaf area, RL: root length, RD: root diameter, RFW: root fresh weight, yield: yield/plot, DM: dry matter; yield, crack%, rotten% and DM% data were taken on 100 DAP

Table 4. Effects of organic manures and the interaction between variety and organic manures on yield and quality characters of beetroot at different days after planting (DAP)

Treatment	LA (cm^2)		RL (cm)		RD (cm)		RFW (g)		Crack%	Rotten%	DM%
	85 DAP	100 DAP	85 DAP	100 DAP	85 DAP	100 DAP	85 DAP	100 DAP			
OM (T)											
T0	110.17	105.3	3.83	4.08	3.83	4.05	82	91.52	18.33	16.67	17.07
T1	132.76	120.16	5.18	6.54	4.88	5.29	116.11	173.23	8.33	10	22.6
T2	131.12	117.64	4.88	5.46	4.64	5.02	118.68	185.61	11.67	8.67	18.66
T3	140.24	123.7	5.35	6.33	5	5.82	118.13	180.69	10.83	7	21.68
T4	159.19	132.61	6.15	7.67	5.59	6.53	123.37	193.48	9.17	5	30.24
T5	172.69	142.8	5.82	8.65	5.79	7.06	134.86	200.68	8.33	3.33	33.26
T6	140.16	127.65	5.86	7.14	5.71	6.82	140.43	190.86	9.17	7.5	20.75
T7	185.15	167.68	6.84	9.75	5.78	7.02	160.69	221.56	7.5	5	27.3
LSD0.05	6.19	2.19	0.81	0.8	0.16	0.4	5.11	6.95	1.56	1.07	0.34
LSD0.01	8.36	2.95	1.1	1.08	0.22	0.54	6.9	9.37	2.11	1.44	0.47
Sig. level	**	**	**	**	**	**	**	**	**	**	**
V*T											
V1T0	105.15	103.5	3.5	4.03	3.57	4.03	78.33	81.67	18.33	21.67	18.06
V1T1	120.23	110.18	5.25	5.92	4.26	4.5	100.67	146.33	13.33	8.33	24.07
V1T2	120.16	110.2	4.5	4.78	4.22	4.57	106.67	200.37	11.67	11.67	19.18
V1T3	130.24	112.17	4.4	5.17	4.5	5.06	95.33	130.66	13.33	8.33	23.12
V1T4	150.18	120.11	5.17	6.08	5.05	5.56	95.7	141.07	11.67	6.67	31.24
V1T5	170.26	135.31	5.13	7.32	5.07	6.06	99.33	150.67	8.33	3.33	34.19
V1T6	120.19	115.15	5.5	6.04	5.5	5.93	135.07	141.4	11.67	8.33	21.26
V1T7	180.09	160.25	5.5	8.25	4.5	5.53	120.67	169.96	8.33	6.67	28.35
V2T0	115.18	107.09	4.15	4.13	4.1	4.06	85.67	101.37	18.33	11.67	16.08
V2T1	145.29	130.14	5.1	7.17	5.5	6.08	131.54	200.12	3.33	11.67	21.12
V2T2	142.09	125.08	5.25	6.13	5.07	5.53	130.69	170.85	11.67	5.67	18.15
V2T3	150.24	135.22	6.3	7.5	5.5	6.58	140.92	230.72	8.33	5.67	20.25
V2T4	168.2	145.1	7.13	9.26	6.12	7.51	151.04	245.88	6.67	3.33	29.23
V2T5	175.11	150.29	6.5	9.99	6.5	8.06	170.38	250.7	8.33	3.33	32.32
V2T6	160.13	140.14	6.21	8.25	5.92	7.7	145.79	240.32	6.67	6.67	20.23
V2T7	190.21	175.11	8.18	11.26	7.07	8.51	200.71	273.16	6.67	3.33	26.25
LSD0.05	8.76	3.1	1.15	1.14	0.23	0.57	7.23	9.82	2.21	1.51	0.49
LSD0.01	11.82	4.18	1.55	1.53	0.31	0.77	9.76	13.25	2.98	2.04	0.66
Sig. level	**	**	*	**	**	**	**	**	**	**	**

DAP: days after planting; ** = Significant at 1% level of probability V1=Beet Palong and V2= Red Ball; T0= Control, T1=Cow dung, T2=Mustard oil cake, T3= Vermicompost, T4=Cow dung +mustard oil cake, T5= Cow dung + vermicompost, T6=Mustard oil cake + vermicompost, T7=Cow dung + mustard oil cake+ vermicompost; LA: leaf area, RL: root length, RD: root diameter, RFW: root fresh weight, DM: dry matter; crack%, rotten% and DM% data were taken on 100 DAP

highest dry matter content percentage (33.26%) was found in T5 treatment preceded by T2 (30.24%) (Table 4). The Red Ball variety with T0 treatment (V2T0) produced the minimum dry matter content percentage (16.08 %) followed by V1T2 (18.15%) whereas the Beet Palong variety with T5 treatment (V1T5) produced the maximum root dry matter content percentage (34.19%) preceded by V2T5 (32.32%) (Table 4). In comparison to the solid properties, the hybrid variety (Red ball) contains more watery contents than V1 (Beet Palong). For this reason, in Red Ball variety (V2) root weight was higher but solid properties was lower than Beet Palong (V1). Zdravkovic et al. (1990) also found similar results on organic fertilizer effects of quality of beet.

4 Conclusion

The results indicated that Red Ball variety in combination with cowdung+ mustard oil cake + vermicompost application gave the highest yield but dry matter content was highest in Beet Palong with combined treatment of cow dung + vermicompost. In general, combination application of different organic manures gave better yield and quality (uniform size, shape, color development, unblemished skin, rigidity of root, less hairy) root production than single application of any manure studied . Therefore, it can be concluded that Red Ball variety along with the combined application of cowdung + mustard oil cake + vermicompost along with recommended chemical fertilizer may be recommended for better growth, yield and quality of beetroot.

Acknowledgments

The authors are thankful to the Ministry of Science and Technology, Peoples Republic of Bangladesh for Providing National Science and Technology (NST) Scholarship.

Conflict of Interest

The authors declare that there is no conflict of interests regarding the publication of this paper.

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The Official Journal of the **Farm to Fork Foundation**
ISSN: 2518–2021 (print)
ISSN: 2415–4474 (electronic)
http://www.f2ffoundation.org/faa