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Alok Tiwari
Department of Horticulture, K.A.P.G. College, Prayagraj, Prof. Rajendra Singh (Rajju Bhaiya) University Prayagraj, Uttar Pradesh, India

Dr. Rajendra Prasad
Department of Horticulture, K.A.P.G. College, Prayagraj, Prof. Rajendra Singh (Rajju Bhaiya) University Prayagraj, Uttar Pradesh, India

Corresponding Author:
Alok Tiwari
Department of Horticulture, K.A.P.G. College, Prayagraj, Prof. Rajendra Singh (Rajju Bhaiya) University Prayagraj, Uttar Pradesh, India

Studies on effect of organic manures on growth yield and quality of beetroot (*Beta vulgaris* L.) cv. 'Lali

Alok Tiwari and Dr. Rajendra Prasad

Abstract
The present field experiment entitled "Effect of organic manures on growth yield and quality of Beetroot (*Beta vulgaris* L.) cv. Lali" was carried out during Rabi season of the year 2021-2022 at K.A.P.G. College, Prayagraj U.P. The result and conclusion of the about experiment are briefly explain here. The experiment was laid out in a randomized block design with 3 replication 11 treatments *viz*., T_1: FYM (100%), T_2: Poultry manure (100%), T_3: Green manure (100%), T_4: Neem cake (100%), T_5: Vermicompost (100%), T6:FYM (50%) + Poultry manure (50%), T_7: FYM (50%) + Green manure (50%) T_8: FYM (50%) + Neemcake (50%), T_9: FYM (50%) + Vermicompost (50%), T10: RDF, T_{11}: Control. The data were recorded on days required for germination of seedlings, plant height (cm), no of leaves per plant, crop growth rate (g m^{-2} d^{-1}), root length (cm), root diameter (cm), root yield per plot (kg $plot^{-1}$), root yield per ha (t ha^{-1}), harvest index (%). The early germination was recorded in T_2: poultry manure (100%) and it was at par with T_9: FYM (50%) + vermicompost (50%) and vermicompost (100%). The highest plant height and no. of leaves was recorded with T_2: poultry manure (100%) which was at par with T_6: FYM (50%) + poultry manure (50%). The highest crop growth rate, was recorded with poultry manure (100%). Among the yield parameters the root length and harvest index were maximum with T_6: FYM (50%) + poultry manure (50%) whereas root diameter was maximum with poultry manure (100%). The highest root yield was recorded with T_2: poultry manure (100%) which was at par with T_5: vermicompost (100%). The highest N uptake in plant was recorded with FYM (50%) + vermicompost (50%). The highest P and K uptake in plant was recorded with poultry manure (100%). Whereas FYM (50%) in combination with neemcake (50%) recorded maximum values for betanin content reducing, non- reducing and total sugars. The highest TSS of root was with neem cake (100%). However, the higher net returns and BCR were obtained with poultry manure (100%).
The results of the present investigation revealed that among different organic manures tried, application of T_2: Poultry manure (100%) is reported higher plant growth, root yield, NPK uptake, maximum net returns whereas application of T8: FYM (50%) + neemcake (50%) recorded better quality of beetroot.

Keywords: Beetroot, growth, yield, organic manures, CGR

Introduction
Beetroot is one of the major root vegetables grown throughout the world and is mainly consumed as a salad vegetable, though the leaves can also be eaten as spinach. Beetroot belongs to Beta L. genus, the Betaoidide subfamily of the goosefoot family (Amaranthaceae). Beetroot is a vegetable consumed worldwide due to its high content of biologically active substance, such as minerals and vitamins present in the tuberous root. Beetroot (*Beta vulgaris* L.), is an alkaline food with pH in range 7.5 to 8.0 it is the taproot (bulb) portion of the beetroot plant. In India major beet root crop growing states are Haryana, Uttar Pradesh, Himachal Pradesh, West Bengal and Maharashtra. Nationally beetroot is grown in an area of 0.079 lakh hectares with an annual production of 1.51 lakh million tonnes and share of UP is 0.08 lakh hectares with an annual production of 0.15 lakh million tonnes (HAPIS portal database 2019-2020). It is grown in temperate countries and bienniel plant. The beetroot and its juice are freely consumed for its great taste. Nutritional benefit and flavour content. It contains vitamins, A, B, and C. it is also a good source of calcium, magnesium, copper, phosphorous, sodium, and iron. its powder is used as a natural red food colorant which used to applied in dry mixes (soup, Indian curry mixes) sweets, jams, jelly etc. The bright red colour of beetroot is due to the red pigments known as a betalains.

Color of root is due to presence of
Red violet pigment – Beta- cyanins
A-Yellow pigment – Beta- xanthins

Beetroot is also called as garden beet or table beet, is one of the major root vegetable belongs to the family Chenopodiaceae along with spinach, palak, swiss chard, parsley, celery and it has chromosome number of 2n = 18 and is native to Western Europe. It is a rich source of protein, carbohydrate, calcium, phosphorous and vitamin C, hence it is an ideal vegetable for health conscious people (Deuter and Grundy, 2004) [5]. Beetroot is an excellent source of fiber, folate, manganese, potassium, iron and vitamin-C. The carbohydrates in beetroot are mainly simple sugars like glucose and fructose. Beets are high in fiber content however, it have FODMAPs (Fermentable Oligosaccharides Disaccharides Monosaccharides and Polyols) which may cause digestive problems in some people. It was used as medicine in Indian ancient time specially to enhance the activity of steroid hormone. Beetroot is a rich source of folic acid which was useful for pregnant women. It makes an excellent dietary supplement being not only rich in minerals, nutrients and vitamins but also unique phyto constituents, which have several medicinal properties. Several parts of this plant are used in medicinal system such as anti-oxidant, anti-depressant, anti-microbial, antifungal, anti-inflammatory, diuretic, expectorant and carminative. It is one of the natural foods which boosts the energy in athletes as it has one of the highest nitrates and sugar containing plant (Yadav *et al*., 2016) [19].

