

**Effect of Varieties and Fertility Levels on
Growth, Yield and Quality of Turnip
(*Brassica rapa* L.)**

THESIS



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by

Diksha Rathore

Department of Vegetable Science

Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior

K. N. K. College of Horticulture, Mandsaur (M.P.) 458002

2021

CERTIFICATE- I

This is to certify that the thesis entitled “**Effect of varieties and fertility levels on growth, yield and quality of turnip (*Brassica rapa* L.)**” submitted in partial fulfillment 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 **Ms. DIKSHA RATHORE** 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.

(Rakesh Kumar Sharma)

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MEMBER OF STUDENT’S ADVISORY COMMITTEE

Chairman (Dr. R. K. Sharma) :.....

Member (Dr. S. S. Kushwah) :.....

Member (Dr. O. P. Singh) :.....

Member (Dr. G. P. S. Rathore) :.....

CERTIFICATE- II



Aadhaar No.: 826630479334

ID No.: 18141415

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Place: Mandsaur

Date: 23-11-2021

(Rakesh Kumar Sharma)

Chairman of the Advisory Committee

MEMBERS OF THE ADVISORY COMMITTEE

Chairman (Dr. R. K. Sharma) :

Member (Dr. S. S. Kushwah) :

Member (Dr. O. P. Singh) :

Member (Dr. G. P. S. Rathore) :

Head of the Department :

Dean of the College :

Director Instructions :

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List of symbols/abbreviations

Symbol	Abbreviation	Stands for
/	-	Per
@	-	At the rate of
%	-	Percentage
^o C	-	Degree Celsius
-	ANOVA	Analysis of Variance
-	B:C	Benefit cost ratio
-	CD	Critical difference
-	cm	Centimeter
-	cm ²	Centimeter square
-	CV	Coefficient of Variance
-	cv.	Cultivar
-	DAP	Di Ammonium Phosphate
-	DAT	Days After Transplanting
-	D.f.	Degrees of Freedom
-	DW	Distilled Water
-	EMS	Error Mean Sum of Squares
-	<i>et al.</i>	et-alii (And others)
	<i>etc.</i>	Etcectera
-	Fig.	Figure
-	g	Gram
-	h	Hour
-	ha	Hectare
-	<i>i.e.</i>	That is
-	K	Potassium
-	kg	Kilogram
-	Kg/ha	Kilogram per hectare
-	L	Liter
-	Max.	Maximum
-	mg	Milligram
-	Min.	Minimum

-	ml	Milliliter
-	mm	Millimeter
-	MSS	Mean Sum of Squares
-	MOP	Murate of potash
-	m ²	Meter square
-	m	Meter
-	N	Nitrogen
-	NS	Non Significant
-	No.	number
-	P	Phosphorus
-	pH	Potential of hydrogen
-	ppm	Parts Per Million
-	q/ha	Quintal per hectare
-	FRBD	Factorial Randomized Block Design
-	R.H.	Relative Humidity
-	Rs.	Rupees
-	RVSKVV	Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya
-	S. Ed.	Standard Error of Difference
-	S. Em ±	Standard Error of Mean
-	SPAD	Soil plant analysis development
-	SS	Sum of Squares
-	t	ton
-	TSS	Total soluble solids
-	var.	Variety
-	Temp.	Temperature
-	Viz.	Videlicet (Namely)



CHAPTER- I
INTRODUCTION

Chapter-I

INTRODUCTION

Turnip (*Brassica rapa* L.) belongs to the family cruciferae and it is believed to have originated from a wild form of Eurasian origin. It has been known for about 4000 years. Turnip is a herbaceous biennial and winter vegetable crop it is white and bulbous. Turnip has a taproot system. Its small tender varieties are grown for human consumption, while larger varieties are grown to feed livestock. It has a crisp white flesh and a zesty mustard-like flavour and it is a rapidly maturing crop. Its root is called underground modified root, which is napiform in shape. Turnip has considerable nutritive value compared to other cole crops that we commonly used in our daily diet. The fleshy root and young leaves is the main edible portion.

The fresh roots are used in salads or consumed as cooked vegetable and it is also used as pickles. The turnip roots contains 4.4 g carbohydrates, 3.5 g dietary fiber, 0.2 g fat, 1.1 g protein, 381 µg vitamin-A, 118 µg vitamin B9, 27 mg vitamin-C, 368 µg vitamin-K, 137 mg Calcium, 3 g sugars, 0.027 mg vitamin B1, 0.023 mg vitamin B2, 0.299 mg vitamin B3, 33 mg calcium, 0.18 mg iron, 9 mg magnesium, 0.071 mg manganese, 26 mg phosphorus, 177 mg potassium, 16 mg sodium and 0.12 mg zinc. The green leaves of the turnip top are a good source of vitamin-A, folate, vitamin-C, vitamin-K and calcium (Khetran *et al.*, 2016).

A decoction of the leaves or stems is used in the treatment of cancer. The powdered seed is said to be a folk remedy for cancer. The crushed ripened seeds are used as a poultice on burns. Turnip extract is also useful for lowering uric acid and extracting renal stones. It increases visual keenness and is used to treat night blindness. Turnip's syrup strengthens the memory. Turnip root peelings contain a natural insecticide (Aisa *et al.*, 2014).

India is the world's second largest producer of vegetables next to China along with number of varieties grown in the country. In India, Turnip is cultivated in an area of 33 thousand ha with an annual production of 515 thousand tonnes with a productivity of 15 tonnes per hectare (Anonymous, 2013).

The fleshy thickened underground part of turnip is truly the hypocotyls, the colour and shape of which vary depending mainly on the cultivar. Its shape may vary from flat through globular to top- shaped and long. The below ground colour may be white or yellow, while the skin colour of above ground portion may be red, purple, white or yellow (Thamburaj and Singh, 2001).

To attain considerable production and quality yield for any crop it needs proper management including ensuring the availability of essential nutrient components in proper doses. Turnip thrives well in fertile, clay loam soil because it requires considerable amount of nutrients to sustain rapid growth in short time. A large amount of fertilizer is required for the growth and development of vegetable crops (Sadia *et al.*, 2013b).

Nitrogen is an essential macronutrient needed by all plants to thrive. It is an important component of many structural, genetic and metabolic compounds in plant cells. Increasing the levels of nitrogen during the vegetative stage can strengthen and support plant roots, enabling plants to take in more water and nutrients; and allows a plant to grow more rapidly and produce large amounts of succulent, green foliage, which in turn can generate bigger yields, tastier vegetables, and a crop that is more resistant to pests, diseases (Khetran *et al.*, 2016).

Phosphorus is one of the important essential macro elements for the normal growth and development of plant. The phosphorus requirements vary depending upon the nutrient content of the soil. Phosphorus shortage restricted the plant growth and remains immature. Turnip is a short duration crop, for that easily soluble fertilizer like as phosphorus should be applied in the field. The optimum proportion of fertilizer enhances the growth and development of a crop as well as ensures the availability of other essential nutrients for the plant. Again secondary mechanism of interference was the absorption of phosphorus from the soil through luxury consumption, increasing the tissue content without enhancing smooth biomass accumulation (Sadia *et al.*, 2013b).

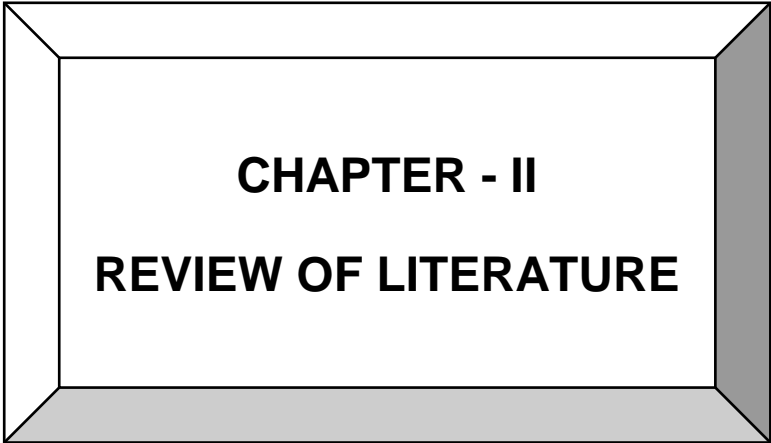
The role of potassium element in metabolism and many processes needed to sustain and promote plant vegetative growth and development.

Moreover, K plays a major role in many physiological and biochemical processes such as cell division and elongation and metabolism of carbohydrates and protein compounds (Shafeek *et al.*, 2015).

The aim of this study was to determine the effects of varieties and different levels of fertility on the growth, yield and quality of turnip. The information about the fertility levels in turnip under the agro-climatic conditions of Malwa region of Madhya Pradesh is rather limited and sketchy.

Keeping in view, the above facts, an experiment entitled “Effect of varieties and fertility levels on growth, yield and quality of turnip (*Brassica rapa* L.)” was carried out at Department of Vegetable Science, College of Horticulture, Mandsaur during *Rabi* season, 2019-20 with the following objectives:

1. To evaluate the performance of turnip varieties
2. To study the effect of fertility levels on growth, yield and quality of turnip
3. To assess the combined effect of varieties and fertility levels on growth, yield and quality of turnip



CHAPTER - II
REVIEW OF LITERATURE

Chapter- II

REVIEW OF LITERATURE

The literature related to the various aspects of the present investigation entitled “Effect of varieties and fertility levels on growth, yield and quality of turnip (*Brassica rapa* L.) ” and related aspects have been briefly reviewed in this chapter under following headings:

- 2.1 Effect of varieties
- 2.2 Effect of fertility levels
- 2.3 Combined effect of varieties and fertility levels

2.1 Effect of varieties

Pervez *et al.* (2003) evaluated various radish cultivars to find out high yielding better cultivar. The data suggested that the cultivar “Sixty days” superceded all the cultivars in relation to yield potential whereas, Mino Early Long White and Green Neck appeared to be promising for adoption in future.

Ijoyah *et al.* (2008) evaluate 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’.

Bhattarai *et al.* (2015) identified suitable variety for mid-hills in turnip. The local genotype from Kathmandu Valley was used as the base material for the selection of genotype HRDTUR001. The performance of selected genotype was evaluated for size, colour, taste, yield and other characters using Purple Top a released variety as the standard check. The on station results revealed that genotype HRDTUR001 was found promising because of attractive root colour, excellent root size (224.45 g) and better taste for vegetable purpose.

Dongarwar *et al.* (2017) investigated growth, yield and qualitative parameters of various radish varieties. Seven varieties of radish, used for the study as treatments were viz., V₁- Pusa Desi, V₂- Pusa Chetki, V₃-Pusa Reshmi, V₄- Pusa Himani, V₅- Japanese White, V₆- Arka Nishant and V₇- IHR-1-1. The plant height was supreme (28.29 cm) in Arka Nishant, maximum chlorophyll content of leaves (3.10 mg g⁻¹) recorded in Arka Nishant. The variety Arka Nishant required minimum (43 days) number of days, in weight of total fresh weight of plant (190.06 g to 226.60 g) were observed. It was maximum in variety Arka Nishant, whereas, minimum in variety Pusa Desi. The variations in fresh weight of root (122.76 g to 161.74 g) were observed. The maximum root to shoot ratio (1.37) was observed in variety Arka Nishant. The values of root diameter were maximum (3.69 cm) in variety Arka Nishant. The maximum root yield plot⁻¹ (32.34 kg plot⁻¹) and hectare⁻¹ (53.91 t ha⁻¹) was produced in variety Arka Nishant. The maximum moisture content of root (97.75%) was recorded in Arka Nishant variety. The ascorbic acid content was maximum (18.36 mg 100 g⁻¹), TSS (4.00°B) was recorded in the variety Arka Nishant.

Dongarwar *et al.* (2018) investigated growth, yield and qualitative parameters of various radish varieties. Seven varieties of radish, used for the study as treatments were viz., Pusa Desi, Pusa Himani, Pusa Reshmi, Pusa Chetaki, Arka Nishant, Japanese White, IHR-1- 1. The growth parameters like plant height was maximum at 28.29 cm in Arka Nishant, while it was minimum at 22.70 cm in Pusa Himani, also the chlorophyll content of leaves was 3.10 mg g⁻¹ recorded in Arka Nishant. However, the minimum leaf area was 85.04 cm² recorded in Pusa Himani and minimum chlorophyll content of leaves was 1.61 mg g⁻¹ in variety Pusa Desi. The substantial variations in weight of total fresh weight of plant (190.06 g to 226.60 g) were observed. It was maximum in variety Arka Nishant, whereas, minimum in variety Pusa Desi. The values of root diameter were minimum in IHR -1-1 (2.60 cm) and maximum (3.69 cm) in variety Arka Nishant. The maximum root yield per plot was 32.34 kg plot⁻¹ produced in variety Arka Nishant. The maximum moisture content of root (97.75%) was recorded in Arka Nishant variety, whereas it was found minimum (95.35%) in the variety IHR-1-1. The maximum crude fiber content

of root was 1.71% in variety IHR-1-1 and minimum content recorded in the variety Arka Nishant was 1.32%.

Ola *et al.* (2018) indicated that analysis of variance revealed highly significant differences among varieties for almost all the traits in radish. The yield parameters showed that Snow White variety significantly maximum plant height (66.33 cm) and number of leaves (23.70). The maximum root diameter (5.91 cm) was observed in Pusa Murdula and maximum total weight of plant (435.31 g plant⁻¹) root yield per plot (30.56 kg) and root yield hectares (509.28 q) was recorded in variety of evergreen. From nutritional point of view the variety local 3 recorded highest TSS content of 6.13 °Brix. The variety J. U. recorded highest acidity (0.45 mg/100 g) and highest vitamine- C (27.14 mg/100 g) was found in Baramasi variety.

