Effect of Varieties, Organic Manures and Inorganic Fertilizers on Growth, Yield and Quality of Beetroot (*Beta vulgaris* L.)

THESIS

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(VEGETABLE SCIENCE)

By

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CERTIFICATE- I

This is to certify that the thesis entitled **"Effect of varieties, organic manures and inorganic fertilizers on growth, yield and quality of beetroot (*Beta vulgaris* L.)"** submitted in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE** in **Ag. Horticulture (Vegetable Science)** of Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior is a record of the bona-fide research work carried out by **Mr. PREMSINGH KANASE** under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee and the Director of Instruction.

No part of the thesis has been submitted for any other degree or diploma or has been published. All the assistance and help received during the course of this investigation has been acknowledged by the scholar.

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This is to certify that the thesis entitled **"Effect of varieties, organic manures and inorganic fertilizers on growth, yield and quality of beetroot (*Beta vulgaris* L.)"** submitted by **Mr. PREMSINGH KANASE** to Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE** in **Ag. Horticulture (Vegetable Science)** in the Department of **Vegetable Science** has been accepted after evaluation by the External Examiner and approved by the Student's Advisory Committee after an oral examination on the same.

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Premsingh Kanase

Contents

List of tables

List of figures

List of plates

List of appendices

List of symbols/abbreviations

Symbol	Abbreviation	Stands for
/	-	Per
@	-	At the rate of
%	-	Per cent
^0C	-	Degree Celsius
&	-	And
-	ANOVA	Analysis of variance
-	CD	Critical difference
-	cm	Centimeter
-	cv.	Cultivar
-	CV	Coefficient of variance
-	DAS	Days after Sowing
-	DAP	Di Ammonium Phosphate
-	df	Degrees of freedom
-	EC	Emulsifiable Concentrate
-	EMSS	Error Mean Sum of Squares
-	*et al.*	and others
-	Fig.	Figure
-	FYM	Farm Yard Manure
-	g	Gram
-	ha	Hectare
-	Hrs.	Hours
-	HW	Hand Weeding
-	*i.e.*	That is
-	kg/ha	Kilogram per hectare
-	K_2O	Potash
-	m	Meter
-	m^2	Meter square
-	Max.	Maximum
-	mg	Milli Gram
-	Min.	Minimum

-	MOP	Muriate of potash
-	M.S.S.	Mean sum of square
-	MT	Metric tone
-	N	Nitrogen
-	No.	Number
-	NS	Non-significant
-	P	Phosphorus
-	q/ha	Quintal per hectare
-	RDF	Recommended dose of fertilizer
-	R.H.	Relative humidity
-	Rs.	Rupees
-	Rs./ha	Rupees per hectare
-	RVSKVV	Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya
-	S. Em	Standard Error of Mean
-	var.	Variety

Chapter-I

INTRODUCTION

Beetroot (*Beta vulgaris* L.) is one of the winter vegetable crops of the Chenopodiaceous family and has the chromosome number of 2n=18. This crop is biennial grown as annual. This crop is classified as root crops and are distinguished by the presence of betanin pigment (Betacyanins red-violet and Betaxanthins yellow) and that the concentration of the pigments in the roots depends on the ratio between the two pigment. Betanin pigment had a Bioactive agent, which has wide effects that inhibit oxidation reactions such as (Lipid peroxidase and Decomposition hem in the blood), and the beetroots juice also has cytotoxic properties against the formation of cancer cells (Alenzi and Manea., 2020).

They are biennials although they usually grow as annuals. Beetroot is essentially a modern vegetable and has become an important home-garden and market garden crop, cultivated for its fleshy roots. Beetroot produces green tops and swollen root during its first growing season. It is highly productive as it grows quickly and usually free from pests and diseases. The total area under beetroot cultivation and production of beet root in India is about 2164 hectares and 36260 tones, respectively. The productivity of beetroot in India is 16.75 T/ha (Kadam *et al*., 2018).

A freshly harvested sugar beet root contains 75-76% water, 15-20% sugars, 2.6% non-sugars and 4-6 % the pulp. Processing of one ton of fresh sugar beet roots yields 121 kg sugar, 38 kg molasses (containing 18.2 kg sugar, 12.1 kg impurities and 7.8 kg water) and 50 kg of pulp (Barar *et al.,* 2015).The crop is widely cultivated for the production of commercial sugar, forage plants, natural dye and food for human consumption. The extracts used as a natural colorant for food products have been shown to possess effective antioxidant properties. They are consumed as salad or cooked and used in pickling and canning (Devi *et al.,* 2016).

The high cost of synthetic fertilizers and the lack of knowledge on how to use them properly are also other factors which cause farmers to fail to produce beetroot on a large scale. Furthermore, synthetic fertilizers have adverse effects to the soil; these effects include decrease in soil fertility, soil and ground-water pollution. Nitrogen and potassium based synthetic fertilizers leach into ground water and increase its toxicity, causing water pollution. They also increase the nitrate levels of soil and damage the natural make-up of soil in the long term (Dlamini *et al.,* 2020).

Integrated Nutrient Management is an alternative for sustainable crop production rather than use of inorganic fertilizers only. Integrated Nutrient Management is an approach of supplying nutrition to the crop by including organic and inorganic sources of nutrients. The combined use of organic manures, biofertilizers with a reduced dose of chemical fertilizers, helps to reduce pollution problems, increase the yield and quality of the product and also maintain soil health (Mounika *et al*., 2020).

Organic manure is regarded as especially important for root crops, as it improves the physical, chemical, and biological conditions of soil and ultimately favors better root growth. Farmyard manure is highly used organic manure that supplies some essential plant nutrients (N, P, and K) and other macronutrients and micronutrients (Sapkota *et al.,* 2021).The addition of organic fertilizer to agricultural soil has beneficial effect on crop development and yield by improving soil physical and biological properties (Ingole *et al*., 2018).

Organic manure supplies the plants with many nutrients which improve the physical properties of the soil consequently improve the plant growth. Also it is very cheap and expressed cash money improving the income of farmer, in addition, uses this organic materials are safe for human health (Shafeek *et al*., 2019).

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. It acts directly for increasing crop yield by accelerating the respiratory process through cell permeability or by hormones through growth action. It supplies nitrogen, phosphorus and sulphur in available form to the plants through biological decomposition. Indirectly it improves the physical properties of soil such as aggregation, aeration, permeability and water holding capacity (Jagadeesh *et al., 2018*).

Vermicompost is usually a finely divided peat-like material with excellent structure, porosity, aeration, drainage and moisture holding capacity. When they added to the soil enhances crop growth and yield, promote humification and increases microbial activity and enzyme production. This results the aggregate stability of soil particles and better aeration. The greatest plant growth responses and yields have occurred usually when vermicompost constituted a relatively small proportion of the total volume of the plant growth medium in which they are incorporated (Kibatu and Mamo 2014).

Keeping in view the above facts, an experiment entitled “Effect of varieties, organic manures and inorganic fertilizers on growth, yield and quality of beetroot (*Beta vulgaris* L.)” was conduct during *Rabi*, 2021-22 with the following objectives:

Objectives:

1. To evaluate the performance of beet root varieties
2. To assess the effect of organic manures and inorganic fertilizers on growth, yield and quality of beet root
3. To find out the interactive effect of variety, organic manures and inorganic fertilizers on the growth, yield and quality of beetroot

Chapter-II

REVIEW OF LITERATURE

Beetroot is a very important root crops which grown in different parts of India. The review of the literature available on the work carried out on the similar aspect in the past in India and abroad has been summarized under the following headings:

1. Effect of varieties
2. Effect of organic manure and inorganic fertilizers
3. Interactive effect of varieties, organic manure and inorganic fertilizer

2.1 Effect of varieties

Jah *et al*. (2003) evaluated exotic genotypes of sugar beet. The germplasms included Kewe Terma, Prima Poly, KWS Pak-9211, Allyx, Aura, Sibel, KWS Pak-937, KWS Pak-961, Candyx and KWS Pak-238. From the results it is concluded that Aura produced maximum sugar yield and is recommended for commercial cultivation after confirmation of these results in future evaluation.

Ijoyah *et al.* (2008) evaluated the yield performance of four beetroot varieties, 'Moronia', 'Lola', 'Crosby' and 'Detroit -243' against the commonly grown variety 'Detroit' under open field conditions. The results obtained showed that while variety 'Moronia' was the earliest to maturity the longest root length and largest root width were produced by variety Crosby. Similarly the same variety 'Crosby' gave the highest root yield with root yield being 39.7% and 33.1% higher than the popular variety 'Detroit' in both years, respectively. Hence the variety 'Crosby' was recommended as a potential replacement for 'Detroit'.

Hozayn *et al*. (2014) assessed the performance of ten exotic sugar beet varieties in three locations in Egypt. Maximum fresh root beet yield was produced by Monte Rose (34.08 ton fed^{-1}) followed by Rosana (33.02 ton fed^{-1}) and DS-9007 (32.65 ton fed^{-1}), which were grown in clay soil, Swallow (35.20 ton fed^{-1}), Rosana (33.00 ton fed^{-1}) and Torro (33.21 ton fed^{-1}) in sandy clay soil and DS-9004 (31.20 ton fed^{-1}) and R-Hist (29.66 ton fed^{-1}) in sandy soil. Similar trends were recorded for gross sugar yield. In terms of sucrose

%, varieties, Toro, DS-9007 and DS-9004 recorded the highest value (18.00, 19.00 and 17.65%) in clay, sandy clay and sandy soil respectively.

Ruboczki *et al*. (2015) examined morphological and sensory evaluations on 10 varieties of beetroot harvested in autumn. The highest red pigment content (betanin) was observed in Mona Lisa, Akela and Cylindra (34.58–47.66 mg/100 g). A similar trend could be observed in yellow pigments (vulgaxanthins) which proves the close correlation between the quantities of the two pigments (r=0.898). Highest total polyphenol (77.13–83.37 mg GAE/100g) and flavonoid (21.73–22.73 mg CE/100g) contents were detected in Akela, Mona Lisa and Bonel. These varieties are favourable for fresh salad and they can satisfy processing requirements also. Highest water soluble solids content was found in Akela (7.15%).

Patel *et al.* (2017) determined the production and profitability of beetroot of beetroot cultivars to date of planting and spacing. All the marketable yield contributing characters were the highest to the plants found with 30th October date of planting at the spacing of 30 cm x 15 cm with Crimson Globe (C_1) and the lowest on 15th October at the spacing of 15 cm x 15 cm with Detroit Dark Red (C_2). Maximum gross yield (44.83 t ha^{-1}) was found in $P_2S_1C_1$ and the minimum (15.33 t ha^{-1}) was in $P_1S_3C_2$. The maximum (31.74 t ha^{-1}) and the minimum (7.48 t ha^{-1}) marketable yield were also found in the treatment of $P_2S_2C_1$ and $P_1S_1C_2$. The highest (6.23) Benefit:Cost ratio (BCR) was observed in $P_2S_2C_1$ and the lowest (1.45) was in $P_1S_1C_2$.

Nagib *et al*. (2018) reported that: 1. Harvest age exhibited a significant effect on all studied traits in both seasons. Beets harvested at older age (210 days after sowing) surpassed those harvested earlier (180 days after sowing) in all traits in both seasons, except loss in sugar yield/fed and α-amino- N%. 2. The tested sugar beet varieties varied significantly in all studied traits in both seasons. Beta 398variety recorded the best values of root, top, and sugar yields/ fed, in both seasons. The best values of sucrose %, loss in sugar/fed and sugar recovery % was obtained by Drena variety in both seasons. Lammia variety recorded the highest values of α-amino-N %, while the highest value of alkalinity coefficient was obtained by Kosmas variety, in both seasons. Planting Beta 398 sugar beet variety and harvesting it after180 or 210 days from sowing could be concluded get the highest productivity and quality of sugar beet under conditions of Minia Governorate.

Nargave et al. (2018) reported that radish variety V_3 (Kashi Sweata) exhibited maximum plant height (44.30 cm), number of leaves (9.38), leaf length (41.98 cm), fresh weight (150.61 g) and dry weight of shoot (17.88 g). Maximum root length (27.17 cm), root diameter (4.51 cm), root weight (228.45 g), root yield (580.58 q/ha), harvest index (81.08 %) and earliest days to harvest (41.67) were observed with variety V_3 (Kashi Sweata). Under quality parameters highest fiber content (664.00 mg/100 g), T.S.S. (4.51^{0}Brix) and ascorbic acid (33.54 mg/100 g) in root were also found in case of variety V_3 (Kashi Sweata).

Paul *et al*. (2018) observed that highest soil plant analysis development (SPAD) value (97.7 at 80 DAS), beet length (30.4 cm), beet girth (36.7 cm) and individual beet weight (1.3 kg) were observed in PAC-60008 at the spacing of 50 cm 9 30 cm when fertilized with urea 290, TSP 125, MOP 265, gypsum 100, $ZnSO_4$ 10, boric acid 7 kg ha^{-1}. The maximum beet weight (1.3 kg) was found in PAC-60008 at 50 cm 9 30 cm spacing with urea 290, TSP 125, MOP 265, gypsum 100, $ZnSO_4$ 10 and boric acid 7 kg ha^{-1} followed by (1.2 kg) PAC-60008 at 50 cm 9 30 cm with urea 260, TSP 105, MOP 225, gypsum 100, $ZnSO_4$ 10 and boric acid 7 kg ha^{-1}, and the lowest one was found in Shubhra (0.6 kg) at 50 cm 9 25 cm with urea 230, TSP 85, MOP 185, gypsum 100, $ZnSO_4$ 10 and boric acid 7 kg ha^{-1} . The highest beet yield (92.3 t ha^{-1}) was recorded in the interaction among PAC-60008 at the spacing 50 9 20 cm when fertilized with urea 290, TSP 125, MOP 265, gypsum 100, $ZnSO_4$ 10, boric acid 7 kg ha^{-1}. At 135 DAS, the highest ^{o}brix (20.3%) was recorded in PAC-60008 at 50 cm 9 20 cm with urea 290, TSP 125, MOP 265, gypsum 100, $ZnSO_4$ 10 and boric acid 7 kg ha^{-1} therefore, it may be concluded that PAC-60008 appears as the promising sugarbeet variety in terms of beet yield and quality cultivated at the spacing 50 cm 9 20 cm fertilizing with urea 290, TSP 125, MOP 265, gypsum 100, $ZnSO_4$ 10 and boric acid 7 kg ha^{-1}.

Mekki *et al*. (2019) conducted an experiment to study the effect of varietal differences and seed type on sugar beet yield and quality. The experiment included the evaluation of 10 sugar beet varieties in the first season, which were five monogerm seed varieties i.e., Francesca, Karem, AS 0082, Ravel and MK 4114 used and another five polygerm seed varieties Samba, Rizobel, MK 4016, SV 1841 and Amina used in production areas in 16/2017. In 2018/19 season Karem, AS 0082, Ravel was evaluated as well as Rizobel, MK 4016, SV 1841 and Amina as monogerm and polygerm varieties, respectively. Generally, it seems that the monogerm seeds produced stronger sugar beet plants under sandy soil conditions compared with plants produced from the polygerm seeds. The plants produced from the monogerm seeds have longer and wider beets and possessed greater roots and shoot yields per plant and per feddan. The results showed significant differences among the tested varieties in mean root length and diameter, root and top weight per plant as well as root and top weight per feddan. The data show that Ravel variety significantly surpassed the other varieties in root and top yields per plant and per feddan and possessed reasonable criteria for root length and diameter. However, the varieties SV 1841 and Amina gave the lowest studied parameters in root length and diameter as well as root and top yields per plant and per feddan. The data of the extractable sugar indicated similar tendency for the gross sugar yield per feddan Gross sugar yield per feddan ranged between 2.925 and 5.076 with an average of 3.856 ton fed in 2016/17 season while the corresponding values for 2018/19 1 season were 3.358 and8.186 for the minimum and maximum yields with an average of 5.403 ton fed. It is worthy 1 to note that the lowest sugar beet varieties in yield contained the extractable and gross sugar yields per feddan whereas the variety SV 1841 could compensate the lower production ability as occurred by the higher sugar % in 2016/17 season. Moreover, it can be noticed that the high purity percentage expressed as (Qz%) shared in the partial compensation of the extractable for some tested varieties.

Thalooth *et al*. (2019) evaluated the yield and quality response of some sugar beet varieties to humic acid and yeast application. The obtained results show significant differences among tested cultivars in most studied character but cultivar Heba surpassed the other two cultivars. The results also indicate that either humic acid or yeast had promoting effect on all studied character but yeast application was more effective than humic acid. Maximum sugar yield and quality obtained by Haba variety foliar sprayed with combined application with humic acid and yeast.

Fitters *et al*. (2020) examined the rooting patterns and overall plant growth of sugar beet under both rainfed and irrigated conditions. In the first year, three varieties were assessed, and in the second year, five varieties. No significant yield differences were found between the rainfed and irrigated treatments, which is likely due to the applied drought stress only being mild in both years. There were, however, significant varietal differences in plant growth and rooting patterns in rainfed plants which were most distinct when plants were subjected to mild drought stress. Varietal differences observed might indicate the possibility of breeding for certain root traits to mitigate drought stress in sugar beet in the future.

Lencha and Dalga (2020) conducted an experiment to identity best performing beetroot variety and optimum rate of nitrogen (N) fertilizer. The treatments were consisted of four varieties (Dark red, Crimson globe, Samba and Farida) with four N fertilizer rates (0, 50, 100 and 150 kg N kg ha^{-1}). The result showed that interaction of variety and rates of N fertilizer significantly ($P < 0.05$) affected total yield, marketable root yield and significantly ($P < 0.001$) affected root length, root width. Numerically the highest marketable root yield (16.3 t ha^{-1}) was achieved from dark red coupled with rate of 100 kg N ha^{-1} followed by variety dark red at the rate of 50 kg Nha^{-1} (14.9 tha^{-1}) Whereas the lowest root yield was recorded from dark red at 0kg N ha^{-1}.

Yasaminshirazi *et al*. (2020) investigated the agronomic potential of new and existing open-pollinated genotypes of beetroot and their performance. Fifteen beetroot genotypes, including one F_1 hybrid as a commercial control and one breeding line, were compared. The cylindrical-shaped genotype, Carillon RZ, demonstrated significantly higher total and marketable yields, with 53.28 ± 3.34 t ha^{-1} and 44.96 ± 3.50 t ha^{-1}, respectively, compared to the yellow-colored genotype, Burpees Golden, which obtained the lowest total yield, 36.06 ± 3.38 t ha^{-1}, and marketable yield, 27.92 ± 3.55 t ha^{-1}. Moreover, the comparison of the open-pollinated genotypes with the F_1 hybrid, Monty RZ F_1, revealed that except for the traits yield, scab, and uniformity, the open-pollinated genotypes indicated desirable competitive outcomes and thus offer suitable alternatives for organic cropping systems. Overall, the observed genetic variability can be beneficial for breeding and food product development.

Yassin *et al.* (2022) evaluated three sugar beets varieties growing under different water deficit condition. Results indicated that reducing water supply reduced alpha - amino N present in the second season, Na present in the second season, and K present and sugar lost to molasses, but increased sucrose present, extractable present, QZ present, purity present, extractability present. Increasing harvesting date increased K present, sucrose present, extractable present, QZ present, purity present, extractability present but reduced alpha - amino N present, Na present and sugar lost to molasses in the second season. Sucrose present, extractable present, QZ present purity present and extractability present of RAVEL and SA1686 varieties were almost comparable but higher than those of SV1841 variety.

2.2 Effect of organic manure and inorganic fertilizers

Zaki (2006) tested the response of sugar beet to fresh or composted farmyard manures (FFYM or CFYM) at rate 10 of ton/fed in combination with 40 kg N/fed added from different sources, i.e., urea, ammonium nitrate and diluted nitric acid. Plant samples were taken after 16 and 25 weeks from planting to define vegetative parameters (plant height, leaf numbers, root length and diameter). Shoots and roots were chemically analyzed to determine chlorophyll A, B, carotene, total soluble sugar and reducing sugar contents. Data obtained showed that applying organic manures (FFYM and CFYM) led to improve many of soil variables such as organic matter content, soil pH, soil salinity, CEC and available NPK, with superiority for CFYM. The combination of CFYM and ammonium nitrate exhibited the best results of vegetative growth parameters, yield, sugar concentration and its purity. Also, a positive correlation was found between sugar purity and potassium content in leaves. Reducing sugar content was more affected by the studied treatments as compared to the total soluble sugar content.

Straus *et al*. (2012) determined the internal quality (the total phenol, sugar, organic acid contents, antioxidant activity, and mineral components) and physical parameters in the flesh of red beetroots produced in different production systems (conventional, integrated, organic, and control) using established methods. Organic cropping of red beetroot plants significantly reduced the yield by 27% of some macro minerals (P at 23.1, K at 13.1, and Mg at 7.7%) in comparison with conventional cropping but increased the ascorbic acid by 23.3%, antioxidant activity by 30.3%, and some micro minerals (Na at 39.1, Cu at 5.0, Fe at 17.9, Mn at 3.4, and Zn at 2.1%). The organic system can also result in better economic feasibility under assumption that price and expected yield are achieved. The results showed that a decrease in nitrogen supply, which is inherent in organic cropping, enhances the levels of secondary metabolites and micro minerals, which are associated with increased free radical scavengers and antioxidant activity in plant tissue.

Hasanen *et al*. (2013) carried out an experiment to influence of nitrogen and organic fertilization on growth, yield and quality of sugar beet. The result obtained showed significant increase in shoot fresh weight, root fresh weight, root length, root yield and sugar yield in plants with increasing fertilization up to 350 kg N/fed. Organic fertilization by farmyard manure (FYM) and poultry manure (PM) was tested. The yield of these attributes of sugar beet was increased but the estimating effect was higher for PM than FYM. The technological characters of sugar beet (Sugar percentage, Purity, K, Na and Alfa-amino-N) rose with increasing N fertilization rate with application of PM or FYM. Under conditions of the present work, supplying sugar beet with 350 kg N/fed with FYM or PM resulted in the highest root and sugar yields/fed.

Szopinskaand Gaweda (2013) conducted an experiment of red beet roots using conventional, integrated, and organic methods. The greatest impact on total and commercial yield, the average root weight, dry weight and chemical constituents' content in the roots had the season. In the years 2006 and 2008, the highest total and marketable yields of beet roots were obtained by organic method, but in 2009 these parameters were the lowest in organically produced plants. Total yield was correlated with mean root weight. In the years 2006 and 2008, betanine content was the lowest in organically produced roots while in the year 2009 it was the highest. The low yield of marketable roots and the low nitrates' content were the only two parameters, which distinguished organically produced red beet roots throughout the years of experiment.

Lehrsch *et al*. (2014) observed the sugar beet yield and quality when substituting compost or manure for conventional nitrogen fertilizer. Sucrose yield averaged across years and organic N rates at Site A was 12.24 Mg ha^{-1} for urea, 11.88 Mg ha^{-1} for compost, and 11.20 Mg ha^{-1} for manure, all statistically equivalent. Doubling the organic N rates at Site A increased the yield of roots up to 26% and sucrose up to 21%. Applying organic amendments in place of urea affected neither root nor sucrose yields but, at one location, decreased sugarbeet quality, though without hindering sucrose recovery. Sugarbeet producers can use compost or manure to satisfy crop N needs without sacrificing sucrose yield.

Magro *et al.* (2015) evaluated the production and quality of beetroot under different rates of organic compost at planting and K top dressing fertilization. Five rates (0, 20, 40, 60 and 80 t ha^{-1}) of organic compost applied at planting, in the presence (60 kg ha^{-1} of K_2O) or absence of K top dressing fertilization were evaluated. The K top dressing fertilization did not affect the production traits; however, it increases the contents of K in shoot and root and the contents of non-reducing and total sugars. The rates of the compost do not affect the quality traits, but the rate of 49 t ha^{-1} resulted in the maximum root yield estimated in 43 t ha^{-1} of roots.

Ali and Yasin (2016) investigated the effect of four nitrogen fertilizer rates i.e. 35, 70, 105 and 140 kg N/fad. And four compost rates i.e. 0, 2, 4 and 6 t/fad., and their interactions on yield and its attributes as well as quality of sugar beet. They found that increasing N fertilizer level from 35 to 140 kg N/fad, root length was responded only to 105 kg N/fad. There was significant increase in root length and diameter, fresh top weight/plant, fresh root weight/plant. Results clearly revealed that increasing compost rates up to 4 t/fad., significantly increased root length and diameter, fresh top weight/plant, fresh root weight/plant, Na (%) and SLM (%). The highest top, root and recoverable sugar yields as well as alpha amino-N (%) were achieved by application the highest rate of compost (6 t/fad.). It could be summarized that N-fertilizer level of 105 kg N/fad., with application of compost at 6 t/fad., could be applied for maximizing sugar production and minimizing soil pollution by reducing the application of N- fertilize.

Devi *et al.* (2016) studied the effect of organic nutrient and biostimulants on yield characters of beetroot the organic manures used in the study were FYM, vermicompost, consortium of biofertilizers (CBF) and biostimulants like panchakavya, effective microorganism and humic acid. The organic manures viz., FYM @ 25 t ha^{-1}, vermicompost @ 5 t ha^{-1} and consortium of biofertilizers (CBF) @ 2 kg ha^{-1}, were applied in the soil as basal application. The bio stimulants like panchakavya (PK) (3%), effective microorganism (EM) (1:1000 dilution ha^{-1}) and humic acid (HA) (2%) were given as foliar spray once in 10 days intervals. The results of the experiment revealed that the yield parameters viz., root length, root girth, root weight, shoot: root ratio $plant^{-1}$, yield $plot^{-1}$ and yield $hectare^{-1}$ were recorded maximum in the treatment which received the soil application of vermicompost @ 5 t ha^{-1} and CBF @ 2 kg ha^{-1}, combined with foliar application of EM @ 1:1000 dilution ha^{-1}, PK @ 3% and HA @ 2%.

Kebede *et al*. (2016) showed that the application of 10/23 kg N/P_2O_5 ha^{-1} + 9 t FYM ha^{-1} fertilizers as a mixture gave the highest plant survival rate (81.9%), plant height (30.3 cm), leaf DM yield (2.7 t ha^{-1}), tuber DM yield (10.3 t ha^{-1}) and total DM yield (13.0 t ha^{-1}) while the lowest values of the above traits were recorded from the control treatment in fodder beet. Application of fertilizers mixture at a rate of 10/23 kg N/P2O5 ha^{-1} + 9 t FYM ha^{-1} increased the survival rate, plant height, leaf DM yield, tuber DM yield and total DM yield by 34, 57, 286, 296 and 294% over the control treatment. But, the highest seed yield (3.0 q ha^{-1}) was obtained by applying the highest level of fertilizer mixture (15/33 kg N/P_2O_5 ha^{-1} + 9 t FYM ha^{-1}) which gave 900% seed yield advantage over the control treatment. Therefore, applying 10/23 kg N/P_2O_5 ha^{-1} + 9 t FYM ha^{-1} and 15/33 kg N/P_2O_5 ha^{-1} + 9 t FYM ha^{-1}

fertilizer mixture were found to be the optimum fertilizers mixture rate for forage and seed yields of fodder beet. Therefore, this preliminary result recommends using FYM alongside with mineral fertilizers to increase forage and seed yields of fodder beet.

Jabeen *et al*. (2017) evaluated the effect of organic manures and biofertilizers on growth and leaf yield of spinach beet. The treatments comprised of organic manures viz., farm yard manure, sheep manure, vermicompost, mustard cake and two types of bio-fertilizers namely Azospirillum and PSB, including RFD (recommended fertilizer dose) as control. Results revealed that growth parameters like plant height (27.18, 27.44 and 27.48 cm), weight of leaf blade (1.13, 2.55 and 3.54 g), weight of leaf petiole (0.48, 0.50 and 0.63 g), seedling emergence per cent (97.68 %), seedling root length (9.09 cm), seedling shoot length (6.19 cm) and seedling vigour index (1492.55) were highest in the treatment in which vermicompost @ 3 tonnes ha^{-1} + biofertilizers @ 5 kg ha^{-1} was applied. Lowest values for growth parameters were recorded in treatment where mustard cake @ 1.2 tonnes ha^{-1} was applied. Yield parameters like number of leaves (10.97, 9.37 and 7.09), leaf area (20.10, 64.10 and 104.30 cm^2), leaf yield per plant (17.62, 29.27 and 29.26 g) and per hectare (58.73, 97.58 and 97.88 q) were also registered highest in vermin compost @ 3 tonnes ha^{-1} + biofertilizers @ 5 kg ha^{-1}. Treatment RFD (control) recorded the lowest values for yield parameters.

Ingole *et al*. (2018) conducted an experiment with ten treatments comprises 100 % RDF, FYM, vermicompost, neem cake alone and in combination with azotobacter, PSB, VAM as soil treatment. The treatment combination of organic nutrient sources T_6 i.e. vermicompost @ 9.2 tha^{-1} + azotobacter (10 kg ha^{-1}) + PSB (10 kg ha^{-1}) + VAM (40 kg ha^{-1}) as soil treatment was found to be significantly superior for growth viz., plant height (28.85 cm), Number of leaves/plant(14.27), Leaf area(107.60 cm^2),Days required for harvesting (78.33) and yield attributes i.e. root weight (158.33 g), root length (8.03 cm), Root yield $hectare^{-1}$ (q) (234.33) of beetroot, which was at par with treatment T_7 i.e. neem cake @ 2.5 tha^{-1} + azotobacter (10 kg ha^{-1}) + PSB (10 kg ha^{-1}) + VAM (40 kg ha^{-1}) as soil treatment. Considering the cost economics, the treatment T_6 i.e. vermicompost @ 9.2 t ha^{-1} + azotobacter (10 kg ha^{-1}) + PSB (10 kg ha^{-1}) + VAM (40 kg ha^{-1}) were found to be most remunerative and profitable as per its benefit cost ratio (3.51:1) as compared to remaining treatment and absolute control (T^{10}).

Jagadeesh *et al.* (2018) studied the effect of organic manures on growth and yield attributes of beetroot. The early germination was recorded in poultry manure (100%) and it was at par with FYM (50%) + vermicompost (50%) and vermicompost (100%). The highest plant height and no of leaves was recorded with poultry manure (100%) which was at par with FYM (50%) + poultry manure (50%). The highest specific leaf weight, crop growth rate, net assimilation rate and leaf area were recorded with poultry manure (100%). The highest relative growth rate was recorded with vermicompost (100%). The highest SPAD value was recorded with RDF. Among the yield parameters the root length and harvest index were maximum with FYM (50%) + poultry manure (50%) whereas root diameter was maximum with poultry manure (100%). The highest root yield was recorded with poultry manure (100%) which was at par with vermicompost (100%). The highest root: shoot ratio was recorded with FYM (50%) + poultry manure (50%) followed by vermicompost (100%).