Soils supplied with nitrogen (N), phosphorous (P), and potassium (K) through the addition of organic and inorganic fertilizers influence the growth and harvest of the beetroot crop. The climatic requirements of crop *viz*., temperature, humidity, light, CO2 concentration and radiation should be in permissible range of the crop to obtain higher yield. The environmental factors can be controlled under protective cultivation and optimization of growing conditions enhances the production multifold, compared to open field conditions. In general, the main purpose of growing high value crops in protective environment is to obtain blemish free high quality produce. Beetroot responds well to increasing nitrogen, phosphorus and potassium levels, as these nutrients are essential to produce higher yield along with good quality. Nitrogen is the most important element of those supplied to sugar beet in fertilization. Nitrogen fertilizer has a pronounced effect on the growth and physiological and chemical characteristics of the crop. So that, nitrogen could caused desirable effect on sugar beet growth and yield characters. Decidedly, potassium is major plant nutrient in needed for sugar beet, which plays an important role in plant nutrition association with the quality of the production. Planting dates of sugar beet is considered most important factors that influence its growth and productivity. Also, planting date is the great important factor in organizing and securing work schedule of beet factories. Thus, planting sugar beet on suitable date according to environmental conditions of region is best method to maximize sugar beet yield and quality. It is necessary to optimize fertilizer rates for beetroot in varying environments. Organic farming aims in creating a healthy soil, helps in proper energy flows in soil, crop, water, environment while the plant systems keeps biological life cycle alive and helps in sustaining considerable levels in yield (Lampkin, 1990) [18]. For a sustainable crop production system, chemical nutrients removed by the crop must be replenished and physical conditions of these oil is to be maintained. Organic nutrient management provides excellent opportunities to overcome all the imbalances besides sustaining soil health and enhancing crop production. This optimize the benefit from all possible sources of plant nutrients in an organic manner (Greenland, 1975) [17]. Organic manuring aims in creating a healthy soil, helps in proper energy flows in soil, crop, water, environment while the plant system keeps biological life cycle alive and helps in sustaining considerable levels in yield (Lampkin,1990) [18]. Many studies have also reported positive effect of organic manures and/or organic fertilizers on the yield of vegetables such as carrot, radish, cabbage, and tomato Adopting appropriate fertilizer management strategies results in significant economic benefits to producers Agriculture, as an economic sector, should operate profitably while adhering to the fundamental principles of sustainable agricultural production, with minimal environmental effect and judicious application of fertilizers. In addition to the nutrient requirements, the genetic characteristics of a variety determine the amount of yield. The variety should be selected as per the growing environment and season. Further, there has been limited research carried out on the available beetroot varieties as per the growing environment. To achieve more returns per unit area, the selection of a suitable variety as well as the good fertilization strategy combining the use of organic and inorganic nutrients is necessary.

Material and Methods

A field experiment was conducted during *Rabi* 2021 to study the **"**Effect of organic manures on growth yield and quality of beetroot (*Beta vulgaris* L.) cv. Lali". The details of material and methods used and the experimental technique adopted during the course of investigation are described below. The experiment was laid out at the "college farm" K.A.P.G. College Prayagraj, Prof. Rajendra Singh (Rajju Bhaiya) University Prayagraj Uttar Pradesh. This region falls under IV Agro climatic zone of Uttar Pradesh state. The experiment was laid out in a randomized block design with 3 replication 11 treatments *viz*., T_1: FYM (100%), T_2: Poultry manure (100%), T_3: Green manure (100%), T_4: Neem cake (100%), T5: Vermicompost (100%), T_6: FYM (50%) + Poultry manure (50%), T_7: FYM (50%) + Green manure (50%) T_8: FYM (50%) + Neem cake (50%), T_9: FYM (50%) + Vermicompost (50%), T_{10}: RDF, T_{11}: Control. Total no. of plots: 33, Row to Row distance: 50cm, Plant to plant distance: 10cm, Net plot size: 5m x 3m =15m^2, Observation intervals: 25 days.

The experimental site located at college farm, College of K.A.P.G College, Prayagraj comes under sub-tropical zone and is situated at altitude of 25.45$^{0'}$ N and longitude of 81.84$^{0'}$ E in the southern part of the Uttar Pradesh at the elevation of 98 meters (322ft) and stand at the confluence of two, the gangas and Yamuna. The altitude of the place is 90m (295ft) above mean sea level. The mean annual precipitation on the basis of last ten years is 767 mm (30.21 inches) which is received almost from South-West Monsoon during July to September. The average minimum and maximum temperatures recorded during crop growth period were 12.68°C and 32.67 °C respectively. The average humidity ranges from 33.38% to 81.93%. Prayagraj (dist) thus has hot dry summer and moderate cold winter.

Seeds of beetroot (Variety 'LALI') were collected from KVK, Prayagraj, Uttar Pradesh. Soil samples were taken from the top (0 to 30 cm) layer before the commencement of the experiment and analyzed for its some physical and chemical

properties. Three composite soil samples were then prepared by mixing the collected subsamples before sowing. Each composite sample represented each block of the experimental design. Total N was determined by Macro–Kjeldahl method [22], available P by Olsen's bio-carbonate method, and available K by ammonium acetate method [23]. Organic matter was determined by Walkely and Black method [24], pH by Beckman Glass Electrode PH.

The plant height was measured from ground level to the tip of longest leaf at 25, 50 days after sowing and at harvest from five tagged plants and their mean was worked out. Total number of leaves counted for five randomly selected plants and counted at 25, 50 days after sowing and at harvest and their mean was worked out.

The length of root from five randomly selected plants in each plot was recorded by means of scale from apex to the base of the root and the average is expressed in centimeters. The root diameter was recorded with the help of vernier calipers and the average was expressed in cm. Root and shoot ratio was calculated for five randomly selected plants from each plot by measuring the root and shoot dry weight with the help of electronic balance. The total soluble solids of all the roots of five randomly selected plants from each plot. Total soluble solids content was determined with the help of 'Zeissh and Refractometer' and values obtained were corrected at 20 ºC (AOAC, 1960) at time of harvesting of roots. Two to three drops of juice were placed on the prism of refractometer and reading was observed on scale and averages were expressed in ºBrix. Reducing sugars were determined by the method of Lane and Eyon (AOAC, 1965). Lane- Eynon titration is one of the method of the determining the concentration of reducing sugar in sample a using titration. Lane- Eynon method is based on the principle of reduction of Fehling's solution by reducing sugar. Sample of 10 g was blended with 100 ml distilled water and neutralized with 0.1 Na OH. 2 ml of 45% of lead acetate solution was added to the flask shaken and kept aside for 10 min. Then add 2 ml of 22% of potassium oxalate solution was added to this solution to precipitate the lead and the volume was made up to 250 ml using distilled water and the contents were then filtered through Whatman No. 1 filter paper. Reducing sugars in the lead-free solution were then estimated by taking this solution in a burette and titrating against 10 ml of standard Fehling's solution mix of A and B (1:1), using methylene blue as an indicator and formation of brick red precipitate as an end point. The titration was carried out by keeping the Fehling"s solution boiling on the heating mantle. The results were expressed as percent reducing sugar. Total sugars were determined by the method described by Lane and Eyon (AOAC, 1965). A quantity 50 ml of lead free filtrate solution was taken in a 100 ml volumetric flask and to 5 ml of concentrated HCl was added, mixed well and then kept for 24 hours at ambient temperature. Add 5 g of citric acid and 50 ml of water boil gently for 10 minutes to complete the inversion of sucrose and allow to cool. Transfer the inverted solution to a 250ml volumetric flask and neutralize with 1 n NaOH using phenolphthalein as indicator and make up the volume to 250 ml with water. Place this solution into the burette and use for filtration. 10 ml of mixed Fehling's solution (5 ml each of Fehling A and B) with 25 ml of distilled water was taken in to a 150ml conical flask. The flask containing mixed Fehlings solution was heated on a hot plate and add the sample solution, drop wise from the burette till finest Blue color remained. 2-3 drops of methylene blue indicator were added and completed the titration till the color changed to brick red. At the end point, the readings were noted and calculated the total reducing sugars. Betanine content of roots was determined at harvest with the procedure suggested by Nilsson (1970) [9] and was expressed in mg $100g^{-1}$ sample.