Singh *et al.* (2019) evaluated the performance of different varieties of radish. The silent findings of the experimentation are as Using 9 genotype namely, Suneha, Pusa hill queen, Punjab Pasand, Hongkong-11, Snow white, Pusa Reshmi, White icicle, Pusa Himani, Japanese White of radish the early stages Pusa Himani, Pusa hill queen and Pusa Reshmi a rapid increase in plant height was noted during early stages of growth up to 30 DAS. There was a significant variation regarding the plant height between the nine varieties. The lowest leaf weight was recorded in Hong kong-11 (T-4, 10.4 g) and maximum in Pusa Himani (T-3, 17.56 g) at 15 DAS. At the harvesting stage maximum number of leaves per plant was recorded in Pusa Himani (T-3, 13.66) variety and was found significantly superior to other varieties. Data on the leaf length were recorded maximum leaf length in Pusa Reshmi (T-2, 18.80 cm) and minimum leaf length was recorded in Suneha (T-1, 11.63 cm). At 30 DAS maximum leaf width recorded in Pusa Reshmi (T-2, 7.43 cm) and minimum leaf width in Suneha (T-1, 5.26 cm) at harvesting stage maximum root length was recorded in variety Pusa Himani (T-3, 24.40 cm) and minimum root length recorded in Suneha (T-1, 19.00 cm). Maximum root thickness recorded in Pusa Himani (T-3, 5.26 cm) at harvesting stage. Variety White icecle (T-9, 1.62) reported maximum leaf: root ratio and was significantly superior other varieties and minimum in variety Snow white (T-5, 0.60) at 15 DAS. However, leaf: root weight ratio in the variety Pusa hill queen (T-7, 0.82) was found maximum and minimum in the variety Pusa Reshmi (T-

2, 0.62) at 45 DAS. T The maximum fresh root weight was recorded in the variety Pusa Himani (T-3, 85.53 g) and minimum in the variety Suneha (T-1, 63.80 g) at 30 DAS. The maximum yield at harvest time was recorded in the variety Pusa Himani (T-3, 33.14 t/ha) which was followed by Pusa Reshmi (T-2, 32.65 t/ha) and Japanese white (T-8, 32.28 t/ha).

2.2 Effect of fertility levels

Pearson and Thomson (1996) evaluated the growth and yield responses of turnips to nitrogen (N) fertilizer (0, 25, 50, 100, and 200 kg N/ha), phosphate (P) fertilizer (0, 38 and 100 kg P/ha) and soil Olsen P level (28, 48 and 81). All trial sites had an Olsen P greater than 26 and where measured, total soil nitrogen content greater than 0.63%. From sowing, the accumulation of the components of turnip yield (leaf and bulbs) varied. The accumulation of leaf yield peaked (96 kg DM/ ha/ day) 70 - 90 days from sowing with no further increase, whereas the accumulation of bulb yield increased at a relatively constant rate through to the end of the 120 day measurement period. All trials exhibited similar trends in response to applied N. Increasing rates of N gave lower ($P < 0.05$) bulb yield and higher leaf to bulb ratio ($P < 0.05$). Total dry matter yield (ranging from 7 to 12 t DM/ha at 90 days after sowing) was unaffected by N. There was no response to N following a 12 month cropping rotation of turnips/winter green feed/turnips. Neither soil phosphate status nor the addition of P had any effect on turnip yield.

Ndang and Sema (1999) investigated the effect of varying levels of nitrogen and potassium on growth and yield of radish. Nitrogen significantly influenced number of leaves and leaf area index (LAI) but not dry matter content of leaf. Potassium and interaction of N and K failed to significantly increase the number of leaves, and dry matter content with an exception of N and K interaction on LAI. In general, potassium significantly influenced the yield and their attributes while the influence of N and interaction failed to reach the level of significance except for fresh weight. However, there was a marked increase in various parameters of yield and their attributes following nitrogen application. In general, N₁ (25 kg/ ha) and K₃ (60 kg/ha) proved to be promising than all the other treatments.

Ali *et al.* (2003) studied the effect of nitrogen and potassium on quality and yield of carrot root which involved four doses of nitrogen, namely, 0, 100, 150, 200 kg ha⁻¹ and four doses of potassium namely, 0, 150, 200, 250 kg ha⁻¹. Application of N₂₀₀K₂₅₀ increases the yield 324 % over the control. The highest carotene content (20.47 μ g⁻¹) was recorded in the plants received 200 kg ha⁻¹ nitrogen and the lowest carotene content (9.50 μ g⁻¹) from the plant grown without nitrogen. The maximum carotene content (33.43 μ g⁻¹) was obtained from the plant under treatment N₂₀₀K₂₅₀ and minimum (4.47 μ g⁻¹) was obtained from plants under control treatment. The highest reducing sugar content (573.9 mg g⁻¹) was found from the plants receiving 200 kg ha⁻¹ nitrogen and the lowest (450.6 mg g⁻¹) from the plants receiving no. nitrogen, potassium had adverse effects on sugar accumulation in the carrot root. The lowest (287.7 mg g⁻¹) reducing sugar content was obtained from K₂₅₀ and highest reducing sugar content (704.4 mg g⁻¹) recorded in plants grown without potassium. The highest (755mg g⁻¹) reducing sugar content was found in plants grown without nitrogen and potassium and lowest (329.3 mg g⁻¹) were found in plants under treatment N₂₀₀K₂₅₀ root cracking was increased progressively and significantly with increasing application of both nitrogen and potassium but their interaction effects was in significant.

Pervez *et al.* (2004) observed the effect of various nitrogen levels (0, 100, 150 & 200 kg ha⁻¹) and spacing (5, 10 & 15 cm) on growth and yield of radish. Application of 200kg N ha⁻¹ planted at 10 cm plant to plant distance was found the best treatment than others in relation to growth and yield of radish.

Abdel-Motagally and Attia (2009) examined the effects of different rates of nitrogen (143, 214 & 285 kg N ha⁻¹) and potassium (0, 57 & 114 kg K₂O ha⁻¹) fertilization on yield, quality and nutrient contents of sugar beet. Adding the highest level of K (114 kg K₂O ha⁻¹) under different rates of N significantly increased sucrose contents, recoverable sugar yield (ton ha⁻¹) and some quality traits. By adding the highest level of N (285 kg N ha⁻¹) under different rates of K significantly increased sugar loss (ton ha⁻¹) and increased content and uptake of N and K in both root and foliage of sugar beet over two seasons. Increasing N level up to 285 kg N ha⁻¹ (under 0.0 kg K₂O ha⁻¹)

significantly increased impurities (Na, K & α -amino-N) and sugar loss percentage. In crux, N fertilizer at a level of 285 kg N/ha accompanied with 114 kg K₂O ha⁻¹ were the most effective in improving yield, quality and nutritional status of sugar beet grown in a sandy calcareous soil.

Turk *et al.* (2009) determine the effects five different nitrogen doses (N 0, 50, 100, 150 and 200 kg ha⁻¹) and four phosphorus doses (P₂O₅ 0, 40, 80 and 120 kg ha⁻¹) on root and leaf yields and yield components of forage turnip (*Brassica rapa* L.) under Mediterranean region of Turkey in the 2006 and 2007 growing seasons. According to averages of two years, the effect of N doses was significant at all components and P doses were significant at leaf yield, leaf DM yield, root and leaf CP contents, leaf CP yields, ADF and NDF contents in root and leaf. N doses increased root length, root diameter, root yield and DM yield, leaf yield and DM yield, root CP content and yield, leaf CP content and yield, P treatments increased leaf yield, leaf DM yield, root CP content, leaf CP yields. Nitrogen and phosphorus doses decreased ADF and NDF contents of root and leaf of forage turnip.

Wilson *et al.* (2009) studied the effects of varying levels of NPK fertilizers on the growth and yield of radish [*Raphanus sativus* (L.)]. Nitrogen fertilization at the rates of 60, 120 and 180 kg/ha in the presence of varying rates of phosphorus (30, 60 and 90 kg/ha) and potassium (180 and 220 kg/ha) fertilizers were applied at planting under field conditions. The application of 120 kg N, 60 kg P and 180 kg K/ha had a significant effect (P = 0.05) on all agronomic characteristics including leaf number, leaf length, root length, root girth, root weight and yield per hectare. Increased levels of nitrogen to 180 kg/ha had a significant impact on plant characteristics, with lower root length, root girth and yield per hectare. The response to levels of phosphorus and potassium were less pronounced, with significant effect at 60 kg P/ha and no effect of potassium fertilizer.

Jilani *et al.* (2010) studied the effect of different levels of nitrogen on growth and yield of radish five N levels (50, 100, 150, 200 and 250 kg/ha) along with a control (no nitrogen) were tried. Maximum number of leaves (18.70, 18.17 and 18.10), leaf length (33.33, 32.80 and 31.10 cm), weight of leaves (160.67, 132.83 and 140.82 g), root length (23.77, 22.10 and 22.23

cm), root diameter (4.43, 4.87 and 4.15 cm), root weight (139.28, 122.73 and 127.16 g) and yield (99.88, 85.10 and 89.24 t/ha) were recorded when N was applied @ 200, 250 and 150 kg per hectare, respectively.

Turk (2010) determined the effects of twenty four different fertilizer combinations included four different nitrogen doses (0, 75, 150 and 225 kg N ha⁻¹), two phosphorus doses (0 and 50 kg P₂O₅ ha⁻¹) and three potassium doses (0, 50 and 100 kg K₂O ha⁻¹) on root yield and yield components of fodder beet (*Beta vulgaris var. crassac Mansf.*) Fertilizer applications increased root yield, dry matter yield, crude protein content, crude protein yield, root diameter and root length but decreased ADF and NDF contents of roots. The highest root yield and crude protein yields were obtained from 225 kg ha⁻¹ N + 50 kg ha⁻¹ P treatments.

El-Sherbeny *et al.* (2012) evaluated the effect of various levels of NPK (N₁₀₀ P₁₀₀ K₅₀ and N₂₀₀ P₂₀₀ K₂₀₀), humic acid (0.02%, 0.04% and 0.06%) or compost tea (100, 200, 300 ml/L) on *Brassica rapa* (turnip) plants. The highest growth parameters or biomass represented by leaves and roots were obtained with the second level of NPK or humic acid, but it can recommend to applied humic acid as an organic fertilizer for producing organic products. Humic acid or compost tea increased carbohydrate content while the two levels of NPK fertilizers caused inhibition for its accumulation. Moreover, affect of these treatments on minerals content, total lipids and fatty acids were studied.

Moniruzzaman *et al.* (2013) evaluated the effect of four levels of applied nitrogen on the growth and yield of carrot. The maximum plant height (47.36 cm), root length (16.17 cm), fresh weight of leaves (145.1 g), dry matter content (11.66 g) of leaves, fresh weight of root (68.33 g), dry matter content of root (15.90%), gross yield (22.55 t/ha) and marketable yield (20.67 t/ha) were found in 100 kg N/ha.

Sadia *et al.* (2013b) studied the influence of different phosphorus levels on growth and yield of turnip. The experiment considered as different levels of phosphorus (P₀: 0 kg P₂O₅/ha (control); P₁: 40 kg P₂O₅/ha; P₂: 70 kg P₂O₅/ha and P₃: 100 kg P₂O₅/ha). Tallest plant (12.2 cm and 22.7 cm) was recorded

from P₃ at 20 and 30 DAS. At 40, 50 DAS and at harvest the tallest plant (34.0 cm, 58.4 cm and 60.6 cm) was recorded from P₂. On the other hand at same DAS, the shortest plant (10.2 cm, 18.2 cm, 28.3 cm, 50.0 cm and 52.8 cm) was recorded from P₀. The highest diameter of root (3.7 cm) and yield per hectare (24.9 ton) was recorded from P₃ and the lowest root diameter (3.0 cm) and lowest yield per hectare (19.1 ton) was recorded from P₀.

Sadia *et al.* (2013a) tested the effect of nitrogen on growth and yield of turnip. The experiment consisted of four different levels of nitrogen (N₀: 0 kg N ha⁻¹ (control); N₁: 40 kg N ha⁻¹; N₂: 70 kg N/ha and N₃: 100 kg N ha⁻¹) with 3 replications. Results showed that at 20, 30, 40, 50 DAS and at harvest, the tallest plant (11.9 cm, 22.6 cm, 34.8 cm, 58.4 cm and 60.8 cm, respectively) was recorded from N₂ whereas the shortest plant (10.1 cm, 18.5 cm, 27.3 cm, 48.6 cm and 51.3 cm, respectively) was recorded from N₀. The highest diameter of root (3.7 cm) and highest yield per hectare (25.8 tons) were recorded from N₃ and, the lowest diameter (2.9 cm) and lowest yield (18.8 ton) were recorded from N₀.

Sarag and Moselhy (2013) studied the effect of four N levels (105, 141, 176, 211, N kg ha⁻¹) and four K levels (60, 100, 140, and 180 K₂O kg ha⁻¹) on multi germ sugar beet cultivar (Ymer) results showed that the highest sugar beet yields of top (15.478 and 17.695 t ha⁻¹), root (41.184 and 49.88 t ha⁻¹) and gross sugar (7.622 and 8.936 t ha⁻¹) were obtained by adding the highest fertilizer rest (211 N kg and 140 K₂O Kg per hectare). The maximum sucrose percent (18.64 and 18.87%) was achieved by adding 100 K₂O kg and 141 N kg ha⁻¹ gross sugar yield per hectare was positively correlated with yields of sugar beet top (0.974) and roots (0.823) ha⁻¹ but negatively correlated with quality index (-0.987).