Kushwah *et al*. (2019) investigated the influence of organic manures, inorganic fertilizers and their combinations on growth and quality of radish. The experiment consisted of 10 different treatments of organic manures, inorganic fertilizers and their combinations i.e. T_1 RDF(100:80:50 kg NPK/ha), T_2 (100% N through FYM), T_3 (100% N through vermicompost), T_4 (100% N through poultry manure), T_5 (75% NPK + 25% N through FYM), T_6 (75% NPK + 25% N through vermicompost), T_7 (75% NPK + 25% N through poultry manure), T_8 (50% NPK + 50% N through FYM), T_9 (50% NPK + 50% N through vermicompost), T_{10} (50% NPK + 50% N through poultry manure). These treatments were evaluated under Randomized Block Design (RBD) with 3 replications. The application of 75% NPK + 25% nitrogen through vermicompost (T_6) resulted in maximum values of growth attributes viz., fresh weight of shoot (91.5 g), dry weight of shoot (9.2 g) and SPAD value (57.49) at harvesting stage. The quality attributes viz. fiber content (763.67 mg/100 g), TSS (5 ^{o}Brix) and ascorbic content (37.17 mg/100g) in roots were also reported maximum by the application of 75% NPK + 25% nitrogen through vermicompost.

Sarwade *et al*. (2019) investigated the effect of leaf litter composts on yield and nutrient of beet root they concluded that the application of dung treatment and NADEP tank compost of leaf litter has been found promising organic manure enhancing growth, nutrient uptake and yield of crop plants. Leaf litter compost generated from the plantation floor assist to increase the organic matter contents along with the nutrients in the soil. In the present investigation, application of cattle dung, NADEP compost and vermicompost increase total reducing sugar in the beet root as well as total plant. While significant reduction was observed after the application of fertilizer and many times it was less than the control. Leaf litter can be considered as a source of Agricultural waste which return directly to the soil after the formation of compost. Compost supplies considerable quantities of essential nutrients for the succeeding crops after mineralization by soil organisms.

Shafeek *et al*. (2019) investigated the effect of organic cattle manure fertilizer at rates of (0, 10 and 20 m^3/fed.) as well as foliar application of potassium fertilizer at (0, 1 and 2 cm/L) for influence plant growth, roots physical and chemical quality of beet root plants c.v. Balady. The traits related to production evaluated were: 1- Adding cattle manure fertilizer at high levels (20 m^3/fed.) had a significant increased growth characters, i.e. plant length, number of leaves/plant, fresh and dry weight/plant as well as root fresh and dry weight and its components (root length and diameter). Also, gave the highest percentage of total sugar, vitamin C and TSS contents. 2- By increasing concentration of potassium increased growth characters, root yield parameters and increment the percentage of total sugar, vitamin C and TSS contents of beet root tissues. 3 - The highest values of the growth characters, roots parameters and the percentage of total sugar, vitamin C and TSS contents in beet root tissues were associated with that plants received higher cattle manure level (20 m^3/fed.) with higher concentration of potassium (2 cm/L).

Acharyya *et al*. (2020) studied the impact of nine different organic mulches used during the cultivation of beet root crop, c.v. Detroit Dark Red. Sawdust, water hyacinth and unwoven jute mulch enhanced vegetative growth as well as overall yield of the crop to a satisfactory level. Soil temperature was kept moderate under water hyacinth and sawdust mulch. Low water potential values were observed under sawdust, coal ash, FYM and banana leaf mulch thus confirming better water conservation. Mango leaf mulch was more successful than rest of the mulches in arresting weed growth due to it's allelopathic nature. None of the organic mulches had an impact on qualitative traits like TSS, total sugar, ascorbic acid and antioxidant activity.

Dlamini *et al.* (2020) studied the effects of cattle manure on growth, yield, quality and shelf-life of beetroot. Five treatments were applied in this experiment, and included cattle manure applied at 20, 40, 60, and 80 t/ha and a control of inorganic fertilizer, NPK [2:3:2 (22)] applied at 100 kg/ha as basal dressing and limestone ammonium nitrate (LAN) (28) applied at 80 kg as a top dressing. The results obtained showed that beetroot grown under the application rate of 80 t/ha exhibited higher values in plant height (32.5 cm), number of leaves (9), leaf area (206 cm^2), root diameter (5.1 cm), root length (11.7 cm), root fresh mass/plant (10.8 g), root dry mass/plant (9.2 g), marketable yield/plant (9.2 g) and quality [(aroma (33.5%), flavor (34%), texture (35%)] of the edible part. Plants supplied with 20 t/ha of cattle manure and inorganic fertilizer (control) gave the lowest vegetative growth parameters, quality parameters and marketable yield.

Ghaly *et al*. (2020) worked on the effect of sources of organic fertilizers (farmyard manure "FYM", compost "CO" and poultry manure "PM") and its rates (0, 3, 5 and 7 t fed^{-1}) on yields and its components and quality of sugar beet cv. Plino under newly reclaimed sandy soil conditions. The obtained results showed that organic fertilizing of sugar beet plots with PM induced a gradual increment and produced in the utmost values of all studied yields and its components and quality parameters as contrasted with supplementary treatments within the two growing seasons. Application the utmost rate of organic fertilizers (7 t fed^{-1}) formed the utmost values of yield and yield components and N, P and K contents in roots and foliage in mutually seasons. Although, the utmost values of sucrose and quality percentages resulted from using the organic fertilizers at 3 t fed^{-1} and the utmost values of sodium percentage were resulted as of control treatment in mutually seasons.

Gyewali *et al*. (2020) examined the effect of organic manure on growth yield and quality of radish. The poultry manures combined with bone meal and PSB significantly increased the growth and yield attributes viz., plant height (43.43 cm), number of leaves (20.9), shoot length (44.49 cm), root length (21.68 cm), root diameter (3.77 cm), root weight (211.3 gm plant^{-1}), shoot weight (170.9 gm plant^{-1}), biological yield (82.28 gmplant^{-1}), dry root weight (46.89 gm plant^{-1}), dry shoot weight (50.33 gm plant^{-1}), total dry weight (97.22 gm plant^{-1}), root yield (49.31 tha^{-1}), shoot yield (939.87 tha^{-1}) and biological yield (89.19 tha^{-1}) at 70 days after sowing. The vitamin-C in radish root was recorded highest (2.87 mgml^{-1}) with PM. However, the total soluble solid remains unchanged among the treatments. In total, the results suggested that poultry manures combined with bone meal and PSB is suitable to cultivate radish.

Mounika *et al.* (2020) carried out an experiment to study the effect of integrated nutrient management on quality and economics of beetroot (*Beta vulgaris* L.) cv. Crimson Globe. The experiment was conducted with three sources of nutrients viz. organic, inorganic and biofertilizers combinations in randomized block design with eight treatments. Among the treatments, T_3 treatment 75 % RDN PK + FYM (6 t ha^{-1}) +VC (1.5 t ha^{-1}) + Azatobactor (10 kg ha^{-1}) + PSB (10 kg ha^{-1}) recorded the highest ascorbic acid content (3.4 mg 100g^{-1}), betanine content (1.92 mg 100g^{-1}), total soluble solids (9.170 brix), highest gross returns (Rs. 2,29,920), net returns (Rs. 1,83835) and best benefit cost ratio (3.9:1)

Nadeeka and Seran (2020) concluded that fresh weight of root yield and total yield of beetroot per plant were increased in 10 t/ha goat manure, 2 t/ha sugarcane molasses and 50% TSP (T_4) and 10 t/ha goat manure, 3 t/ha sugarcane molasses and 50% TSP (T_5) when compared to the control treatment (T_1). The total yield of beetroot per m_2 was 1,792.62 g in T_4 and 1,402.68 g in T_1. The root yield of beetroot was increased in T_4 in comparison to T_5. It can be concluded that 10 t/ha of goat manure with 2 t/ha of sugarcane molasses and 50% TSP could be applied for obtaining a high yield of beetroot in sandy regosol.

Hlisnikovsky *et al.* (2021) compared the ten fertilization treatments: unfertilized control, farmyard manure (FYM), mineral fertilizers NPK1–4, and FYM + NPK1–4. The applications of FYM, NPK, and FYM + NPK resulted in significantly higher yields of beetroots and tops as compared with the control, while no significant differences were recorded among FYM, NPK, and FYM + NPK treatments. The SC was not affected by the fertilization. The application of NPK resulted in a lower pH value, while the highest values were recorded for the control and FYM treatments. The application of FYM + NPK increased the content of organic carbon (Corg) in the soil, the total content of nitrogen (Ntot), and P and K concentrations. According to the results of the linear-plateau model, the recommended dose of N is 112 kg ha^{-1}, corresponding to a beetroot yield of 66 t ha^{-1}.

Pamula and Kerketta (2021) carried out an experiment to study the effect of organic manures and inorganic fertilizers on growth and yield of turnip. Results revealed that the application of T_{10}:25% RDN (20:12.5:12.5)+75% PM (7.5 t ha^{-1}) influenced most of the characteristics significantly and recorded the highest values of plant height (46.74cm), number of leaves per plant (22.30), leaf length (cm) (30.23), shoot weight (23.87g), root weight (117.48g), root length (5.61cm), root diameter (6.67cm), root yield per plot (14.92kg^{-1}) and root yield (355.17q/ha).

Rawat and Pant (2021) investigated the effect of organic manure, inorganic fertilizers and their combinations on yield of radish. The study consisted of 9 treatments having sole application of organic manure, inorganic fertilizers and their combinations. The results revealed that root weight (144.53 g), root length (28.21 cm), middle diameter of root (3.49 cm), yield per plot (4.65 kg/), yield per hectare (258.32 q) and total soluble solids (5.67 °Brix) was observed in treatment T_5 [50% FYM + 50% VC]. Further maximum cost: benefit ratio (1: 2.49) was obtained in treatment T_6 [50% FYM + 50% RDF (NPK)].

2.3 Interactive effect of varieties, organic manure and inorganic fertilizers

Chapagain *et al*. (2010) tested five commercial (Any sesion, Tikimashi, Mino Early, Forty Days and Chetki) and a local (Bhedetar Local) varieties of radish for their performance at different levels of manures and fertilizers. The highest root yield (65.1 t ha^{-1}) was obtained from Mino Early which was at par with Bhedetar Local (62.85t ha^{-1}) in varietal trial. In fertilizer trial, the highest mean root yield of Bhedetar Local was obtained from 100:80:40 N_2:P_2O_5 :K_2O kg ha^{-1} + FYM 20 t ha^{-1} which was at par with 75:50:50 N_2 :P_2O_5 :K_2O kg ha^{-1} + FYM 20 t ha^{-1}, however, differed statistically with other treatments. The root yield obtained from the exiting farmers practice was statistically at par with 75:50:50 N_2:P_2 O_5:K_2O kg ha^{-1}. Root yield (t ha^{-1}) was positively and significantly (0.01) correlated with root length, plant height, root diameter and number of leaves per plant.

Safina and Abdel Fatah (2011) conducted an experiment to study the response of three sugar beet varieties, i.e. KWS1436, Swello and Faraha growing in sandy soil to compost (CM), Mineral-N fertilizer and their combinations on yield and quality of sugar beet under drip irrigation system. KWS1436 variety surpassed the other two varieties in sucrose %, extractable sugar % as well as sugar yield, also, it gave the highest root yield (28.81 ton fed^{-1}) and purity in the 1st season. Swello variety recorded the highest root yield (29.96 ton fed^{-1}), in the 2nd season. In combination treatments, increasing N levels from 40 to 80 kg N fed^{-1} significantly increased top, root and sugar yields and sucrose %, in the two seasons. Combination of CM + 80 kg N fed^{-1} (100 % N), produced the highest extractable sugar % (15.53 %) in the 1st season and increased root yield by (11.42 and 3.16 %), sugar yield by (13.62 and 5.22 %) in the 1st and 2nd seasons, respectively and sucrose % by (2.08 %) in the 1st season, as compared with adding 80 kg N fed^{-1} (100% N) alone. Combination of CM + 60 kg N fed^{-1} increased sucrose % by (4.13 %) as compared with 80 kg N fed^{-1} alone in the 2nd season. Various interaction orders among the two factors affected significantly all traits under study. According to this investigation, to gain high sugar yield of sugar beet, KWS1436 fertilized by 4 tons compost + N level of 80 kg N fed^{-1} (100% N) is recommended.

Pandy *et al*. (2017) revealed that all vegetative attributes were higher in Nepadream at early growth stage, but at later stage it was lower than OP varieties. However, Nepadream produced significantly higher yield (28.56 t ha^{-1}) than OP varieties. Comparing the nutrient treatments, independent on the varieties, all combinations of 50% RDF were found significantly effective in achieving better physio-morphological, growth attributes and yield and yield attributes as compared to their sole applications. The root yield obtained by 100% RDF (24.06 t ha^{-1}), 50% RDF plus 50% FYM (24.68 t ha^{-1}) and 50% RDF plus 50% vermicompost (25.28 t ha^{-1}) were comparable. However application of 50% RDF along with 50% vermicompost performed best among all nutrient sources.

Kiran *et al.* (2019) worked on radish to check the enhancing effect of NPK with various organic manures on radish production. Experiment included 6 treatments (control, NPK + FYM, NPK + PM, NPK + GM, NPK + PM and NPK + SS) and 3 replications. Results showed significant improvement in almost all studied parameters with the application of NPK and different organic manures. Highest mean data for all the parameters studied were recorded in NPK + PM, as maximum leaves' count (21.67 and 22.33 plant-1), leaf length (32.20 and 38.33 cm), leaves weight (66.00 and 63.67 g $plant^{-1}$), root length (29.87 and 29.37 cm), root diameter (4.01 and 3.83 cm), root weight (285.00 and 274.00 g $plant^{-1}$), total biomass (351.00 and 337.67 g $plant^{-1}$) and root yield (80.42 and 77.80 t ha^{-1}) were produced in it both the years, respectively. It was trailed by NPK + GM and NPK + SS amongst all the other treatments used.

Kushwah *et al.* (2019) studied the effect of organic Result indicated that variety V_1 (Pusa Rudhira) recorded maximum plant height, number of leaves per plant, length of leaves, fresh weight and dry weight of plant, length, diameter, root girth, fresh and dry weight of root, yield of root and TSS at harvesting stage as compare to Pusa Kesar. Application of N_7 recorded higher values of plant height, number of leaves per plant, length of leaves, fresh and dry weight of plant, length, diameter, root girth, fresh and dry weight of root, yield of root and TSS as compare to other nutrient levels. Economic evaluation of different combinations showed that V_1 (Pusa Rudhira) and nutrient level N_7 were promising with highest net income and B:C ratio(1:3.78).

Patel and Patel (2019) studied the effect of integrated nutrient management on growth, yield, quality and economics of fodder sugar beet (*Beta vulgaris*) varieties. Total ten treatment combinations comprising of two varieties viz., V_1: JK Kuber and V_2: JK magnolia and five levels of integrated nutrient management i.e. F_1 : 100% RDF (RDF: 120 : 60 : 60 NPK kg/ ha), F_2 : 75% RDF+ 25% N through BC, F_3 : 75% R DF + 25% N through BC + bio-fertilizer (Azotobacter + PSB + Potash solubilizing bacteria, 108 CFU/ml, 1.25 lit/ha each), F_4 : 50% RDF + 50% N through BC and F_5: 50% RDF + 50% N through BC + bio-fertilizer (Azotobacter + PSB + Potash solubilizing bacteria, 108 CFU/ml, 1.25 lit/ha each) all these parameters beared higher values with application of 50% RDF + 50% N through BC + bio-fertilizer (F_5) followed by 75% RDF + 25% N through BC + bio-fertilizer (F_3). Maximum net realization (108353 ha^{1}) and BCR (3.14) were registered under JK Kuber (V_1) followed by JK magnolia (V_2) with net realization of 98119 ha^{-1} and BCR of 2.94. Whereas looking to the integrated nutrient management, application of 50% RDF + 50% N through BC + bio-fertilizer (F_5) accrued the maximum net realization of 114897 ha^{-1} and BCR of 3.25 followed by application of 75% RDF + 25% N through BC + bio-fertilizer (F_3) with net realization of Rs. 110147/ha and BCR of 3.17d.

Alenzi and Manea (2020) investigated the effect of organic and bio-fertilization on growth and yield of beetroot. The results indicate of the Detroit Dark Red cultivar significantly excelled in root diameter of 7.18 cm, average market root weight 178.7 g, marketing root yield 39.4 tons ha). Bio-health + Corn Fertilizers also gave the highest average of the percentage of Total Soluble Solids (TSS) 11.50% and Betanin pigment (9.05), The treatment of bi-interaction between Detroit Dark Red with fertilizer + Bio-health poultry fertilizer) excelled in the average marketing root weight of 200 g, and the marketing root yield reached (44.0 tons ha^{-1}) and Betanin pigment 12.13%, Detroit Detroit Dark Red cultivar with corn fertilizer excelled in root diameter

8.14 -1 cm. The interaction between the Crimson globe cultivar with fertilizer (Bio-health and corn cobs fertilizer) was excelled and gave the higher in TSS 12.33%). The cultivar Crimson globe with poultry manure excelled in nitrogen percentage by roots (1.85%).

Sapkota *et al.* (2021) evaluated the effect of organic and inorganic sources of nitrogen (N) on growth, yield and quality of beetroot varieties. This study indicated a significant impact of N sources and varieties on the assessed parameters. During harvest, a significantly higher plant height, number of leaves per plant, leaf length, leaf width, and beetroot diameter were observed in the N_2 treatment. Likewise, higher economic and biological yields were also recorded in the N_2 compared to other N sources. Out of the two varieties, the Madhur variety was significantly better in most growth and yield parameters. Similarly, the Madhur variety showed significantly higher economic and biological yields compared to the Ruby Red variety. However, the physiological weight loss was higher in the Ruby Red variety.

Chapter-III

MATERIAL AND METHODS

This chapter comprises of the methods applied and material used during present investigation entitled "Effect of varieties, organic manures and inorganic fertilizers on growth yield and quality of beetroot (*Beta vulgaris* L.)" was carried out at the Experimental Farm of the Department of Vegetable Science, College of Horticulture, Mandsaur (M.P.) during *Rabi* season, 2021-22. The details of the material and methods are being elaborated as follows:

3.1 Geographical situation

The present study was carried out at the Experimental Farm, Department of Vegetable Science, College of Horticulture, Mandsaur (M.P.) during *Rabi* season, 2021-22. The Experimental farm is situated in Malwa plateau agro-climatic zone in Western part of Madhya Pradesh from 23.450 to 24.130 North latitude and 74.440 to 75.180 East longitudes and at an altitude of 435.02 meters above Mean Sea Level. The topography of the experimental field was plain**.** This region lies under 9^{th} Agro climatic zone of the state.

3.2 Agro-climatic conditions

Mandsaur belongs to sub-tropical and semi-arid climatic conditions having a temperature range of minimum 5˚ C and maximum 44˚ C in winter and summer respectively. South–West monsoon is the main factor for major part of annual precipitation. In this area the maximum rainfall is received during mid June to September with occasional shower in winter. The average rainfall is 544.05 mm. Meteorological data (maximum and minimum temperature, relative humidity, rainfall and sunshine hours) as recorded at the meteorological observatory of the College of Horticulture, Mandsaur during cropping period (November, 2021 to March, 2022) are presented in Table 1 and graphically depicted through Fig. 1 in cropping season. Weekly mean temperature varied from 4.81 to 38.20^0 C while relative humidity ranged from 30.14 to 93.29 % with 129 mm rainfall (March, 2022) and sunshine 6.76 to 10.14 hours.

Table 1: Meteorological parameters recorded during the period of investigation (November, 2021 to March, 2022)

SMW	Period	Temperature (°C)		Relative Humidity (%)		Rainfall (mm)	Sunshine hrs.
		Max.	Min.	I	II		
47	19-25 Nov 21	26.13	8.84	93.00	56.71	0.00	8.37
48	26 Nov-2 Dec 21	24.27	11.56	89.43	43.57	8.00	7.37
49	3-9 Dec 21	22.56	13.24	92.29	56.29	0.00	8.33
50	10-16 Dec 21	23.60	13.86	89.71	56.86	0.00	8.09
51	17-23 Dec 21	22.01	7.56	88.71	34.14	0.00	9.11
52	24-31 Dec 21	20.49	10.03	91.13	59.00	0.00	7.53
1	1-7 Jan 22	22.63	11.14	93.14	61.86	0.00	6.76
2	8-14 Jan 22	18.01	15.71	93.29	59.86	0.00	8.60
3	15-21 Jan 22	20.21	6.03	90.71	50.43	0.00	9.14
4	22-28 Jan 22	18.29	4.81	90.57	43.00	0.00	9.16
5	29-4 Feb 22	24.83	9.69	86.43	36.43	0.00	9.70
6	5-11 Feb 22	24.24	11.19	88.14	35.43	0.00	9.24
7	12-18 Feb 22	24.33	6.11	84.86	33.29	0.00	9.51
8	19-25 Feb, 22	28.80	9.31	82.86	30.14	0.00	10.13
9	26 Feb-4 March, 22	28.67	9.33	85.43	32.29	0.00	10.14
10	5-11 March, 22	30.41	11.66	84.71	33.43	129.00	8.54
11	12-18 Mar 22	36.98	14.50	76.00	22.00	0.00	10.37
12	19-25 March, 22	35.60	16.50	58.60	21.70	0.00	9.77
13	26 March-1 April, 22	38.20	17.10	51.70	15.40	0.00	10.64

Source: Meteorological observatory of the College of Horticulture, Mandsaur (M.P.)

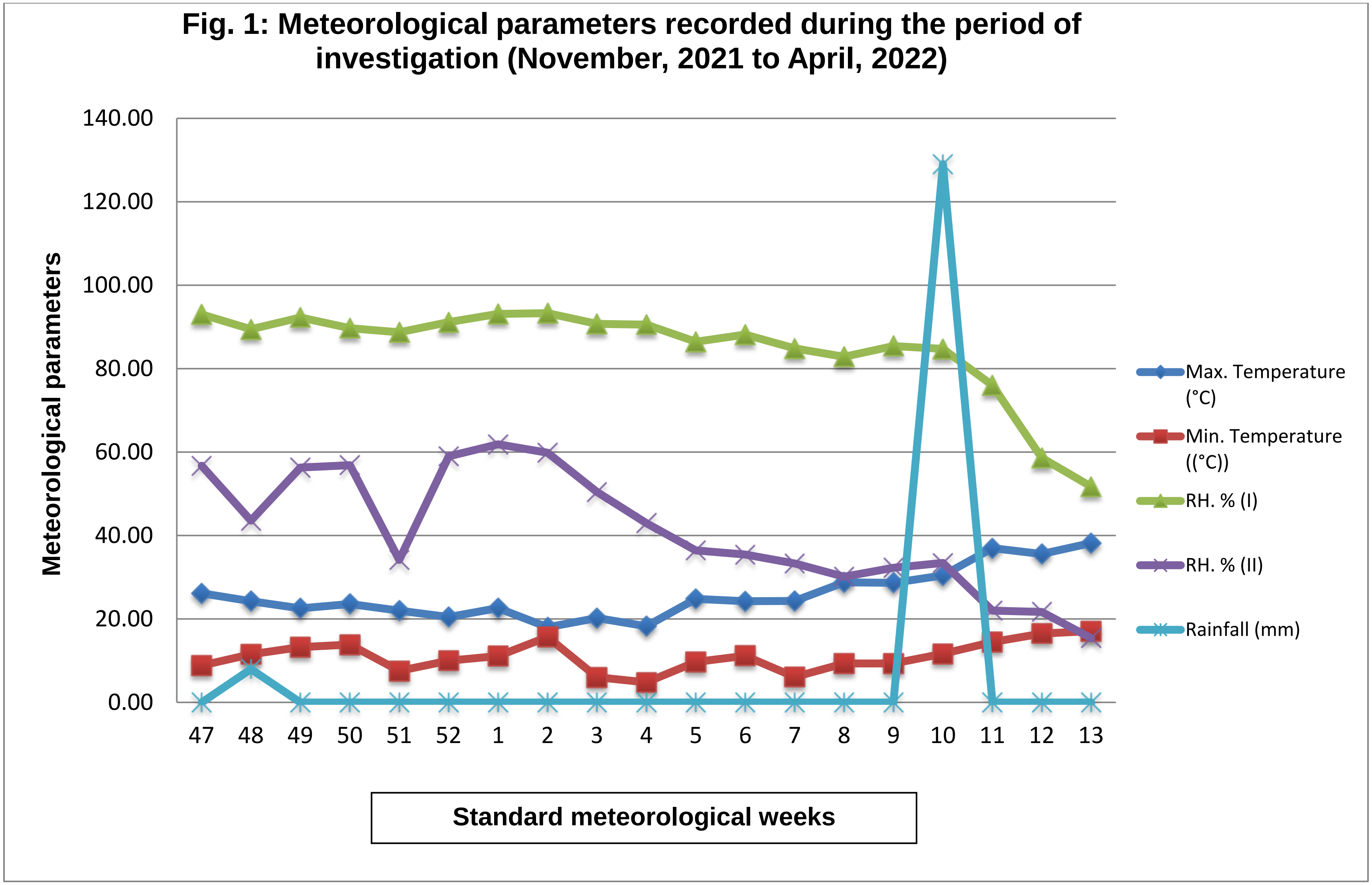
Fig. 1: Meteorological parameters recorded during the period of investigation (November, 2021 to April, 2022)
Meteorological parameters
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
47
48
49
50
51
52
1
2
3
4
5
6
7
8
9
10
11
12
13
Standard meteorological weeks
Max. Temperature (°C)
Min. Temperature ((°C))
RH. % (I)
RH. % (II)
Rainfall (mm)

3.3 Soil of experimental field

The soil of the experimental field was medium black (Vertisol) clay loam in texture with uniform topography. Before laying out the experiment, soil samples were collected randomly up to a depth of 20 cm from the different spots of the experimental field with the help of soil auger. All the soil samples were mixed to prepare a homogeneous sample, which was then oven dried, sieved through 2 mm sieve and finally used for physical and chemical analysis. The results are presented in Table 2.

Table 2: Physical and chemical composition of the soil

S.N.	Composition	Content	Category	Methods
(i)	Sand %	47	-	By Bouyoucos Hydrometer
(ii)	Silt %	33	-	By Bouyoucos Hydrometer
(iii)	Clay %	20	-	By Bouyoucos Hydrometer
(iv)	Soil pH	7.63	Neutral	Glass electrode pH meter
(v)	Electrical Conductivity (dSm^{-1})	0.504	Normal	By conductivity bridge at 25^{o}C
(vi)	Available Nitrogen (Kg/ha)	205.00	Medium	Rapid titration method (Walkley & Black ,1934)
(vii)	Available Phosphorus (Kg/ha)	17.33	Medium	Olson's extraction method (Olson *et al*., 1954)
(viii)	Available Potassium (Kg/ha)	366.13	High	Flame photometer (Ghosh *et al*.,1981)

Table 3: Previous year's crop history of the experimental field

Year	***Kharif***	***Rabi***
2018-19	Soybean	Fallow
2019-20	Soybean	Gram
2020-21	Soybean	Cauliflower

3.4 Experimental details and layout:

3.4.1 Experimental details

Location: Research Field of Department of Vegetable Science, College of Horticulture, Mandsaur (M.P.)

Experimental details:

Name of crop	:	Beetroot (*Beta vulgaris* L.)
Season	:	*Rabi* season, 2021-22
Design	:	Factorial Randomized Block Design
Number of replications	:	3
Number of treatments		
(a) Varieties	:	2
(b) Nutrient levels	:	7
Treatment combinations	:	14
Total numbers of plots	:	42
Spacing	:	30 x 10 cm
Gross plot size	:	2.1 x 1.8 m (3.78 m^2)
Net plot size	:	1.7 x 1.6 m (2.72 m^2)
Total experimental area	:	263.11 m^2
Net experimental area	:	158.76 m^2
Date of Sowing	:	28 November, 2021
Date of Harvesting	:	27 February to 28 March 2022

3.4.2 Treatment details

A. Varieties (V):

V_1-Crimson Globe

V_2-Detroit Dark Red

B. Nutrient sources (N):

N_1 - RDF (120:60:75 kg NPK/ha)

N_2 - 100% N through FYM

N_3 - 100% N through vermicompost

N_4 - 75% RDF + 25% N through FYM

N_5 - 75% RDF + 25% N through vermicompost

N_6 - 50% RDF + 50% N through FYM

N_7- 50% RDF + 50% N through vermicompost

Table 4: Treatment combinations

Treatment	Treatment Symbol	Treatment details
T_1	V_1N_1	Crimson Globe + RDF (120:60:75 kg NPK/ha)
T_2	V_1N_2	Crimson Globe + 100% N through FYM
T_3	V_1N_3	Crimson Globe + 100% N through vermicompost
T_4	V_1N_4	Crimson Globe + 75% RDF + 25% N through FYM
T_5	V_1N_5	Crimson Globe + 75% RDF + 25% N through vermicompost
T_6	V_1N_6	Crimson Globe + 50% RDF + 50% N through FYM
T_7	V_1N_7	Crimson Globe + 50% RDF + 50% N through vermicompost
T_8	V_2N_1	Detroit Dark Red + RDF (120:60:75 kg NPK/ha)
T_9	V_2N_2	Detroit Dark Red + 100% N through FYM
T_{10}	V_2N_3	Detroit Dark Red + 100% N through vermicompost
T_{11}	V_2N_4	Detroit Dark Red + 75% RDF + 25% N through FYM
T_{12}	V_2N_5	Detroit Dark Red + 75% RDF + 25% N through vermicompost
T_{13}	V_2N_6	Detroit Dark Red + 50% RDF + 50% N through FYM
T_{14}	V_2N_7	50% RDF + 50% N through vermicompost + Detroit Dark Red

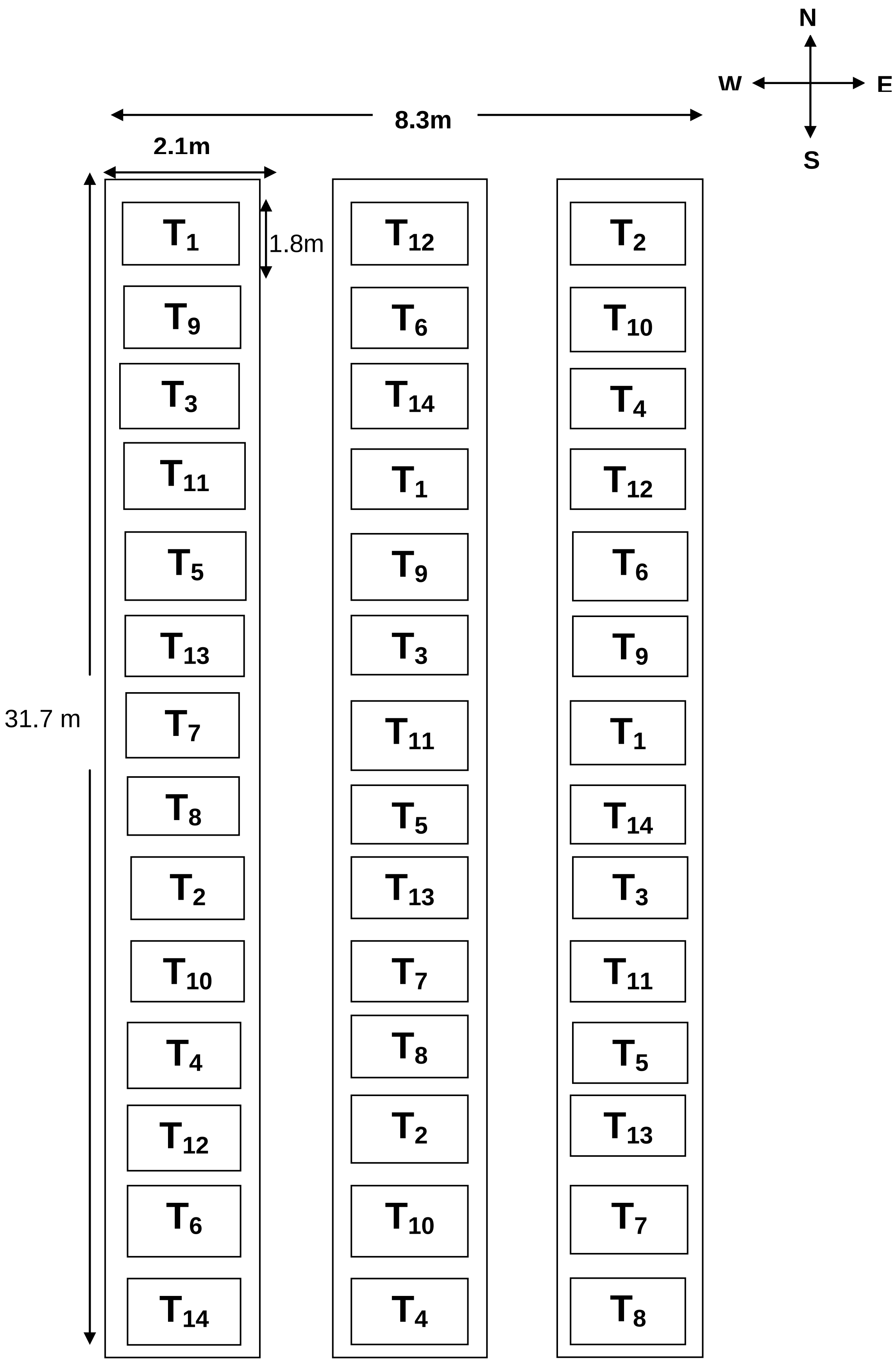

Fig. 2: Layout of the experimental field of beetroot

3.5 Agronomical operations

3.5.1 Field preparation

The field was ploughed with tractor drawn mould board plough. Thereafter cross harrowing was done followed by planking to make the field leveled. Almost all the big clods were broken into pieces. Weeds and stubbles were removed as far as possible and leveling is done. Plots are prepared according to layout plan of the experiment.