For data collection, a set of 5 random plants from each plot excluding the border plants was taken during the crop growing period and after harvesting. The observations recorded during the crop growing period were plant height (cm), number of leaves per plant, leaf length (cm), and canopy diameter (cm). Similarly, after harvest, the measured parameters were beetroot diameter (mm), beetroot length (cm), economic yield (t ha^{-1}), biological yield (t ha^{-1}), root and leaf dry matter %, and physiological weight loss (%).

Results and Discussion

Growth and yield parameters

Number of days taken for germination, plant height, number of leaves, leaf length, leaf width and average leaf area are important growth characters. The observations were taken 25 days interval commencing from 25 days after sowing while the last observation was recorded after 75 days.

Plant height (cm)

Plant height is an important character of the vegetative phase and indirectly influences the yield components. The plant height was significantly increased by the application of poultry manure (100%) followed by FYM (50%) + poultry manure (50%) at different stages of plant growth. The data pertaining to plant height were recorded at 25, 50 and 75 days after sowing which were presented in Table1.

AT 25 DAYS The results showed that there was a significant difference among the treatments in plant height at 25 days after sowing (DAS). At 25 DAS the highest plant height (20.18 cm) was recorded in T_2 with poultry manure (100%) and it was at par with T_6 (19.39 cm) with FYM (50%) + poultry manure (50%) and T_9 (17.36) with FYM (50%) + vermicompost (50%) but significantly superior to all other treatments. RDF (T_{10}) recorded a plant height of 15.06 cm and the lowest was recorded in T_{11} (11.35 cm) under control condition.

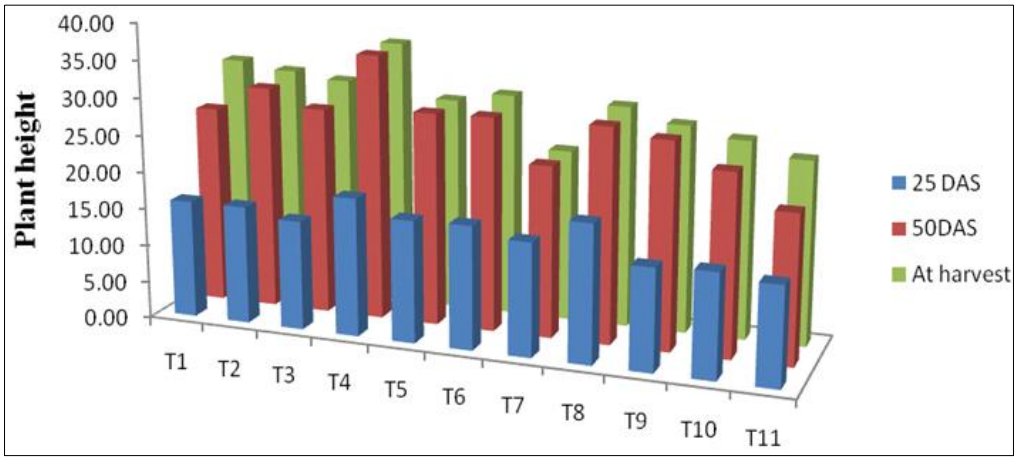
AT 50 DAYS The results indicated that there was a significant difference among the treatments with respect to plant height at 50 DAS (Days after sowing). At 50 DAS the highest plant height (36.10 cm) was recorded in T_2 with poultry manure (100%) which was significantly superior to all other treatments. RDF (T_{10}) recorded a plant height of 25.37 cm and the lowest was recorded in T_{11} (25.57).

AT 75 DAS At harvest the highest plant height 36.52 cm was recorded in T_2 with poultry manure (100%) which was significantly superior to all other treatments. RDF (T_{10}) recorded a plant height of 27.09 cm and the lowest was recorded in T_{11} (25.57 cm). The plant height of beet root was significantly affected in all stages of crop growth with the application of organic manures. Among different organic manures soil application of poultry manure (100%) improved plant height at all the growth stages. Nitrogen being a major element has a profound effect on plant growth and development and as a constituent of proteins and also its effect on production of plant hormones in plants. The increased plant height with the application of poultry manure (100%) may be attributed to their higher N content of (1.18%). The positive effect of organic manure on plant height could be due to the contribution made by manure to fertility status of the soils as the soils were low in organic carbon content. Manure when decomposed increases both macro and micro nutrients as well as enhances the physico-chemical properties of the soil. This could have led to its high vegetative growth. The results are in support with findings of Tiamiyu *et al.*, 2012 in okra. Though the green manure

contains high 'N' content (1.80%) than applied poultry manure (1.18%) it could not record maximum plant height over poultry manure (100%) may be because of slow release of nutrient availability. Okokoh and Bisong (2011) [10] reported similarly that application of 10 to 15t/ha of poultry manure resulted in increased height of amaranthus plants.