Baloch *et al.* (2014) conducted a field experiment to find out the effect of nitrogen along with constant doses of phosphorus and potassium. Four different levels of *i.e.* 00, 50, 100 and 150 kg ha⁻¹ of N in the form of urea were on radish (*Raphanus sativus L.*) cv. Early Long White). Phosphorus and potassium were used at constant rates of 75 and 100 kg ha⁻¹. After compiling the results it was known that an increase in nitrogen levels from 100 to 150 Kg ha⁻¹ positively affected all growth and yield parameters of radish. Control plots

where no fertilizers were applied remained inferior for all characteristics. The root yield plot⁻¹ (Kg) and root yield (t ha⁻¹) were 73.37, 86.81, 98.45 and 45.64, 64.00, 72.60 were obtained at 00, 100 and 150 Kg ha⁻¹ of nitrogen, respectively.

Nahar *et al.* (2014) studied the effect of phosphorus on growth and yield of carrot. Four levels of phosphorus viz., P₀: 0 kg P₂O₅/ha (control), P₁: 50 kg P₂O₅/ha, P₂: 60 kg P₂O₅/ha and P₃: 70 kg P₂O₅/ha were used. Most of the characters including yield/ha showed higher results for P₃. The highest marketable yield (35.9 t ha⁻¹) was recorded from P₃ whereas lowest (24.1 t ha⁻¹) from P₀. It can be suggested to use 70 kg P₂O₅ per hectare for higher production of carrot.

Kumar *et al.* (2015) studied the effect of nitrogen application on growth and yield of fodder turnip (*Brassica campestris var. rapa* L.) with four levels of nitrogen (0, 50, 100 and 150 kg N/ha). Among N treatments of 150 kg application N/ha gave the highest growth, yield and quality. For weed management,

Shafeek *et al.* (2015) Conducted two field experiments to find out the influence of foliar spraying of yeast extracts at 3 levels (0, 1% and 2 %) with potassium fertilizer applied at 3 levels (100, 150 and 200 kg/fed.) on plant growth, yield, yield components and root chemical contents of turnip plants cv. "Balady". Results indicated that the highest values of plant growth criteria, total roots yield and its components were recorded when sprayed by high level of yeast extract (2%) with high level of potassium soil fertilizer as compared the other interaction treatments. The statistical analysis of the obtained data revealed insignificant differences between the interaction treatments except fresh weight of leaves/plant and the percentage of nitrogen and protein contents in root tissues at second season only.

Uikey *et al.* (2015) examined the effect of application of nitrogen levels on yield and chemical composition of turnip (*Brassica campestris var. rapa* L.) fodder using five levels of nitrogen (0, 40, 80, 120, 160 kg N/ha) The highest DM yield (81.85 q/ha) and CP content (13.50%) were obtained with N application @ 160 kg/ha.

Khetran *et al.* (2016) examined the production response of turnip to different levels of nitrogenous and phosphatic fertilizers. The turnip crop fertilized with N-P levels of 125-75 kg ha⁻¹ resulted in 40.67 cm plant height, 15.86 leaves plant⁻¹, 81.74 g fresh weight of leaves plant⁻¹, 113.62 g single turnip root weight, 7.35 kg root yield plot⁻¹ and 14690.88 kg root yield ha⁻¹. The turnips given N-P fertilizers at the rate of 125-50 kg ha⁻¹ produced 40.00 cm plant height, 15.60 leaves plant⁻¹, 80.40 g fresh weight of leaves plant⁻¹, 111.76 g single turnip root weight, 7.23 kg root yield plot⁻¹ and 14450.23 kg root yield ha⁻¹. The crop fertilized with N-P levels of 100-75 kg ha⁻¹ produced 35.00 cm plant height, 13.65 leaves plant⁻¹, 70.35 g fresh weight of leaves plant⁻¹, 97.79 g single turnip root weight, 6.32 kg root yield plot⁻¹ and 12643.79 kg root yield ha⁻¹. It was concluded that the differences in all the growth and yield parameters of turnip fertilized with N-P levels of 125-75 kg and 125-50 kg ha⁻¹ was non-significant ($P < 0.05$) and hence, 125-50 kg ha⁻¹ N-P level was considered as an optimum level for economical turnip production.

Ukai *et al.* (2016) reported that forage yield was significantly improved by application of nitrogen at 160 kg N/ha compared to lower nitrogen levels in turnip. Response of nitrogen to forage yield of turnip was linear. Net returns (Rs 62,411/ha) and benefit: cost ratio (2.56) were the highest with 160 kg N/ha.

Wahocho *et al.* (2016) evaluated the growth and yield response of turnip to various nitrogen (N) application rates. The growth and yield related traits of turnip were assessed using five N rates (0, 50, 80, 110 and 140 kg N ha⁻¹). They observed improvement in plant height (36.46 cm), number of leaves (16.47), fresh weight of leaves (72.64 g), fresh weight of a single root (106.17 g), root yield (15.77 kg plot⁻¹) and root yield (15063 kg ha⁻¹) at high level of N (140 kg ha⁻¹). However, the results of all these trails remained statistically similar to the results obtained from the plants receiving 110 kg N ha⁻¹. Hence, it can be concluded that the turnip crop may be fertilized with N @ 110 kg ha⁻¹ for obtaining better growth and root development.

Sulfab *et al.* (2017) studied the effect of mineral nitrogen fertilizer on growth, root yield and juice quality of sugar beet under saline soil. The results showed that 80 Kg N/ha treatment was highly significant ($P < 0.01$) increased

leaves number, leaf area index, leaves fresh weight, shoot fresh weight, root fresh weight and root diameter per plant over all other treatments and the control. However treatment 60 Kg N/ha significantly ($P < 0.05$) produced more leaves number, shoot fresh weight, root fresh weight and root diameter per plant. Each of nitrogen treatments significantly ($P < 0.05$) increased root yield per plant over the control. The increases in root yield compared to control were 13%, 33% and 46% for the 40 Kg N/ha, 60 Kg N/ha, and 80 Kg N/ha respectively. Each level of nitrogen fertilizer significantly ($P < 0.05$) reduced Sugar percentage, (Pol %), °Brix percentage, and Purity percentage. However, treatments 60 Kg N/ha and 80 Kg N/ha was significantly ($p < 0.05$) increased moisture percentage over the other treatments.

Lakra *et al.* (2017) conducted an experiment to study the effect of nitrogen and phosphorus on growth and yield of radish (*Raphanus sativus* L.) cv. Pusha Chetki under shade net condition. On the basis of above findings it is concluded that the treatment T₉ (50 kg N through Urea + 50 kg P through S.S.P) was recorded the best among in all the treatment in terms of growth and yield attributes and also with increased T.S.S. The T₉ was also recorded highest in terms of cost benefit ratio (10.10) under shade net condition.

Tripathi *et al.* (2017) revealed that wider spacing and 100% nitrogen fertilizer level significantly increased the plant height, number of leaves (7.17) at 25 DAS, length of leaves, root length (18.81 cm), root diameter (3.66), biomass (270.86 g) and yield of root in similar treatments. It was concluded that increment in yield due to higher spacing and nitrogen fertilizer level.

Kadam *et al.* (2018) studied the effect of spacing and fertilizer levels on growth and quality of beet root Treatment consisted of three levels of spacing S₁ (15 cm ×15 cm), S₂ (20 cm×15 cm) and S₃ (30 cm×15 cm) and three levels of fertilizers F₁ (100% RDF), F₂ (125% RDF) and F₃ (150% RDF). Growth characters such as number of leaves per plant at harvest (15.64) were observed maximum with the treatments S₃ (30 cm×15 cm) and F₃ (150% RDF) with (15.88). The quality characters like TSS (11.63%), total sugar (8.50%), anthocyanin content (33.02 mg/100 g) and iron content (1.14 mg/100 g) were observed maximum with the treatment S₃ (30 cm×15 cm) and quality characters like TSS (11.62%), total sugar (8.45%), anthocyanin content

(35.77 mg/100 g) and iron content (1.18 mg/100 g) were observed maximum with the treatment F₁ (100% RDF). The maximum physiological loss in weight (%) at 11th days (51.89%) was observed in the treatment S₁ (15 cm×15 cm) and at 11th days (54.00%) was observed in the treatment F₁ (100% RDF).

Poudel *et al.* (2018) assessed the role of five different levels of nitrogen (100, 150, 200, 250 and 300 kg per ha) application on growth and yield attributes of radish. Significant differences were found on root length and plant height. Maximum root length and plant height was observed at 250 and 300 kg per ha reflecting better yield performance in these levels of nitrogen. This indicates that 250 kg per ha of nitrogen was best for better yield (mean root weight =121.3 g per plant).

Shrestha and Thapa (2018) investigate the effect of six different levels (0 kg, 30 kg, 60 kg, 90 kg, 120 kg and 120 kg/ha) of nitrogen on growth and yield parameters of radish. The results showed that the higher level of nitrogen has no any significant effect on some parameters such as number of leaves at 40 DAS, leaf length, leaf breadth and root diameter however increased doses of nitrogen showed highly significant relationship with the number of leaves at 50 DAS, root length at 40 DAS, root weight at 40 & 50 DAS. The maximum number of leaves (20.87, 15.58, 14.08), root length at 40 DAS (13.37, 12.32, 11.50 cm), root weight at 40 DAS (46.63, 42.00, 35.50 g) root weight at 50 DAS (307.50, 302.50, 234.50 g) were recorded when N was applied @ 90, 120 and 150 kg per hectare respectively.

Chhetri *et al.* (2019) studied the effect of K and spacing on growth and yield of radish cv Mino Early. Maximum number of leaves, shoot weight, shoot per plot, root length, root girth, root weight and root yield (48.01 ton) was obtained with application of 50 kg K₂O ha⁻¹ whereas minimum value was obtained with control for all parameters. K level from 20-50 kg ha⁻¹ was resulted similar yield attributes and yield. In case of spacing, 20 cm x 30 cm produced maximum number of leaves, shoot weight, shoot per plot, root length and root girth but root yield was minimum. Spacing 20 cm x 20 cm was resulted maximum root yield (50.94 ton ha⁻¹). Interaction effect of spacing and potassium was found to be significant for none of the parameters. These results suggested that total root yield can be increased by planting radish at

spacing of 20 cm x 20 cm and of 20 kg K₂O ha⁻¹ might be economic to use but further research with same levels of K and spacing is suggested.

Haque *et al.* (2019) evaluated the effect of five levels of applied potassium on the growth and yield of carrot. Five treatments were applied viz. 0, 30, 60, 90, 120 kg Potassium per hectare. Root yield increased progressively and significantly with the increased application of potassium. Application of potassium 120 kg/ha increased the Leaf number per plant (11.93), root length (16.11 cm), root diameter (5.04 cm), fresh weight (184.8 g) and yield (49.29 t/ha). High dose of potassium also increased cracked and branched root which reduced the marketable quality of yield.

Kushwah *et al.* (2019) indicated that variety 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.

Nawaz *et al.* (2020) revealed that all the studied parameters were significantly improved with nitrogen application @ 80 and 100 kg ha⁻¹ in ridge sowing of turnip. However, 80 kg N ha⁻¹ in ridge sowing documented maximum economic benefit as compared to other treatments and is suggested as most cost-effective technique for turnip production under moderately salt-affected soils.

Satari *et al.* (2020) concluded an experiment to find out the optimum nutrient levels of NPK on growth and yield of radish cv. Pusa Chetki in open field condition. The experiment consists of different levels of nutrition which were tried in various combinations and assessed for growth and yield parameters. Among the different nutrition levels, T₄ (200:100:50 kg NPK / ha) recorded significantly maximum plant height (42.71 cm), number of leaves per plant (14.47), leaf length (32.57 cm), fresh weight of root (271.33 g), dry weight of root (9.89 g/plant), total chlorophyll content (1.75 mg/g fr. wt), root length (23.60 cm), root girth (13.13 cm) as compared to control. The maximum root yield per plot (5.00 kg) and per hectare (33.33 t) was also recorded in T₄ (200:100:50 kg NPK/ha).

Ziaf *et al.* (2020) revealed that high dose of nitrogen with moderate level of phosphorus (N-P@100-50 kg ha⁻¹) proved the best in promoting the growth (leaf and root size), leaf chlorophyll contents, fresh and dry weight of leaves and roots, and yield of turnip. But, further increase in dose of phosphorus (N-P@100-75 kg ha⁻¹) did not improve the values of these parameters. Nitrogen contents of leaves and root were highest in response to N-P @100-50 kg ha⁻¹. While, highest concentration of phosphorus in leaves and roots was recorded for N-P@100-75 kg ha⁻¹. Interestingly, the value of yield response (60.4%), agronomic efficiency (109 kg of root per kg of N and 218 kg root per kg of P), and physiological efficiency of phosphorus (296 kg of root per kg of P) were also higher for N-P@100-50 kg ha⁻¹ than N-P@100-75 kg ha⁻¹, which also implies more efficient use of fertilizer applied @ 100-50 kg ha⁻¹. Moreover, apparent recovery of nitrogen was also greatest for N-P@100-50 kg ha⁻¹ but, apparent recovery of phosphorus was highest for N-P@100-75 kg ha⁻¹. Furthermore, total nitrogen concentration in the roots was within permissible range even for the highest level of fertilizers. Therefore, farmers can use N-P @100-50 kg ha⁻¹ to get high yield at a high benefit:cost ratio, while keeping nitrate nitrogen within non-toxic range.