3.5.2 Treatment application

1. Fertilizer: Nitrogen, Phosphorus and Potassium were provided through urea, DAP and muriate of potash according to the treatment. Full quantity of phosphorus, potash and 1/3 of nitrogen was applied at basal at the time of sowing while the remaining was applied 15 and 30 days after sowing. The recommended dose of NPK was 120:60:75 kg ha^{-1}.
2. Organic manures: Organic manures viz., FYM and vermicompost were incorporated as per treatment to respective plots prior to sowing on the basis of nitrogen percentage.

3.5.3 Seed rate and sowing

Seeds of Crimson Globe and Detroit Dark Red were obtained from Head, IARI Regional Station, Katrain, Kullu Valley (H.P.) - 175129.The pure, healthy, disease and insect free vigorous and good quality seeds of beetroot (Crimson Globe and Detroit Dark Red) were used for sowing. Seed were treated with mancozeb 2g+ Carbendazim 1g per kg of seed. Seed was sown by hand dibbling method with maintain different row to row and plant to plant distance 30x10cm. The seed sowing was done 1.25 cm deep. It is facilitate good root production.

3.5.4 Gap filling

After complete germination, gap filling was done to maintain desired plant population. When the re-sowing seeds were germinated, thinning was done to maintain proper spacing and to facilitate the development of roots.

3.5.5 Thinning

The thinning operations were carried out by removing weak and diseased plants and maintaining only one healthy and vigorous per hill.

3.5.6 Irrigation

Uniform soil moisture throughout the maintained in the field by regular irrigation as given below:

Irrigation	Date
First	29th November, 2021
Second	10th December, 2021
Third	19th December, 2021
Fourth	4th January, 2022
Fifth	18th January, 2022
Sixth	29th January, 2022
Seventh	10th February 2022
Eighth	20thFebruary

3.5.7 Weeding and intercultural operation

Three weeding were done by manual *i.e*. first after 15 days and second 30 days after germination.

3.5.8 Earthing up

At the time of weeding, the roots were covered with the loose soil for protecting from Sunrays.

3.5.9 Plant protection measures

Spray of insecticide chloropyrifos @ 2.5 ml/liter, dimethoate 1.5 ml/liter and imidacloprid @ 0.3 ml/liter of water was done for control of pests during crop growth period.

3.5.10 Harvesting

Harvesting of beetroot was done from 27 February to 28 March 2022. The roots were pulled out with the help of *Khurpi*. All precautions were taken while pulling out the beetroot to avoid damage. The soil was washed out from roots with fresh water.

3.6 Observations recorded

Observations were recorded at successive growth stages. The details of the observations recorded during the course of investigation are given below:

3.6.1 Growth parameter

(i) Plant height (cm) of plant

The plant height was measured from soil surface up to the tip of leaves with the help of measuring scale and average was worked out. Height of the five randomly selected and tagged plant was measured at 30, 45 and 60 days after sowing and at harvesting stage.

(ii) Number of leaves per plant

The number of leaves from five randomly selected plants of each plot was counted at 30, 45 and 60 days after sowing and at harvesting stage. The average was computed and expressed as number of leaves per plant.

(iii) Leaf area (cm^2)

Area of leaves of five-tagged plants was measured at harvesting stage with the help of leaf area meter and mean was calculated for each treatment. It was expressed in cm^2.

(iv) SPAD Value

SPAD value in leaves of five randomly selected plants was estimated by using instrument SPAD chlorophyll meter by simple damping the device over leaf tissue at 30, 45 and 60 days after sowing and at harvesting time.

(v) Fresh weight of plant (g)

Five plants were randomly selected from each plot were weighed at harvesting stage and their average was worked out and expressed as fresh weight of plant in gram.

(vi) Dry weight of plant (g)

After taking fresh weight plants were dried under sun for 2 days and then kept in hot air oven at 65±2°C temperature till constant weight. The weight of such dried plant was recorded at harvest.

3.6.2 Yield parameters

(i) Root length (cm)

The length of five randomly selected roots from each plot was measured by using meter scale at harvesting stage and the means were worked out and expressed in centimeter.

(ii) Root diameter (cm)

The diameter of five roots from each plot was measured by using vernier caliper at harvesting stage and the means were worked out and expressed in centimeter. The diameter was taken from middle portion of the root.

(iii) Root weight (g)

Five randomly selected roots were weighed at harvesting stage and their average was calculated and expressed in grams.

(iv) Root yield (q/ha)

After cutting the leaves, roots were weighed on digital balance and root yield per net plot was recorded in kilogram which was converted into quintal per hectare as given below:

$$\text{Root yield (q/ha)} = \frac{\text{Root yield (kg/plot)} \times 10{,}000}{\text{Net area of plot (m}^2\text{)} \times 100}$$

(v) Harvest Index (%)

The Harvest index was calculated by using the formula

$$\text{Harvest Index (\%)} = \frac{\text{Economical yield}}{\text{Biological yield}} \times 100$$

3.6.3 Quality parameters

(i)Total soluble solids (°Brix)

A piece of root of each tagged plant was crushed to form a homogenized sample and then the juice was extracted through muslin cloth. The extract was used for determination of T.S.S. in °brix by hand refractometer. Few drops of juice were placed on the surface of prism. The hinged part was placed back. The refractometer was then placed against the sun. The reading was noted by revolving the eyepiece at room temperature (A.O.A.C., 1970).

(ii) Root dry matter content (%)

The composite sample was drawn from root of each tagged plant and 50 g of sample was weighed and sun dried. The sun dried sample was put in an oven at 65±2°C temperature and dried till constant weight. Then dry matter content (%) was calculated as:

$$\text{Dry matter content (\%)} = \frac{\text{Weight of dry sample}}{\text{Weight of fresh sample}} \times 100$$

3.7 Economics of the Treatments

The cost of carrot per hectare under different treatments was calculated on the basis of expenditure incurred on different operations for growing the crop separately under each treatment. The treatment wise net income was worked out by deducting the cost of cultivation from gross income per hectare. The cost: benefit ratio was also calculated by dividing gross income with cost of cultivation.

3.8 Statistical analysis

The data obtained from set of observation for each character were subjected to “Analysis of Variance” as advocated by Panse and Sukhatme (1984). The Skeleton of ANOVA as per design is as given in Table 5.

The data have been presented in the form of summary tables with mean values of the characters and C.D. at 5% level of probability. All data have also been given as appendices.

Table 5: Skeleton of analysis of variance (ANOVA)

Source of Variation (S.V.)	Degree of freedom (df)	Sum of Square (SS)	Mean sum of Squares (MSS)	"F" value (Calculated) (F-cal)	"F" value (Table) at 5% level of significance (F-tab)
Replication(r)	(r-1) = 2	SSR	MSR	MSR/ MSE	3.37
Variety	(v-1) = 1	SSV	MSV	MSV/ MSE	4.23
Nutrient	(n-1) = 6	SSN	MSN	MSN/MSE	2.47
Interactions	(v-1)x(n-1) = 6	SSVN	MSVN	MSVN/MSE	2.47
Error	{total DF (r+v+rn)= 26	SSE	MSE		
Total	(vnr-1) = 41	SST			

The significance of the treatment difference was judged by using critical difference (C.D.), which was calculated by using formula given by Panse and Sukhatme (1984).

(i) Standard error of mean (SEm±)

$$\text{S.Em.}\pm\text{for V} = \sqrt{\frac{\text{EMS}}{\text{No. of replication X Level of N}}}$$

$$\text{S.Em.}\pm\text{ for N} = \sqrt{\frac{\text{EMS}}{\text{No. of replication X Level of varieties}}}$$

$$\text{S.Em.}\pm\text{ for VxN} = \sqrt{\frac{\text{EMS}}{\text{No. of replication}}}$$

Critical difference (CD)

(a) CD for V = S.Em± (V) x $\sqrt{2}$ x $t_{5\% \ (edf)}$

(a) CD for V = S.Em± (N) x $\sqrt{2}$ x $t_{5\% \ (edf)}$

(a) CD for V = S.Em± (VxN) x $\sqrt{2}$ x $t_{5\% \ (edf)}$

Where,

EMS	= Error mean sum of squares
R	= Replications
$t_{5\% \ (edf)}$	= Table value at error degree of freedom
V	= Variety
N	= Nutrient levels
S.Em. ±	= Standard error of mean
CD	= Critical differences

Plate 1:- Panoramic view of the experimental field of beetroot

Chapter-IV

RESULTS

In order to accomplish the objectives of the present investigation, the experiment entitled "Effect of varieties, organic manures and inorganic fertilizers on growth, yield and quality of beetroot (*Beta vulgaris* L.)" was conducted during the *Rabi* season, 2021-22 at the Vegetable Research Block, Bahadari Farm, College of Horticulture, Mandsaur (M.P.). The observations recorded on the growth, yield and quality parameters of beetroot during the investigation were statistically analyzed. The results obtained from the experiment are being described with the help of tables and graphs based on the mean values in this chapter under following headings.

4.1 Growth Parameter

The data of growth attributes of beetroot viz. plant height, number of leaves per plant, leaf area (cm^2) SPAD value, fresh weight of plant and dry weight of plant were recorded at different stages of growth, are presented as follows:

4.1.1 Plant height (cm)

Plant height was recorded at 30, 45, 60 DAS and at last harvesting stage. The findings on plant height (cm) as significantly influenced by varieties and nutrient sources are presented in Table 6 and Fig. 3. Interaction effect of varieties and nutrient sources was found non significant on plant height at all the growth stages.

The data depicted significant effect of varieties on plant height of beetroot at all the growth stages. Maximum plant height i.e. 14.07, 25.67, 40.12 and 43.07cm was found with variety V_1 (Crimson Globe) at 30, 45, 60 DAS and final harvesting stage, respectively. Lowest plant height i.e.12.25, 23.57, 36.51 and 40.92 cm was recorded in case of V_2 (Detroit Dark Red) at 30, 45, 60 DAS and final harvesting stage, respectively.

Nutrient sources had significant influence on plant height (cm) of beetroot. Maximum plant height i.e. 15.64, 29.23, 42.82 and 46.40 cm was recorded with nutrient source N_7 (50% RDF + 50% N through vermicompost)

Table 6: Effect of varieties, nutrient sources and their Interaction on plant height (cm) of beetroot

Treatment	Plant height (cm)			
	30 DAS	**45 DAS**	**60 DAS**	**At Harvest**
Varieties (V)				
V_1 (Crimson Globe)	14.07	25.67	40.12	43.07
V_2 (Detroit Dark Red)	12.25	23.57	36.51	40.92
SEm±	**0.17**	**0.40**	**0.51**	**0.63**
CD at 5 %	**0.48**	**1.17**	**1.48**	**1.82**
Nutrient sources(N)				
N_1	12.26	22.98	37.42	41.21
N_2	11.36	21.18	33.93	37.32
N_3	11.69	22.56	36.28	40.22
N_4	12.96	24.22	38.49	41.81
N_5	13.72	24.87	39.00	42.49
N_6	14.47	27.33	40.24	44.53
N_7	15.64	29.23	42.82	46.40
SEm±	**0.31**	**0.76**	**0.95**	**1.17**
CD at 5 %	**0.91**	**2.20**	**2.77**	**3.40**
Interaction (VxN)				
V_1N_1	13.11	23.88	39.62	42.55
V_1N_2	12.42	22.57	35.73	38.32
V_1N_3	12.29	23.36	38.27	41.03
V_1N_4	14.03	24.47	40.30	43.16
V_1N_5	14.79	25.25	40.95	43.57
V_1N_6	15.52	29.59	41.68	45.44
V_1N_7	16.33	30.59	44.26	47.40
V_2N_1	11.42	22.07	35.23	39.87
V_2N_2	10.30	19.78	32.13	36.31
V_2N_3	11.09	21.75	34.29	39.40
V_2N_4	11.89	23.97	36.68	40.46
V_2N_5	12.65	24.49	37.05	41.41
V_2N_6	13.42	25.07	38.79	43.63
V_2N_7	14.95	27.87	41.37	45.39
SEm±	**0.44**	**1.07**	**1.35**	**1.66**
CD at 5 %	**NS**	**NS**	**NS**	**NS**

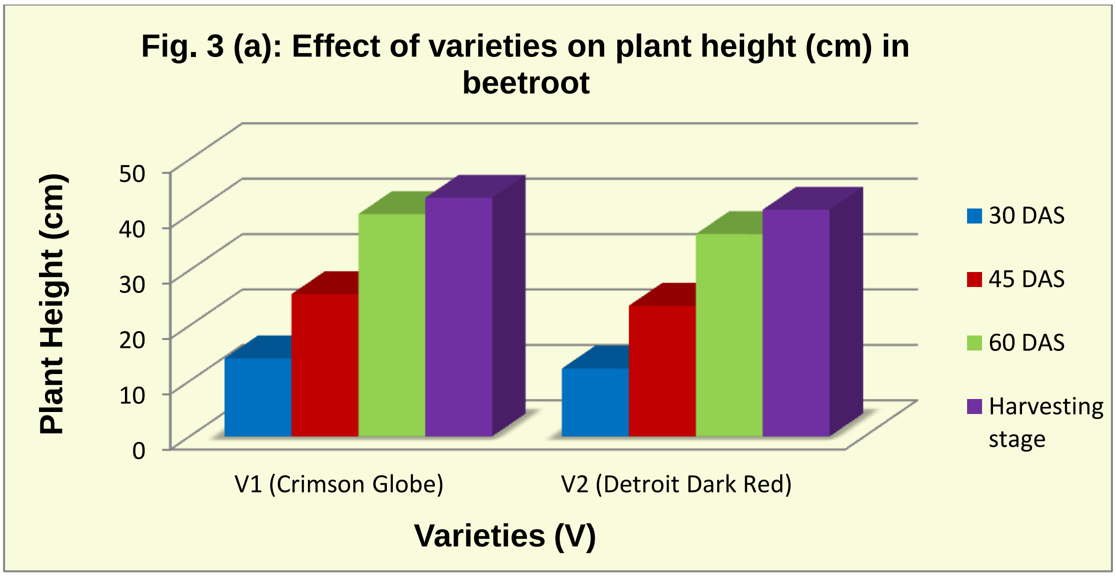
Fig. 3 (a): Effect of varieties on plant height (cm) in beetroot
Plant Height (cm)
50
40
30
20
10
0
V1 (Crimson Globe)
V2 (Detroit Dark Red)
Varieties (V)
30 DAS
45 DAS
60 DAS
Harvesting stage

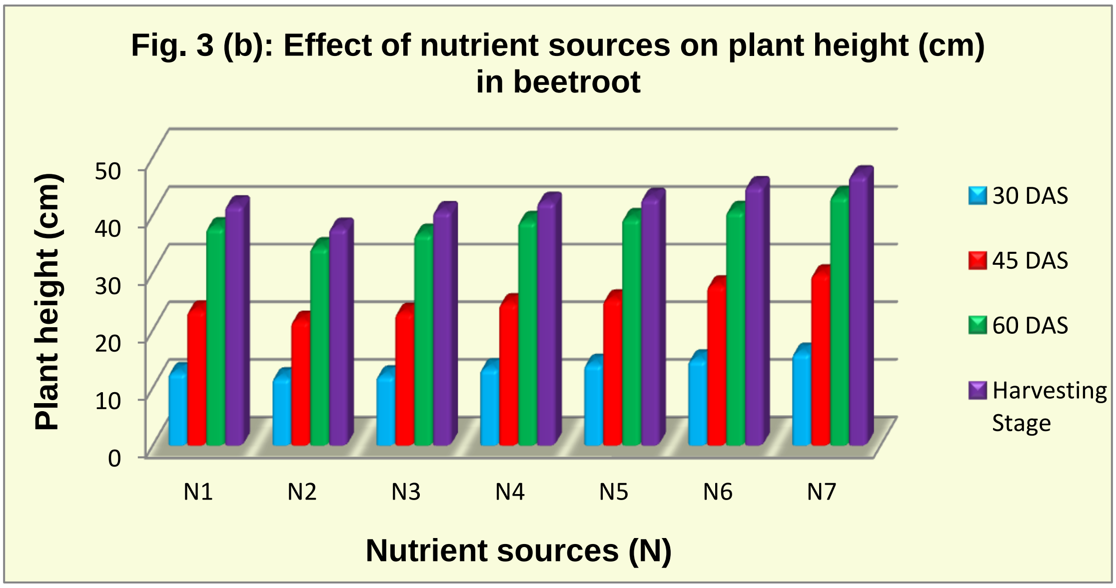
Fig. 3 (b): Effect of nutrient sources on plant height (cm) in beetroot
Plant height (cm)
50
40
30
20
10
0
N1
N2
N3
N4
N5
N6
N7
Nutrient sources (N)
30 DAS
45 DAS
60 DAS
Harvesting Stage

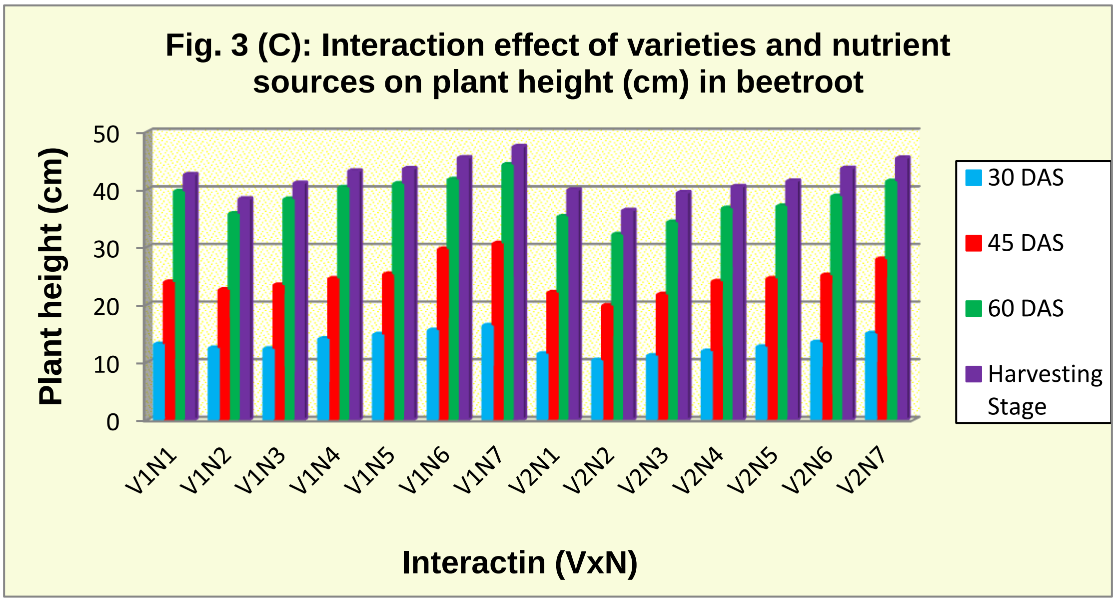
Fig. 3 (C): Interaction effect of varieties and nutrient sources on plant height (cm) in beetroot
Plant height (cm)
50
40
30
20
10
0
V1N1
V1N2
V1N3
V1N4
V1N5
V1N6
V1N7
V2N1
V2N2
V2N3
V2N4
V2N5
V2N6
V2N7
Interactin (VxN)
30 DAS
45 DAS
60 DAS
Harvesting Stage

followed by N_6, N_5, N_4, N_1 and N_3 in descending order at all the growth stages. Lowest plant height *i.e.*11.36, 21.18, 33.93 and 37.32 cm was observed in case of nutrient level N_2 (100% N through FYM) at all growth stages.

Combined effect of varieties and nutrient sources had non significant influence on plant height at 30, 45, 60 DAS and final harvesting stage.

4.1.2 Number of leaves per plant

Number of leaves per plant was recorded at 30, 45, 60 DAS and at harvesting stage. The data presented in Table 8 and Fig. 4 showed significant effect of varieties and nutrient sources on number of leaves per plant at all the growth stage in beetroot.

Varieties had significant effect on number of leaves per plant at all the four stages of growth. Maximum number of leaves per plant i.e. 7.21, 10.67, 13.74 and 17.52 was counted in case of variety V_1 (Crimson Globe) at 30, 45, 60 DAS and at harvesting stage, respectively. Minimum number of leaves per plant i.e. 5.31, 8.51, 12.09 and 15.39 was found in variety V_2 (Detroit Dark Red) at 30, 45, 60 DAS and at harvesting stage, respectively.

Nutrient sources had also significant effect on number of leaves at all the growth stages. Highest number of leaves per plant i.e. 7.41, 11.50, 15.58 and 18.76 was found under nutrient source N_7 (50% RDF + 50% N through vermicompost) at 30, 45, 60 DAS and final harvesting stage, respectively. It was followed by nutrient sources $N_6>N_5>N_4>N_1>N_3$ and N_2 in descending order. Lowest number of leaves per plant i.e. 5.65, 8.60, 11.25 and 13.51 were counted under nutrient source N_2 (100% N through FYM) at 30, 45, 60 DAS and at last harvesting stage, respectively.

Combined effect of varieties and nutrient sources had non significant effect on number of leaves per plant at all the growth stages in beetroot.

Table 7: Effect of varieties, nutrient sources and their interaction on number of leaves per plant in beetroot

Treatment	Number of leaves per plant			
	30 DAS	**45 DAS**	**60 DAS**	**At Harvest**
Varieties (V)				
V_1 (Crimson Globe)	7.21	10.67	13.74	17.52
V_2 (Detroit Dark Red)	5.31	8.51	12.09	15.39
SEm±	**0.12**	**0.24**	**0.38**	**0.24**
CD at 5%	**0.36**	**0.70**	**1.10**	**0.71**
Nutrient sources (N)				
N_1	6.11	9.08	12.10	16.04
N_2	5.65	8.60	11.25	13.51
N_3	5.79	8.72	11.71	14.84
N_4	6.19	9.37	12.56	16.68
N_5	6.25	9.75	12.80	17.39
N_6	6.41	10.12	14.41	17.97
N_7	7.41	11.50	15.58	18.76
SEm±	**0.23**	**0.45**	**0.71**	**0.46**
CD at 5%	**0.67**	**1.31**	**2.05**	**1.32**
Interaction (V x N)				
V_1N_1	7.14	10.10	12.83	17.55
V_1N_2	6.47	9.53	12.36	14.20
V_1N_3	6.66	9.67	12.50	15.90
V_1N_4	7.22	10.53	13.33	17.75
V_1N_5	7.27	11.04	13.43	18.44
V_1N_6	7.30	11.38	15.53	19.15
V_1N_7	8.39	12.46	16.23	19.63
V_2N_1	5.07	8.05	11.37	14.54
V_2N_2	4.82	7.67	10.13	12.82
V_2N_3	4.92	7.78	10.93	13.78
V_2N_4	5.16	8.21	11.80	15.60
V_2N_5	5.23	8.45	12.16	16.33
V_2N_6	5.53	8.85	13.30	16.79
V_2N_7	6.42	10.53	14.92	17.89
SEm±	**0.32**	**0.64**	**1.00**	**0.64**
CD at 5%	**NS**	**NS**	**NS**	**NS**

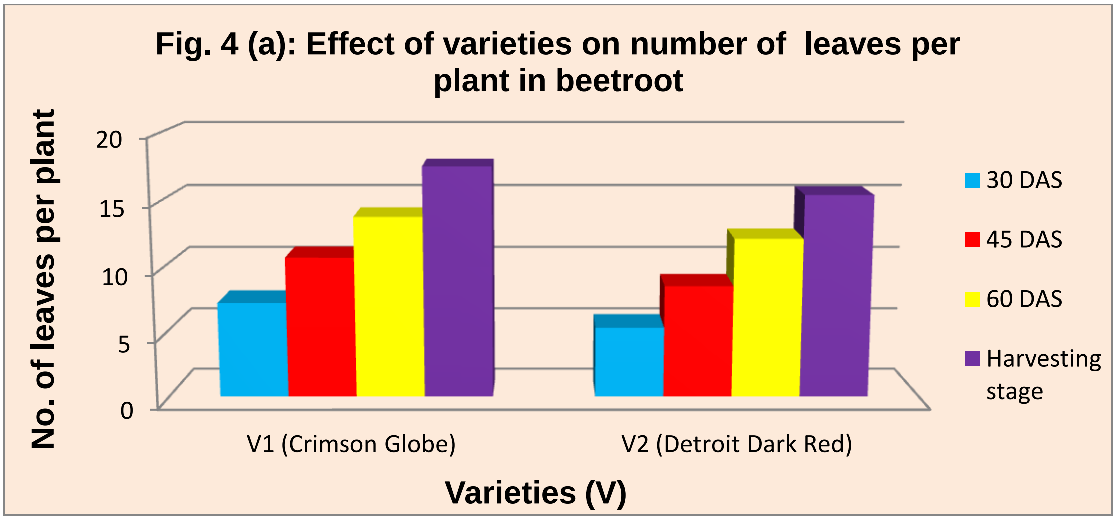
Fig. 4 (a): Effect of varieties on number of leaves per plant in beetroot
No. of leaves per plant
20
15
10
5
0
V1 (Crimson Globe)
V2 (Detroit Dark Red)
Varieties (V)
30 DAS
45 DAS
60 DAS
Harvesting stage

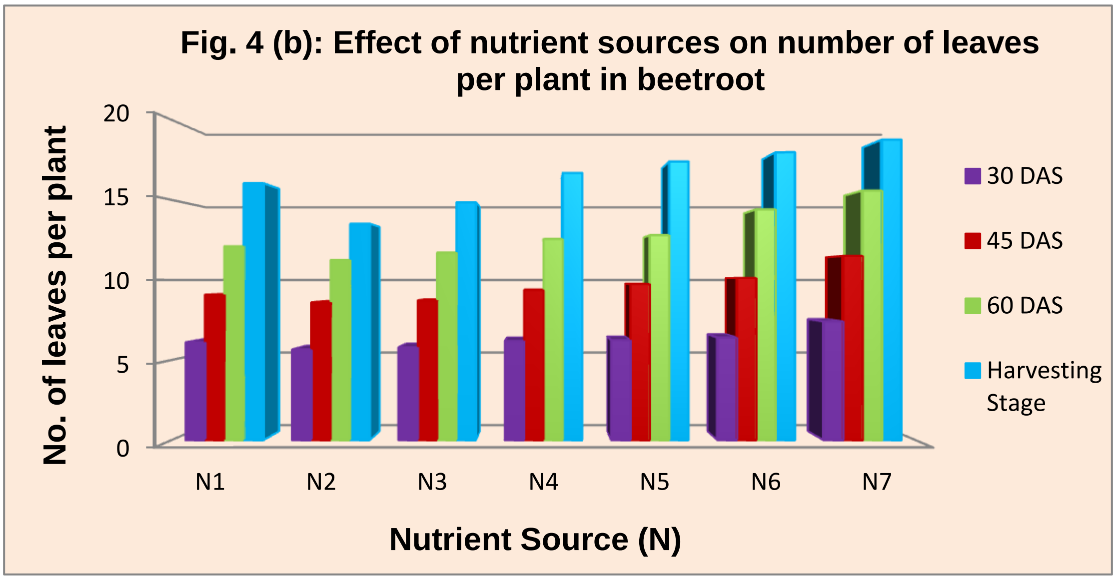
Fig. 4 (b): Effect of nutrient sources on number of leaves per plant in beetroot
No. of leaves per plant
20
15
10
5
0
N1
N2
N3
N4
N5
N6
N7
Nutrient Source (N)
30 DAS
45 DAS
60 DAS
Harvesting Stage

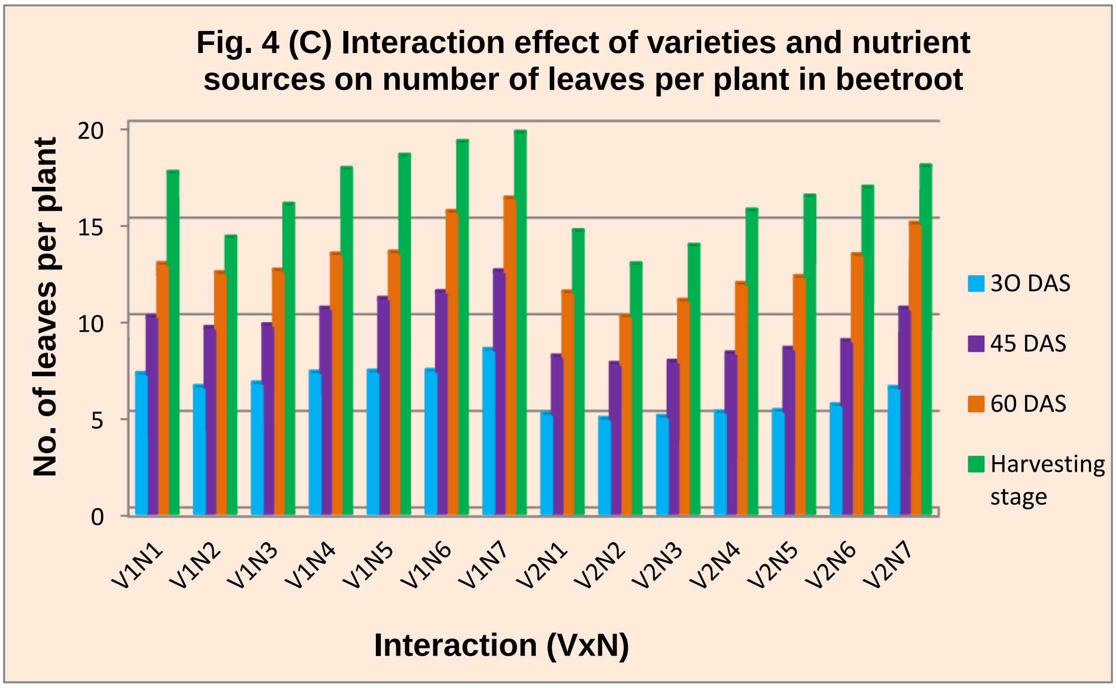
Fig. 4 (C) Interaction effect of varieties and nutrient sources on number of leaves per plant in beetroot
No. of leaves per plant
20
15
10
5
0
V1N1
V1N2
V1N3
V1N4
V1N5
V1N6
V1N7
V2N1
V2N2
V2N3
V2N4
V2N5
V2N6
V2N7
Interaction (VxN)
3O DAS
45 DAS
60 DAS
Harvesting stage

4.1.3 Leaf area (cm^2)

The results on leaf area (cm^2) as influenced with varieties and nutrient sources are presented in Table 9 and Fig.6. Leaf area was recorded at 30, 45 60 DAS and final harvesting stage, exhibited significant effect of varieties and nutrient levels. The combined impact of varieties and nutrient sources was found non significant on leaf area (cm^2) of beetroot.