Table 1: Effect of different organic manures on plant height (cm) of Beetroot at different stages of crop growth

Treatments	25 DAS	50 DAS	At harvest
T_1: FYM (100%)	16.08	26.96	32.10
T_2: Poultry Manure (100%)	20.18	32.10	36.52
T_3: Green Manure (100%)	16.80	28.90	28.97
T_4: Neemcake (100%)	15.30	28.12	30.54
T_5: Vermicompost (100%)	16.10	30.52	31.32
T_6: FYM (50%) + Poultry Manure (50%)	19.39	29.10	29.97
T_7: FYM (50%) + Green Manure (50%)	14.10	27.96	28.10
T_8: FYM (50%) + Neemcake (50%)	15.85	23.33	23.37
T_9: FYM (50%) + Vermicompost (50%)	17.36	28.96	30.24
T_{10}: RDF @ 75 kg N; 100 kg P_2O_5; 75 kg K_2O	15.06	25.37	27.09
T11: Control	11.35	20.10	25.57
S. Ed. (±)	1.055	0.822	1.744
C. D. (P = 0.05)	2.178	1.697	3.600



Graph 1: Effect of different organic manures on plant height (cm) of Beetroot at different stages of crop growth

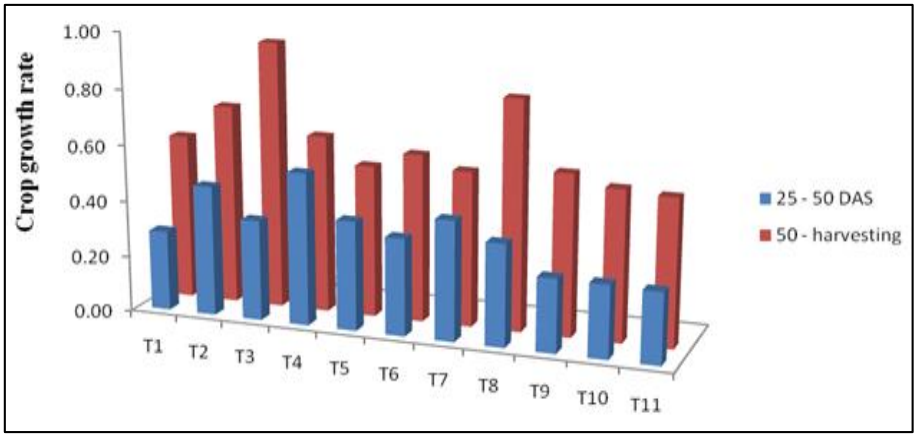
Crop growth rate (CGR) ($gm^{-2}d^{-1}$)

Crop growth rate is the gain in dry matter production on a unit of land in a unit of tune. The crop growth rate recorded during the growth periods of 25-50 DAS and 50 DAS – harvesting were statistically analyzed and presented in table.2.The crop growth rate was low during the early stage (25-50 DAS) of the plant growth but it increased gradually with the advancement of age of the plant. The highest crop growth rate during 25-50 DAS was recorded (0.62) in the treatment (T2) poultry manure (100%) closely followed by T_2 (0.55) with vermicompost (100%) and T8 (0.50) with (FYM (50%) + neemcake (50%), which were statistically *at par*. During advanced stage of crop growth at 50 DAS- harvesting, the maximum crop growth rate (0.98) was recorded with T4 which was at par with T_6 FYM (50%) + poultry manure (50%). In both the stages, crop growth rate enhanced with the increase in the quantity of different kinds of manures. This might be due to the availability of the required quantity of nutrients with increase in the quantity of different kinds of manures. However, the minimum crop growth rate (0.32 and 0.59) was, recorded in control at the said stages of crop growth i.e. 25-50 DAS and 50- harvest, respectively. Increased crop growth rate during growth phase of plant is a usual phenomenon for sufficient vegetative growth necessary for successful transformation for optimum yield. The influence of organic manures on leaf number LAI, DMP, was superior over inorganic fertilizer application (Subbarao and Ravi shankar, 2001) [19]. Moreover, the results are in agreement with findings of Sharu (2002) [20] in chilli.

Table 2: Effect of different organic manures on crop growth rate (gm-2 d-1) of Beet root at different stages of crop growth

Treatments	25-50 DAS	50- At harvest DAS
T_1: FYM (100%)	0.35	0.66
T_2: Poultry Manure (100%)	0.60	0.66
T_3: Green Manure (100%)	0.44	0.59
T_4: Neemcake (100%)	0.41	0.98
T_5: Vermicompost (100%)	0.55	0.78
T_6: FYM (50%) + Poultry Manure (50%)	0.42	0.87
T_7: FYM (50%) + Green Manure (50%)	0.33	0.63
T_8: FYM (50%) + Neemcake (50%)	0.50	0.61
T_9: FYM (50%) + Vermicompost (50%)	0.40	0.65

T_{10}: RDF @ 75 kg N; 100 kg P_2O_5; 75 kg K_2O	0.32	0.61
T_{11}: Control	0.31	0.59
S. Ed. (±)	0.049	0.076
C. D. (P = 0.05)	0.101	0.157



Graph 2: Effect of different organic manures on crop growth rate (gm^{-2} d^{-1}) of Beetroot at different stages of crop growth

Root length (cm)

The root length was significantly affected by the application of FYM, vermicompost, neemcake, poultry manure and green manure at different stages of plant growth. The results are presented in Table 3. The highest root length of 13.40 cm was recorded in T_6 with FYM (50%) + poultry Manure (50%) was at par with T_1 (12.88 cm) with FYM (100%), T_5 vermicompost (100%), T_4, T_2 and T_7. RDF recorded a root length of 9.87 cm at harvest. The lowest root length was recorded in T_{11} (9.55 cm) in control, which was on par with T_{10} (9.87), T_3 (10.72), T_9 (10.92) and T_8 (11.12) treatments. Among all the treatments, the root length of beet root was higher with FYM (50%) in combination with Poultry Manure (50%).This may be due to the higher content of phosphorus (1.70%) in poultry manure. Phosphorus stimulates root growth, greater absorption and translocation of nutrients. It is also a part of various enzymes, co-enzymes and energy rich ATP resulting in increased root growth (Mangal, 1985) [21]. Phosphorus also brings about improvement in the physic-chemical characteristics of the soil (Schmidt, 1954).With the application of organic manures to the soil, physical condition of the soil will be improved by the better aggregation of soil particles (Samanda Singh *et al*., 1988). These aggregates effects the soil fertility and often determine the retention and movement of water, diffusion of gases, growth and development of roots in the soil which contributed to the growth of the plant (Ghildyal and Gupta, 1991 and Arulmozhian, 1996). In addition to this, application of organics helps the soil micro-organisms to produce polysaccharides and thus leads to better soil structure useful for root growth (Balasubramaniam, 1972) [22].

Root diameter (cm)

The root diameter was significantly affected by the application of poultry Manure (100%) and green manure (100%) The results are presented in Table3. The highest root diameter (6.96) was recorded in T_2 with Poultry Manure (100%) which was at par T_3 (6.60 cm) with green manure (100%), T_4 (6.47), T_1 (6.12), T_5 (5.98) and T_9 (6.02) significantly superior to all other treatments. RDF recorded a root diameter of 5.03 with RDF @ 75 kg N; 100 kg P2O5; 75 kg K_2O. The lowest was recorded in T_{11} (4.74) in control (T_{11}). The higher root diameter recorded may be attributed to enhanced cell division and quick cell multiplication. Okokoh and Bisong (2011) [10] reported poultry manure application had significant influence on stem diameter and the result showed that the application of 10, 15 and 20 t/ha of poultry manure resulted in sufficiently larger stem diameter than other treatments.