2.3 Combined effect of varieties and fertility levels

Ali *et al.* (2006) studied the effects of different level of nitrogen on yield and yield contributing characters of three varieties of carrot nitrogen level showed significant effects on growth and yield of carrots. On the other hand, maximum number of leaves, plant height, root length, root diameter, fresh and dry weight of shoot, fresh and dry weight of root and root yield were obtained by the 150 kg N ha⁻¹ applied, the variety SB Kuroda showed the best response in all parameters except leaves per plant, plant height and root length. The results of the study revealed that number of leaves and plant height were significantly influenced by different nitrogen nutrients. The highest number of leaves per plant (9.59) was produced by the treatment 150 kg N ha⁻¹ and the variety Sufola produced maximum number of leaves when applied 150 kg N ha⁻¹ and the lowest number of leaves in control. The tallest plant (28.95 cm) was produced by 150

kg N ha⁻¹ and the lowest plant height in control. The variety Sufola fertilized with 50 kg N ha⁻¹ gave the highest plant height (29.33 cm). Fresh and dry weight of shoot was significantly influenced by nitrogen nutrition. When fertilized with 150 kg N ha⁻¹. The crop produced the highest fresh weight, whereas percent of dry matter higher. Significantly different results were found in case of root length and diameter by nitrogen application. The highest root length and diameter was recorded when applied 150 kg N ha⁻¹. The variety SB Kuroda fertilized with 150 kg N ha⁻¹ and 100 kg N ha⁻¹ produced the highest root length and diameter. The fresh and dry weight of root was also significant influenced by nitrogen dose and variety. 150 kg N ha⁻¹ fertilizing produced the highest fresh and dry weight of root and the variety SB Kuroda gave the best result in fresh and dry weight of root. There were no significant variation among three varieties in respect of leaves per plant, plant height, shoot fresh and dry weight, root length and root diameter. The root yield was significantly influenced by applied nitrogen nutrition. The highest root yield (27.82 t ha⁻¹) was obtained from treatment 150 kg N ha⁻¹ and the lowest yield (18.04 t ha⁻¹) was found when no application of nitrogen. The variety SB Kuroda gave the highest yield of 26.03 t ha⁻¹ while the lowest yield of 19.00 t ha⁻¹ by variety Sufola. The combined effect of nitrogen and variety performed significantly in respect of all parameters. On the other hand, application of nitrogen 150 Kg ha⁻¹ and three varieties showed good response in respect of yield and yield contributing characters. When applied 150 Kg N ha⁻¹, SB Kuroda was the best in all parameters except leaf number, plant height, shoot fresh and dry weight. The highest yield of 31.06 t ha⁻¹ was observed by SB Kuroda while the lowest yields of 14.57 t ha⁻¹ by the variety Sufola in control plot.

Albayrak and Cams (2006) evaluated the effects of five nitrogen rates (0, 50, 100, 150 and 200 kg ha⁻¹) on root, leaf yields and some yield components of four varieties of turnips (Agressa, Siloganova, Polybra and Volenda). Root and leaf yields and their yield components of forage turnip cultivars increased along with increase of nitrogen doses. The highest root

and leaf dry matter yields were obtained from cultivar Volenda (7.19 and 5.24 t ha⁻¹, respectively) in the treatments of 150 kg per hectare nitrogen.

Inam *et al.* (2011) reported that the number of leaves and dry matter content of tops and roots increased with increasing doses of N in radish and turnip. With the increase of N fertilizer, radish biomass production, economic output and the root yield increased with the increase of economic output per kg of nitrogen from the negative to a positive correlation, and the growth yield is also growing. Appropriate amount of nitrogen fertilizer increased the plant's largest leaf length, maximum number of photosynthetic leaves, tops and root dry matter accumulation in various organs in radish and turnip varieties, showed a positive correlation between nitrogen deficiencies reduced dry matter accumulation amount. K content also increased with increasing doses of N, with 200 kg ha⁻¹ giving the highest value. Local variety of each crop possessed comparatively less K content. Maximum K content was noted in Pusa Rashmi (radish) and Snow Ball (turnip) grown with 200 kg ha⁻¹. At early stage, K content was more in tops, but as the plants grew the content became higher in roots.

Boskovic-Rakocevic *et al.* (2012) assessed the effect of increasing nitrogen fertilization rates on nitrate accumulation, vitamin C and β -carotene content in two carrot genotypes. Nitrogen fertilizer (calcium ammonium nitrate, 27% N) was applied at four rates: 0, 60, 120 and 180 kg N ha⁻¹. After harvesting, root samples were collected and tested for quality. The use of increasing nitrogen rates resulted in increased nitrate accumulation in the roots. The increase in nitrogen fertilizer rate from 60 to 120 kg N ha⁻¹ led to a reduction in Vitamin C content and an increase in β -carotene. Differences were observed between cultivars and hybrids in all quality parameters tested.

Yanthan *et al.* (2012) tested the effect of integrated nutrient management on growth, yield and NPK uptake by turnip (*Brassica rapa L.*) cv. Pusa Sweti. Application of different fertilizers and organic manures either alone or in combination significantly increased the growth and yield as compare to control. Based on the experimental findings, it was inferred that combined application of 50% Pig manure+ 50% NPK recorded maximum plant height (50.16 cm) and number of leaves plant⁻¹ (14.43), leaf

area (185.86 cm²), root yield (522.51 q ha⁻¹) and uptake of N (153.56 kg ha⁻¹), P (25.44 kg ha⁻¹) and K (215.01 kg ha⁻¹). The same treatment also produced the highest net return of Rs 72,823 with cost-benefit ratio of 1:3.2. Application of 50% Pig manure+50% NPK can be recommended for cultivation of turnip in foot hill condition of Nagaland, which was found to be the better source of manuring in sustaining the soil fertility with better cost benefit ratio.

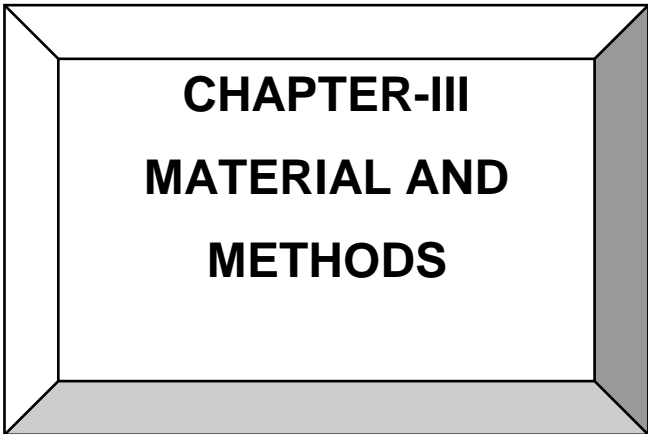
Sincik and Canigenis (2016) determined the effects of different nitrogen fertilizer rates (0, 60, 120, 180, 240 and 300 kg ha⁻¹) on root yield and quality of N (Normal) type Esperenza and NZ (between Normal and Zucker = Sweet) type Isella sugar beet cultivars. As a result of the research, the highest root yield values obtained from 240 and 300 kg ha⁻¹ nitrogen rates. Also, the highest sugar content was taken from 0 kg ha⁻¹ control dose. But, the highest sugar yields per unit area obtained from 180, 240 and 300 kg ha⁻¹ nitrogen applications. In terms of sugar yield there were not found statistically important differences between N and NZ type sugar beet varieties.

Cecilio Filho *et al.* (2017) studied the effects of P (0, 100, 200, 300 and 400 kg ha⁻¹ of P₂O₅) and K (0, 60, 120, 180 and 240 kg ha⁻¹ of K₂O) doses on the growth and productivity of radish cultivars (Sakata 19 and Sakata 25) in a soil with high levels of these nutrients. Number of leaves per plant, leaf area, shoots and root dry mass, total and commercial productivity, percentage of cracked roots and P and K contents in the plant and in the soil were evaluated. The Sakata 19 cultivar performed better than the Sakata 25 in both experiments. The fertilization with P or K did not influence the growth and the productivity of both radish cultivars. Therefore, both cultivars of radish evaluated do not need to be fertilized with P and K when planted in a Latosol with high levels of these nutrients.

Nargave *et al.* (2018) conducted field experiment to study the effect varieties and fertility levels on growth, yield and quality of radish Variety. V₃ (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 V₃ (Kashi Sweata).

Under quality parameters highest fiber content (664.00 mg/100 g), T.S.S. (4.51°Brix) and ascorbic acid (33.54 mg/100 g) in root were also found in case of variety V₃ (Kashi Sweata). Among fertility levels, application of F₈ (100-80-50 NPK kg⁻¹) was recorded maximum growth, yield and quality parameters with all the three varieties of radish. The net income and B:C ratio *i. e.* 1:6.52 and 1:7.75 was found to be superior with variety V₃ (Kashi Sweata) and fertility level F₈ (100:80:50 NPK kg ha⁻¹). The interaction effect of varieties and fertility levels was non-significant with all the characters.

Lencha and Dalga (2020) indentified best performing of beet root variety and optimum rate of nitrogen (N) fertilizer. 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 N ha⁻¹ (14.9 t ha⁻¹). Whereas the lowest root yield was recorded from dark red at 0 kg N ha⁻¹.



CHAPTER-III
MATERIAL AND
METHODS

Chapter- III

MATERIAL AND METHODS

This chapter comprises of the methods applied and material used during the course of the study entitled “Effect of varieties and fertility levels on growth, yield and quality of turnip (*Brassica rapa* L.)” was carried out during Rabi, 2019-20 at Research Field, Department of Vegetable Science, College of Horticulture, Mandsaur (MP).

The methods employed during the research programme and materials utilized have great significance in the present investigation. The details of material used and techniques employed in carrying out the investigation are described under the following heads:

3.1 Geographical situation

The field experiment was conducted during *Rabi season* of 2019-20 at Research Field of the Department of Vegetable Science, College of Horticulture, Mandsaur, Madhya Pradesh. Mandsaur is situated in Malwa plateau in Western part of Madhya Pradesh at North latitude of 23.45⁰ to 24.13⁰ 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 9th Agro climatic zone of the state.

3.2 Agro- Climatic conditions

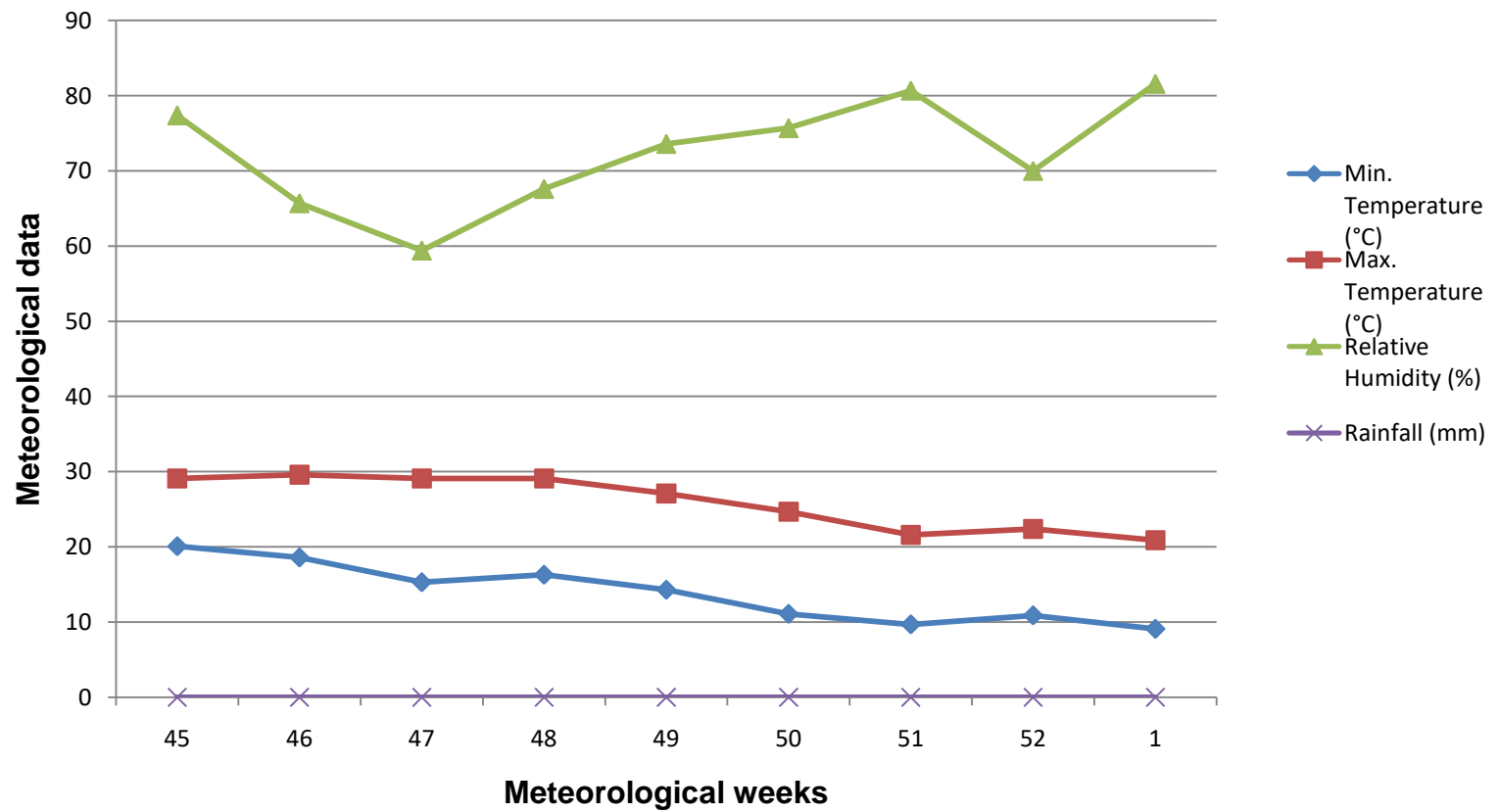
Mandsaur belongs to sub - tropical and semi- arid climatic conditions having a temperature range of minimum 4⁰C and maximum 45⁰C in winter and summer respectively. South- West monsoon is the main factor for major part of annual precipitation. In this area maximum rainfall is received during mid June to September with occasional shower in winter. The average rainfall is 576.6 mm. Meteorological data recorded during the period of investigation are presented in Table 1 and Fig. 1.