Variety V_1 (Crimson Globe) had recorded maximum leaf area (706.95 cm^2) was found with variety V_1 (Crimson Globe) at the final harvesting stages of beetroot, respectively. Minimum leaf area (655.34 cm^2) was recorded with variety V_2 (Detroit Dark Red) at final harvesting stage.

Application of nutrient sources showed significant influence on leaf area per plant. Nutrient level treatment N_7 (50% RDF + 50% N through vermicompost) recorded maximum leaf area per plant (798.22 cm^2). It was followed by N_6, N_5, N_4, N_1, N_3 and N_2 at all the growth stages. Application of N_2 (100 % N through FYM) nutrient level treatment was found minimum leaf area per plant (592.94 cm^2) at all the growth stages.

Combined effect of varieties and nutrient sources showed non significant influence on leaf area per plant at all the growth stages.

Table 8: Effect of varieties, nutrient sources and their Interaction on leaf area (cm^2) of beetroot

Varieties (V)	Leaf area (cm^2)							
	Nutrients sources (N)							MEAN
	N_1	N_2	N_3	N_4	N_5	N_6	N_7	
V_1	652.75	609.56	627.38	682.72	723.49	799.78	850.46	**706.59**
V_2	586.98	576.31	611.13	636.28	703.96	726.70	745.99	**655.34**
MEAN	**619.87**	**592.94**	**619.26**	**659.50**	**713.73**	**763.24**	**798.22**	

Treatment	Varieties (V)	Nutrient sources (N)	Interaction (VxN)
SEm±	16.69	31.22	44.15
CD at 5%	48.51	90.75	NS

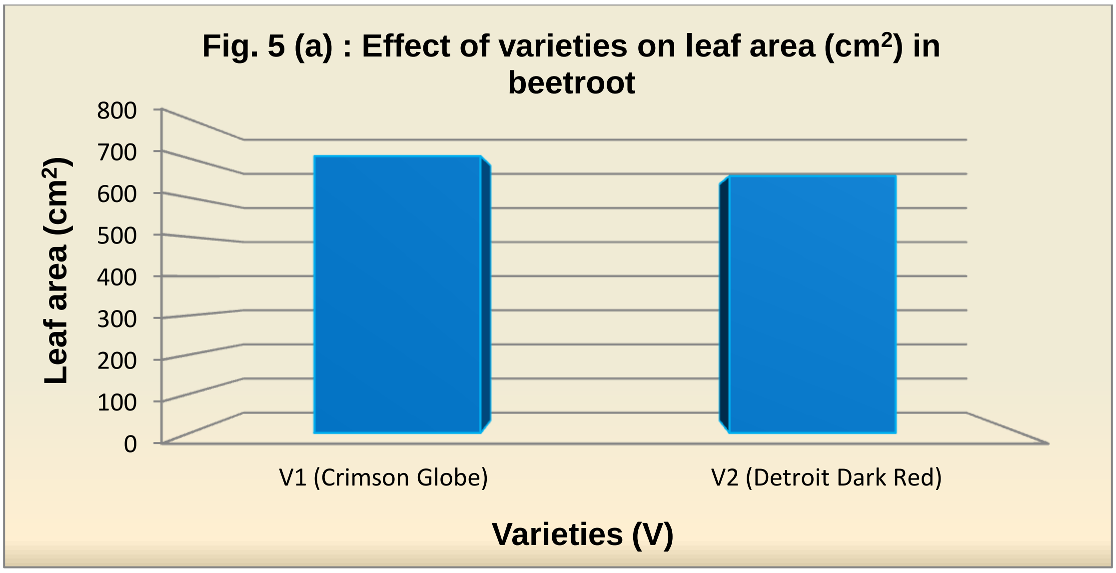

Fig. 5 (a) : Effect of varieties on leaf area (cm²) in beetroot
800
700
600
500
400
300
200
100
0
Leaf area (cm²)
V1 (Crimson Globe)
V2 (Detroit Dark Red)
Varieties (V)

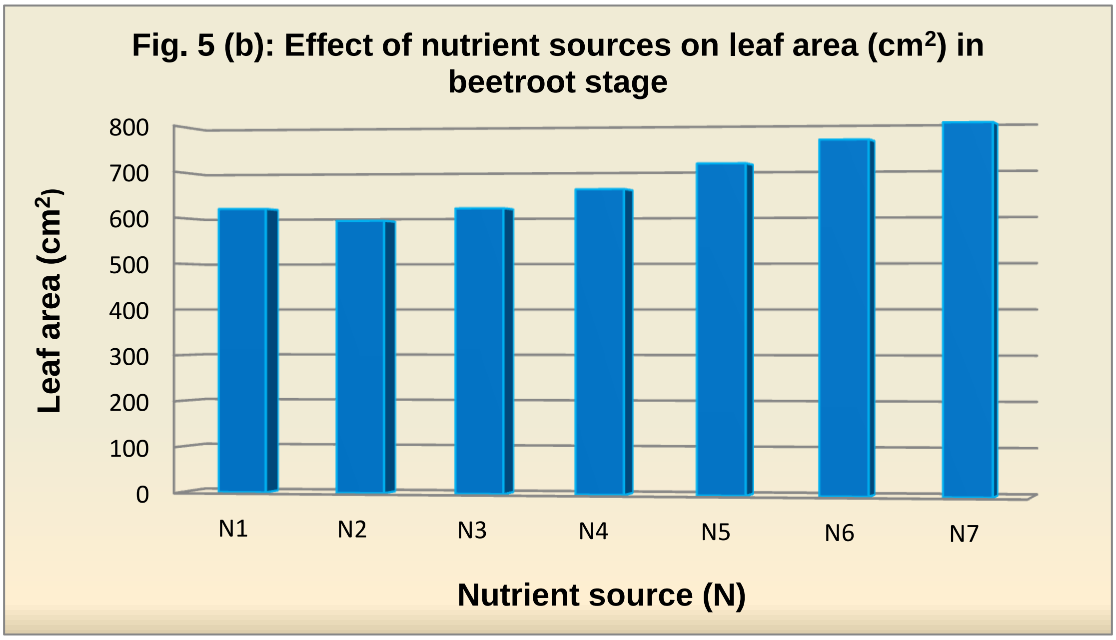

Fig. 5 (b): Effect of nutrient sources on leaf area (cm²) in beetroot stage
800
700
600
500
400
300
200
100
0
Leaf area (cm²)
N1
N2
N3
N4
N5
N6
N7
Nutrient source (N)

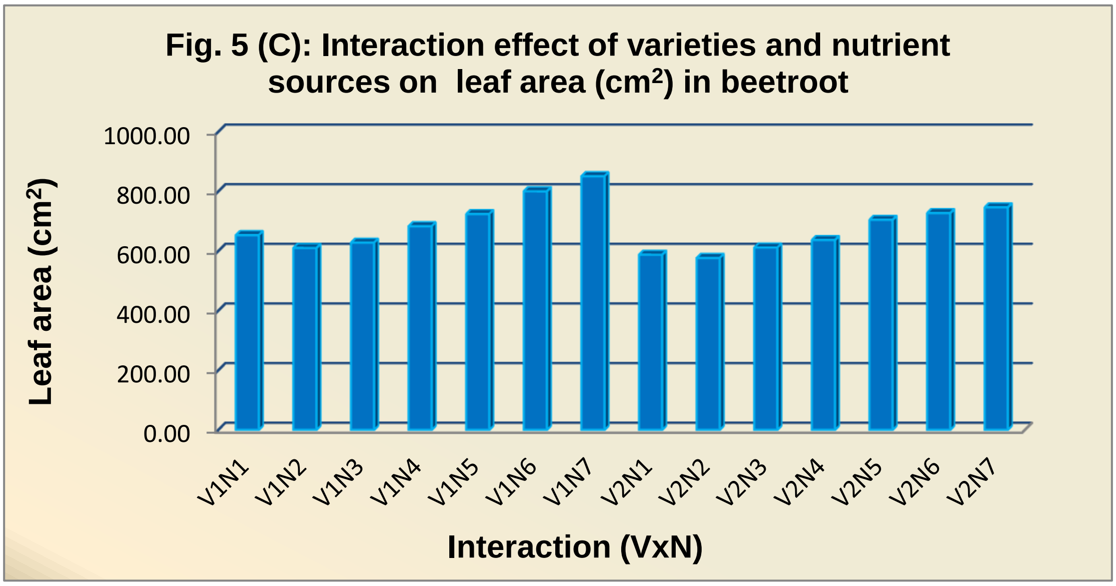

Fig. 5 (C): Interaction effect of varieties and nutrient sources on leaf area (cm²) in beetroot
1000.00
800.00
600.00
400.00
200.00
0.00
Leaf area (cm²)
V1N1
V1N2
V1N3
V1N4
V1N5
V1N6
V1N7
V2N1
V2N2
V2N3
V2N4
V2N5
V2N6
V2N7
Interaction (VxN)

4.1.4 SPAD value

The SPAD value in leaves of beetroot was evaluated at 30, 45 60 DAS and final harvesting stage. The analysis of data presented in Table 8 and Fig. 5 showed that varieties and nutrient sources had a significant effect on SPAD value at all the growth stages. The combined impact of varieties and nutrient sources was found non significant on SPAD value of beetroot.

Maximum SPAD value i.e. 45.54, 46.92, 53.10 and 54.80 was found with variety V_1 (Crimson Globe) at all the four growth stages i.e. 30, 45, 60 DAS and at final harvesting stage of beetroot, respectively. Minimum SPAD value i.e. 43.64, 48.28, 51.07 and 52.74 was noted with variety V_2 (Detroit Dark Red) at 30, 45, 60 DAS and final harvesting stage, respectively.

Application of nutrient sources showed significant influence on SPAD value of plant at all the growth stages. Nutrient source treatment N_7 (50% RDF + 50% N through vermicompost) recorded supreme SPAD value i.e. 47.38, 50.96, 53.49 and 56.38. It was followed by N_6, N_5, N_4, N_1, N_3 and N_2 in descending order at all the growth stages. Application of nutrient source treatment N_2 (100 % N through FYM) was found minimum SPAD value of plant i.e. 42.41, 45.31, 50.65 and 50.71 at all the growth stages, respectively.

Combined effect of varieties and nutrient sources showed non significant influence on SPAD value of plant at all the growth stages. However, numerically among the treatment combination V_1N_7 has maximum SPAD value of plant i.e. 48.13, 51.53, 54.55 and 57.49 at 30, 45, 60 DAS and final harvesting stage, respectively.

Table 9: Effect of varieties, nutrient sources and their Interaction on SPAD value of beetroot

Treatment	SPAD Value			
	30 DAS	45 DAS	60 DAS	At Harvest
Varieties (V)				
V_1 (Crimson Globe)	45.54	46.92	53.10	54.80
V_2 (Detroit Dark Red)	43.64	48.28	51.07	52.74
SEm±	**0.51**	**0.42**	**0.57**	**0.61**
CD at 5%	**1.48**	**1.23**	**1.66**	**1.76**
Nutrient sources (N)				
N_1	44.18	46.68	51.54	53.25
N_2	42.41	45.31	50.65	50.71
N_3	43.62	46.33	50.55	53.25
N_4	44.46	47.32	52.35	53.87
N_5	44.64	47.93	52.71	54.13
N_6	45.43	48.69	53.33	54.82
N_7	47.38	50.96	53.49	56.38
SEm±	**0.95**	**0.79**	**1.07**	**1.13**
CD at 5%	**2.77**	**2.31**	**3.11**	**3.29**
Interaction (V x N)				
V_1N_1	45.48	45.29	52.08	53.96
V_1N_2	43.24	43.91	49.42	51.02
V_1N_3	44.75	44.65	50.65	53.40
V_1N_4	45.33	46.35	52.94	54.73
V_1N_5	45.49	47.38	53.48	54.97
V_1N_6	46.38	48.56	53.62	55.67
V_1N_7	48.13	51.53	54.55	57.49
V_2N_1	42.87	48.08	49.82	51.43
V_2N_2	41.58	46.71	48.03	50.35
V_2N_3	42.50	48.01	49.07	51.20
V_2N_4	43.60	48.28	50.89	51.81
V_2N_5	43.79	48.47	51.08	52.63
V_2N_6	44.49	48.82	52.17	53.97
V_2N_7	46.63	49.30	52.92	55.27
SEm±	**1.35**	**1.12**	**1.51**	**1.60**
CD at 5%	**NS**	**NS**	**NS**	**NS**

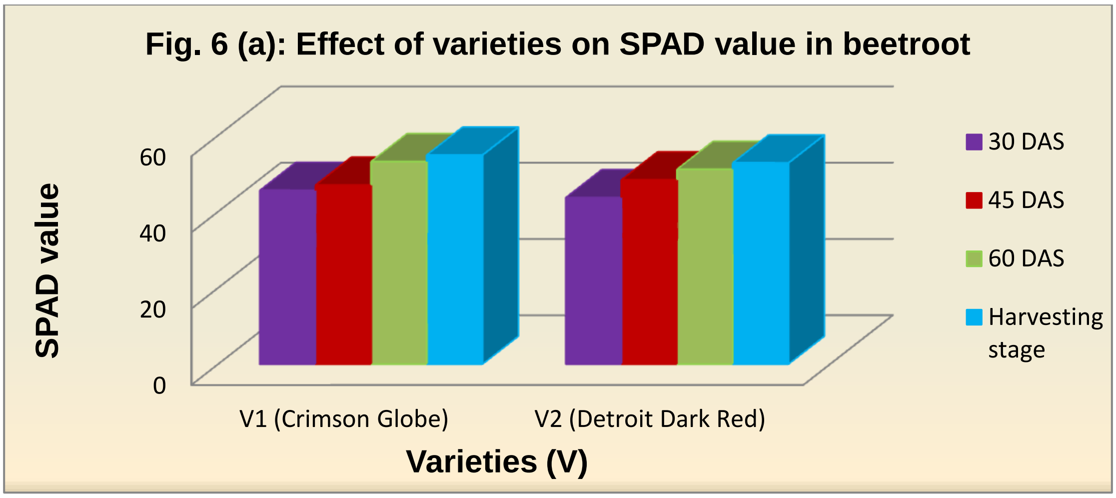
Fig. 6 (a): Effect of varieties on SPAD value in beetroot
SPAD value
60
40
20
0
V1 (Crimson Globe)
V2 (Detroit Dark Red)
Varieties (V)
30 DAS
45 DAS
60 DAS
Harvesting stage

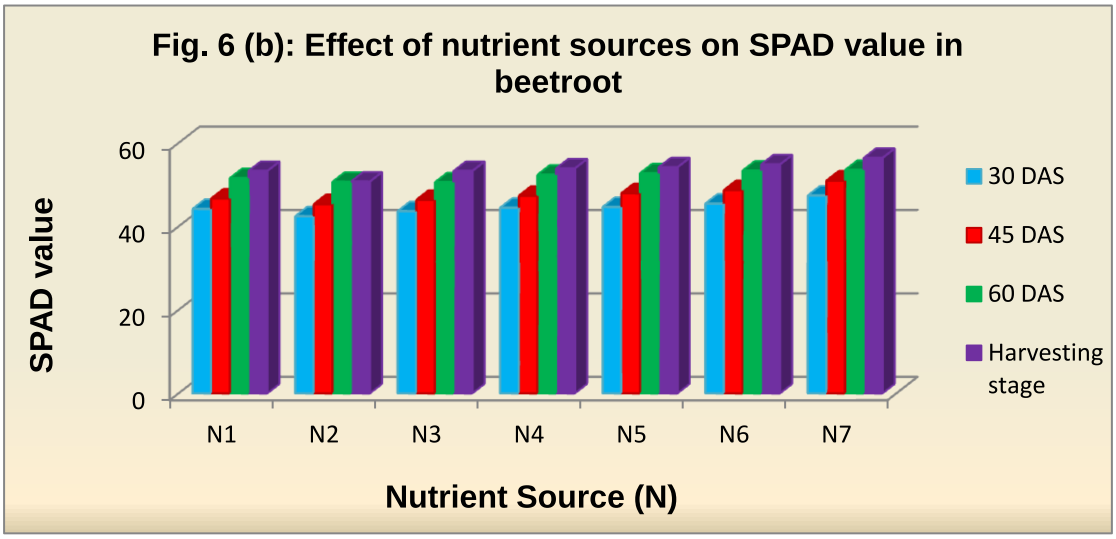
Fig. 6 (b): Effect of nutrient sources on SPAD value in beetroot
SPAD value
60
40
20
0
N1
N2
N3
N4
N5
N6
N7
Nutrient Source (N)
30 DAS
45 DAS
60 DAS
Harvesting stage

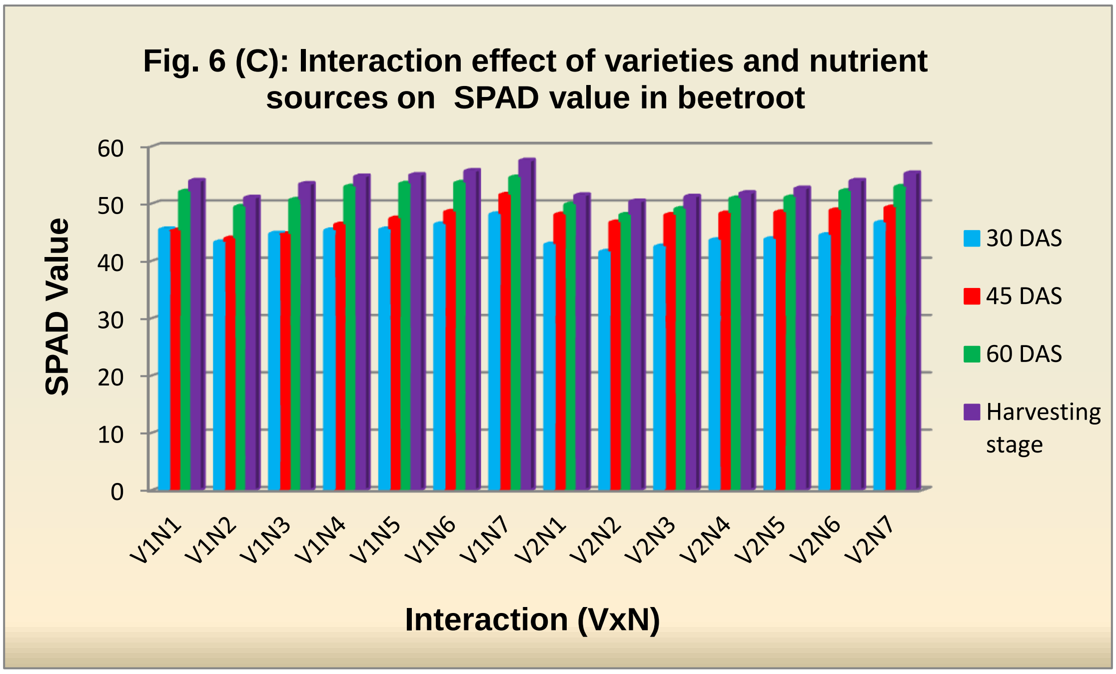
Fig. 6 (C): Interaction effect of varieties and nutrient sources on SPAD value in beetroot
SPAD Value
60
50
40
30
20
10
0
V1N1
V1N2
V1N3
V1N4
V1N5
V1N6
V1N7
V2N1
V2N2
V2N3
V2N4
V2N5
V2N6
V2N7
Interaction (VxN)
30 DAS
45 DAS
60 DAS
Harvesting stage

4.1.5 Fresh weight of plant (g/plant)

Table 10 and Fig. 7 showed the results for fresh weight of plant (kg) as impacted by varieties and nutrient sources. The fresh weight of the plant at the harvesting stage indicated a significant influence of varieties and nutrient sources in beetroot.

The results showed that varieties had a positive influence on the fresh weight of the plant. Maximum fresh weight of plant (303.64 g) was found with variety V_1 (Crimson Globe) after harvesting of beetroot. Minimum fresh weight of plant (297.51 g) was recorded with variety V_2 (Detroit Dark Red) at final harvesting stage.

Application of nutrient sources showed significant influence on fresh weight of plant after harvesting. Nutrient source treatment N_7 (50% RDF + 50% N through vermicompost) was recorded maximum fresh weight of plant (315.82 g). It was followed by N_6, N_5, N_4, N_1 and N_3 in descending order. Application of nutrient source treatment N_2 (100 % N through FYM) was observed minimum fresh weight of plant (289.93 g) at all the growth stages.

Combined effect of varieties and nutrient sources showed non significant influence on fresh weight of plant at harvesting stage of beetroot.

Table 10: Effect of varieties, nutrient sources and their interaction on fresh weight plant (g) of beetroot

Varieties (V)	Fresh Weight of plant (g)							
	Nutrients sources (N)							MEAN
	N_1	N_2	N_3	N_4	N_5	N_6	N_7	
V_1	299.16	290.82	293.04	304.99	308.79	310.42	318.27	**303.64**
V_2	292.43	289.03	292.24	295.93	298.86	300.74	313.38	**297.51**
MEAN	**295.80**	**289.93**	**292.64**	**300.46**	**303.83**	**305.58**	**315.82**	

Treatment	Varieties (V)	Nutrient sources (N)	Interaction (VxN)
SEm±	2.01	3.76	5.32
CD at 5%	5.85	10.94	NS

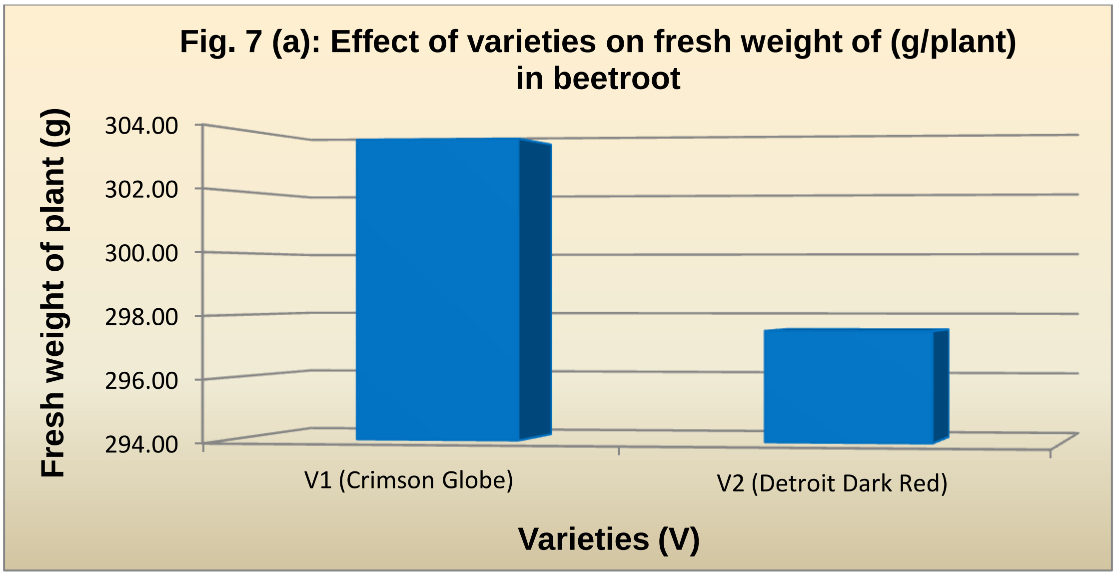

Fig. 7 (a): Effect of varieties on fresh weight of (g/plant) in beetroot

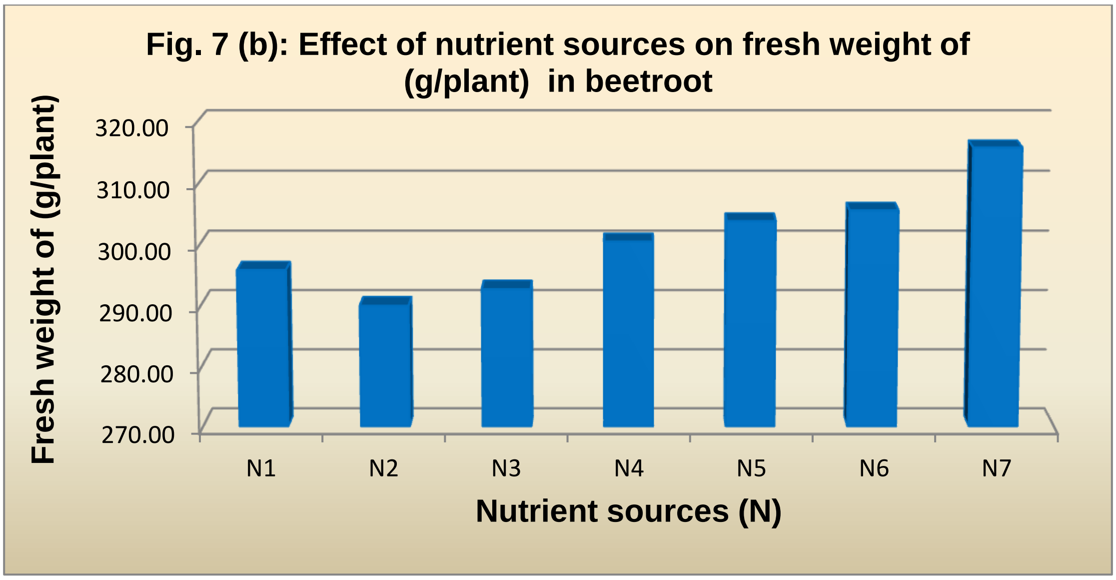

Fig. 7 (b): Effect of nutrient sources on fresh weight of (g/plant) in beetroot

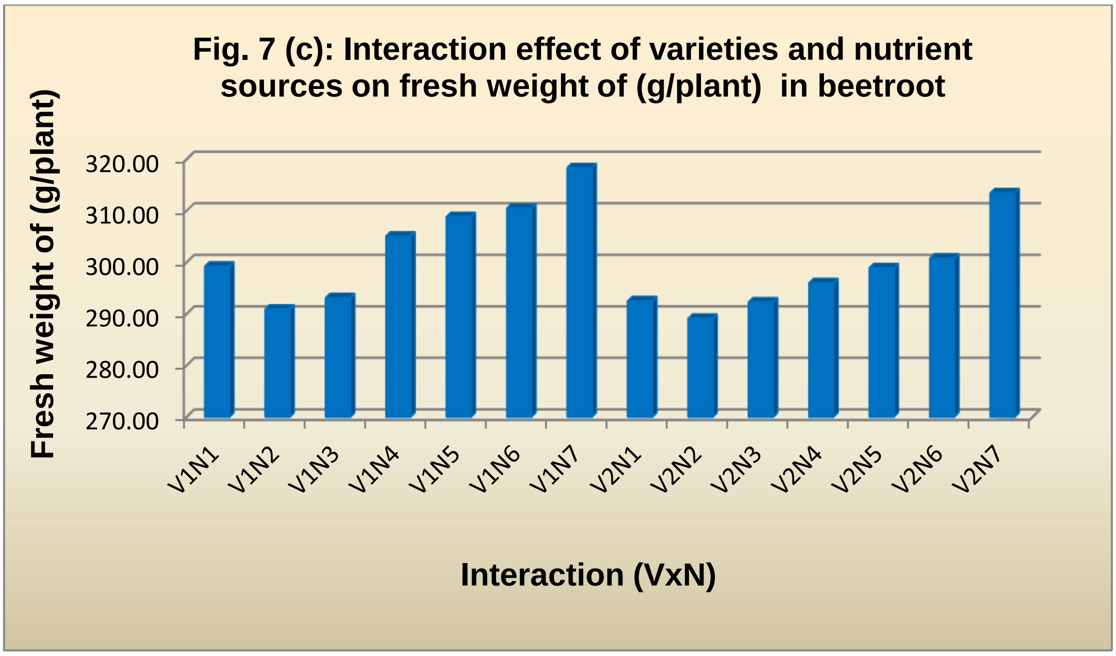

Fig. 7 (c): Interaction effect of varieties and nutrient sources on fresh weight of (g/plant) in beetroot

4.1.6 Dry weight of plant (g)

Dry weight of plant recorded at final harvesting stage. Study of data presented in Table 11 and Fig. 8 exhibited significant effect of varieties and nutrient sources on dry weight of plant at the harvesting stages.

The results indicated that varieties had a significant influence on the dry weight of the plant (g) after harvesting. The data obtained from trial revealed that variety V_1 (Crimson Globe) had registered maximum dry weight of plant (51.32 g) after harvesting. Minimum dry weight of plant (49.68 g) was recorded in case of variety V_2 (Detroit Dark Red) after harvesting.

Application of nutrient sources showed significant influence on dry weight of plant after harvesting in beetroot. Nutrient source treatment N_7 (50% RDF + 50% N through vermicompost) was registered maximum dry weight of plant (55.17 g) after harvesting. It was followed by N_6, N_5, N_4, N_1, N_3 and N_2. Application of nutrient source treatment N_2 (100 % N through FYM) was observed minimum dry weight of plant (46.86 g) after harvesting.

Combined effect of varieties and nutrient sources showed non significant influence on dry weight of plant of beetroot.