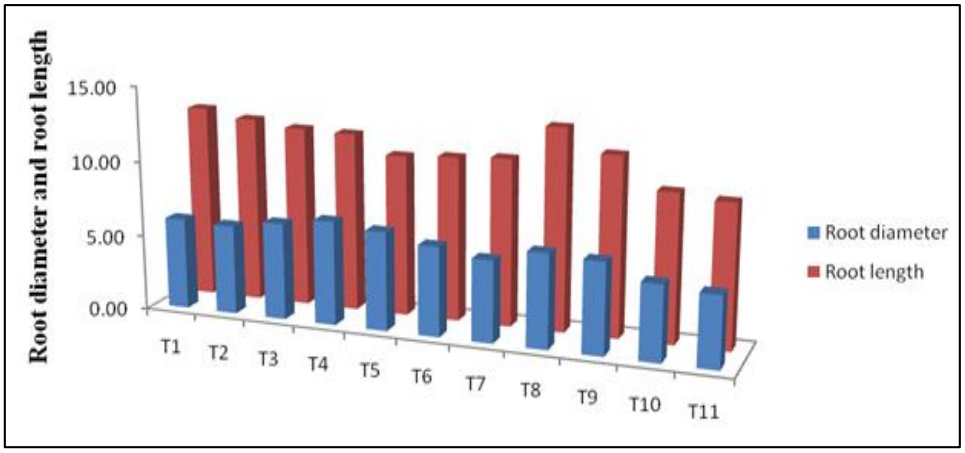
Harvest Index

The Harvest index was significantly affected by the application of FYM (50%) + Poultry Manure (50%) at different stages of plant growth. The Results are presented in Table3. The highest harvest index (0.91) was recorded in T_6 with FYM (50%) + Poultry Manure (50%) was at par T_5 (0.86) with vermicompost (100%) and T_2 with poultry manure (100%) which were significantly superior to all other treatments. RDF recorded harvest index 0.78 and T_{11} with control resulted lowest harvest index i.e. 0.76.

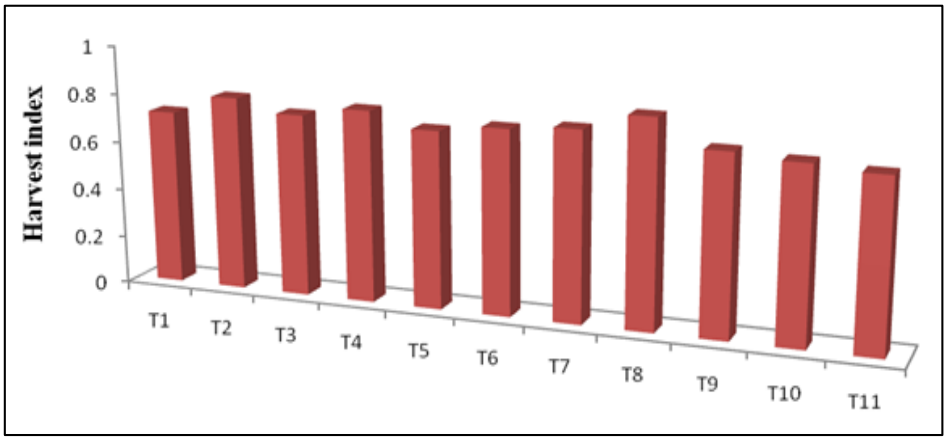
Table 3: Effect of different organic manures on root length (cm), root diameter (cm), harvest index of Beet root at harvest of crop growth

Treatments	Root length	Root diameter	Harvest Index
T_1: FYM (100%)	12.88	6.12	0.76
T_2: Poultry Manure (100%)	11.92	6.96	0.84
T_3: Green Manure (100%)	10.72	6.60	0.78
T_4: Neemcake (100%)	12.01	6.47	0.81
T_5: Vermicompost (100%)	12.39	5.98	0.86
T_6: FYM (50%) + Poultry Manure (50%)	13.40	6.29	0.91
T_7: FYM (50%) + Green Manure (50%)	11.92	6.12	0.79
T_8: FYM (50%) + Neemcake (50%)	11.12	5.47	0.83
T_9: FYM (50%) + Vermicompost (50%)	10.92	6.02	0.81
T_{10}: RDF @ 75 kg N; 100 kg P2O5; 75 kg K_2O	9.87	5.08	0.76
T_{11}: Control	9.56	4.80	0.76

S. Ed. (±)	0.920	0.600	0.033
C. D. (P = 0.05)	1.899	1.238	0.068



Graph 3: Effect of different organic manures on root length (cm) and root diameter (cm) of Beetroot at harvest of crop growth



Graph 4: Effect of different organic manures on harvest index of Beet root at harvest of crop growth

Root yield (Kg/plot)

The total root yield (kg/plot) was significantly affected by the application of vermicompost, poultry manure and FYM (50%) + poultry manure (50%) at Different stages of plant growth. The results are presented in Table 05. The highest root yield (7.62) was recorded in T_2 with the application of poultry manure (100%) which was at a par with T_5 (7.13) with vermicompost (100%) but significantly superior to all other treatments. RDF recorded an yield of 4.02 Kg/plot and the lowest was recorded in T_{11} (2.02).

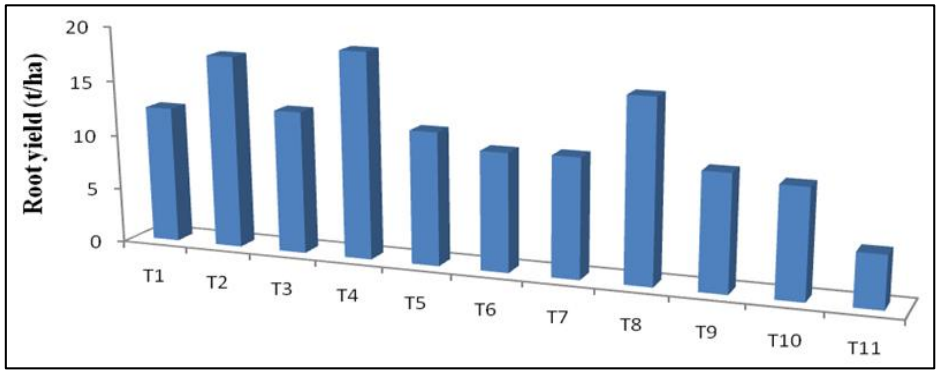
Root yield (tha^{-1})