Table1: Meteorological parameters recorded during the period of investigation (6th November, 2019 to 4th January, 2020)

Period	Standard Meteorological weeks	Average Temperature (°C)		Relative Humidity (%)	Rainfall (mm)
		Min.	Max.		
06 Nov- 12 Nov	45	20.1	29.1	77.4	0
13 Nov- 19 Nov	46	18.6	29.6	65.7	0
20 Nov - 26 Nov	47	15.3	29.1	59.4	0
27 Nov - 3 Dec	48	16.3	29.1	67.6	0
4 Dec - 10 Dec	49	14.3	27.1	73.6	0
11 Dec - 17 Dec	50	11.1	24.7	75.7	0
18 Dec - 24 Dec	51	9.7	21.6	80.7	0
25 Dec - 31 Dec	52	10.9	22.4	70	0
1 Jan - 7 Jan	1	9.1	20.9	81.6	0

Source: Meteorological observatory of the college of Horticulture, Mandasaur (M.P.).

Fig. 1. Meteorological parameters recorded during the period of investigation (6th November, 2019 to 4th January, 2020)



3.3 Soil of the experimental field

The soil of the experimental field was medium black (vertisols) clay in texture with uniform topography. Soil samples were collected randomly up to a depth of 20 cm from the experimental field, with the help of soil auger before sowing of seed. All the soil samples were mixed to prepare a composite sample, which was then air dried sieved through 2 mm sieve and finally used for mechanical and chemical analysis. The results are presented in Table 2.

Table 2: Physico-chemical properties of soil before sowing of the experimental field

S. No.	Composition			Method
	Physical properties	Content	Category	
1.	Sand %	55%	-	Bouyoucos Hydrometer
2.	Silt %	35%	-	Bouyoucos Hydrometer
3.	Clay %	10%	-	Bouyoucos Hydrometer
	Chemical properties	Content	Category	
4.	Soil pH	6.67	Neutral	Glass electrode pH meter
5.	Electrical conductivity (dSm ⁻¹)	0.35	Normal	By conductivity bridge at 25°C
6.	Available nitrogen (Kg/ha)	123.5	Low	Rapid titration method (Walkley and Black, 1934)
7.	Available phosphorus (Kg/ha)	22	Medium	Olsen's extraction method (Olsen <i>et al.</i> ,1954)
8.	Available potassium (kg/ha)	241	High	Flame photometer (Ghosh <i>et al.</i> ,1981)

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

S. No.	Year	Season	
		<i>Kharif</i>	<i>Rabi</i>
1.	2017-18	Soyabean	Gram
2.	2018-19	Soyabean	Fallow
3.	2019-20	Ridge gourd	Present experiment

3.4 Experimental details

Experimental details and layout

Location: Field experiment is to be conducted at Vegetable Research Field, College of Horticulture, Mandasaur (M.P.).

Experiment details:

Name of crop	: Turnip (<i>Brassica rapa</i> L.)
Season	: <i>Rabi</i> season, 2019-20
Design	: Factorial Randomized Block Design
Number of replications	: 3
Numbers of Treatments	
(a) Varieties	: 2
(b) Fertility levels	: 5
Treatment combination	: 10
Total numbers of plots	: 30
Spacing	: Row to Row- 30 cm, Plant to Plant -10 cm
Gross plot size	: 2.1 x 1.8 m (3.78 m ²)
Net plot area	: 1.7 x 1.6 m (2.72 m ²)
Total experimental area	: 168.48 m ²
Net experimental area	: 113.4 m ²
Date of sowing	: 17.11.2019
Date of harvesting	: 1 st January to 4 th January, 2020

Treatment details

The experiment was conducted with two varieties and five fertility levels as given below along with their notations:

1. Varieties (V)
 - V₁ - Pusa Sweti
 - V₂ - Purple Top White Globe
2. Fertility levels (F)
 - F₁- 00:00:00 kg/ha
 - F₂- 40: 30:20 kg/ha
 - F₃- 60:40:30 kg/ha
 - F₄- 80:50:40 kg/ha
 - F₅- 100:60:50 kg/ha

Table 4: Treatment combinations

Treatment	Treatment details	Symbol
T ₁	Pusa Sweti + 00:00:00 kg NPK/ha	V ₁ F ₁
T ₂	Pusa Sweti + 40:30:20 kg NPK/ha	V ₁ F ₂
T ₃	Pusa Sweti + 60:40:30 kg NPK/ha	V ₁ F ₃
T ₄	Pusa Sweti + 80:50:40 kg NPK/ha	V ₁ F ₄
T ₅	Pusa Sweti + 100:60:50 kg NPK/ha	V ₁ F ₅
T ₆	Purple Top White Globe + 00:00:00 kg NPK/ha	V ₂ F ₁
T ₇	Purple Top White Globe + 40:30:20 kg NPK/ha	V ₂ F ₂
T ₈	Purple Top White Globe + 60:40:30 kg NPK/ha	V ₂ F ₃
T ₉	Purple Top White Globe + 80:50:40 kg NPK/ha	V ₂ F ₄
T ₁₀	Purple Top White Globe + 100:60:50 kg NPK/ha	V ₂ F ₅

3.5 Experimental operations

3.5.1 Field preparation

The field was ploughed with tractor drawn mould board plough. There after cross harrowing was done followed by planking to make the field levelled. Plots are prepared according to layout plan.

3.5.2 Nutrient management

The calculated quantities of fertilizers according to treatments were applied to the respective plot. The sources of nutrient were Urea (nitrogen), DAP (phosphorus) and MOP (potash). Half dose of nitrogen and full dose of phosphorus and potash were applied as basal dose prior to sowing of turnip seeds, while the remaining dose of nitrogen was applied at 30 days after sowing. Other intercultural operations and crop management practices were carried out in accordance with the recommended package of practices.

3.5.3 Seed rate and sowing

The pure, healthy, disease and insect free vigorous and good quality seed for turnip was used for sowing. Seed were treated with Mencozeb 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 according to treatment. The seed sowing was done 1.25 cm deep. It is facilitate good root production.

3.5.4 Thinning and 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 Irrigation

First irrigation was given just after sowing and subsequent irrigations are given as per the requirement. Optimum soil moisture was maintained in the field by regular irrigation as given below:

Irrigation	Date
First	17-11-19
Second	13-12-19
Third	25-12-19

3.5.6 Weeding

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

3.5.7 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.

3.5.8 Harvesting

Harvesting of turnip was done from 1st to 4th January 2020. The roots were pulled out with the help of *Khurpi*. All possible cares were taken, while pulling out the turnip root to avoid damage. The soil was washed out from roots with fresh water.

3.6 Observations recorded

Five plants were randomly selected from each treatment under each replication excluding the border plants. The tagging was done 25 days after sowing. Observations were recorded on the tagged plant for the following attributes.

3.6.1 Growth parameters

(I) Plant height (cm)

The height of plants was measured by five tagged plant in each treatment from ground level to the tip of fully opened leaves of main stem with the help of measuring scale at 30, 45 and 60 DAS.

(II) Number of leaves per plant

The number of leaves per plant was counted in five tagged plant in each experimental plot at 30, 45 and 60 DAS.

(III) Leaf area per plant (cm²)

For estimation of leaf area, five plants from each plot were randomly selected and leaf area was measured with the help of leaf area meter (Licor). It was expressed in cm² leaf area was recorded at harvesting.

(IV) Fresh weight of roots (g/plant)

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

(V) Dry weight of roots (g/plant)

After taking fresh weigh roots were dried in 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.

(VI) Fresh weight of leaves (g/plant)

The fresh weight of five randomly selected plants from each plot was determined at harvesting stage.

(VII) Dry weight of leaves (g/plant)

After taking fresh weight, plants were put in hot air oven at 65±2°C temperature for drying till constant weight. Final weigh was recorded after drying of plant.

(VIII) SPAD value

SPAD value in leaves of five randomly selected plants was estimated by using instrument SPAD chlorophyll meter by simple clamping the device over leaf tissue at 30, 45 and 60 DAS.

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 centimetre.

(II) Root diameter (cm)

The diameter of five roots from each plot was measured by using vernier calliper at harvesting stage and the means were worked out and expressed in centimetre.

(III) Root yield per plot (kg)

The whole roots of all the plots in each replication were pulled out and their weight was measured by the balance in kilograms and averages were worked out.

(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:

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

3.6.3 Quality parameters

(I) TSS (°Brix):

All the fruits of each plant were 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., 1980).

(II) Vitamin- C content of root (mg /100 g)

The vitamin-c content in turnip was estimated by using the method given by Ranganna (1977).

A. Reagents

1. 3% Meta phosphoric acid (HPO₃): Prepared by dissolving the pellets of HPO₃ in glass distilled water.
2. Ascorbic acid standard: Weigh accurately 100 mg of l-ascorbic acid and make up to 100 ml with 3% HPO₃. Dilute 10 ml to 100 ml with 3% HPO₃ (1 ml = 0.1 mg of ascorbic acid).

3. Dye solution: Dissolved 50 mg of sodium salt of 2, 6-dichlorophenol-indophenol in approximately 150 ml of hot glass distilled water containing 42 mg of sodium bicarbonate. Cool and diluted with glass distilled water to 200 ml.

B. Standardization of dye

C. Take 5 ml of standard ascorbic acid solution and 5 ml of HPO₃. Fill a micro burette with the dye. Titrate with the dye solution to a pink colour which should persist for 15 seconds. Determined the dye factor, *i.e.* mg of ascorbic acid per ml of the dye, using the formula:

$$\text{Dye factor} = \frac{0.5}{\text{Titre}}$$

D. Preparation of sample

Take 10 gm sample of turnip, blend with 3% HPO₃ and make up to 100 ml with HPO₃. Filter or centrifuge the sample before titration.

E. Procedure

Take an aliquot 10 ml of the HPO₃ extract of sample and titrate with the standard dye to a pink end - point which should persist for at least 15 seconds. Note the reading and calculation was made to determine the ascorbic acid content.

F. Estimation

Calculate the ascorbic acid content of the sample from the following equation:

$$\text{Ascorbic acid} = \frac{\text{Titre} \times \text{Dye factor} \times \text{Volume made up} \times 100}{\text{Aliquot of extract taken} \times \text{Weight of sample for estimation}}$$

3.6.4 Post harvest analysis of plant

3.6.4.1 NPK content (%) in plant

In order to work out the percentage of N, P and K in turnip plant, the samples were analyzed for their NPK content. Nitrogen was estimated by Kjeldal method; P in wet digested samples by ammonium molybdate method (Chapman and Pratt, 1961) and K by flame photometer (Holiday and Preedy, 1953).

Procedure for analysis of total nitrogen in dried plant samples:

- (i) Take 1 g of grind plant sample in digestion tube and add 10 ml of concentrated sulphuric acid (H_2SO_4) in each tube.
- (ii) Add potassium sulphate (K_2SO_4) and copper sulphate ($CuSO_4$) in the ratio 5:2 (3 g/sample).
- (iii) Place the digestion tube on the digestion block and set the digestion system to a temperature of 400- 410°C.
- (iv) The digestion may be continued till black or brown colour of the sample disappears and clear solution is formed. Afterwards leave the samples to cool at room temperature.
- (v) Place the digested sample tube in the distillation unit and distil it using 40% NaOH solution.
- (vi) In a conical flask, take 10 ml of 4% boric acid solution containing methyl red and methyl green indicator and dip the condenser outlet in the flask.
- (vii) After distillation, boric acid solution is titrated against 0.1 N HCl. Blank is also run and titration is carried out to the same end point as that of the sample.
- (viii) The nitrogen content in plant samples is calculated as follows:

$$\text{Nitrogen (\%)} = \frac{(\text{Sample reading} - \text{Blank reading}) \times \text{Normality of HCl} \times 14 \times 100}{\text{Weight of sample (g)} \times 1000}$$

Procedure for analysis of total phosphorus in plant sample:

- i. Digest the plant sample in diacid mixture (Ammonium molybdate and Ammonium vanadate).
- ii. Transfer 5 ml of digest to 50 ml volumetric flask and add 10 ml of vanadomolybdate reagent.
- iii. Make up the volume with distilled water and shake thoroughly.
- iv. Read the absorbance of solution after 30 minutes at 420 nm on spectrophotometer.
- v. Find the P concentration in aliquot with the help of standard curve (Absorbance = Slope of curve x Concentration).

The phosphorus content in plant samples is calculated as follows:

$$P (\%) = \frac{C \times 100 \times \text{Volume of digest (ml)}}{\text{Wt of sample (g)} \times \text{Aliquot ml taken} \times 1000}$$

Where,

Weight of plant sample = 1 g

Aliquot (digest) taken = 1 ml

Volume of digest = 50 ml and Concentration of P in aliquot (obtained from standard curve) = C ppm.

Procedure for total potassium analysis in plant samples:

- i. Above solution from di- acid mixture is used for total potassium analysis.
- ii. Measure K concentration in the solution using flame photometer at 548 nm wavelength.

The potassium content in plant samples is calculated as follows:

$$K(\%) = \frac{R \times 5 \times 100}{100 \times W \times 100000}$$

Where,

R = Flame photometer reading

V = Total volume of plant digest (20 ml)

W = Weight of plant sample taken (1g)

3.6.4.2 Post harvest sampling method:

Post harvest soil samples were collected randomly up to a depth of 20 cm from each treatment separately with the help of soil auger. All the soil samples were to prepare separately, which was then oven dried, sieved through 2 mm sieve and finally used for chemical analysis.