Table 11: Effect of varieties, nutrient sources and their interaction on dry weight of plant (g) of beetroot

Varieties (V)	Dry Weight of plant (g)							
	Nutrients sources (S)							MEAN
	N_1	N_2	N_3	N_4	N_5	N_6	N_7	
V_1	49.70	47.94	48.50	50.98	52.41	53.49	56.20	**51.32**
V_2	48.07	45.79	47.62	49.24	50.62	52.30	54.15	**49.68**
MEAN	**48.88**	**46.86**	**48.06**	**50.11**	**51.51**	**52.90**	**55.17**	

Treatment	Varieties (V)	Nutrient sources (N)	Interaction (VxN)
SEm±	0.56	1.05	1.49
CD at 5%	1.63	3.05	NS

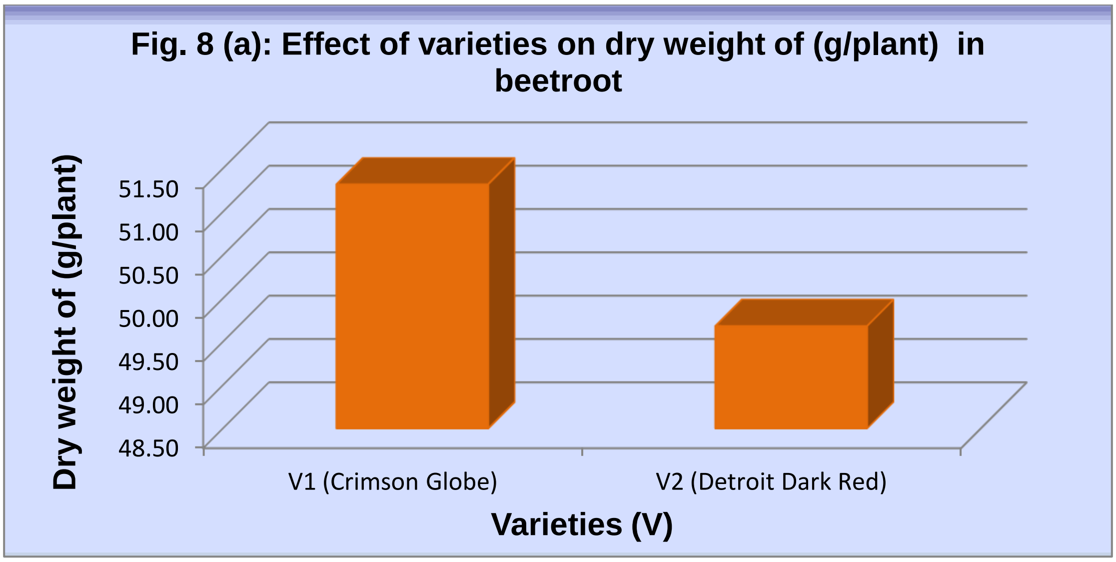
Fig. 8 (a): Effect of varieties on dry weight of (g/plant) in beetroot
Dry weight of (g/plant)
51.50
51.00
50.50
50.00
49.50
49.00
48.50
V1 (Crimson Globe)
V2 (Detroit Dark Red)
Varieties (V)

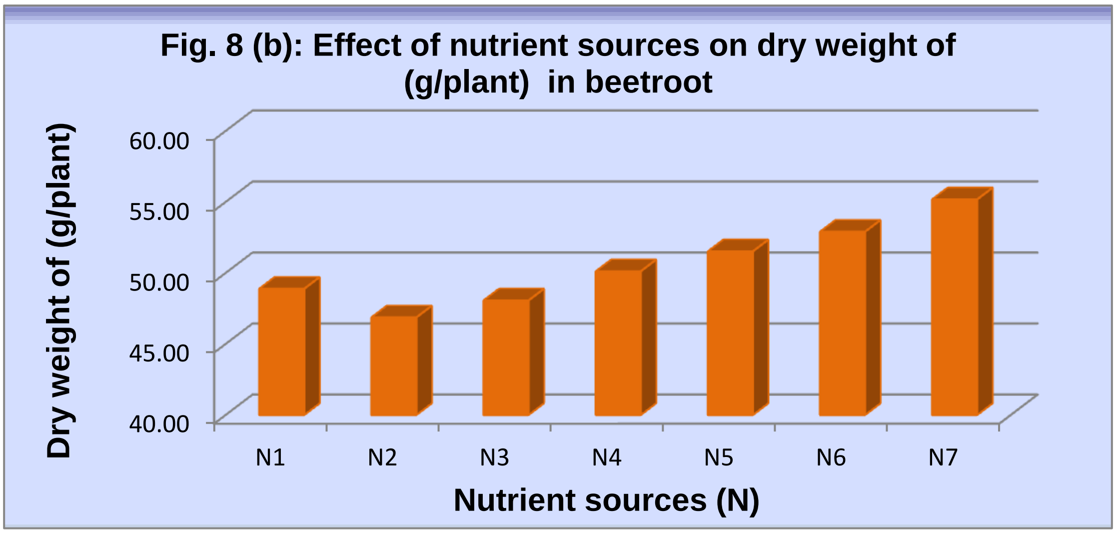
Fig. 8 (b): Effect of nutrient sources on dry weight of (g/plant) in beetroot
Dry weight of (g/plant)
60.00
55.00
50.00
45.00
40.00
N1
N2
N3
N4
N5
N6
N7
Nutrient sources (N)

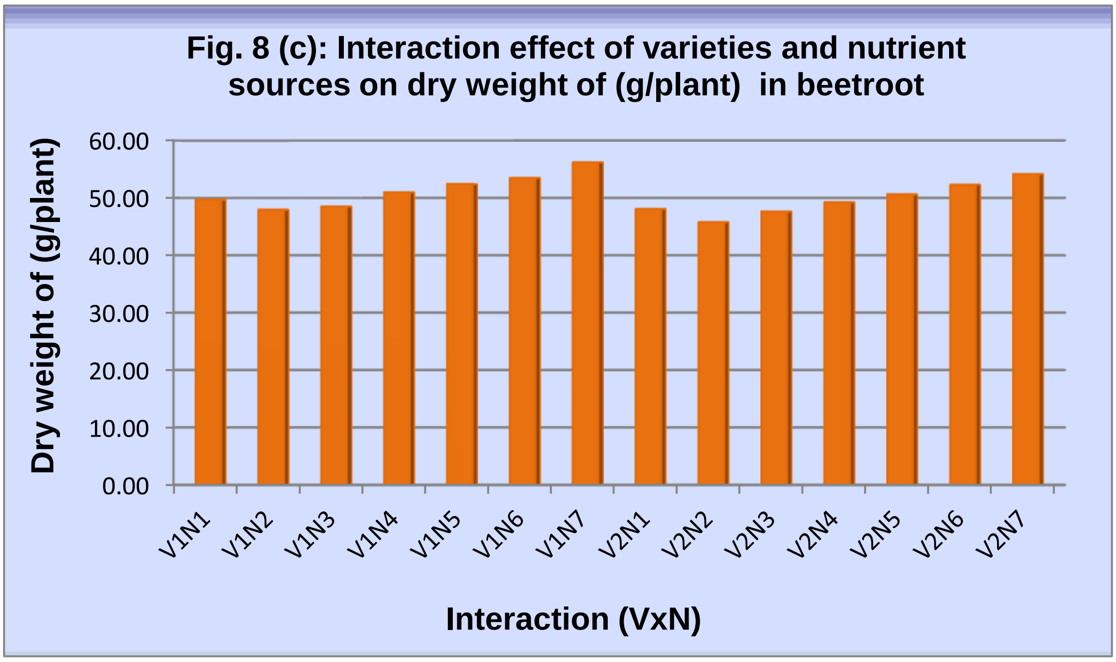
Fig. 8 (c): Interaction effect of varieties and nutrient sources on dry weight of (g/plant) in beetroot
Dry weight of (g/plant)
60.00
50.00
40.00
30.00
20.00
10.00
0.00
V1N1
V1N2
V1N3
V1N4
V1N5
V1N6
V1N7
V2N1
V2N2
V2N3
V2N4
V2N5
V2N6
V2N7
Interaction (VxN)

4.2 Yield attributes

4.2.1 Root length (cm)

The data expressed in Table 12 and represent in Fig. 9 denoted significant effect of varieties and nutrient sources on root length of beetroot.

The maximum root length (8.24 cm) was admeasured with variety V_1 (Crimson Globe), as compared to minimum root length (7.50 cm) was measured in case of variety V_2 (Detroit Dark Red).

Application of nutrient sources exhibited positive effect on root length. Maximum root length (9.15 cm) was recorded with nutrient source treatment N_7 (50% RDF + 50% N through vermicompost) which is significantly excellence over all other nutrient sources. It was followed by N_6, N_5, N_4, N_1, N_3 and N_2 i.e. 8.58, 8.27, 7.79, 7.32, 7.14 and 6.84 cm, respectively. Lowest root length (6.84 cm) was observed under nutrient source treatment N_2 (100 % N through FYM).

Combined effect of varieties and nutrient sources had non significant influence on root length in beetroot.

Table 12: Effect of varieties, nutrient sources and their interaction on root length (cm) in beetroot

Varieties (V)	Root length (cm)							
	Nutrients levels (N)							MEAN
	N_1	N_2	N_3	N_4	N_5	N_6	N_7	
V_1	7.70	7.52	7.61	7.93	8.60	8.93	9.39	**8.24**
V_2	6.93	6.16	6.66	7.66	7.93	8.23	8.90	**7.50**
MEAN	**7.32**	**6.84**	**7.14**	**7.79**	**8.27**	**8.58**	**9.15**	

Treatment	Varieties (V)	Nutrient sources (N)	Interaction (VxN)
SEm±	0.23	0.42	0.60
CD at 5%	0.66	1.23	NS

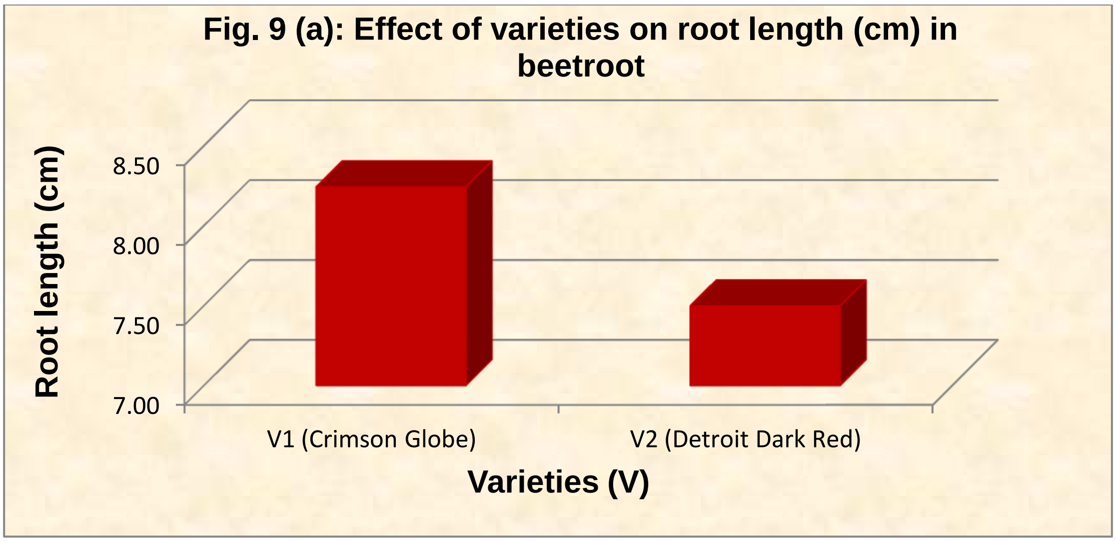
Fig. 9 (a): Effect of varieties on root length (cm) in beetroot
Root length (cm)
8.50
8.00
7.50
7.00
V1 (Crimson Globe)
V2 (Detroit Dark Red)
Varieties (V)

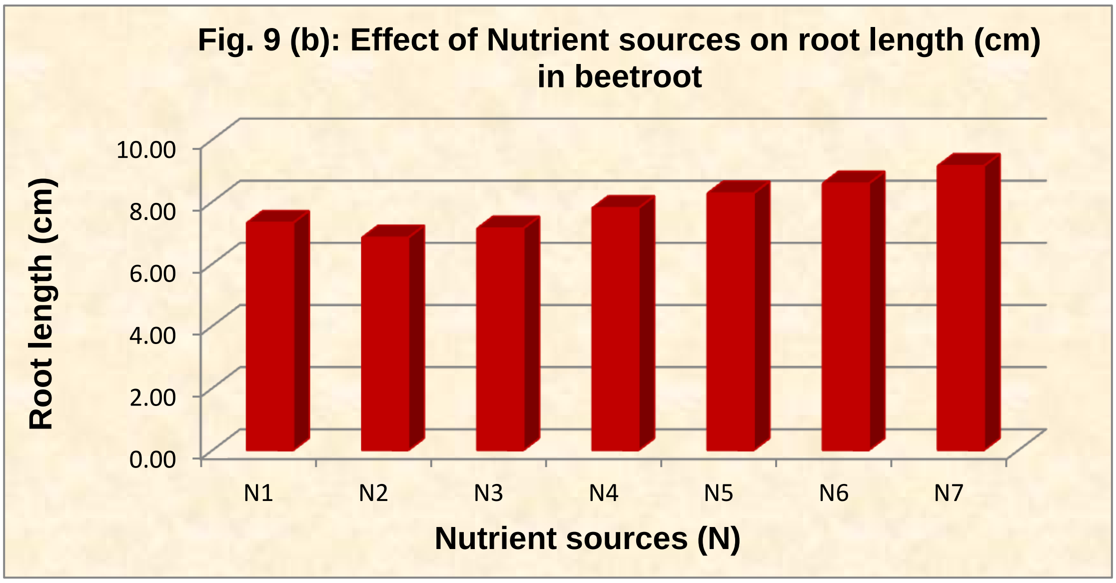
Fig. 9 (b): Effect of Nutrient sources on root length (cm) in beetroot
Root length (cm)
10.00
8.00
6.00
4.00
2.00
0.00
N1
N2
N3
N4
N5
N6
N7
Nutrient sources (N)

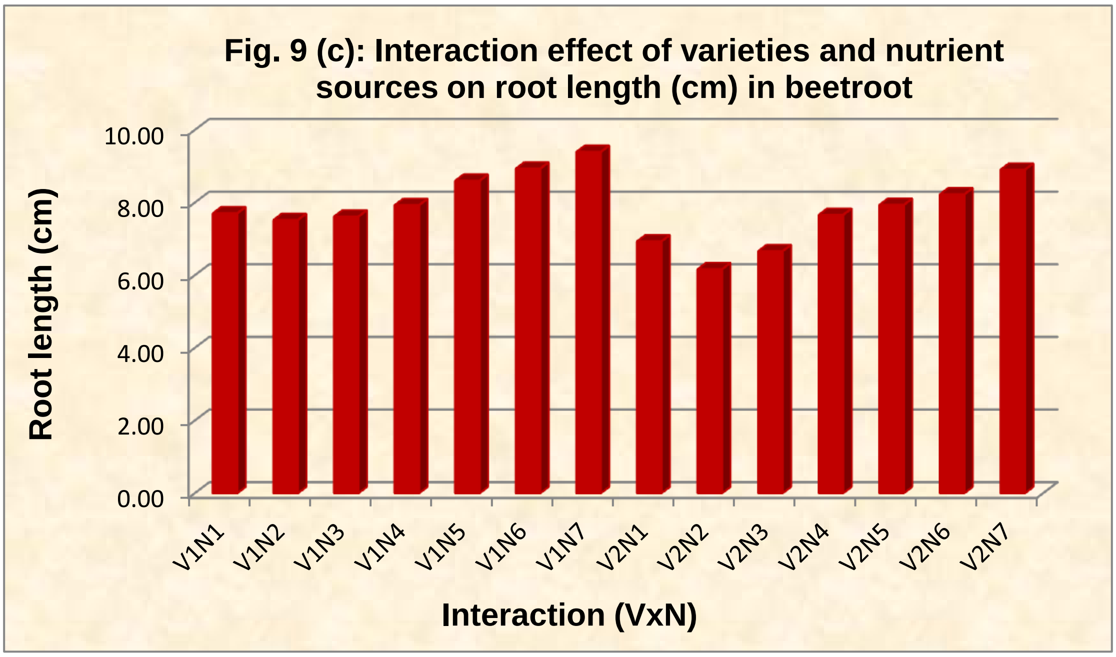
Fig. 9 (c): Interaction effect of varieties and nutrient sources on root length (cm) in beetroot
Root length (cm)
10.00
8.00
6.00
4.00
2.00
0.00
V1N1
V1N2
V1N3
V1N4
V1N5
V1N6
V1N7
V2N1
V2N2
V2N3
V2N4
V2N5
V2N6
V2N7
Interaction (VxN)

4.2.2 Root diameter (cm)

The data with respect of root length as statically influenced by varieties and nutrient sources are presented in Table 13 and depicted in Fig. 10. The combined effect of varieties and nutrient sources had non significant influence on root diameter of beetroot.

Among the varieties, V_1 (Crimson Globe) was recorded maximum root diameter (7.40 cm). Minimum root diameter (6.78 cm) was recorded with variety V_2 (Detroit Dark Red).

Application of nutrient sources exhibited significantly positive effect on diameter of root in beetroot. Maximum root diameter (8.03 cm) was obtained with nutrient source treatment N_7 (50% RDF + 50% N through vermicompost), which is significantly greater than all other nutrient sources. It was followed by N_6, N_5, N_4, N_1 and N_3 i.e. 7.65, 7.47, 7.06, 6.72 and 6.56 cm, respectively while minimum root diameter (6.13 cm) was observed under nutrient source treatment N_2 (100 % N through FYM).

Combined effect of varieties and nutrient sources had non significant influence on root diameter (cm) in beetroot.

Table 13: Effect of varieties, nutrient sources and their interaction on root diameter (cm) in beetroot

Varieties (V)	Root diameter (cm)							
	Nutrients levels (N)							MEAN
	N_1	N_2	N_3	N_4	N_5	N_6	N_7	
V_1	7.08	6.60	6.90	7.36	7.59	7.87	8.40	**7.40**
V_2	6.35	5.65	6.22	6.77	7.36	7.44	7.66	**6.78**
MEAN	**6.72**	**6.13**	**6.56**	**7.06**	**7.47**	**7.65**	**8.03**	

Treatment	Varieties (V)	Nutrient sources (N)	Interaction (VxN)
SEm±	0.14	0.25	0.36
CD at 5%	0.40	0.74	NS

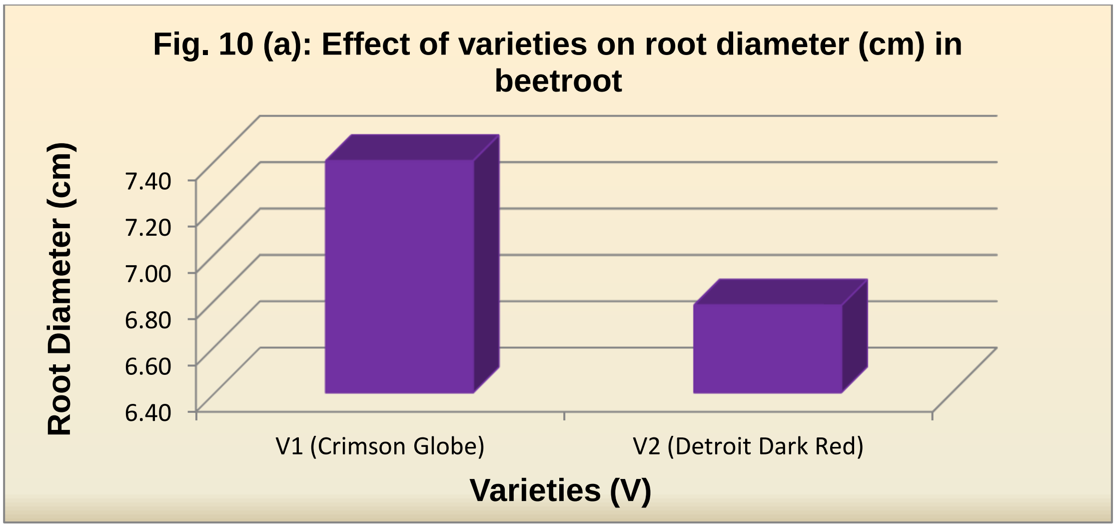

Fig. 10 (a): Effect of varieties on root diameter (cm) in beetroot
Root Diameter (cm)
7.40
7.20
7.00
6.80
6.60
6.40
V1 (Crimson Globe)
V2 (Detroit Dark Red)
Varieties (V)

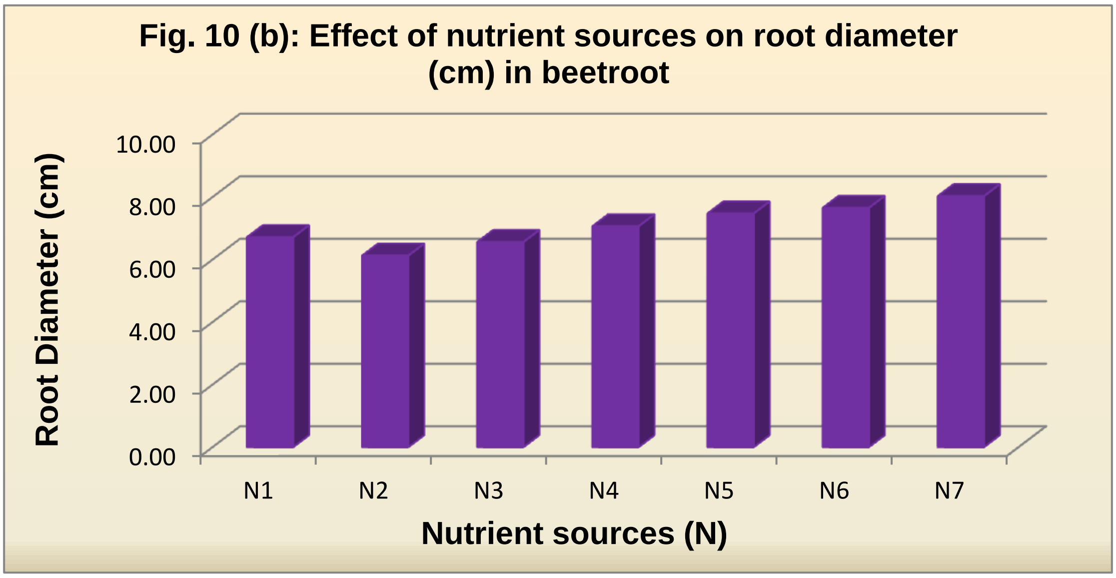

Fig. 10 (b): Effect of nutrient sources on root diameter (cm) in beetroot
Root Diameter (cm)
10.00
8.00
6.00
4.00
2.00
0.00
N1
N2
N3
N4
N5
N6
N7
Nutrient sources (N)

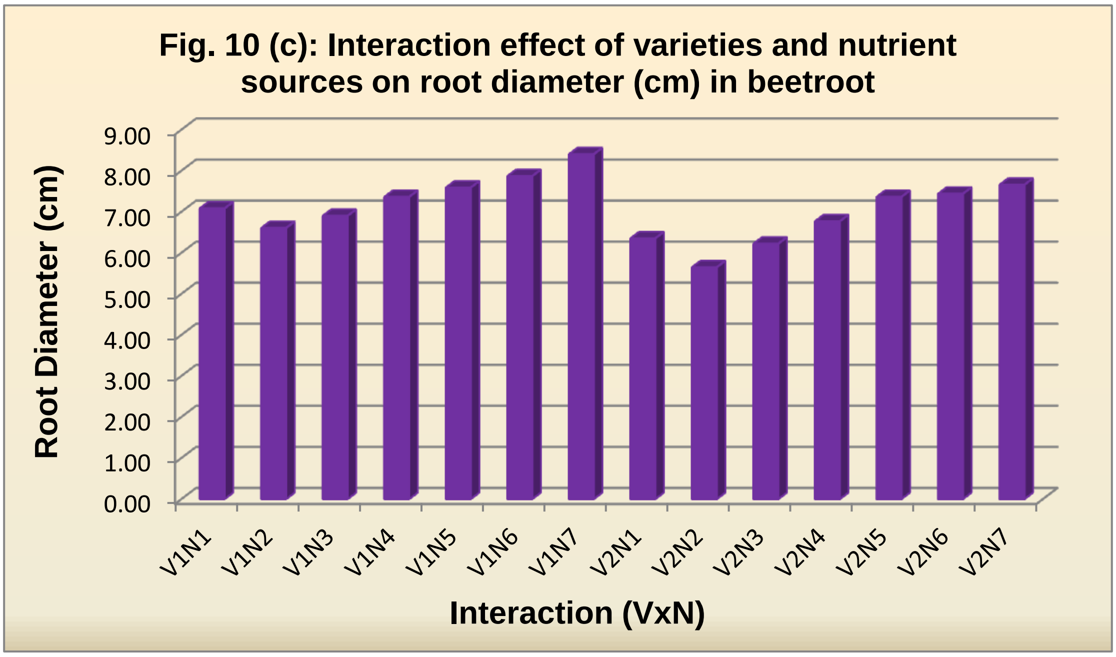

Fig. 10 (c): Interaction effect of varieties and nutrient sources on root diameter (cm) in beetroot
Root Diameter (cm)
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
V1N1
V1N2
V1N3
V1N4
V1N5
V1N6
V1N7
V2N1
V2N2
V2N3
V2N4
V2N5
V2N6
V2N7
Interaction (VxN)

4.2.3 Root weight (g/plant)

The average weight of root was recorded at harvesting stage. The data presented in Table 14 and Fig. 11 indicated significant effect of varieties and nutrient sources on root weight. The combined effect of varieties and nutrient sources had non significant influence on root weight in beetroot.

Among the varieties, maximum root weight (173.97 g) was recorded with variety V_1 (Crimson Globe). Minimum root weight (165.69 g) was found with variety V_2 (Detroit Dark Red).

Application of nutrient sources affected significant influence on root weight (g). Maximum root weight (188.15 g) was obtained under nutrient source treatment N_7 (50% RDF + 50% N through vermicompost). It was followed by N_6, N_5, N_4, N_1 and N_3 i.e. 176.88, 173.80, 169.23, 165.02 and 159.26 g, respectively, whereas minimum root weight (156.47 g) was taken under nutrient source treatment N_2 (100 % N through FYM).

Interactive effect of varieties and nutrient sources had non significant influence on root weight in beetroot.

Table 14: Effect of varieties, nutrient sources and their interaction on root weight (g) in beetroot

Varieties (V)	Root weight (g/plant)							
	Nutrients sources (N)							MEAN
	N_1	N_2	N_3	N_4	N_5	N_6	N_7	
V_1	168.29	161.12	165.25	173.26	177.34	180.26	192.25	**173.97**
V_2	161.75	151.81	153.26	165.19	170.27	173.49	184.05	**165.69**
MEAN	**165.02**	**156.47**	**159.26**	**169.23**	**173.80**	**176.88**	**188.15**	

Treatment	Varieties (V)	Nutrient levels (N)	Interaction (VxN)
SEm±	2.11	3.96	5.59
CD at 5%	6.15	11.50	NS

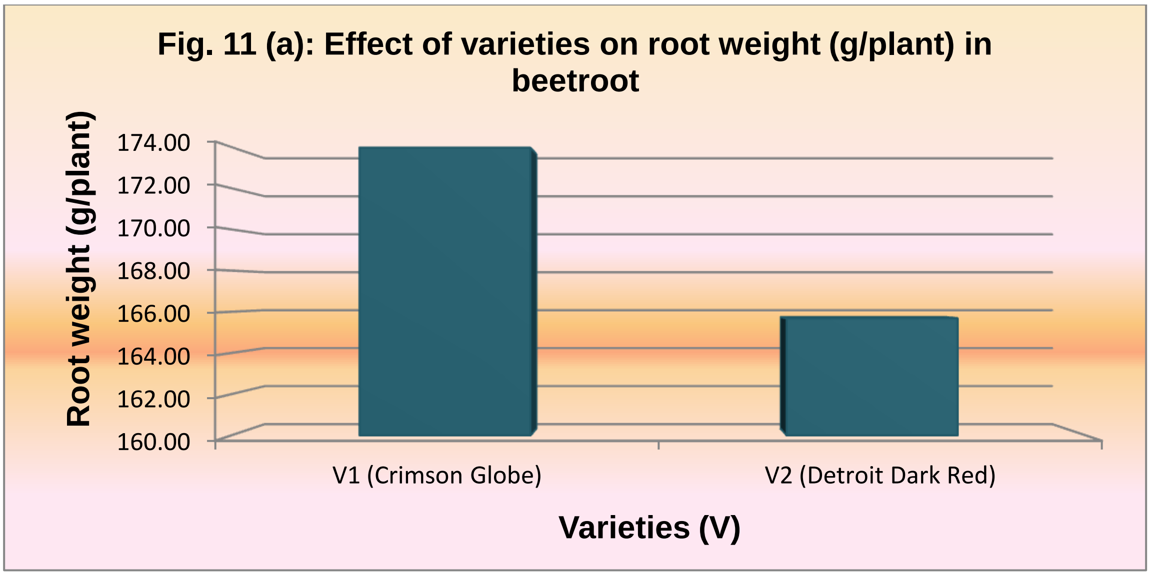

Fig. 11 (a): Effect of varieties on root weight (g/plant) in beetroot

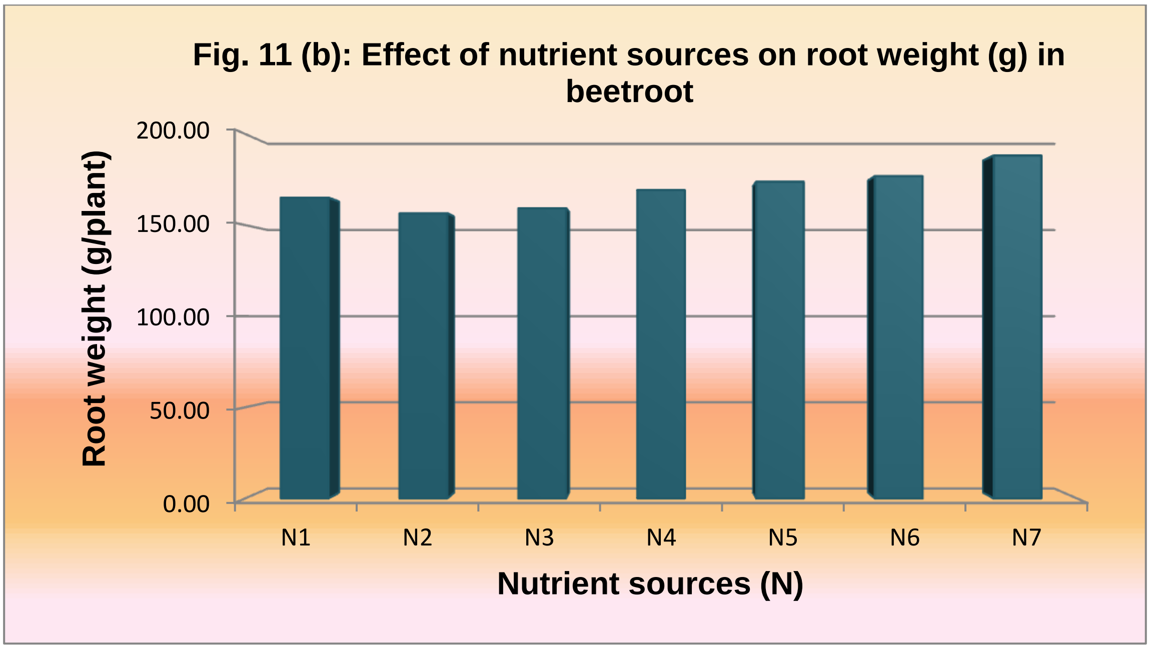

Fig. 11 (b): Effect of nutrient sources on root weight (g) in beetroot

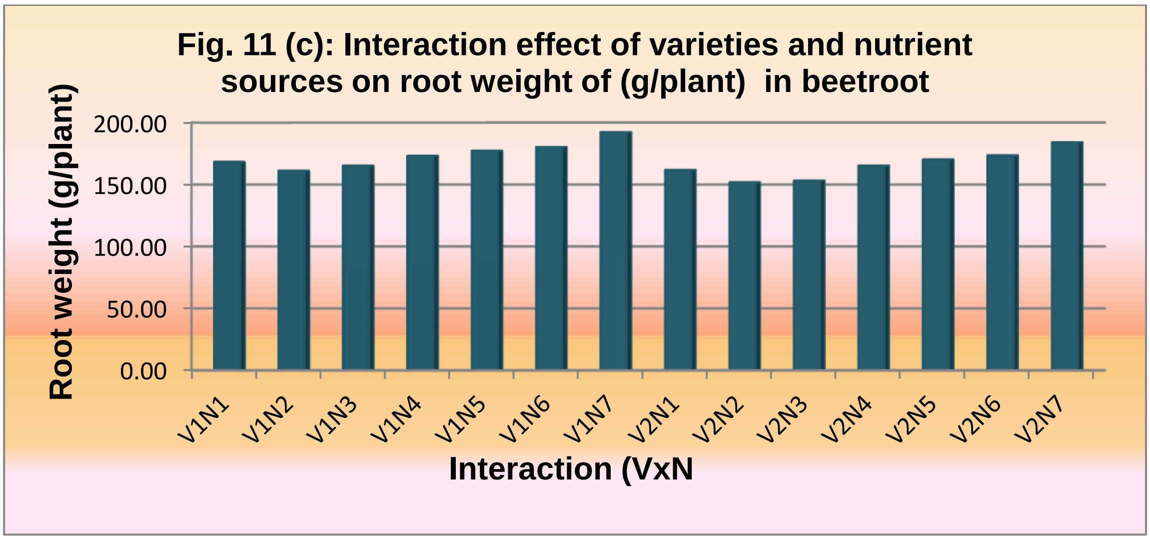

Fig. 11 (c): Interaction effect of varieties and nutrient sources on root weight of (g/plant) in beetroot

4.2.4 Root yield (q/ha)

Root yield per hectare (q) as presented in Table 15 and depicted in Fig. 12 revealed significant influence of varieties and nutrient sources on roots yield per hectare (q). Interactive effect of varieties and nutrient sources was found non significant influence on root yield (q/ha).