The total root yield was significantly affected by the application of vermicompost, poultry manure and FYM (50%) + poultry manure) at different Stages of plant growth. The results are presented in Table 05. The highest root yield (18.85) was recorded in T_2 with the application of poultry manure (100%) followed by T_5 (17.65) with vermicompost (100%) Highest yield with sole application of poultry manure (100%) may be positive effect of all yield components *viz*., root length, root diameter, fresh and dry weight of root in this treatment. The result can be attributed to slow release of nutrients from organic manures and their better utilization by beetroot through out the growing period which might have resulted in higher root yields of beet root. The increased root yield with the application of poultry manure may be attributed to their higher N content of 1.18%. Okokoh and Bisong (2011) [10] reported similar finding that higher yield of fresh leaf and fresh stem in Amaranth were obtained when 12 and 15 t/ha of poultry manure were used. It may be due to the fact that nitrogen is the major constituent of chlorophyll, proteins and amino acids, the synthesis of which is accelerated by the increased supply of nitrogen in soil (Arnon, 1943; Gupta and Rao, 1979; and Verma *et al*., 1974) [24, 23, 25].Which were at par but significantly superior to all other treatments. RDF recorded an yield of 9.96 and the lowest was recorded in T_{11} (4.88) with control (T_{11}).

Increased yield due to better availability of nutrients and the balanced C/N ratio might have increased the synthesis of carbohydrates which ultimately promoted greater yield (Jose *et al*., 1998) [26]. It can also be attributed to better carbon assimilation and better accumulation of carbohydrates in the plants. Similar findings with the application of organics were observed by Kamala Singh (2000) [27] in the tuber yields of potato. The translocation of photo-synthates from source (leaves) to sink (Root) might have contributed to increased root length and diameter resulting in root yield. These findings are in conformity to the observation made by Devlin (1973) [28].

Table 5: Effect of different organic manures on root yield (kg plot -1), root yield (t ha-1) of Beet root at harvest

Treatments	Root Yield	Root Yield	
T_1: FYM (100%)		5.11	12.49
T_2: PoultryManure (100%)		7.62	18.85
T_3: GreenManure (100%)		5.21	12.15
T_4: Neemcake (100%)		5.21	13.04
T_5: Vermicompost (100%)		7.13	17.65
T_6: FYM (50%) + Poultry Manure (50%)		6.66	16.57
T_7: FYM (50%) + Green Manure (50%)		4.42	10.60
T_8: FYM (50%) + Neemcake (50%)		10.92	10.92
T_9: FYM (50%) + Vermicompost (50%)		10.81	10.81
T_{10}: RDF @ 75 kg N; 100 kg P2O5; 75 kg K_2O		4.02	9.96
T_{11}: Control		2.02	4.88
S. Ed. (±)		0.600	1.245
C. D. (P = 0.05)		1.238	2.571



Graph 6: Effect of different organic manures on root yield (tha^{-1}) of Beetroot at Harvest.

Quality parameters

Data on various quality parameters of beetroot crop as influenced by the different organic manures and their combinations are presented in Tables 06 and 07.

Betanine content ($mg100g^{-1}$)

The Betanine content of beetroot roots was significantly affected by the Different treatments applied to the experiment. The results are presented in Table 06.The highest betanine (2.02) was recorded in T_8 with the application of FYM (50%) + Neemcake (50%) which was on par with T_4 (1.96) with Neemcake (100%), T_9 with FYM (50%) + vermicompost (50%) and T_6 with FYM (50%) + poultry manure (50%) which were significantly superior to all other treatments. The lowest betanine content (4.37) was recorded in control RDF @ 75 kg N; 100 kg P2O5; 75 kg K_2O recorded betanine content of 1.67. Betanine content of roots was determined at harvest with the procedure suggested by Singh *et al*. (2017) and was expressed in (mg 100 g^{-1}) sample.

Total soluble solids (°Brix)

The TSS of beetroot roots was significantly affected by the application of Neemcake (100%).The results are presented in Table 06. The highest TSS (8.71) was recorded in T_4 with the application of neemcake (100%) followed by T_8 (8.36) with FYM (50%) + Neem cake (50%) which were significantly superior to all other treatments. The lowest TSS content (6.31) was recorded in Control (T_{11}).

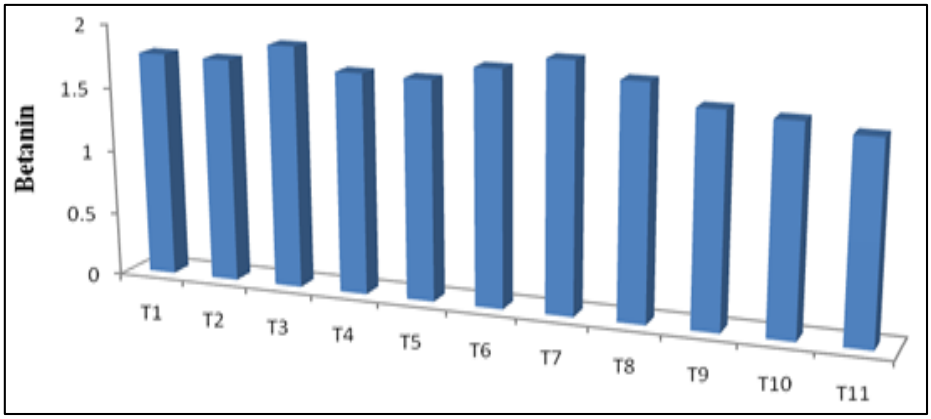
Ascorbic acid ($mg100^{-1}$g fresh weight)

The Ascorbic acid of beet root roots was significantly affected by the application of vermicompost (100%) and FYM (50%) + Poultry Manure (50%). The results are presented in Table 06. The highest ascorbic acid (3.38) was recorded in T5 with the application of Vermicompost (100%) which was at par (3.35) of T6 with FYM (50%) + Poultry Manure (50%) and were significantly superior to all other treatments. The lowest ascorbic acid content (2.58) was recorded in Control (T11). Ascorbic acid content of some Indian spices was determined by 2, 6- dichlorophenol indophenol (DCPIP) titration method described by (Rao and Deshpande, 2006).