3.6.4.3 Post Harvest Analysis of soil:

3.6.4.4 Available nitrogen in soil after harvesting:

Procedure for available nitrogen analysis Volumetric method (Walkley and Black, 1934)

- i. Weigh 1g soil sample in a 500 ml conical flask.
- ii. Add 10 ml of KMnO_4 and 20ml of NaOH and distill on kel – plus distil EM automatic nitrogen analyzer.
- iii. Take 20 ml of Boric acid in a conical flask.
- iv. Add one drope of Methyl red indicator and absorb the distillate in the Boric acid for 15 minutes.
- v. Titrate the distillate against 0.1 N HCl taken in burette until pink colour starts appearing.

3.6.4.5 Available phosphorus in soil after harvesting:

Procedure for available phosphorus analysis (Olsen's, 1954)

- i. Weigh 2.5 g of soil sample in 100 ml conical flask.
- ii. Add 20 ml of Olsen's reagent (0.5 M NaHCO_3) Sodium bicarbonate.
- iii. Shake for 30 minute on a mechanical shake.
- iv. Filter through Whatman No. 1 filter paper in 100 ml volumetric flask.
- v. Transfer 10 ml of clear and colourless filtrate into a 25 ml volumetric flask.
- vi. Gradually add ml of ammonium molybdate solution containing 400 ml of 10 N HCl per litre.
- vii. Shake slowly and carefully to drive out the CO_2 evolved.
- viii. Add 1 ml of freshly diluted SnCl_2 solution, shake a little and make the volume to 25 ml.
- ix. Read the blue colour intensity at 630 nm (red filter).
- x. Run a blank without soil under identical manner.

3.6.4.6 Available potassium in soil after harvesting:

Procedure for available potassium analysis (Holiday and Preedy, 1953)
potassium is estimated by flame photometer

- i. Weigh of 5 g soil sample in 100 ml conical flask.
- ii. Add 25 ml of the neutral 1 N ammonium acetate solution and shake for 5 minutes.
- iii. Filter through Whatman No. 1 filter paper.

- iv. Measure K concentration in the filtrate using flame photometer.

3.7. Economics of the treatments:

The cost of cultivation per hectare under different treatments was calculated on the basis of expenditure incurred on different operation 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 observation for each character were subjected to "Analysis of Variance" as advocated by Panse and Sukhatme (1985). The Skeleton of ANOVA as per design is as given in Table 5.

Table 5: Template for Analysis of Variance (ANOVA)

ANOVA					
Source of Variation (S.V.)	Degree of Freedom (d.f.)	Sum of Square (SS)	Mean Sum of Square (MSS)	"F" value (Calculated) (F_{cal})	"F" value (Table) At 5% level of Signification (F_{tab})
Replication	$(r-1) = 2$	SSR	MSR	MSR/MSE	3.555
Varieties (V)	$(v-1) = 1$	SSV	MSV	MSV/MSE	4.414
Fertility level (F)	$(f-1) = 4$	SSF	MSF	MSV/MSE	2.928
Interaction (VxF)	$(v-1) \times (f-1) = 4$	SSVF	MSVF	MSV/MSE	2.928
Error	{total DF - (r+v+rf)}=18	SSE	MSE	MSVF/MSE	
Total	$(vfr - 1) = 29$	SST			

The significant differences between different treatments were judged by using critical difference (CD), which was calculated with the formula given by Panse and Sukhatme (1985).

(i) Standard error of mean (S.Em±):

$$(a) \text{ S.Em } \pm \text{ for V} = \sqrt{\frac{\text{EMS}}{\text{No. of replication} \times \text{Levels of F}}}$$

$$(b) \text{ S.Em } \pm \text{ for F} = \sqrt{\frac{\text{EMS}}{\text{No. of replication} \times \text{Varieties}}}$$

$$(c) \text{ S.Em } \pm \text{ for VxF} = \sqrt{\frac{\text{EMS}}{\text{No. of replication}}}$$

(ii) Critical difference (CD):

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

$$(b) \text{ CD for F} = \text{S. Em} \pm (\text{F}) \times \sqrt{2} \times t_{5\% (\text{edf})}$$

$$(c) \text{ CD for VxF} = \text{S. Em} \pm (\text{VxF}) \times \sqrt{2} \times t_{5\% (\text{edf})}$$

Where:

r = Number of replication

V = Number of varieties

F = Number of fertility levels

t = 't' Table value at error degree of freedom

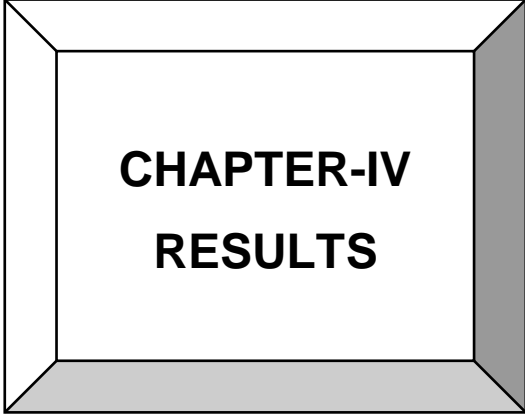
EMS = Error mean sum of square

S. Em± = Standard error of mean

CD = Critical difference



Plate 1:- Panoramic view of experimental field of turnip



CHAPTER-IV
RESULTS

Chapter-IV

RESULTS

This chapter deals with the analysis of data recorded during the experiment entitled “Effect of varieties and fertility levels on growth, yield and quality of turnip (*Brassica rapa* L.)”. The results of various observations recorded during experiment were statistically analyzed with factorial randomized block design in order to find out the significance of different treatments by using the analysis of variance technique. The experimental results are interpreted along with the corresponding tables and figures as follows:

4.1 Growth Parameters

Observation on plant height (cm), number of leaves per plant, leaf area per plant (cm²), fresh and dry weight of roots (g/plant), fresh and dry weight of leaves, SPAD value was recorded at different stages of growth is presented as follows:

4.1.1 Plant height (cm)

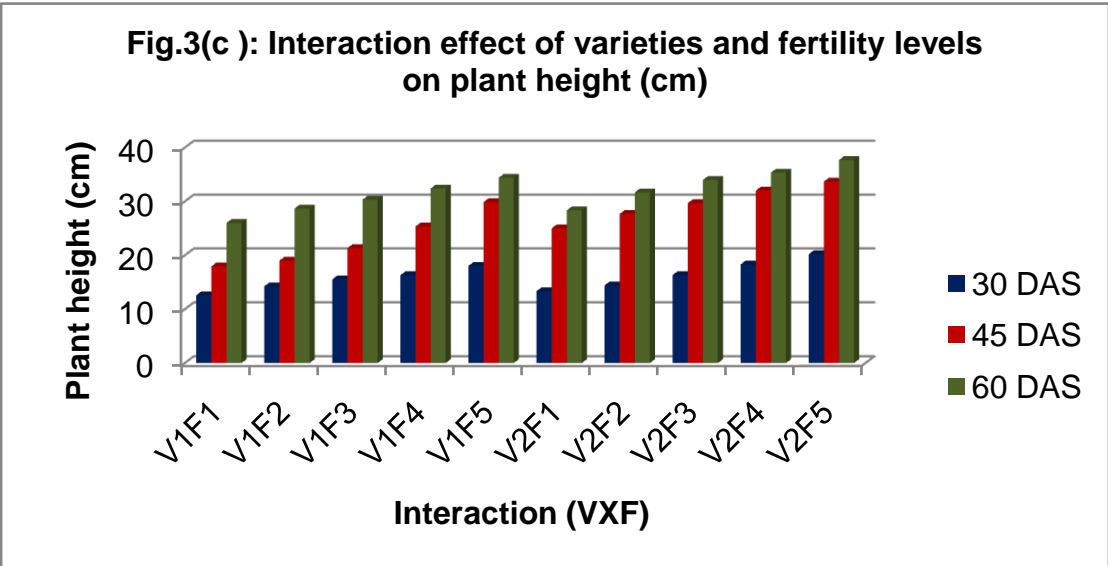
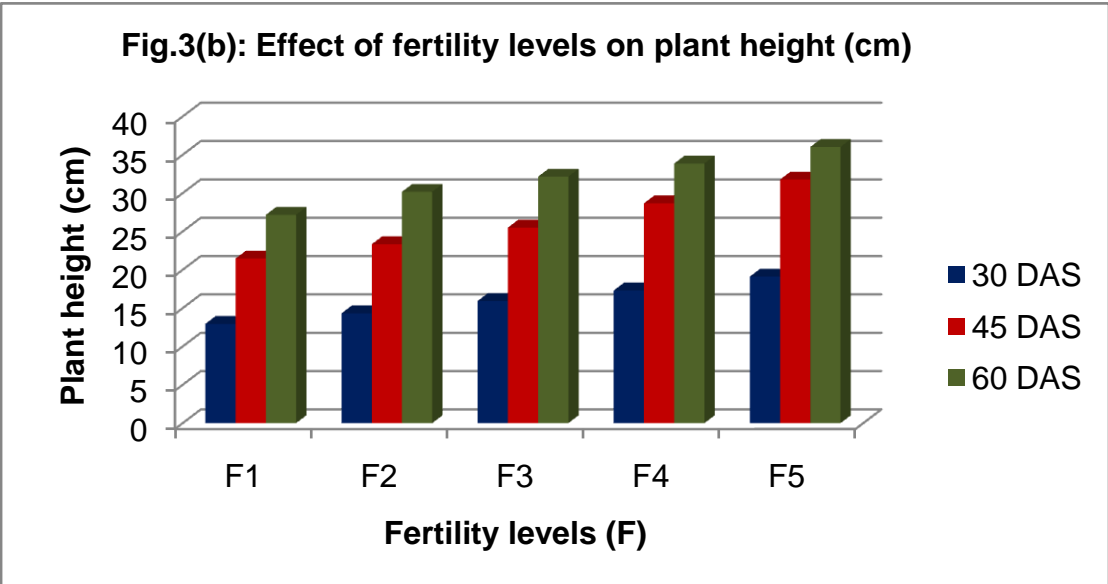
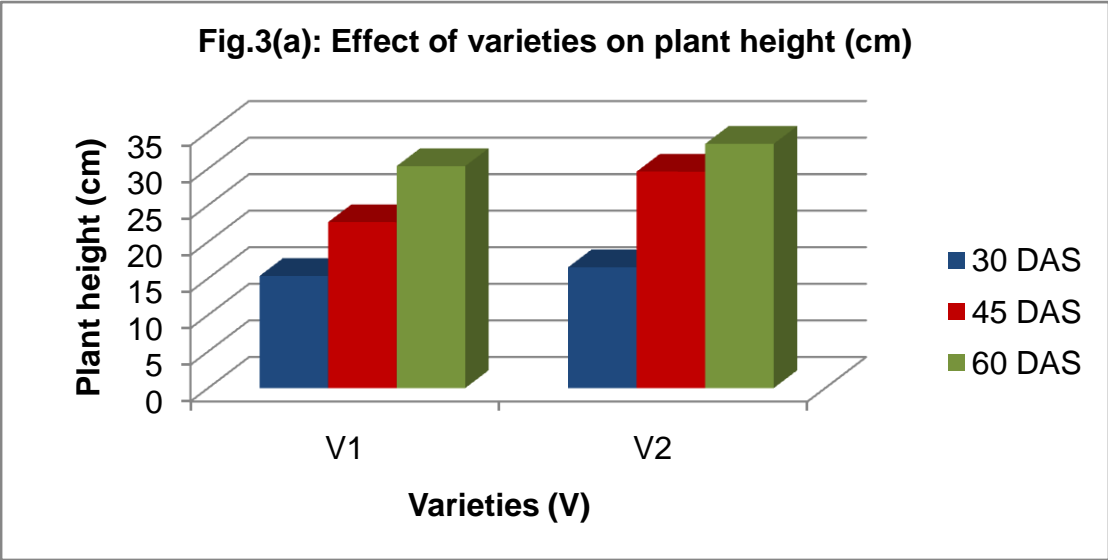
Plant height was recorded at 30, 45 and 60 DAS. The findings on plant height (cm) as influenced by varieties and fertility levels are presented in Table 6 and Fig. 3. In general, there was an increase in plant height up to 60 days after sowing in turnip.

The data revealed significant effect of varieties on plant height of turnip at all the growth stages. Maximum plant height of 16.51, 29.60 and 33.39 cm was found in variety V₂ (Purple Top White Globe) at 30, 45 and 60 DAS, respectively. Minimum plant height of 15.33, 22.69 and 30.35 cm was recorded in case of V₁ at 30, 45 and 60 DAS, respectively.

Fertility levels exerted significant influence on plant height (cm) in turnip. Maximum plant height *i.e.* 19.11, 31.77 and 36.02 cm was recorded with fertility levels F₅ (NPK-100:60:50 kg/ha) at 30, 45 and 60 DAS, respectively. It was followed by F₄ > F₃ > F₂ in descending order. Minimum plant height was found in case of fertility level F₁ (NPK-00:00:00) *i.e.* 12.95, 21.47 and 27.17 cm at 30, 45 and 60 DAS, respectively.