It can be observed that variety V_1 (Crimson Globe) recorded maximum root yield (579.89 q/ha). Minimum root yield (552.29 q/ha) was observed under variety V_2 (Detroit Dark Red).

Nutrient source had a considerable influence on root yield per hectare of beetroot. Maximum root yield (627.17 q/ha) was observed with nutrient source treatment N_7 (50% RDF + 50% N through vermicompost). It was followed by N_6 N_5, N_4, N_1 and N_3 nutrient sources i.e. 589.58, 579.34, 564.08, 550.07 and 530.85 q/ha, respectively. The lowest root yield (521.55 q/ha) was observed in case of nutrient source treatment N_2 (100 % N through FYM).

Interactive influence of varieties and nutrient sources had not showed any remarkable effect on root yield per hectare. Though, numerically maximum root yield per hectare (640.83 q) was recorded in variety V_1 (Crimson Globe) with treatment combination V_1N_7.

Table 15: Effect of varieties, nutrient sources and their interaction on root yield (q/ha) in beetroot

Varieties (V)	Root yield (q/ha)							
	Nutrients levels (N)							MEAN
	N_1	N_2	N_3	N_4	N_5	N_6	N_7	
V_1	560.97	537.07	550.83	577.53	591.12	600.87	640.83	**579.89**
V_2	539.17	506.03	510.87	550.63	567.57	578.30	613.50	**552.29**
MEAN	**550.07**	**521.55**	**530.85**	**564.08**	**579.34**	**589.58**	**627.17**	

Treatment	Varieties (V)	Nutrient sources (N)	Interaction (VxN)
SEm±	7.05	13.19	18.65
CD at 5%	20.49	38.33	NS

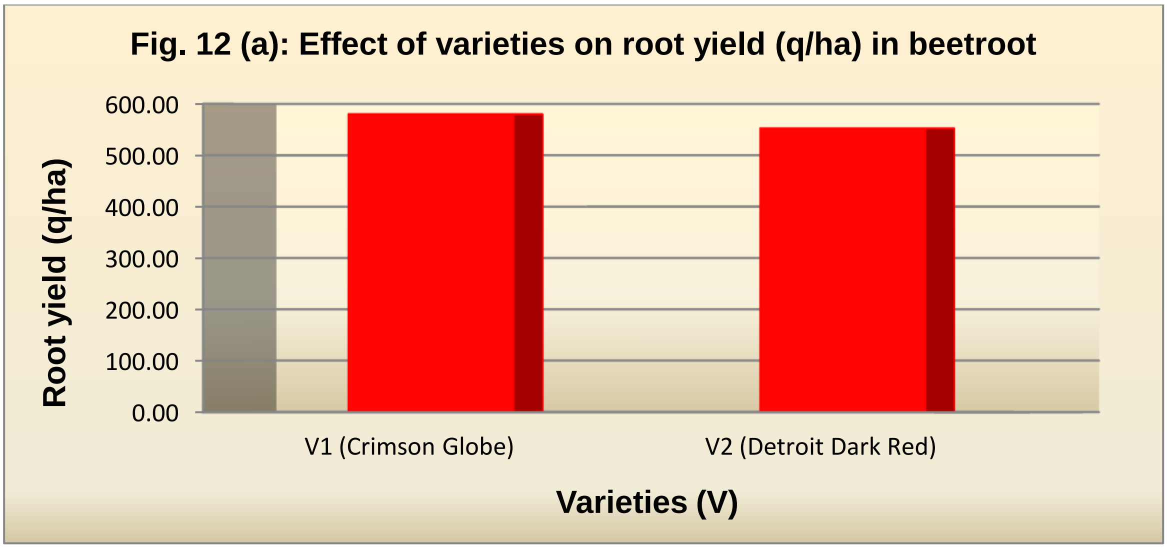
Fig. 12 (a): Effect of varieties on root yield (q/ha) in beetroot
Root yield (q/ha)
600.00
500.00
400.00
300.00
200.00
100.00
0.00
V1 (Crimson Globe)
V2 (Detroit Dark Red)
Varieties (V)

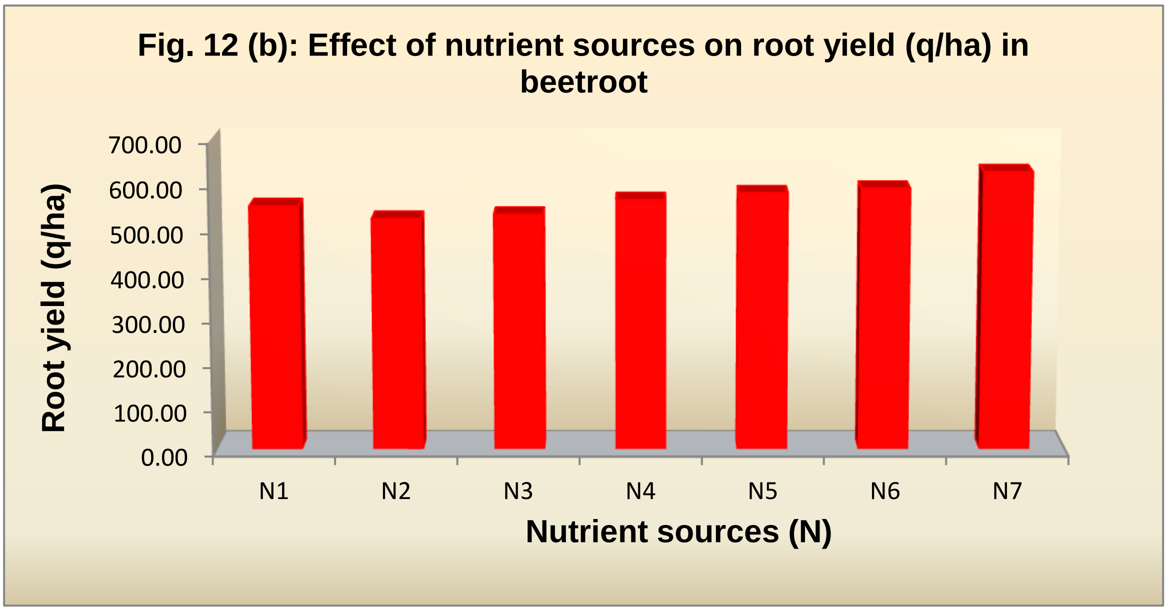
Fig. 12 (b): Effect of nutrient sources on root yield (q/ha) in beetroot
Root yield (q/ha)
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
N1
N2
N3
N4
N5
N6
N7
Nutrient sources (N)

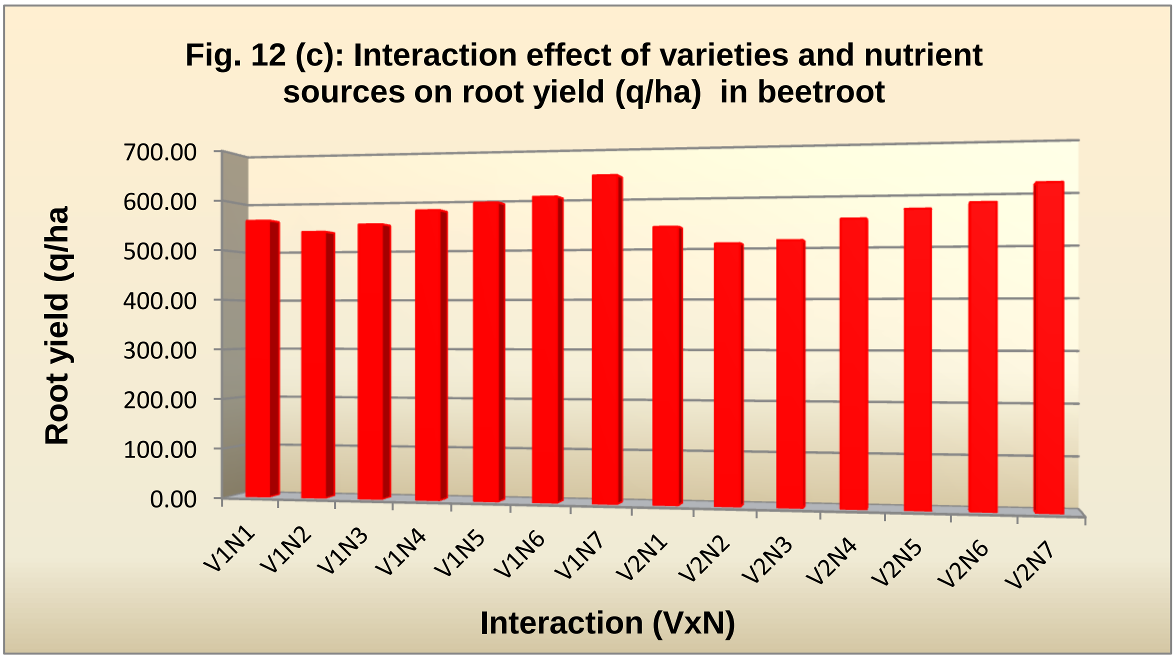
Fig. 12 (c): Interaction effect of varieties and nutrient sources on root yield (q/ha) in beetroot
Root yield (q/ha
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
V1N1
V1N2
V1N3
V1N4
V1N5
V1N6
V1N7
V2N1
V2N2
V2N3
V2N4
V2N5
V2N6
V2N7
Interaction (VxN)

4.2.5 Harvest index (%)

The analysis of the data presented in Table 16 and Fig. 13 indicated that the harvest index (percent) was strongly impacted by varieties and nutrient sources. The interaction impact of varieties and nutrient sources on beetroot harvest index was found non significant.

Maximum harvest index (58.33%) was found under variety V_1 (Crimson Globe). Lowest harvest index (54.60%) was observed under V_2 (Detroit Dark Red).

Nutrient sources also had exerted significant effect on harvest index (%).Maximum harvest index (59.59%) was observed with nutrient source treatment N_7 (50% RDF + 50% N through vermicompost). It was followed by N_6 N_5, N_4, N_1 and N_3nutrient sources i.e. 57.91, 57.19, 56.35, 55.81, and 54.45% harvest index, respectively. The lowest harvest index (53.97%) was observed in case of nutrient source treatment N_2 (100 % N through FYM).

Combined effect of varieties and nutrient sources had not showed influence on harvest index (%). Though, numerically maximum harvest index (61.25%) was recorded in variety V_1 (Crimson Globe) with treatment combination V_1N_7.

Table 16: Effect of varieties, nutrient sources and their interaction on harvest index (%) in beetroot

Varieties (V)	Harvest index (%)							
	Nutrients levels (N)							MEAN
	N_1	N_2	N_3	N_4	N_5	N_6	N_7	
V_1	57.45	55.65	56.45	58.45	59.21	59.84	61.25	**58.33**
V_2	54.16	52.29	52.45	54.25	55.17	55.98	57.92	**54.60**
MEAN	**55.81**	**53.97**	**54.45**	**56.35**	**57.19**	**57.91**	**59.59**	

Treatment	Varieties (V)	Nutrient sources (N)	Interaction (VxN)
SEm±	0.53	0.99	1.41
CD at 5%	1.54	2.89	NS

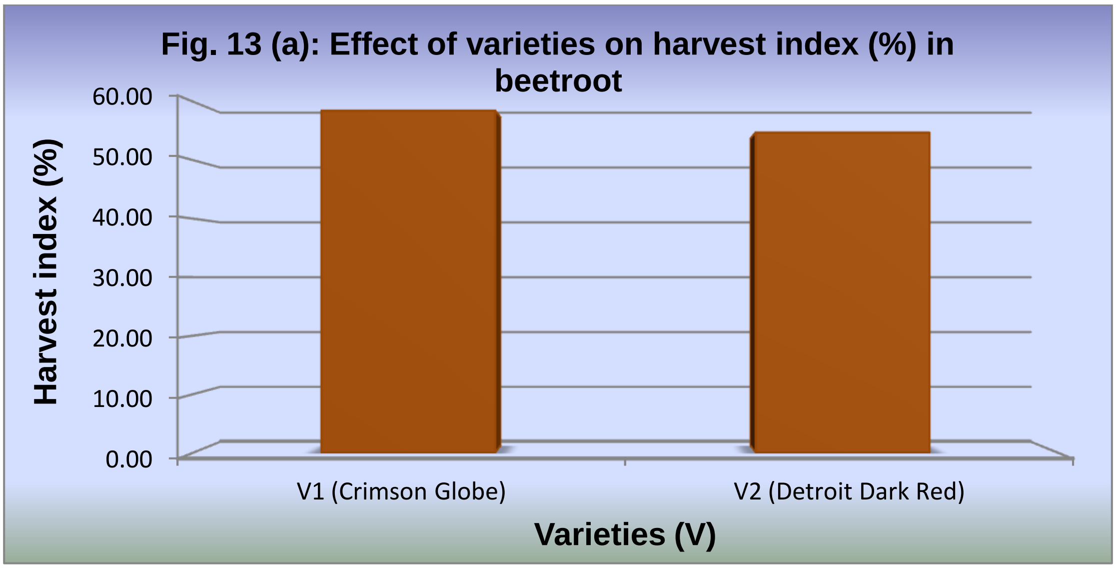
Fig. 13 (a): Effect of varieties on harvest index (%) in beetroot
60.00
50.00
40.00
30.00
20.00
10.00
0.00
Harvest index (%)
V1 (Crimson Globe)
V2 (Detroit Dark Red)
Varieties (V)

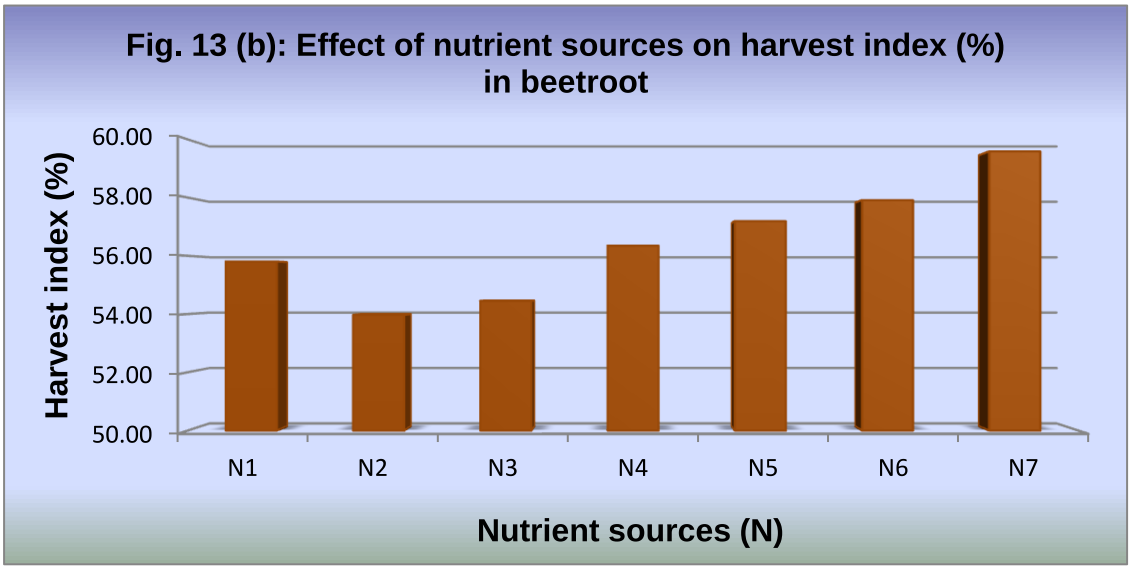
Fig. 13 (b): Effect of nutrient sources on harvest index (%) in beetroot
60.00
58.00
56.00
54.00
52.00
50.00
Harvest index (%)
N1
N2
N3
N4
N5
N6
N7
Nutrient sources (N)

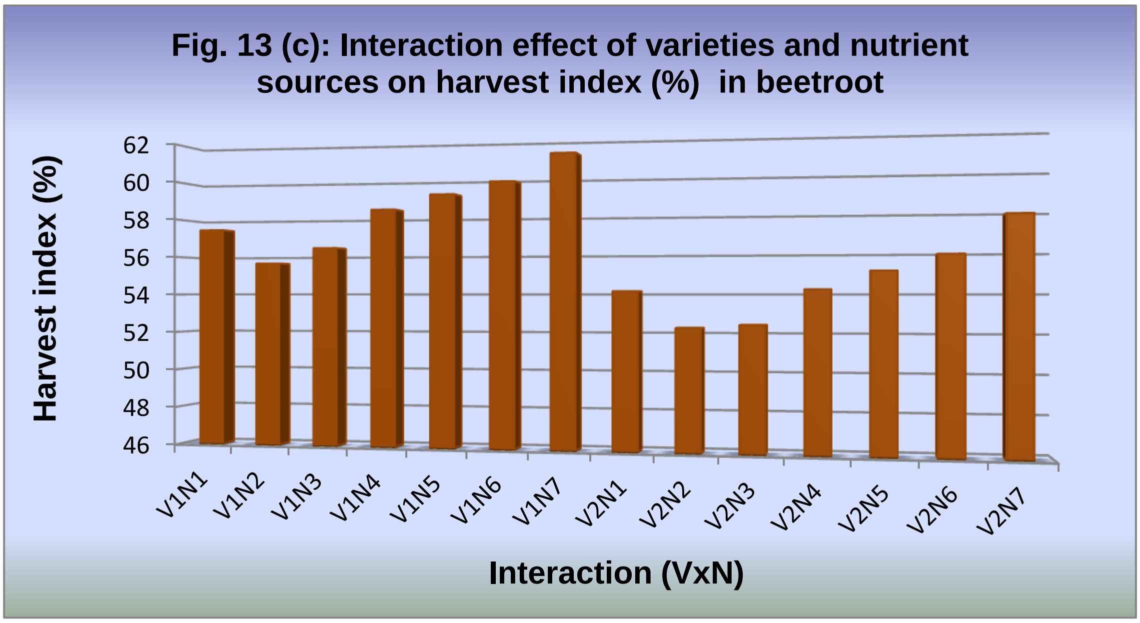
Fig. 13 (c): Interaction effect of varieties and nutrient sources on harvest index (%) in beetroot
62
60
58
56
54
52
50
48
46
Harvest index (%)
V1N1
V1N2
V1N3
V1N4
V1N5
V1N6
V1N7
V2N1
V2N2
V2N3
V2N4
V2N5
V2N6
V2N7
Interaction (VxN)

4.3 Quality attributes

The quality attributes was observed with respect to total soluble solids (^{0}Brix) and root dry matter content (%) in beetroot.

4.3.1 Total soluble solids (^{0}Brix)

The findings of the present experiment (Table 17 and Fig. 14) revealed significant influence of varieties and nutrient sources on total soluble solids (^{0}Brix).

Variety V_2 (Detroit Dark Red) had the highest total soluble solids content (11.68 ^{0}Brix) among varieties evaluated. Lowest total soluble solids content (10.28 ^{0}Brix) was observed under V_1 (Crimson Globe).

Nutrient sources also had exerted significant effect on total soluble solids (^{0}Brix). A highest total soluble solid (12.02 ^{0}Brix) was observed with treatment N_7 (50% RDF + 50% N through vermicompost). It was followed by N_6 N_5, N_4, N_1 and N_3 nutrient sources with total soluble solids content of 11.30, 11.11, 10.78, 10.85, and 10.52 ^{0}Brix, respectively. The lowest total soluble solids content (10.27 ^{0}Brix) was observed in case of nutrient source treatment N_2 (100 % N through FYM).

Combined effect of varieties and nutrient sources was found non significant influence on total soluble solids (^{0}Brix).

Table 17: Effect of varieties, nutrient sources and their interaction on total soluble solids (^{0}Brix) in beetroot

Varieties (V)	Total soluble solids (^{0}Brix)							
	Nutrients sources (N)							MEAN
	N_1	N_2	N_3	N_4	N_5	N_6	N_7	
V_1	10.10	9.56	9.72	10.15	10.36	10.53	11.54	**10.28**
V_2	11.59	10.97	11.32	1141	11.85	12.07	12.51	**11.68**
MEAN	**10.85**	**10.27**	**10.52**	**10.78**	**11.11**	**11.30**	**12.02**	

Treatment	Varieties (V)	Nutrient Sources (N)	Interaction (VxN)
SEm±	0.15	0.27	0.39
CD at 5%	0.43	0.80	NS

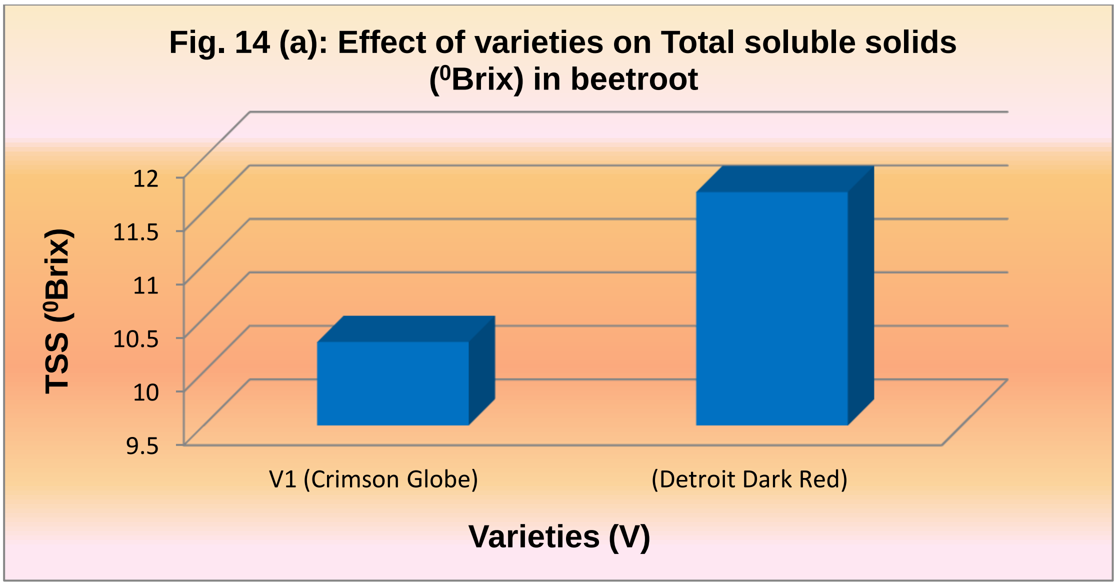
Fig. 14 (a): Effect of varieties on Total soluble solids (⁰Brix) in beetroot
TSS (⁰Brix)
12
11.5
11
10.5
10
9.5
V1 (Crimson Globe)
(Detroit Dark Red)
Varieties (V)

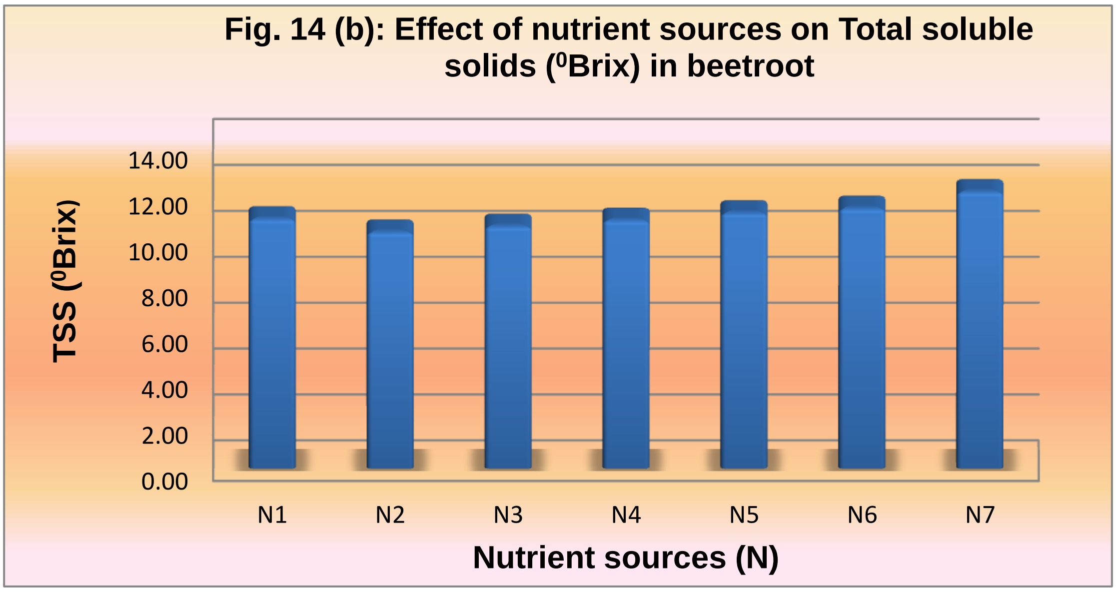
Fig. 14 (b): Effect of nutrient sources on Total soluble solids (⁰Brix) in beetroot
TSS (⁰Brix)
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
N1
N2
N3
N4
N5
N6
N7
Nutrient sources (N)

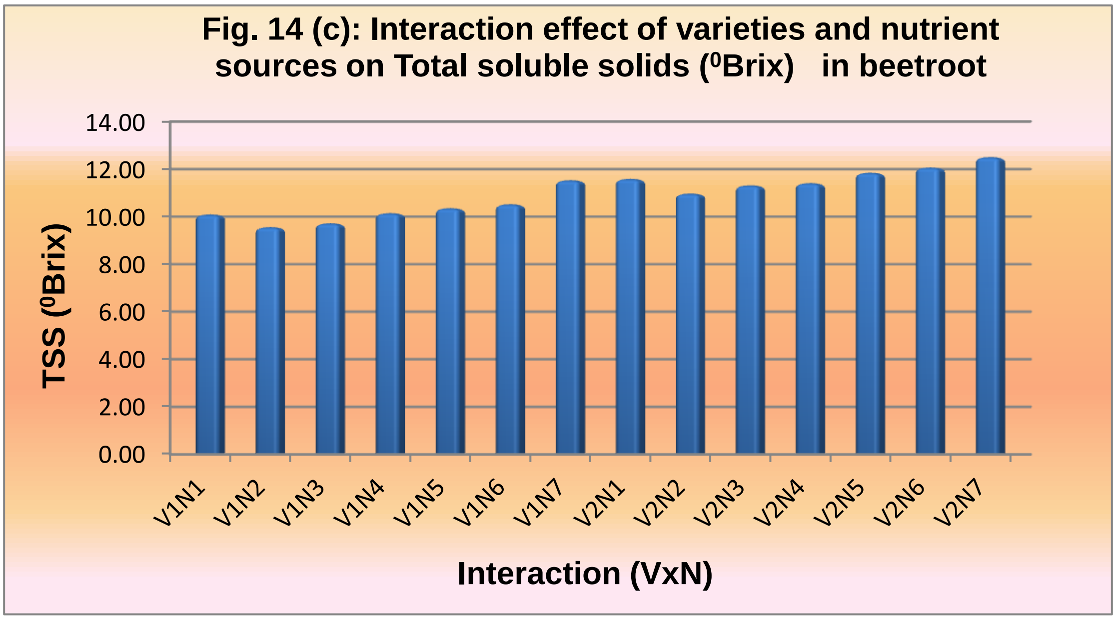
Fig. 14 (c): Interaction effect of varieties and nutrient sources on Total soluble solids (⁰Brix) in beetroot
TSS (⁰Brix)
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
V1N1
V1N2
V1N3
V1N4
V1N5
V1N6
V1N7
V2N1
V2N2
V2N3
V2N4
V2N5
V2N6
V2N7
Interaction (VxN)

4.3.2 Root dry matter content (%)

Findings on root dry matter content (%) as influenced with varieties and nutrient sources are presented in Table 18 and Fig. 15.

Maximum root dry matter content (12.39%) was determined with variety V_1 (Crimson Globe) as compared to lowest root dry matter content (10.44%) was observed with variety V_2 (Detroit Dark Red).

Nutrient sources had exerted significant effect on root dry matter content (%) in beetroot. The highest root dry matter content (13.34%) was recorded with nutrient source treatment N_7 (50% RDF + 50% N through vermicompost). It was followed by nutrient level N_6, N_5, N_4, N_1 and N_3 in descending order. The minimum root dry matter content (10.38%) was recorded under nutrient level N_2 (100 % N through FYM).

Combined effect of varieties and nutrients levels showed non significant influence on root dry matter content (%) in beetroot.