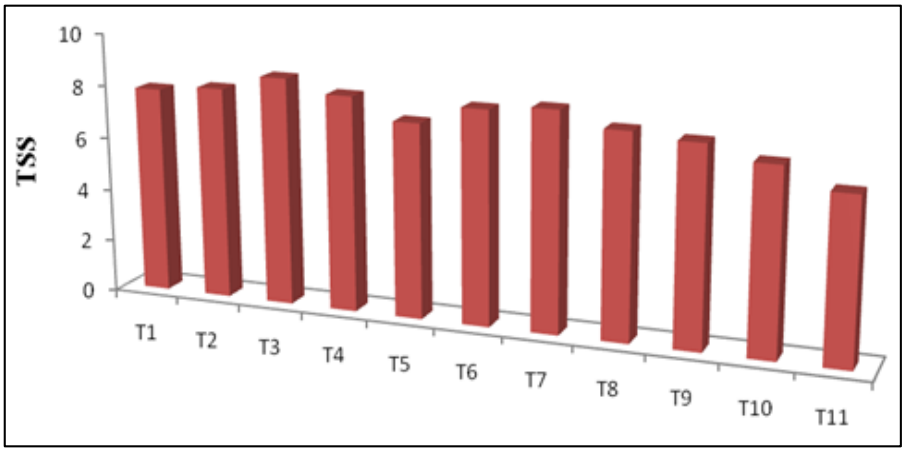
Table 6: Effect of different organic manures on betanine content (mg $100g^{-1}$), TSS (%) and ascorbic acid (mg $100g^{-1}$) of Beetroot at harvest

Treatments	Betanine	TSS	Ascorbic acid
T_1: FYM (100%)	1.81	7.89	2.92
T_2: Poultry Manure (100%)	1.77	8.22	2.92
T_3: Green Manure (100%)	1.76	7.42	2.95
T_4: Neemcake (100%)	1.96	8.70	2.95
T_5: Vermicompost (100%)	1.80	8.10	3.38
T_6: FYM (50%) + Poultry Manure (50%)	1.88	7.79	3.35
T_7: FYM (50%) + Green Manure (50%)	1.70	7.59	2.86
T_8: FYM (50%) + Neemcake (50%)	2.02	8.36	2.81
T_9: FYM (50%) + Vermicompost (50%)	1.98	8.14	2.85

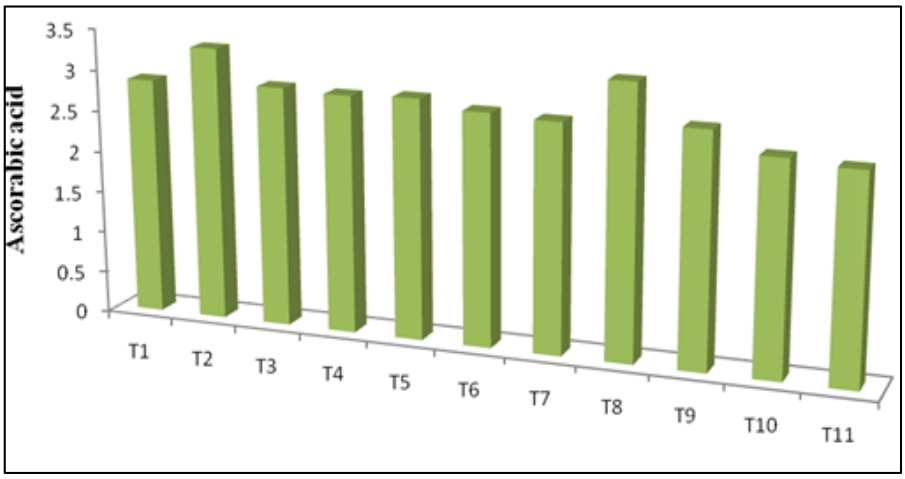
T_{10} : RDF @ 75 kg N; 100 kg P_2O_5; 75 kg K_2O	1.67	7.07	2.61
T_{11}: Control	1.62	6.31	2.58
S. Ed. (±)	0.076	0.600	0.09
C. D. (P = 0.05)	0.157	1.238	0.122



Graph 7: Effect of different organic manures on betanin content (mg $100g^{-1}$ of Beetroot at harvest



Graph 8: Effect of different organic manures on TSS (%) of Beetroot at harvest.



Graph 9: Effect of different organic manures on ascorbic acid (mg $100g^{-1}$) of Beetroot at harvest

Reducing sugars (%)

The reducing sugars content of beet root roots was significantly affected by the application of FYM (50%) + Neemcake (50%). The results are presented In Table 07. The highest reducing sugars content (5.22) was recorded in T8 with the application of FYM (50%) + Neem cake (50%) which was at par with T_9 (5.17) with FYM (50%) + Vermiompost (50%) and were significantly superior to all other treatments. The lowest reducing sugar content (4.65) was recorded in Control (T_{11}).

Non-reducing sugars (%)

The non-reducing sugars content of beetroot roots was significantly affected by the application of FYM,

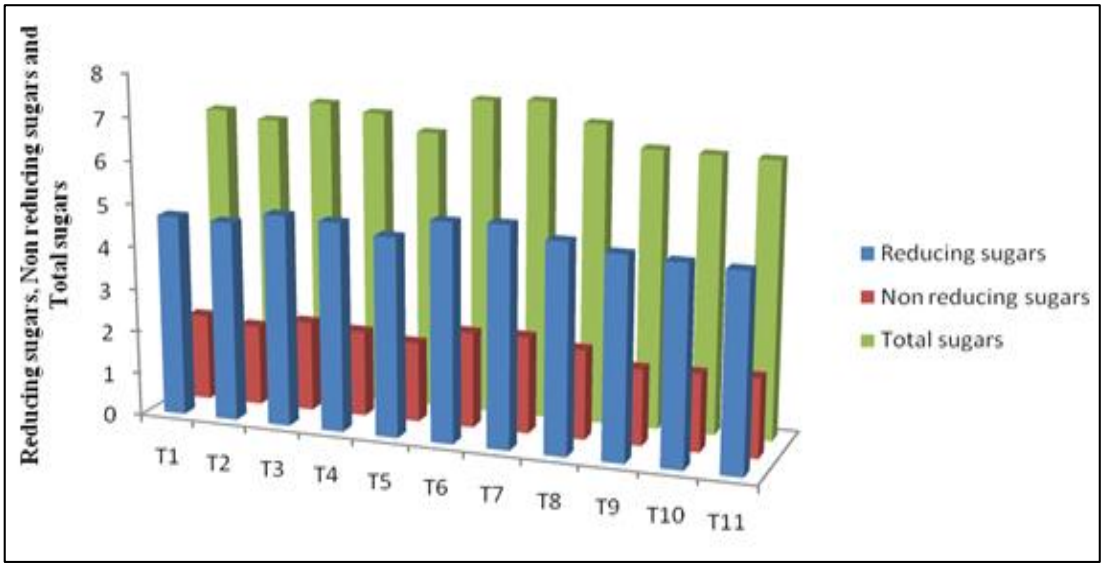
vermicompost, neemcake, poultry manure And green manure. The results are presented in Table 07. The highest non-reducing sugars content (2.33) was recorded in T_8 with the application of FYM (50%) + Neem cake (50%) which was at par with T_9 (2.31) with FYM (50%) + Vermicompost (50%) and were significantly superior to all other treatments. The lowest non-reducing sugar content (1.85) was recorded in FYM (50%) + green manure (50%) and was on par with T_{10} (1.88), T_7 (1.85), T_3 (1.93) and T5 (1.95).