Table 6: Effect of varieties, fertility levels and their interactions on plant height (cm) of turnip

Treatments	Plant height (cm)		
	30 DAS	45 DAS	60 DAS
Varieties (V)			
V ₁	15.33	22.69	30.35
V ₂	16.51	29.60	33.39
S.Em±	0.372	0.576	0.652
CD at 5%	1.104	1.712	1.936
Fertility levels (F)			
F ₁	12.95	21.47	27.17
F ₂	14.32	23.33	30.17
F ₃	15.93	25.50	32.15
F ₄	17.30	28.67	33.86
F ₅	19.11	31.77	36.02
S.Em±	0.587	0.911	1.030
CD at 5%	1.746	2.706	3.061
Interaction (VXF)			
V ₁ F ₁	12.57	17.93	26.00
V ₁ F ₂	14.23	19.00	28.67
V ₁ F ₃	15.53	21.33	30.33
V ₁ F ₄	16.30	25.33	32.39
V ₁ F ₅	18.02	29.87	34.37
V ₂ F ₁	13.33	25.00	28.34
V ₂ F ₂	14.40	27.67	31.67
V ₂ F ₃	16.33	29.67	33.97
V ₂ F ₄	18.30	32.00	35.33
V ₂ F ₅	20.20	33.67	37.67
S.Em±	0.83	1.29	1.46
CD at 5%	NS	NS	NS



Combined effect of varieties and fertility had non-significant influence on plant height of turnip at all the growth stages under study.

4.1.2 Number of leaves per plant

Number of leaves per plant was counted at 30, 45 and 60 DAS. The data presented in Table 7 and Fig. 4 showed significant influence of varieties and fertility levels on number of leaves per plant at all the stages of growth in turnip.

Varieties had exerted significant effect on number of leaves per plant at 30, 45 and 60 DAS harvesting stage in turnip. Among varieties, V₂ (Purple Top White Globe) counted maximum number of leaves per plant (6.84, 8.45 and 11.67) followed by variety V₁ (Pusa Sweti) observed minimum number of leaves per plant *i.e.* 6.39, 7.51 and 10.89 at 30, 45 and 60 DAS, respectively. There was a linear increase in number of leaves per plant with advancement of growth stage.

Each increasing dose of fertility levels enhanced the number of leaves per plant at 30, 45 and final 60 DAS. Maximum number of leaves per plant *i.e.* 7.50, 9.37 and 12.83 was recorded with fertility level F₅ (NPK- 100:60:50 kg/ha) followed by F₄>F₃>F₂ in descending order at 30, 45 and 60 DAS, respectively. Minimum number of leaves per plant was recorded in case of fertility level F₁ (NPK-00:00:00 kg/ha) *i.e.* 5.82, 6.90 and 9.80 at 30, 45 and 60 DAS, respectively.

Combined effect of varieties and fertility levels had non-significant influence on number of leaves per plant at 30, 45 and 60 DAS at harvesting stage in turnip.

Table 7: Effect of varieties, fertility levels and their interactions on number of leaves per plant of turnip

Treatments	Number of leaves per plant		
	30 DAS	45 DAS	60 DAS
Varieties (V)			
V ₁	6.39	7.51	10.89
V ₂	6.84	8.45	11.67
S.Em±	0.139	0.124	0.161
CD at 5%	0.412	0.368	0.479
Fertility levels (F)			
F ₁	5.82	6.90	9.80
F ₂	6.18	7.48	10.73
F ₃	6.57	7.82	11.35
F ₄	7.00	8.35	11.68
F ₅	7.50	9.37	12.83
S.Em±	0.219	0.196	0.255
CD at 5%	0.651	0.582	0.757
Interaction (VXF)			
V ₁ F ₁	5.47	6.13	9.60
V ₁ F ₂	6.00	7.07	10.67
V ₁ F ₃	6.47	7.57	11.03
V ₁ F ₄	6.93	8.13	11.33
V ₁ F ₅	7.07	8.67	11.83
V ₂ F ₁	6.17	7.67	10.00
V ₂ F ₂	6.37	7.90	10.80
V ₂ F ₃	6.67	8.07	11.67
V ₂ F ₄	7.07	8.57	12.03
V ₂ F ₅	7.93	10.07	13.83
S.Em±	0.31	0.28	0.36
CD at 5%	NS	NS	NS

Fig.4(a): Effect of varieties on number of leaves per plant

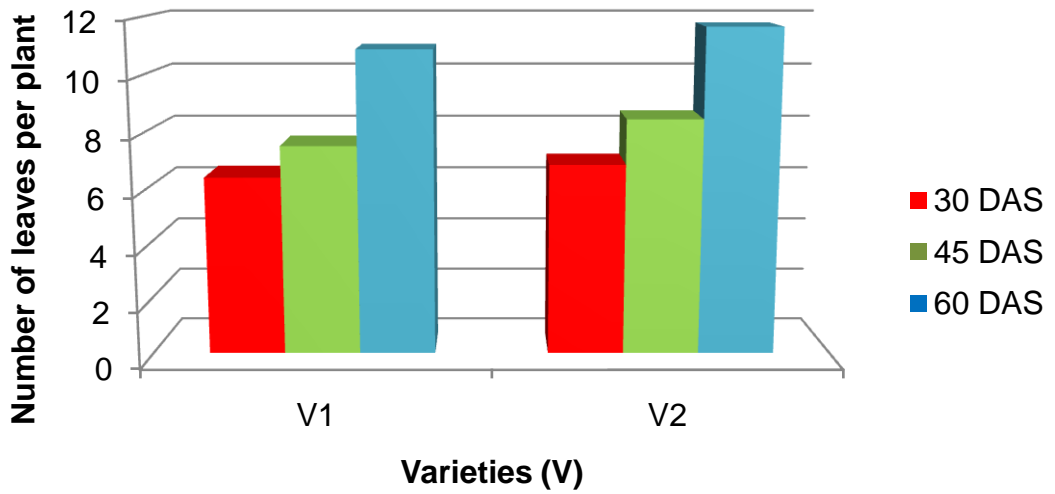


Fig.4(b): Effect of fertility levels on number of leaves per plant

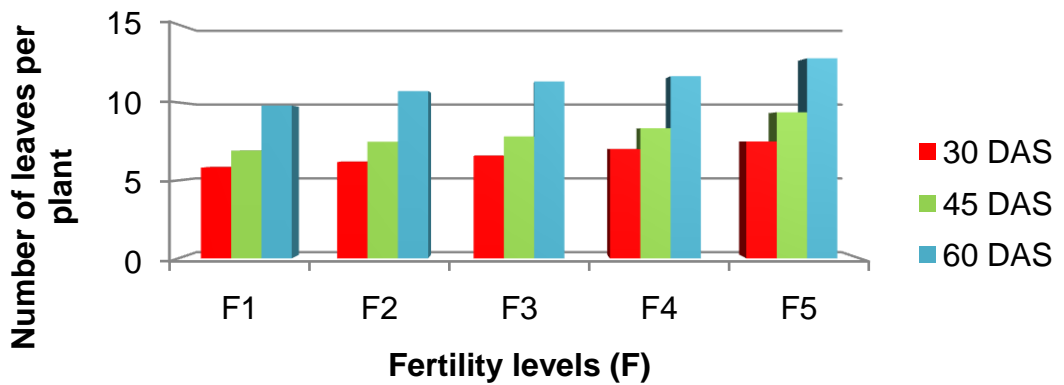
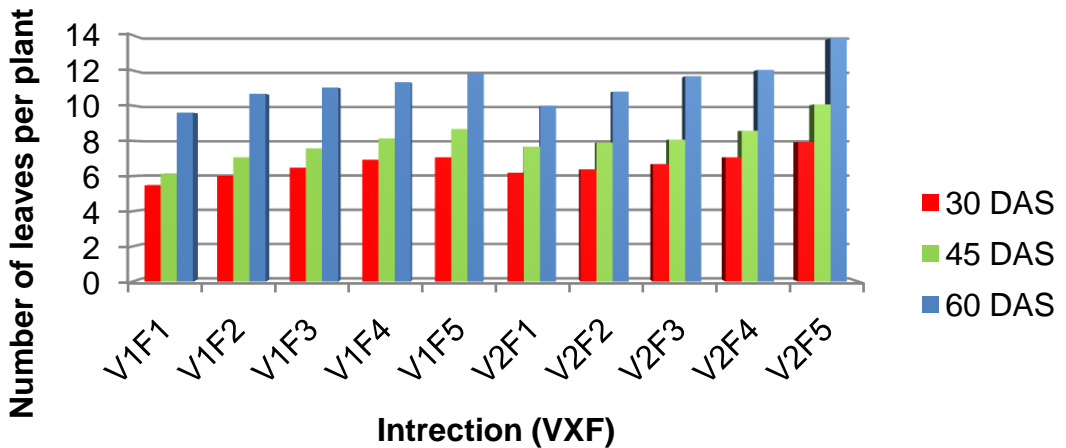


Fig.4(c): Interaction effect of varieties and fertility levels on number of leaves per plant



4.1.3 Leaf area per plant (cm²)

Leaf area per plant (cm²) in turnip was revealed at harvesting stage. The data presented in Table 8 and in graphically illustrated in Fig. 5 showed significant effect of varieties and fertility levels on leaf area per plant in turnip.

The data indicates significant influence of varieties and fertility levels on leaf area of turnip. Maximum leaf area (641.78 cm²) at harvesting stage, was in variety V₂ (Purple Top White Globe) while minimum leaf area (486.50 cm²) was observed in variety V₁ (Pusa Sweti) at harvesting stages.

Fertility levels had exerted significant influence on leaf area in turnip. Maximum leaf area (686.19 cm²) was recorded with fertility level F₅ (NPK-100:60:50 kg/ha) harvesting stage. It was followed by F₄ > F₃ > F₂ in descending order. Minimum leaf area (420.00 cm²) was recorded in fertility level F₁ (NPK-00:00:00 kg/ha) at harvesting stage.

Combined effect of varieties and fertility levels had non - significant influence on leaf area at harvesting stage in turnip.

Table 7: Effect of varieties, fertility levels and their interactions on leaf area per plant (cm²) of turnip

Varieties (V)	Leaf area per plant (cm ²)					
	Fertility levels (F)					MEAN
	F ₁	F ₂	F ₃	F ₄	F ₅	
V ₁	337.01	399.79	453.00	606.67	636.04	486.50
V ₂	503.00	566.33	691.00	712.24	736.33	641.78
MEAN	420.00	483.06	572.00	659.45	686.19	

Treatment	Varieties	Fertility levels	Interaction
S.Em±	19.866	31.411	44.42
CD at 5%	59.026	93.328	NS

Fig.5(a): Effect of varieties on leaf area per plant (cm²)

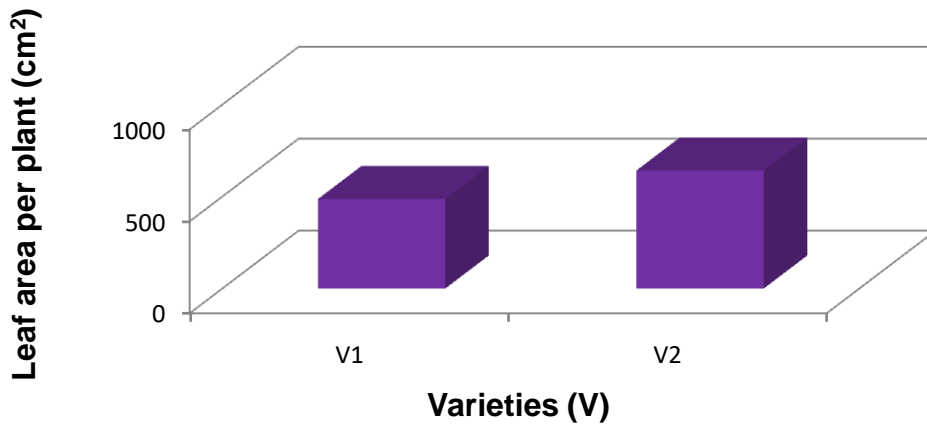


Fig.5(b): Effect of fertility levels on leaf area per plant (cm²)

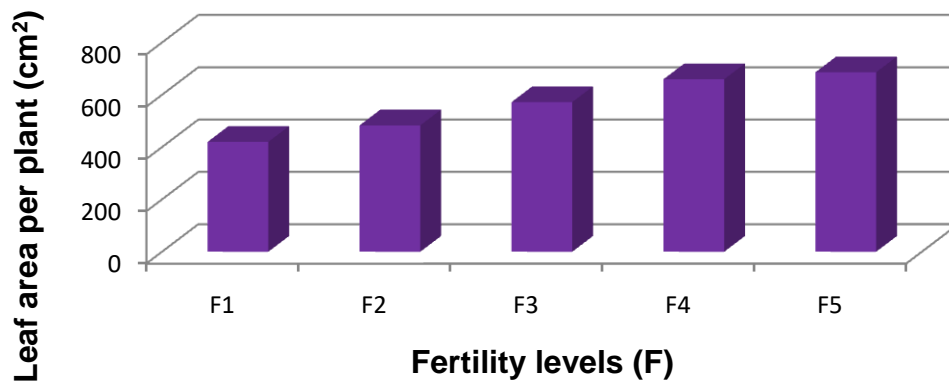
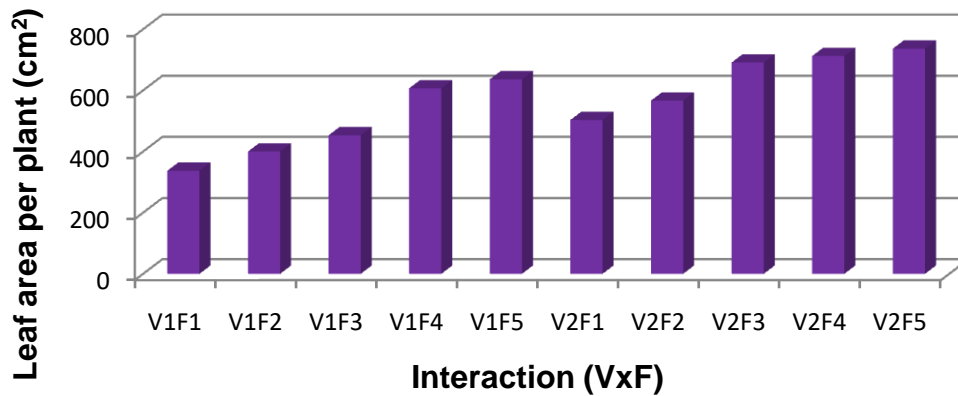


Fig.5(c): Interaction effect of varieties and fertility levels on leaf area per plant (cm²)



4.1.4 Fresh weight of root (g/plant)

Fresh weight of plant in turnip was recorded at harvesting stage exhibited significant effect of varieties and fertility levels. The results on fresh weight of root (g/plant) as influenced with varieties and fertility levels are presented in Table 9 and depicted in Fig. 6.