Table 18: Effect of varieties, nutrient sources and their interaction on root dry matter content (%) in beetroot

Varieties (V)	Root dry matter content (%)							
	Nutrients sources (N)							MEAN
	N_1	N_2	N_3	N_4	N_5	N_6	N_7	
V_1	11.66	11.38	11.55	12.02	12.35	13.52	14.25	**12.39**
V_2	9.83	9.37	9.65	10.16	10.46	11.16	12.43	**10.44**
MEAN	**10.75**	**10.38**	**10.60**	**11.09**	**11.41**	**12.34**	**13.34**	

Treatment	Varieties (V)	Nutrient sources (N)	Interaction (VxN)
SEm±	0.16	0.30	0.42
CD at 5%	0.46	0.86	NS

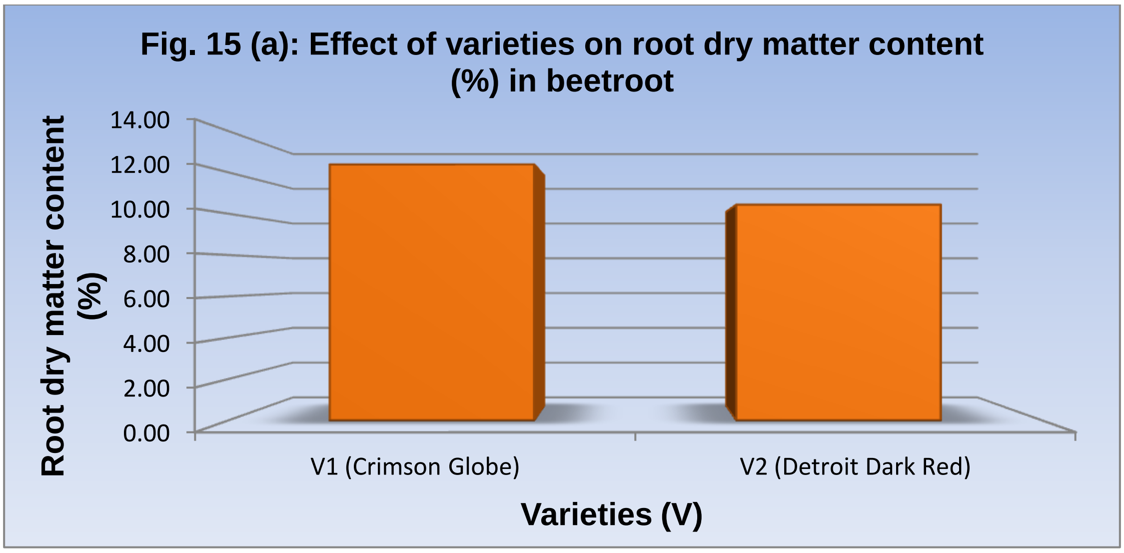
Fig. 15 (a): Effect of varieties on root dry matter content (%) in beetroot
Root dry matter content (%)
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
V1 (Crimson Globe)
V2 (Detroit Dark Red)
Varieties (V)

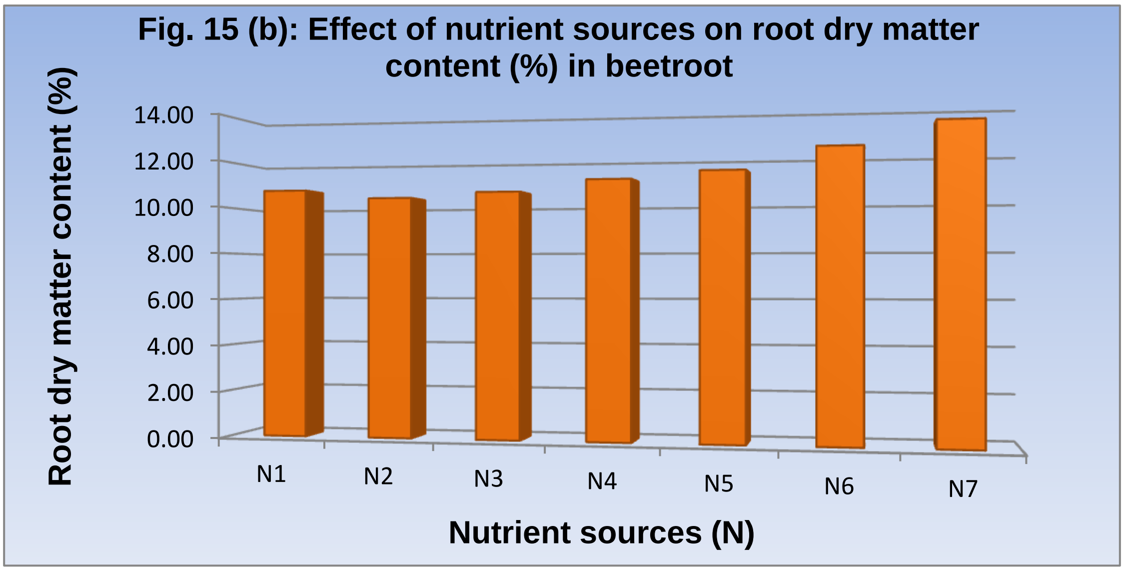
Fig. 15 (b): Effect of nutrient sources on root dry matter content (%) in beetroot
Root dry matter content (%)
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
N1
N2
N3
N4
N5
N6
N7
Nutrient sources (N)

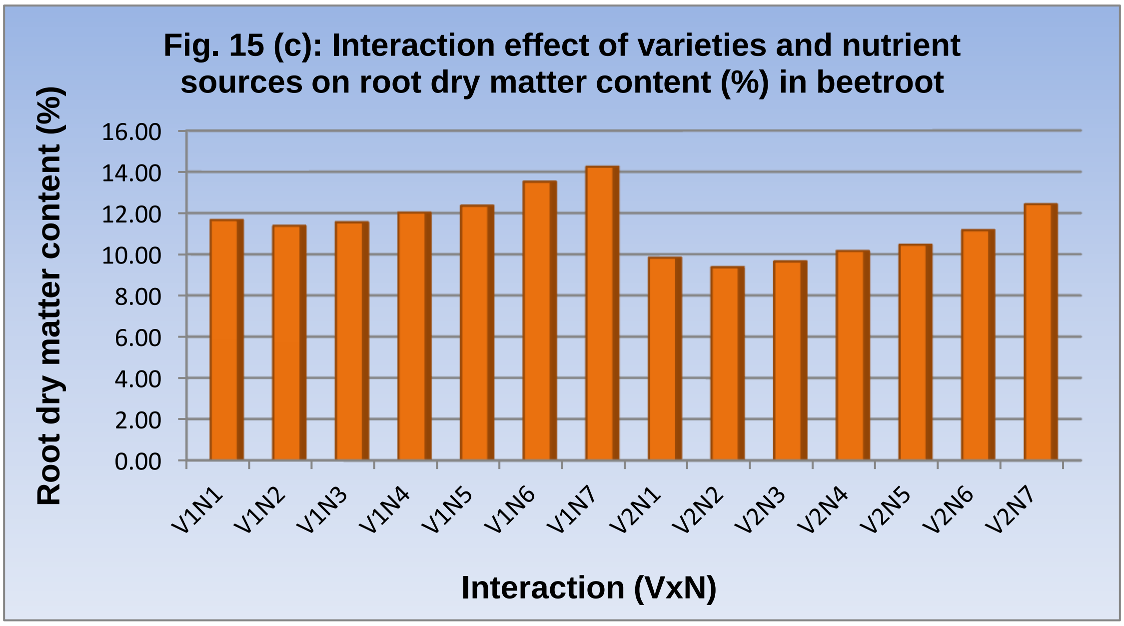
Fig. 15 (c): Interaction effect of varieties and nutrient sources on root dry matter content (%) in beetroot
Root dry matter content (%)
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
V1N1
V1N2
V1N3
V1N4
V1N5
V1N6
V1N7
V2N1
V2N2
V2N3
V2N4
V2N5
V2N6
V2N7
Interaction (VxN)

4.4 Economics of different treatments for beetroot production

Table 19 and Fig. 16 and 17 showed a significant influence of beetroot varieties and nutrient sources on gross income (Rs./ha), net income (Rs./ha) and B:C ratio. The interactive effect of varieties and nutrient sources had non significant influence on gross income (Rs./ha), net income (Rs./ha) and B:C ratio.

Among the varieties, the highest gross income (289944.15 Rs./ha), net income (199108.08 Rs./ha) and B:C ratio (2.26) was recorded in variety V_1 (Crimson Globe) followed by variety V_2 (Detroit Dark Red), which revealed the minimum gross income (276147.34 Rs./ha), net income (185311.26 Rs./ha) and B:C ratio (2.11).

Nutrient source had a significant effect on gross income (Rs./ha), net income (Rs./ha) and B:C ratio in beetroot. The maximum gross income (313583.02 Rs./ha), net income (225785.90 Rs./ha) and B:C ratio (2.57) was recorded with the application of nutrient source N_7 (RDF 50% + 50 % N through Vermicompost), which was found significantly superior over other nutrient sources. The minimum gross income (260774.74 Rs./ha), net income (146274.74 Rs./ha) and B:C ratio (1.28) were recorded under nutrient source N_2 (100% N through FYM).

Interactive effect of different varieties and nutrient source showed had exerted non significant effect on gross income, net income and B:C ratio. Significant effect of varieties and nutrient sources presented in Table 20 and Fig. 17 in beetroot.

Interactive effect of varieties and nutrient source shad exerted non significant influence on gross income, net income and B:C ratio. However, numerically maximum gross income (320416.35 Rs./ha), net income (232619.23 Rs./ha) and B:C (2.65) was recorded with treatment combination V_1N_7.

Table 19: Effect of varieties, nutrient sources and their interaction on economics of root production in beetroot

Treatment	Economics of different treatments		
	Gross income (Rs.)	Net income (Rs.)	B:C ratio
Varieties (V)			
V_1 (Crimson Globe)	289944.15	199108.08	2.26
V_2 (Detroit Dark Red)	276147.34	185311.26	2.11
S.Em±	**3524.22**	**3524.22**	**0.04**
CD at 5%	**10244.75**	**10244.75**	**0.11**
Nutrient sources(N)			
N_1	275033.06	202302.46	2.78
N_2	260774.74	146274.74	1.28
N_3	265424.73	162561.10	1.58
N_4	282041.38	198868.43	2.39
N_5	289671.93	208498.98	2.55
N_6	294791.37	201176.07	2.15
N_7	313583.02	225785.90	2.57
S.Em±	**6593.21**	**6593.21**	**0.07**
CD at 5%	**19166.17**	**19166.17**	**0.21**
Interaction (V x N)			
V_1N_1	280483.05	207752.45	2.86
V_1N_2	268533.06	154033.06	1.35
V_1N_3	275416.39	172552.75	1.68
V_1N_4	288766.38	205593.43	2.47
V_1N_5	295560.82	214387.87	2.64
V_1N_6	300433.03	206817.73	2.21
V_1N_7	320416.35	232619.23	2.65
V_2N_1	269583.06	196852.46	2.71
V_2N_2	253016.41	138516.41	1.21
V_2N_3	255433.08	152569.44	1.48
V_2N_4	275316.39	192143.44	2.31
V_2N_5	283783.05	202610.10	2.50
V_2N_6	289149.71	195534.41	2.09
V_2N_7	306749.69	218952.58	2.49
S.Em±	**9324.20**	**9324.20**	**0.10**
CD at 5%	**27105.06**	**27105.06**	**0.30**

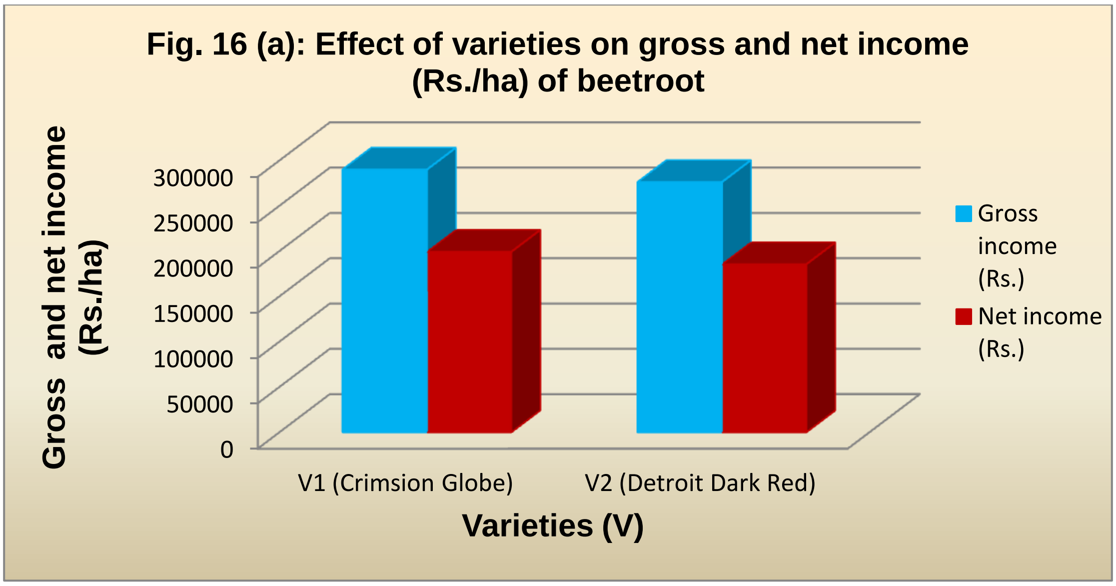

Fig. 16 (a): Effect of varieties on gross and net income (Rs./ha) of beetroot
Gross and net income (Rs./ha)
300000
250000
200000
150000
100000
50000
0
V1 (Crimsion Globe)
V2 (Detroit Dark Red)
Varieties (V)
Gross income (Rs.)
Net income (Rs.)

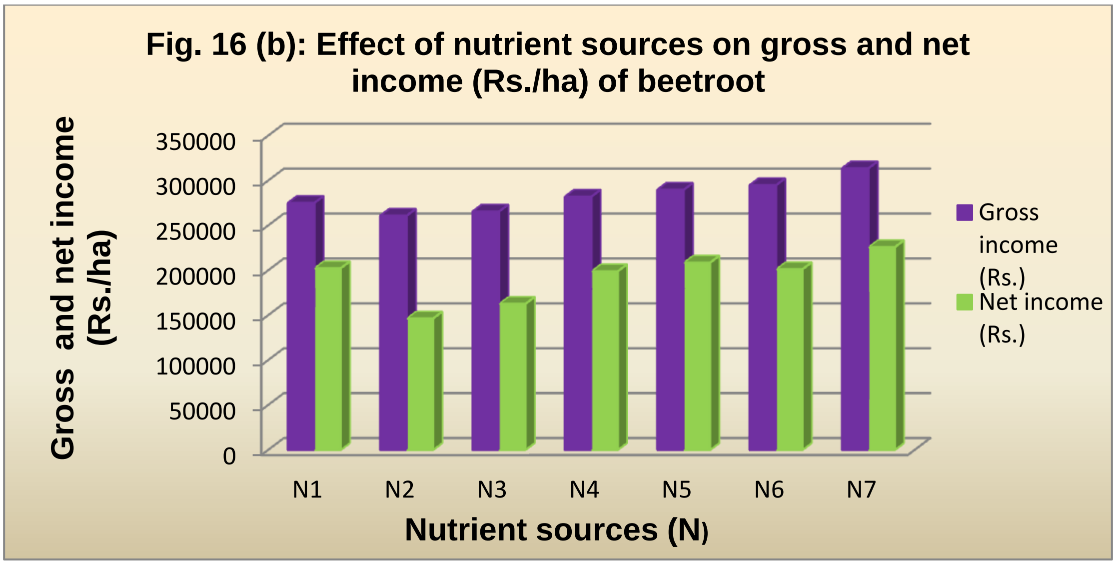

Fig. 16 (b): Effect of nutrient sources on gross and net income (Rs./ha) of beetroot
Gross and net income (Rs./ha)
350000
300000
250000
200000
150000
100000
50000
0
N1
N2
N3
N4
N5
N6
N7
Nutrient sources (N)
Gross income (Rs.)
Net income (Rs.)

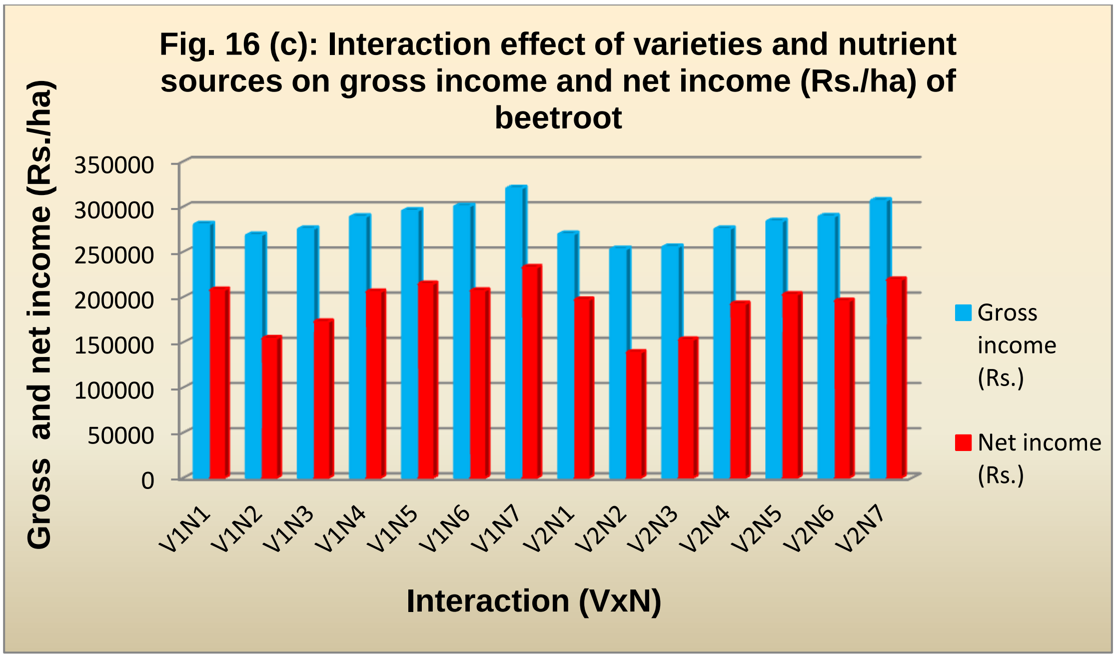

Fig. 16 (c): Interaction effect of varieties and nutrient sources on gross income and net income (Rs./ha) of beetroot
Gross and net income (Rs./ha)
350000
300000
250000
200000
150000
100000
50000
0
V1N1
V1N2
V1N3
V1N4
V1N5
V1N6
V1N7
V2N1
V2N2
V2N3
V2N4
V2N5
V2N6
V2N7
Interaction (VxN)
Gross income (Rs.)
Net income (Rs.)

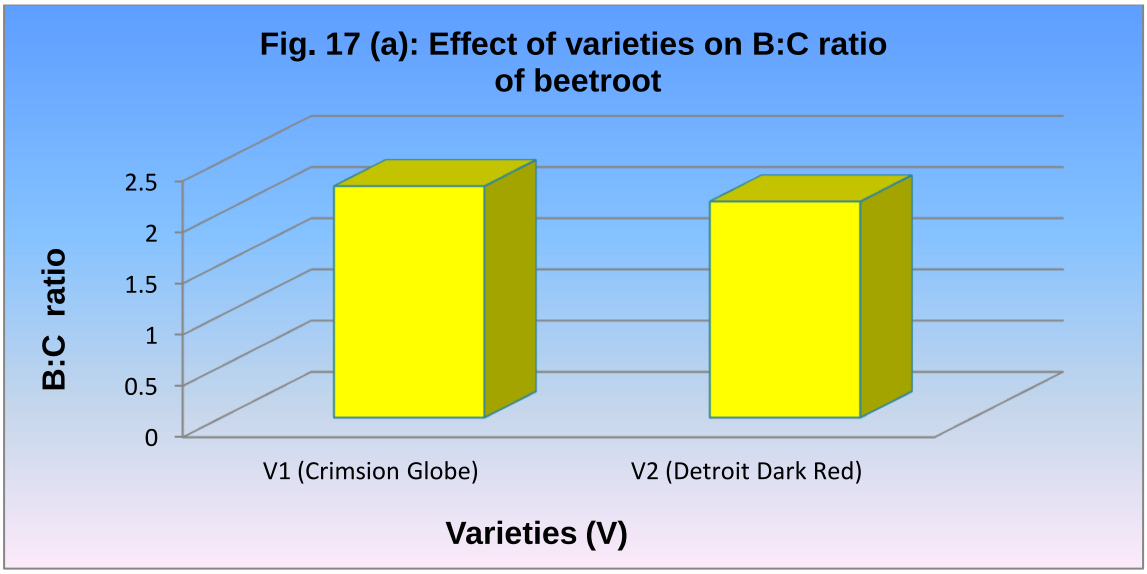
Fig. 17 (a): Effect of varieties on B:C ratio of beetroot
B:C ratio
2.5
2
1.5
1
0.5
0
V1 (Crimsion Globe)
V2 (Detroit Dark Red)
Varieties (V)

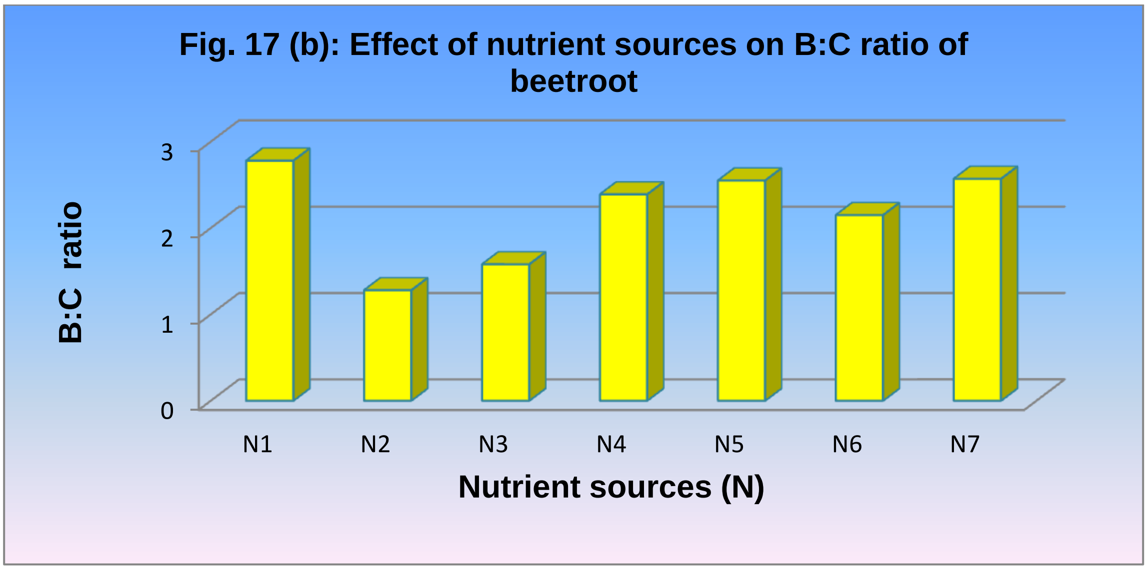
Fig. 17 (b): Effect of nutrient sources on B:C ratio of beetroot
B:C ratio
3
2
1
0
N1
N2
N3
N4
N5
N6
N7
Nutrient sources (N)

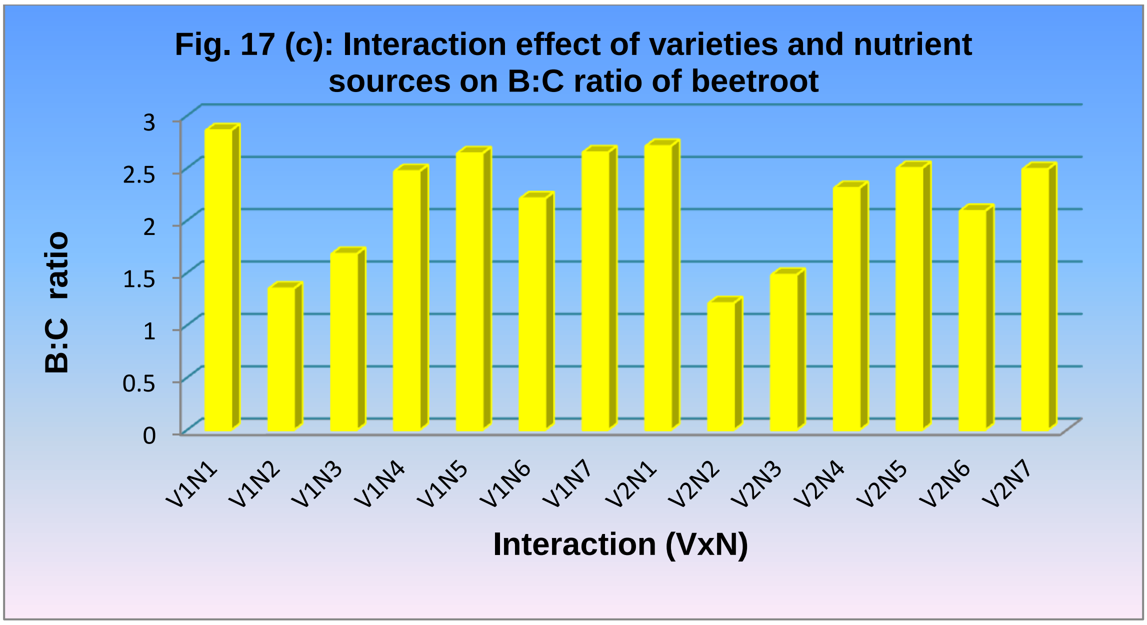
Fig. 17 (c): Interaction effect of varieties and nutrient sources on B:C ratio of beetroot
B:C ratio
3
2.5
2
1.5
1
0.5
0
V1N1
V1N2
V1N3
V1N4
V1N5
V1N6
V1N7
V2N1
V2N2
V2N3
V2N4
V2N5
V2N6
V2N7
Interaction (VxN)

Plate 2:- Different varieties of beetroot

Plate 3(a) :- Effect of different treatments on beetroot

Plate 3(b) :- Effect of different treatments on beetroot

Chapter-V

DISCUSSION

The present investigation entitled "Effect of varieties, organic manures and inorganic fertilizers on growth, yield and quality of beetroot (*Beta vulgaris* L.)" was carried out at Vegetable Research Field, Bhahadri Farm, College of Horticulture, Mandsaur (MP) during *Rabi* season, 2021-22, are discussed and illustrated, keeping in view the findings of previous works, under following headings:

5.1 Growth parameters

Growth parameters of beetroot viz. plant height and number of leaves, SPAD value were recorded at 30, 45, 60 DAS and at last harvesting stage. Leaf area, fresh and dry weight of plant was recorded at harvesting stage. The results showed significant effect of varieties, nutrient sources on all the growth parameters. Interaction effect of varieties and nutrient sources had non significantly on all the growth attributes studied in beetroot.

The plant height was increased with advancement of growth period. The results showed that increase in plant height between 30, 45 and 60 DAS was rapid as compared to final harvesting stage.

The difference among varieties for plant height was significant. Variety V_1 (Crimson Globe) recorded maximum plant height at all the stages of growth. Minimum plant height at all the growth stages was recorded in variety V_2 (Detroit Dark Red). The variation in growth parameters among the various varieties might be due to genetic make-up of plant (Patel and Patel, 2019). These findings are in close agreement with those reported by Sapkota *et al.* (2021) in beetroot and Kushwah *et al.* (2019) in carrot.

Nutrient source N_7 (50 % RDF + 50 % N through Vermicompost) has exhibited maximum plant height at 30, 45, 60 DAS and at harvesting stage. It was followed by N_6> N_5> N_4> N_1> N_3, while minimum plant height was observed in case of nutrient sources N_2 (100 % N through FYM). The improvement in plant height could be due to increase in soil microbial biomass after vermicompost and bio fertilizer application, leading to production of hormones or humates in the vermicompost acting as plant growth regulators such asauxins, gibberellins and cytokinins which might have resulted in increased plant height through increased cell division and rapid cell elongation (Jabeen *et al*., 2017). These results are in conformity with the findings of Ingole *et al.* (2018) and Jagadeesh *et al.* (2018) in beet root.

Combined effect of varieties and nutrient sources showed non-significant influenced on plant height at all the growth stages in beetroot.

Varieties had significant influence on number of leaves per plant at all the stages of growth. Variety V_1 (Crimson Globe) exhibited significantly more number of leaves per plant when compared to variety V_2 (Detroit Dark Red) at 30, 45, 60 DAS and at harvesting. The difference in number of leave might be due to genetic make-up of varieties. These results are in line with Patel and Patel (2019) and Sapkota *et al.* (2021) in beetroot.

Nutrient sources had exhibited significant influence on number of leaves per plant of beetroot at all the growth stages. Significantly maximum number of leaves per plant was counted with nutrient source treatment N_7 (50% RDF + 50% N through Vermicompost) at all the growth stages, followed by N_6> N_5> N_4> N_1> N_3 in descending order. Minimum number of leaves per plant was reported under nutrient source N_2 (100% N through FYM). According to Dlamini *et al.* (2020) the increase in the number of leaves was due to increased solubilisation effect and availability of nutrients by the addition of organic manures which relatively results in better development of more leaves. Similar results were reported by Jabeen *et al*. (2017), Shafeek *et al.* (2019), Mounika et al. (2020) and Nadeeka and Seran (2020) in beetroot and Kushwah *et al.* (2019) in carrot.

Combined effect of varieties and nutrient sources was found non-significant influence on number of leave per plant at all the growth stages in beetroot.

Leaf area (cm^2) was significantly influenced with varieties of beetroot. Variety V_1 (Crimson Globe) showed significantly highest leaf area per plant when the plant were compared to variety V_2 (Detroit Dark Red) at the all growth stage. The effect of different nutrient sources on average leaf area was found to be statistically significant. These variations in leaf area might be attributed to their inherent characters. Further, the growth characters of the plants greatly depend on the genetic makeup of the variety. Leaf area might be helpful for more photosynthesis and making food for better yield potential character of plant growth and produce maximum yield (Dongarwar *et al.* 2018).

The maximum leaf area was recorded in nutrient source treatment N_7 (50% RDF + 50% N through vermicompost) indicating significantly superior over all other treatments at all the growth stage, followed by N_6, N_5, N_4, N_1 and N_3, respectively. The lowest leaf area was observed in nutrient source treatment N_2 (100% N through FYM). Increase in leaf area might be due to supply of adequate nitrogen and other nutrients which might have lead to higher metabolic activity in leaves, synthesis of carbohydrates and phytohormones which in turn might have contributed to increase in leaf area (Jabeen *et al*., 2017). These results are in line with Ingole *et al*. (2018), Jagadeesh *et al.* (2018) and Vethamoni and Kayalvizhi (2018) in beetroot.

The interactive effect of varieties and nutrient sources was found non significant on leaf area (cm^2) of beetroot.

Varieties had significant impact on SPAD value at all the stages of growth. Variety V_1(Crimson Globe) was found maximum SPAD value while compared to variety V_2 (Detroit Dark Red) at 30, 45, 60 DAS and at harvesting.Chlorophyll content of leaves was might be varied according to leaf area and types of leaves and genotypic character (Dongarwar *et al.,* 2018).Similar findings have been reported by Kushwah *et al*. (2019) in radish.