Total sugars (%)

The total sugars content of beetroot roots was significantly affected by the application of FYM, vermicompost, neemcake, poultry manure and green manure. The results are presented in Table 07. The highest total sugar content (7.46) was recorded in T8 with the application of FYM (50%) + Neem cake (50%) which was at par with T_9 (7.39) with FYM (50%) + Vermicompost (50%) and were significantly superior to all other treatments. The lowest total sugars content (6.49) was recorded in control, which was on par with T_{10} (6.51), T_7 (6.54), T_3 (6.56) and T_5 (6.60). Improvement in quality of beetroot with the application of organic manures over inorganic fertilizers was observed. The betanin (2.02 mg $100g^{-1}$), TSS (8.70 °Brix), ascorbic acid (3.38) were higher with the application of FYM (50%) + poultry manure (50%) and sole application of neemcake (100%), vermicompost (100%) respectively, Reducing sugars (5.22%), non-reducing sugars (2.32%) and total sugars content (7.46%) were higher with the application of neem cake in combination with FYM. This may be because of better availability and uptake of nitrogen and other nutrients with the application of manures which might have lead to balanced C/N ratio and increased activity of plant metabolism. Similar findings were made by Singh *et al*. (1970) [33], Matura (1961) [34] and Emura and Hosoya (1979) [6] in carrot. Indumati (2000) [35] reported an increase in TSS content with the application of vermicompost besides other organic manures and with recommended dose of fertilizers in radish. Kolodzieg and Kostecka (1994) [29] also observed better root quality when carrot was grown with vermicompost than mineral fertilizers. Increase in carotene content with the increasing dosage of vermicompost was also reported by Ravindra babu (1999) [30]. Hallmann (2012) [31] showed an increase in the total content of sugars and in a higher sugar to organic acids ratio in organic tomatoes when compared to these produced conventionally. Rembiałkowska *et al*. (2012) [31] confirmed a higher content of total sugars in organic fruits and vegetables, including carrots, beets, potatoes, spinach, kale, cherries, black currants and apples, which contributes to an increase in the technological and sensory quality (taste) of organic products. Kale *et al*. (1992) [32] observed that vermicompost application enhanced the activity of beneficial microbes and colonization of mycorrhizal fungi which play an important role in mobilization of nutrients by plants.

Table 7: Effect of different organic manures on Sugars (%) and storage life (days) of Beetroot at harvest

Treatments	Reducing Sugars	Non-reducing Sugars	Total Sugars
T_1: FYM (100%)	4.75	2.06	6.75
T_2: Poultry Manure (100%)	4.92	2.05	6.92
T_3: Green Manure (100%)	4.70	1.93	6.55
T_4: Neemcake (100%)	4.98	2.15	7.07
T_5: Vermicompost (100%)	4.71	1.95	6.59
T_6: FYM (50%) + PoultryManure (50%)	4.93	2.14	7.02
T_7: FYM (50%) + GreenManure (50%)	4.76	1.85	6.53
T_8: FYM (50%) + Neemcake (50%)	5.22	2.33	6.46
T_9: FYM (50%) + Vermicompost (50%)	5.17	2.31	6.39
T_{10}: RDF @ 75 kg N; 100 kg P_2O_5; 75 kg K_2O	4.69	1.88	6.50
T_{11}: Control	4.65	1.91	6.49
S. Ed. (±)	0.083	0.101	0.121
C. D. (P = 0.05)	0.170	0.208	0.250



Graph 10: Effect of different organic manures on Sugars (%) of Beetroot at harvest.

Conclusion

In conclusion, all the growth and yield parameters of beet root were significantly influenced by the organic manures such as FYM, vermicompost, poultry manure, neem cake and green manure.

Among different organic manures, soil application of poultry manure (100%) improved plant height at all the growth stages each recorded the highest plant height of 20.18, 36.10, and 36.52 cm at 25, 50, and at harvest DAS respectively. Among different organic manures, the highest crop growth rate during 20- 50 DAS was recorded (0.60) in poultry manure (100%) which was at par (0.55) with vermicompost (100%) and (0.50) with FYM (50%) + neem cake (50%). At 50 DAS - harvest the maximum crop growth rate (0.98) was recorded with neem cake (100%) which was at par with FYM (50% + poultry manure (50%). At harvest highest root length of 13.40 cm respectively was recorded with the application of FYM (50%) + poultry manure (50%) was at par 12.87 with FYM (100%). Maximum root diameter (6.96 cm) was recorded with poultry manure (100%) at harvest which was at par with green manure (100%), neem cake (100%), FYM (100%), vermicompost (100%) and FYM (50%) + vermi comopost (50%). The highest total root yield (18.85 tha^{-1}) was recorded with the application of poultry manure (100%) which was at par with vermicompost (100%) (17.65 tha^{-1}). Higher harvest index (0.91) was recorded with the application of FYM (50%) + poultry manure (50%) was at par vermicompost (100%) and poultry manure (100%) (0.86). All the quality parameters were improved significantly with the organic manures over inorganic fertilizers. The highest betanine (2.02) content was recorded with FYM (50%) + neem cake (50%) which was at par (1.96) with neem cake (100%), FYM (50%) + vermicompost (50%) (1.90) and FYM (50%) + poultry manure (50%) (1.88). The highest total soluble solids (8.70) was recorded with neemcake (100%) which was at par with FYM (50%) + neemcake (50%) (8.36).

The highest ascorbic acid (3.38) was recorded with vermicompost (100%) which was at par with FYM (50%) + poultrymanure (50%) (3.35). The highest reducing sugars (5.22) was recorded with FYM (50%) + neemcake (50%) which was at par (5.17) with FYM (50%) + Vermicompost (50%). The highest non reducing sugars (2.33) was recorded with FYM (50%) + neemcake (50%) which was at par (2.31) with FYM (50%) + Vermicompost (50%). The highest total sugar content (7.46) was recorded with FYM (50%) + neem cake (50%) which was at par (7.39) with FYM (50%) + Vermicompost (50%).

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