The SPAD value was significantly affected by the treatment of nutrient sources at different stages of plant growth. The highest SPAD value was recorded in nutrient source treatment N_7 (50% RDF + 50% N through vermicompost) was followed by nutrient sources N_6, N_5, N_4, N_1, and N_3 at all the growth stage. The lowest SPAD value was recorded under nutrient source treatment N_2 (100% N through FYM).According to Jagadeesh *et al*. (2018) Better availability of nutrients and the balanced C/N ratio might have increased synthesis of higher chlorophyll index in all the organic sources applied treatments (Jagadeesh *et al*., 2018).These results are in accordance with that of Dlamini *et al.* (2020) in beetroot and Kushwah *et al*. (2019) in radish.

The interactive effect of varieties and nutrient sources was found non significant influence on SPAD value of beetroot.

Results showed that significant effect of varieties on fresh weight (g/plant) in beetroot. Maximum fresh weight (g/plant) was observed in variety V_1 (Crimson Globe) and minimum fresh weight (g/plant) by V_2 (Detroit Dark Red). The variation in fresh weight of plant under cultivars may be attributed to their genetic architecture.Similar results were also reported by Thalooth *et al*. (2019) in sugar beet and Kushwah *et al*. (2019) in carrot.

Fresh weight of plant was significantly differed among various nutrient source treatments at harvesting. Nutrient source treatment N_7 (50% RDF + 50% N through vermicompost) was recorded maximum fresh weight of plant. It was followed by N_6, N_5, N_4, N_1 and N_3in descending order. Application of nutrient source treatment N_2 (100 % N through FYM) was observed minimum fresh weight of plant at all the growth stages.This was attributed due to solubilizing effect of plant nutrients by the addition of vermicompost leading to increased uptake of NPK. Organic manure plays 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 (Kushwah *et al.,* 2019). Similar findings have been reported by Thalooth *et al*. (2019) and Nadeeka and Seran (2020) in beetroot.

Combined effect of varieties and nutrient sources showed non significant influence on fresh weight of plant at harvesting stage of beetroot.

The results indicated that varieties had a significant influence on the dry weight of the plant (g) after harvesting. The data obtained from trial revealed that variety V_1 (Crimson Globe) had registered maximum dry weight of plant after harvesting. Minimum dry weight of plant was recorded in case of variety V_2 (Detroit Dark Red) after harvesting.Similar findings have been reported Lencha and Dalga (2020) in beetroot and Kushwah *et al*. (2019) in carrot.

Application of nutrient sources showed significant influence on dry weight of plant after harvesting in beetroot. Nutrient source treatment N_7 (50% RDF + 50% N through vermicompost) was registered maximum dry weight of plant after harvesting. It was followed by N_6, N_5, N_4, N_1, N_3 and N_2. Application of nutrient source treatment N_2 (100 % N through FYM) was observed minimum dry weight of plant after harvesting. Similar results were obtained by Safeek *et al.* (2019) in beetroot and Gyewali *et al.* (2020) in radish.

Combined effect of varieties and nutrient sources showed non significant influence on dry weight of plant of beetroot.

5.2 Yield parameter and yield

Yield parameter and yield of beetroot viz. root length (cm), root diameter (cm), root weight (g/plant), root yield (q/ha) and harvest index (%) of root were recorded after harvesting. The results showed significant effect of varieties, nutrient sources on all the yield parameters. Interaction effect of varieties and nutrient sources had non significant on the entire yield attributes studied in beetroot.

The difference among varieties for root length was significant, maximum length of root was recorded with variety V_1 (Crimson Globe). Minimum length of root was observed by variety by V_2 (Detroit Dark Red). Similar results found by Patel and Patel (2019) in sugar beet and Nargave *et al.* (2018) in radish.

The root length was significantly influenced by different nutrient sources. The highest root length was recorded in nutrient source treatment N_7 (50% RDF + 50% N through vermicompost) followed by the N_6, N_5, N_4, N_1 and N_3. The lowest root length was recorded in N_2 in (100% N through FYM). The application of organic manures to the soil, physical condition of the soil may be improved by the better aggregation of soil particles. These aggregate affects 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. 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 (Jagadeesh *et al.*, 2018). Similar findings have been reported by Devi *et al*. (2016), Ingole *et al*. (2018), Acharyya *et al*. (2020) in beetroot and Kiran *et al*. (2021), Rawat and Pant (2021) in radish.

The interactive effect of varieties and nutrient sources was found non significant influence on root length of beetroot.

Varieties had significant influence on root diameter (cm) after harvesting. Variety V_1 (Crimson Globe) had observed more root diameter (cm) when compared to variety V_2 (Detroit Dark Red). These results are in line with Sapkota *et al.* (2021) Alenzi and Manea (2020) in beetroot and Kushwah *et al*. (2019) in carrot.

Application of nutrient sources exhibited significantly positive effect on diameter of root in beetroot. Maximum root diameter was obtained with nutrient source treatment N_7 (50% RDF + 50% N through Vermicompost), which is significantly greater than all other nutrient sources. It was followed by N_6, N_5, N_4, N_1 and N_3 while minimum root diameter was observed under nutrient source treatment N_2 (100 % N through FYM). This might be due to the reason that application of vermicompost increase the root diameter. Decrease in bulk density and increase in porosity and water holding capacity of the soil due to organic manures might have contributed in increasing the root diameter of the plants. The root diameter may be attributed to solubilization of plant nutrients by addition of vermicompost leading to increase uptake of NPK (Rawat and Pant, 2021). The given results are in agreement with those reported by Jagadeesh *et al.* (2018) and Nadeeka and Seran (2020) in beetroot and Vithwel and Kanaujia (2013) in carrot.

The interactive effect of varieties and nutrient sources was found non significant influence on root diameter (cm) of beetroot.

Findings revealed that significant effect of varieties on root weight (g) in beetroot. Maximum root weight was commenced in variety V_1 (Crimson Globe). Minimum root weight was observed in case of varieties V_2 (Detroit

Dark Red). Similar results founded by Ijoyah *et al*. (2008) and Sapkota *et al.* (2021) in beetroot and Nargave *et al*. (2018) in radish.

Application of nutrient sources caused significant effect on average root weight (g). Maximum value of root weight was taken with application of N_7 (50% NPK + 50% N through vermicompost). It was followed by N_6> N_5> N_4> N_1 and N_3 under study. Minimum value of root weight was attained in nutrient source treatment N_2 (100% N through FYM).The combined use of inorganic and organic manures might have enhanced the nutrient availability by improving the fertilizer use efficiency, which might have contributed to higher root weights (Kiran *et al*., 2019). This fact can be explained by the direct relationship among them, after all, greater diameter and/or length determine greater root weight and, consequently, yield. Similar findings have been reported Acharyya *et al.* (2020), Nadeeka and Seran (2020), in beetroot and Pamula and Kerketta (2021) in turnip.

Interactive effect of varieties and nutrient sources had exerted non significant influence on root weight (g) in beetroot

Root yield per hectare was significantly influenced by varieties. The highest root yield was attained by the variety V_1 (Crimson Globe) as compared to minimum root yield with variety V_2 (Detroit Dark Red). This variation might be attributed to the genetic potential of the crop. These results are in close conformity with the findings of Patel *et al*. (2017), Lencha and Dalga (2020) and Sapkota *et al*. (2021) in beetroot.

Nutrient sources exerted significant influence on root yield per hectare (q). Highest root yield has taken under the nutrient source treatment N_7 (50% NPK + 50% N through vermicompost). It was followed by N_6, N_5, N_4, N_1 and N_3. Lowest root yield was observed in case of nutrient source treatment N_2 (100 % N through FYM). The result can be attributed to slow release of nutrients from organic manures and their better utilization by beet root throughout the growing period which might have resulted in higher root yields of beet root. The increased nutrient availability from the organic manures might have increased the various endogenous hormonal levels in the plant tissues, which might be responsible for enhanced root growth, which ultimately increased the yield levels (Devi *et al*., 2016). Similar result were reported by Ingole *et al*. (2018), Jagadeesh *et al*. (2018) and Sapkota *et al*. (2021) in beetroot

Combined effect of varieties and nutrient sources revealed statistically non significant influence on root yield quintal per hectare.

Harvest Index (%) was measured at after harvesting and recorded data showed that significant difference was observed among varieties for harvest Index (%) in beetroot. Maximum harvest index was found under variety V_1 (Crimson Globe). Minimum harvest index was observed with variety V_2 (Detroit Dark Red). Similar results were obtained by Nargave *et al*. (2018) in redish.

Harvest index was significantly affected by nutrient sources. Maximum harvest index (%) was found under nutrient source treatment N_7 (50% NPK + 50% N through vermicompost), which was followed by N_6, N_5, N_4, N_1 and N_3. The lowest harvest index (%) was recorded under nutrient source N_2 (100 % N through FYM). Similar results were obtained by Jagadeesh *et al.* (2018) in beetroot and Nargave *et al*. (2018) and Subedi *et al*. (2018) in radish.

Combined effect of varieties and nutrient sources had not showed significant effect on harvest index (%).

5.3 Quality parameter

The quality parameters were studied with respect to total soluble solids content (^{0}Brix) and root dry matter content (%) in beetroot.

Observations on T.S.S. content in roots revealed that variety V_2 (Detroit Dark Red) had higher T.S.S. than variety V_1 (Crimson Globe). These results are conformity with those of Alenzi and Manea (2020) in beetroot and Kushwah *et al.* (2019) in carrot.

Application of nutrient sources exhibited positive effect on total soluble solids content of beetroot. Among the nutrient sources, N_7 (50% NPK + 50% N through vermicompost) was recorded the maximum T.S.S., while the minimum T.S.S. was determine in case of nutrient source treatment N_2 (100 % N through FYM). It might be due to accumulation of more reserve substances in root (Mounika *et al*., 2020). These findings are in line with Acharya et al (2020) in beetroot and Nargave *et al*. (2018) in radish

Combined effect of varieties and nutrient sources revealed statistically non significant influence on TSS (^{0}Brix) in beetroot.

The effect of variety showed a significant effect on root dry matter percentage of beetroot. Highest root dry matter content was noted in under variety V_1 (Crimson Globe), while lowest root dry matter content was observed with variety V_2 (Detroit Dark Red). These results agree with Sapkota *et al*. (2021) and Pate and Patel (2019).

The results showed significant effect of nutrient sources on root dry matter content (%) of beetroot. Highest root dry matter content was recorded with nutrient source treatment N_7 (50% RDF + 50% N through vermicompost) after harvesting. Lowest root dry matter content was observed in case of nutrient source treatment N_2 (100% N through FYM) under the evaluation at harvesting stages. The application of vermicompost would have lead to an increase of accelerated mobility of photosynthates from source to sink as influenced by organic amendments and its accumulation in roots. The higher translocation was possible due to better sink capacity as indicated by the higher weight of root and resulted in increase of root dry matter production (Devi *et al.,* 2016). The results are in conformity with the findings of Szopinska and Aweda (2013) and Sapkota *et al.* (2021) in beetroot.

Combined effect of varieties and nutrient sources had non-significant influence on root dry matter content (%) in beetroot.

5.4 Economics of different treatments for beetroot production

The findings revealed significant influence of beetroot varieties and nutrient sources on gross income (Rs./ha), net income (Rs./ha) and B:C ratio. The interactive effect of varieties and nutrient sources had non significant influence on gross income (Rs./ha), net income (Rs./ha) and B:C ratio.

Among the varieties, the highest gross income, net income and B:C ratio was recorded in variety V_1 (Crimson Globe) followed by variety V_2 (Detroit Dark Red), which revealed the minimum gross income, net income and B:C ratio. Similar results have been reported by Patel *et al*. (2017) in beetroot and Kushwah *et al.* (2019).

Nutrient sources had a significant effect on gross income (Rs./ha), net income (Rs./ha) and B:C ratio in beetroot. The maximum gross income, net income and B:C ratio was recorded with the application of nutrient source N_7 (RDF 50% + 50 % N through Vermicompost), which was found significantly superior over other nutrient sources. The minimum gross income, net income and B:C ratio were recorded under nutrient source treatment N_2 (100% N through FYM). The present findings are in line with those of Mounika *et al*. (2020) in beetroot and Kushwah *et al*. (2019) in carrot.

Interactive effect of varieties and nutrient sources had exerted non significant influence on gross income, net income and B:C ratio. However, numerically maximum gross income, net income) and B:C was recorded with treatment combination V_1N_7.

Chapter-VI
SUMMARY, CONCLUSION AND SUGGESTIONS FOR FURTHER WORK

6.1 Summary

A field investigation entitled “Effect of varieties, organic manures and inorganic fertilizers on growth, yield and quality of beetroot (*Beta vulgaris* L.)” was carried out during *Rabi*, 2020-21 at Vegetable Research Field, Department of Vegetable Science, College of Horticulture, Mandsaur (M.P.). Fourteen treatment combinations comprising of two varieties viz., V_1 (Crimson Globe) and V_2 (Detroit Dark Red) and seven nutrient sources i.e. N_1 [RDF (120:60:75 NPK kg/ha)], N_2 (100 % N through FYM), N_3 (100 % N through Vermicompost), N_4 (75 % RDF + 25 % N through FYM), N_5 (75 % RDF + 25 % N through Vermicompost), N_6 (50 % RDF + 50 % N through FYM) and N_7 (50 % RDF + 50 % N through Vermicompost) were tested in factorial randomized block design with three replications. Seeds of beetroot varieties were sown in the field on 28th November, 2021. The plot size was 2.1 m x 1.8 m and sowing was done at spacing of 30 cm x 10 cm.

The observations were recorded on plant height, number of leaves, leaf area, SPAD value, fresh weight of plant, dry weight of plant, root length (cm), root diameter (cm), root weight (g), root yield (q/ ha), harvesting Index (%), TSS, root dry matter content (%). The benefit cost ratio of the different INM treatments were also worked out. The findings of the experiment have been summarized under following headings:

6.1.1 Effect of varieties

Varieties indicated significant differences for growth attributes under the experiment. Maximum plant height was found in variety V_1 (Crimson Globe) at 30, 45, 60 DAS and final harvesting stage. Minimum plant height was recorded in case of variety V_2 (Detroit Dark Red) at 30, 45, 60 DAS and final harvesting stage. Maximum number of leaves per plant were counted with variety V_1 (Crimson Globe) at 30, 45, 60 DAS and final harvesting stage. Minimum number of leaves per plant was found with variety V_2 (Detroit Dark Red) at 30, 45, 60 DAS and final harvesting stage.

Variety V_1 (Crimson Globe) had recorded maximum leaf area at the final harvesting stages of beetroot. Minimum leaf area was recorded with variety V_2 (Detroit Dark Red) at final harvesting stage. Variety V_1 (Crimson Globe) was found maximum SPAD value while compared to variety V_2 (Detroit Dark Red) at 30, 45, 60 DAS and at harvesting.

Maximum fresh and dry weight was observed in variety V_1 (Crimson Globe) and minimum fresh and dry weight (g/plant) by V_2 (Detroit Dark Red).

Yield attributes viz., root length (cm), root diameter (cm), average root weight (g), root yield (q/ha) harvesting index (%) showed significantly influenced by varieties in beetroot. Highest root length (cm) was found with variety V_1 (Crimson Globe). Lowest head length (cm) was observed in case of variety V_2 (Detroit Dark Red). Maximum root diameter (cm) was measured with varietyV_1 (Crimson Globe). Minimum root diameter (cm) was observed in case of variety V_2 (Detroit Dark Red). Maximum root weight was found with variety V_1 (Crimson Globe). Minimum was observed in case of variety V_2 (Detroit Dark Red). Highest root yield (q/ha) were recorded with variety V_1 (Crimson Globe), which was significantly superior over variety V_2 (Detroit Dark Red).

Quality of beetroot was studied with respect to total soluble solids content and root dry matter content. Highest total soluble solids content was observed in case of variety V_2 (Detroit Dark Red). Minimum total soluble solids content in root was noted in case of variety V_1 (Crimson Globe). Highest root dry matter content was noted in under variety V_1 (Crimson Globe), while lowest root dry matter content was observed with variety V_2 (Detroit Dark Red).

Among the varieties, the highest gross income, net income and B:C ratio was recorded in variety V_1 (Crimson Globe) followed by variety V_2 (Detroit Dark Red), which revealed the minimum gross income, net income and B:C ratio.

6.1.2 Effect of nutrient sources

The findings of the trial with respect to growth characters of beetroot indicated significant effect of nutrient sources. Amongst nutrient source N_7 (50

% RDF + 50 % N through Vermicompost) had recorded maximum plant height, number of leaves per plant, and SPAD value at 30, 45, 60 DAS and at harvesting. Rest of the nutrients was in order of N_6> N_5> N_4> N_1 and N_3. Minimum plant height, number of leaves per plant and SPAD value at 30, 45, 60 DAS and at harvesting were observed in case of nutrient source treatment N_2 (100 % N through FYM kg/ha). The maximum leaf area was recorded in nutrient source treatment N_7 (50% RDF + 50% N through vermicompost) indicating significantly superior over all other treatments at all the growth stage, followed by N_6, N_5, N_4, N_1 and N_3, respectively. The lowest leaf area was observed in nutrient source treatment N_2 (100% N through FYM). Nutrient source N_7 (50 % RDF + 50 % N through Vermicompost) had found maximum fresh and dry weight of plant at harvesting stage. It was followed by N_6> N_5> N_4> N_1 and N_3 in descending order. Minimum fresh weight and dry weight of plant were taken by nutrient source N_2 (100 % N through FYM kg/ha).

Yield attributes viz., root length (cm), root diameter (cm), average root weight (g), root yield (q/ha) harvesting index (%) revealed significant impact of nutrient sources in beetroot. Highest root length was recorded under N_7 (50 % RDF + 50 % N through Vermicompost) nutrient source. It was followed by N_6 > N_5> N_4 > N_1 > N_3. Lowest head length was observed with N_2 (100 % N through FYM kg/ha) nutrient source. Nutrient sources exhibited significant effect on root diameter and average root weight. Maximum root diameter and root weight was found under nutrient source treatment N_7 (50 % RDF + 50 % N through Vermicompost), which was followed by N_6> N_5> N_4> N_1> N_3 in descending order. Minimum root diameter and root weight was found under nutrient source N_2 (100 % N through FYM kg/ha). Nutrient sources exhibited significant impact on total root yield (q/ha) and harvest index. Maximum root yield (q/ha) was found with N_7 (50 % RDF + 50 % N through Vermicompost) nutrient source, which was higher than N_6> N_5> N_4> N_1> N_3 nutrient sources under the study. Minimum root yield (q/ha) were observed under N_2 (100 % N through FYM kg/ha) nutrient source.

Significantly maximum harvest index (%) were found with N_7 (50 % RDF + 50 % N through Vermicompost) nutrient source, which was higher than

N_6> N_4> N_1> N_5> N_3 nutrient sources under the study. Minimum harvest index (%) were observed under N_2 (100 % N through FYM kg/ha) nutrient source.

Results showed significant effect of nutrient sources on quality attributes viz. total soluble solids content and root dry matter content. Highest total soluble solids content and root dry matter content in root was recorded with N_7 (50 % RDF + 50 % N through Vermicompost) nutrient source, which was significantly superior over other nutrient source. It was followed by N_6> N_5> N_4> N_1> N_3, while minimum total soluble solids content and root dry matter content was recorded with N_2 (100 % N through FYM kg/ha) nutrient source.

Nutrient sources had a significant effect on gross income (Rs./ha), net income (Rs./ha) and B:C ratio in beetroot. The maximum gross income, net income and B:C ratio was recorded with the application of nutrient source N_7 (RDF 50% + 50 % N through Vermicompost), which was found significantly superior over other nutrient sources. The minimum gross income, net income and B:C ratio were recorded under nutrient source treatment N_2 (100% N through FYM).

Nutrient sources indicated significant effect on gross income, net income and B:C ratio. Highest gross income, net income and B:C ratio was found with nutrient source N_7 (50 % RDF + 50 % N through Vermicompost) which was significantly superior over all other nutrient sources. Under nutrient source N_2 (100 % N through FYM), the lowest gross revenue, net income and B:C ratio were reported.

6.1.3 Combined effect of varieties and nutrient sources

Combined effect of varieties and nutrient sources on growth parameter such as plant height, number of leaves, leaf area, SPAD value, fresh weight of plant, dry weight of plant was recorded non significant. Interaction effect of varieties and nutrient sources revealed statistically non significant influence on root length (cm), root diameter (cm), average root weight (g), root yield (q/ha) harvesting index (%). Combined effect of varieties and nutrient sources showed non significant effect on gross income, net income as well as B:C ratio in beetroot. However maximum net income and B:C ratio was realized with treatment combination V_1N_7.

6.2 Conclusion

Under Malwa region of Madhya Pradesh, the performance of beetroot variety Crimson Globe was better than Detroit Dark Red with respect to plant growth, yield, quality and profitability. Hence cultivation of Crimson Globe cultivar of beetroot should be performed better over Detroit Dark Red.

The integrated combination of chemical fertilizers, organic manures (50 % RDF + 50 % N through vermicompost) resulted in saving of 50 % fertilizers, better growth, higher yield and net returns.

Hence, the application of 50 % RDF + 50 % N through vermicompost with variety Crimson Globe can be suggested as a cost effective combination for getting higher yield with greater quality on sustainable and economical basis in beetroot.

6.3 Suggestions for further work

- The experiment may be repeated for two or three years for confirmation of the results.
- The experiment may be carried out in other seasons on various soil types under agro-climatic condition of Madhya Pradesh to see the effect of varying locations and weather conditions.
- In the future studies nutrient sources along with more varieties may be tested.
- Integration of organic manures and biofertilizers may be tested along with chemical fertilizers.
- Research on residual effect of various organic sources under different environments and management practices need to be initiated.

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APPENDICES

Appendix - I: Analysis of variance of the plant height (cm) at different growth stage

Source of Variation	D.F.	Mean Sum of Square			
		Plant height (cm)			
		30 DAS	45 DAS	60 DAS	At harvesting
Replication (R)	**2**	0.36	4.19	13.97	17.15
Varieties (V)	**1**	34.93	46.33	136.69	48.24
Nutrient Sources (N)	**6**	14.42	47.64	48.590	51.76
Interaction (V x N)	**6**	0.24	2.85	0.47	0.25
Error	**26**	0.58	3.42	5.46	8.22
CV (%)		**5.80**	**7.52**	**6.10**	**6.83**

Appendix- II: Analysis of variance of the number of leaves per plant at different growth stages

Source of Variation	D.F.	Mean Sum of Square			
		Number of leaves per plant			
		30 DAS	45 DAS	60 DAS	At harvesting
Replication (R)	**2**	0.14	1.67	1.32	1.65
Varieties (V)	**1**	37.92	49.34	28.78	47.34
Nutrient Sources (N)	**6**	1.97	5.99	14.35	20.01
Interaction (V x N)	**6**	0.05	0.14	0.25	0.39
Error	**26**	0.31	1.21	2.98	1.25
CV (%)		**8.96**	**11.48**	**13.37**	**6.78**

Appendix- III: Analysis of variance of the leaf area (cm^2) of plant at harvesting stages

Source of Variation	D.F.	Mean Sum of Square
		Leaf area (cm^2)
Replication (R)	**2**	1907.71
Varieties (V)	**1**	27585.74
Nutrient Sources (N)	**6**	37343.03
Interaction (V x N)	**6**	1524.37
Error	**26**	5847.75
CV (%)		**11.23**

Appendix- IV: Analysis of variance of the SPAD value at different growth Stages

Source of Variation	D.F.	Mean Sum of Square			
		SPAD value			
		30 DAS	45 DAS	60 DAS	At harvesting
Replication (R)	**2**	1.89	0.82	0.82	13.05
Varieties (V)	**1**	38.18	21.41	34.89	45.53
Nutrient Sources (N)	**6**	14.38	16.95	18.43	20.12
Interaction (V x N)	**6**	0.23	5.65	0.25	0.79
Error	**26**	5.45	3.79	6.87	7.71
CV (%)		**5.24**	**4.09**	**5.09**	**5.20**

Appendix- V: Analysis of variance of the fresh weight and dry weight of plant (g) in beetroot

Source of Variation	D.F.	Mean Sum of Square	
		Fresh weight of plant (g)	Dry weight of plant (g)
Replication (R)	**2**	0.68	6.91
Varieties (V)	**1**	394.01	28.04
Nutrient Sources (N)	**6**	467.34	50.56
Interaction (VxN)	**6**	21.18	0.31
Error	**26**	85.01	6.62
CV (%)		**3.07**	**5.10**

Appendix- VI: Analysis of variance of the root length and Root diameter (cm) of plant at harvesting stages

Source of Variation	D.F.	Mean Sum of Square	
		Root length (cm)	Root diameter (cm)
Replication (R)	**2**	0.75	0.72
Varieties (V)	**1**	5.82	4.07
Nutrient Sources (N)	**6**	4.20	2.70
Interaction (V x N)	**6**	0.18	0.08
Error	**26**	1.07	0.39
CV (%)		**13.17**	**8.80**

Appendix - VII: Analysis of variance of the root weight (g) and root yield (q/ha) in beetroot

Source of Variation	D.F.	Mean Sum of Square	
		Root weight (g)	Root yield (q/ha)
Replication (R)	**2**	12.99	144.33
Varieties (V)	**1**	719.53	7994.78
Nutrient Sources (N)	**6**	715.00	7944.40
Interaction (V x N)	**6**	5.41	60.15
Error	**26**	93.90	1043.29
CV (%)		**5.71**	**5.71**

APPENDIX- VIII: Analysis of variance of the harvest index (%) in beetroot

Source of Variation	D.F.	Mean Sum of Square
		Harvest index (%)
Replication (R)	**2**	.99
Varieties (V)	**1**	145.75
Nutrient Sources (N)	**6**	23.08
Interaction (V x N)	**6**	0.22
Error	**26**	5.92
CV (%)		**4.31**

Appendix- IX: Analysis of variance of the total soluble solids (^{0}Brix) and root dry matter content (%) in beetroot

Source of Variation	D.F.	Mean Sum of Square	
		TSS (^{0}Brix)	Root dry matter content (%)
Replication (R)	**2**	0.22	0.03
Varieties (V)	**1**	20.47	40.04
Nutrient Sources (N)	**6**	1.98	6.85
Interaction (V x N)	**6**	0.07	0.05
Error	**26**	0.45	0.52
CV (%)		**6.10**	**6.34**

Appendix – X : Analysis of variance for gross income (Rs./ha), net income (Rs.) and B:C ratio in beetroot

Source of variation	D.F.	Mean Sum of Square		
		Gross income (Rs./ha)	Net income (Rs./ha)	B:C ratio
Replication (R)	**2**	36083386.83	36083386.83	0.00
Varieties(V)	**1**	1998696108.42	1998696108.42	0.24
Nutrient Sources (N)	**6**	1986100855.83	4608360588.67	1.89
Interaction (VxS)	**6**	15038409.08	15038409.08	0.00
Error	**26**	260822232.22	260822232.22	0.03
CV (%)		**5.71**	**8.40**	**8.07**

Appendix -XI: General cost of beet root cultivation excluding the cost of the treatment inputs (Rs.**/ha)**

S.No.	**Particulars**	**Unit**	**Quantity**	**Rate/ unit (Rs)**	**Cost (Rs/ha)**
A	**Land preparation**				
1	Ploughing with M.B. plough@ 0.4ha/hr	Hrs.	4	700	2800
2	Disc harrow	Hrs.	6	700	4200
3	Planking and leveling	Hrs.	2	700	1400
4	Layout of the field	Labour	15	300	4500
B	**Sowing**				
1	Cost of seed	Kg	8	700	5600
2	Labour for sowing and transplanting	Labour	45	300	13500
C	**Gap filling**	Labour	9	300	2700
D	**Irrigation**				
1	Tube well charges – 8 irrigation (2hrs/irrigation)	Hrs.	16	400	6400
2	Labour for irrigation	Labour	8	300	2400
E	**Harvesting, transporting and marketing**	Labour	35	300	10500
F	**Extra (Miscellaneous Expdt.)**				12500
	TOTAL				**66500**

Appendix – XII: Cost of treatments in beetroot

Treatment	Nutrient Sources (Kg per hectare)					Treatment cost (Rs./ha)					
	Urea	DAP	MOP	FYM	V.C.	Urea	DAP	MOP	FYM	V.C.	Total
N_1 - RDF (120:60:75)	210	130	125.00	-	-	1125.6	2925	2180	0	0	6230.6
N_2 - 100 % N through FYM	-	-	-	24000	-	0	0	0	48000	0	48000.0
N_3 -100 % N through Vermicompost	-	-	-	-	7272.73	0	0	0	0	36363.6	36363.6
N_4 - 75 % RDF + 25 % N through FYM	157.5	97.5	93.75	6000	-	844.2	2193.75	1635	12000	0	16673.0
N_5 – 75 % RDF + 25 % N through Vermicompost	157.5	97.5	93.75	-	5454.55	844.2	2193.75	1635	0	10000	14673.0
N_6 – 50 % RDF + 50 % N through FYM	105	65	62.50	12000	-	562.8	1462.5	1090	24000	0	27115.3
N_7 – 50 % RDF + 50 % N through Vermicompost	105	65	62.50	-	3636.36	562.8	1462.5	1090	0	18181.8	21297.1

Appendix– XIII: Economics of different treatments in beetroot

Treatment	Common Expenditure (Rs.)	Treatment cost (Rs.)	Total cost (Rs./ha)	Yield (q/ha)	Gross income (Rs.)	Net income (Rs.)	C:B Ratio
V_1N_1	66500	6230.60	72730.60	560.97	280483.05	207752.45	2.86
V_1N_2	66500	48000.00	114500.00	537.07	268533.06	154033.06	1.35
V_1N_3	66500	36363.64	102863.64	550.83	275416.39	172552.75	1.68
V_1N_4	66500	16672.95	83172.95	577.53	288766.38	205593.43	2.47
V_1N_5	66500	14672.95	81172.95	591.12	295560.82	214387.87	2.64
V_1N_6	66500	27115.30	93615.30	600.87	300433.03	206817.73	2.21
V_1N_7	66500	21297.12	87797.12	640.83	320416.35	232619.23	2.65
V_2N_1	66500	6230.60	72730.60	539.17	269583.06	196852.46	2.71
V_2N_2	66500	48000.00	114500.00	506.03	253016.41	138516.41	1.21
V_2N_3	66500	36363.64	102863.64	510.87	255433.08	152569.44	1.48
V_2N_4	66500	16672.95	83172.95	550.63	275316.39	192143.44	2.31
V_2N_5	66500	14672.95	81172.95	567.57	283783.05	202610.10	2.50
V_2N_6	66500	27115.30	93615.30	578.3	289149.71	195534.41	2.09
V_2N_7	66500	21297.12	87797.12	613.5	306749.69	218952.58	2.49

*Sale price of produce: Rs. 500/- per quintal.

VITA

The author of this thesis Mr. Premsingh Kanase S/O Shree Ranglal Kanase and Smt. Khyalee Bai Kanase was born on 04th August, 1996 at Villege - Gram, Post Mongargaon, Tehsil- Bhagwanpura, District- Khargone (Madhya Pradesh) 451441. He passed higher Secondary School of Education in the year 2014 with 53.68 % marks from the M.P. Board.

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He was allotted an interesting research problem entitled "Effect of varieties, organic manures and inorganic fertilizers on growth, yield and quality of beetroot (*Beta vulgaris* L.)" of him choice for thesis work, which has been duly completed by him and presented in the form of this thesis.

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