The findings showed significant effect of varieties on fresh weight of root at harvesting stage. The highest fresh weight of root (139.22 g/plant) was found in variety V₂ (Purple Top White Globe) at harvesting stage. The lowest fresh weight of root (113.41 g/plant) was recorded in case of variety V₁ (Pusa Sweti) at harvesting stage.

Fresh weight of plant showed significant influence of fertility levels. Maximum fresh weight of root (141.87 g/plant) was observed with fertility level F₅ (NPK-100:60:50 kg/ha) followed by F₄ > F₃ > F₂ in descending order *i.e.* 128.00, 124.00 and 120.80, respectively at harvesting stage. Minimum fresh weight of root (116.92 g/plant) was recorded in case of fertility level F₁ (NPK-00:00:00 kg/ha) at harvesting stage.

Combined effect of varieties and fertility levels showed non-significant influence on fresh weight of root at harvesting stage in turnip.

Table 9: Effect of varieties, fertility levels and their interaction on fresh weight of roots (g/plant) of turnip

Varieties (V)	Fresh weight of roots (g/plant)					MEAN
	Fertility levels (F)					
	F ₁	F ₂	F ₃	F ₄	F ₅	
V ₁	105.00	108.73	111.67	115.33	126.33	113.41
V ₂	128.83	132.87	136.33	140.67	157.40	139.22
MEAN	116.92	120.80	124.00	128.00	141.87	

Treatment	Varieties	Fertility levels	Interaction
S.Em±	2.495	3.945	5.58
CD at 5%	7.413	11.721	NS

Fig.6(a): Effect of varieties on fresh weight of roots (g/plant)

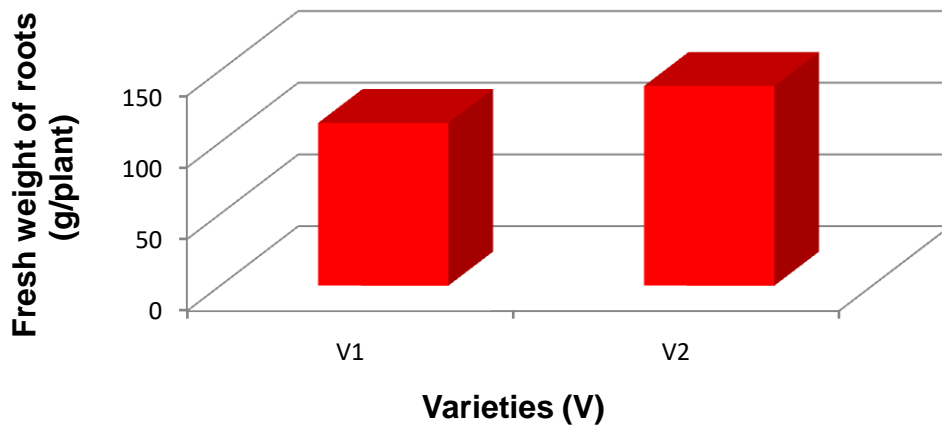


Fig.6(b): Effect of fertility levels of fresh weight of roots (g/plant)

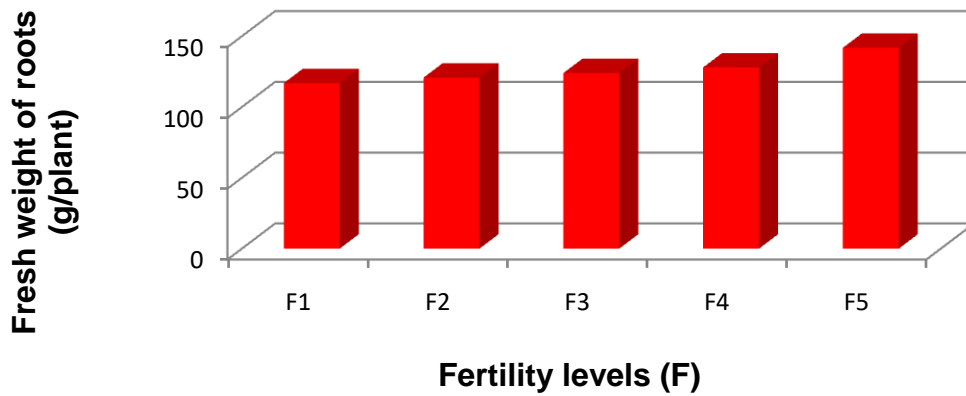
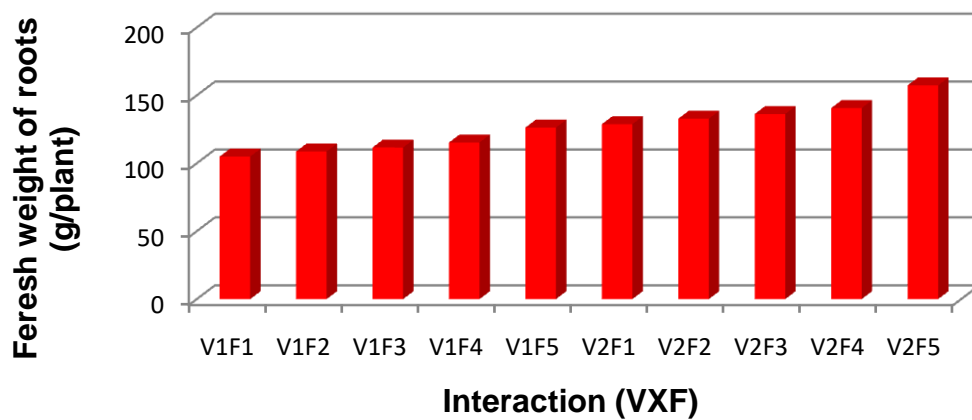


Fig.6(c): Interaction effect of varieties and fertility levels on fresh weight of roots (g/plant)



4.1.5 Dry weight of roots (g/plant)

The results pertaining to dry weight of root (g/plant) as significantly influenced by varieties and fertility levels are presented in Table 10 and Fig.7. Interaction effect of varieties and fertility levels had non-significant influence on dry weight of root in turnip.

The data revealed significant effect of varieties on dry weight of root. Variety V₂ (Purple Top White Globe) found maximum dry weight of root (11.69 g/plant) at harvesting stage. Minimum dry weight of root (9.42 g/plant) was recorded in case of variety V₁ (Pusa Sweti) at harvesting stage.

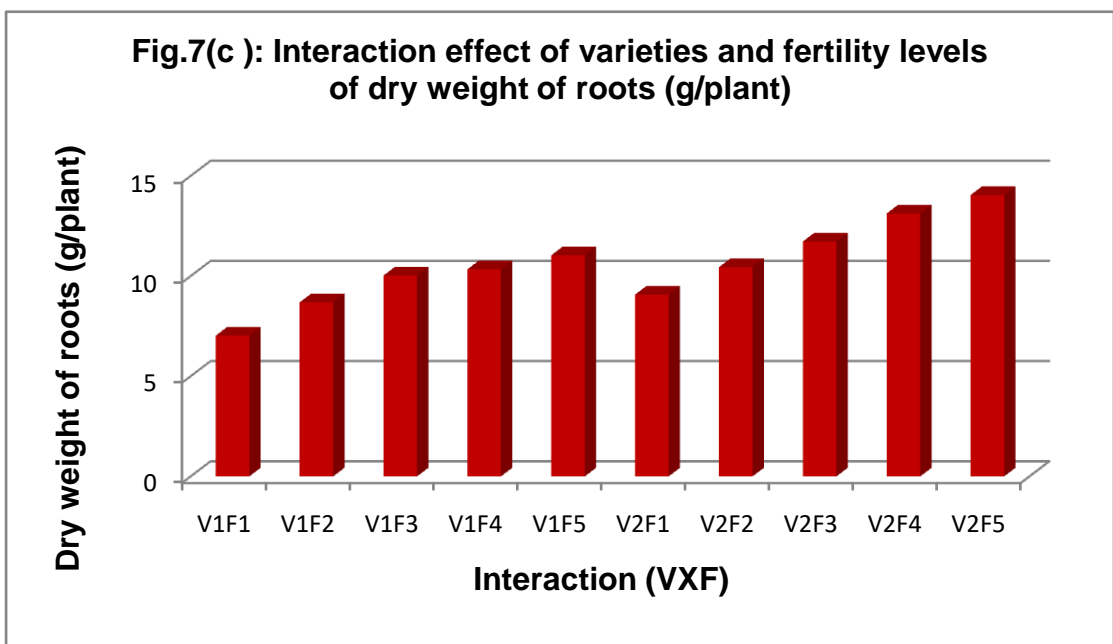
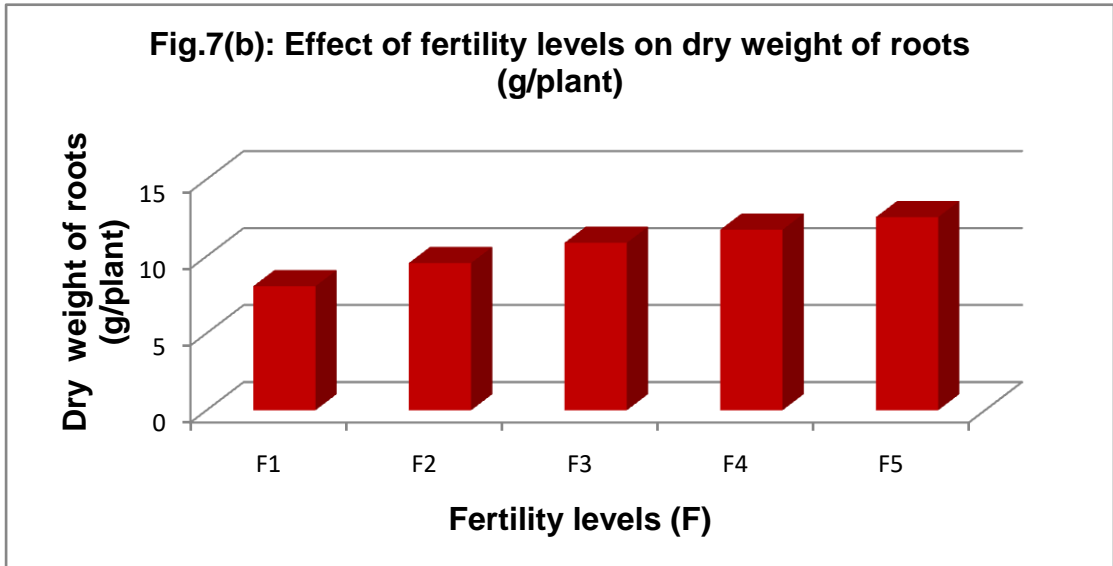
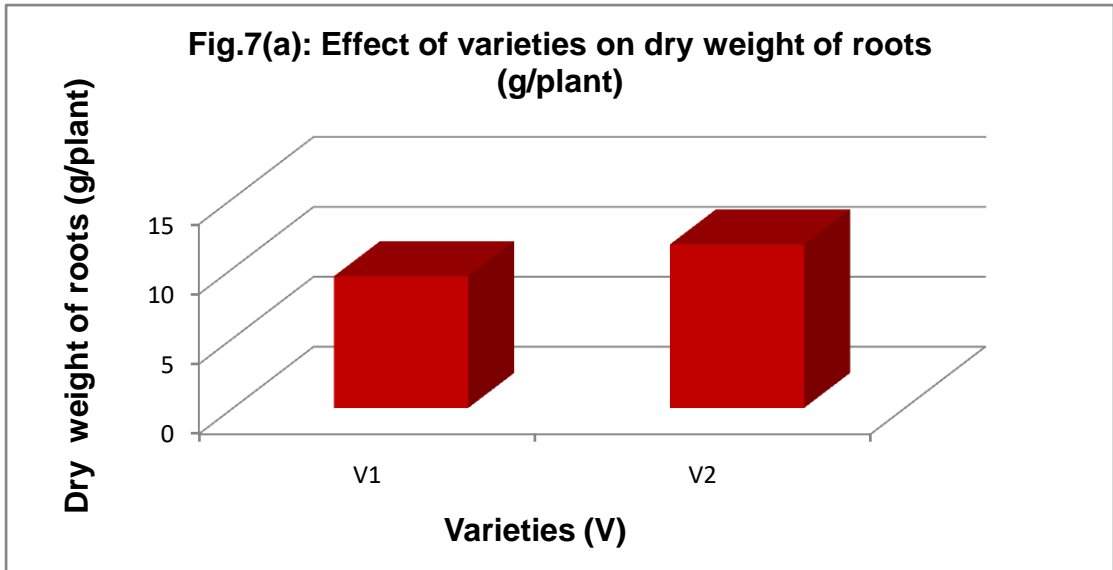
Fertility levels exerted significant influence on dry weight of root in turnip. Maximum dry weight of root (12.55 g/plant) was recorded with fertility level F₅ (NPK-100:60:50 kg/ha) followed by F₄> F₃> F₂ in descending order *i.e.* 11.73, 10.88 and 9.57 g/plant at harvesting stage. Minimum dry weight of root (8.06 g/plant) was recorded at harvesting stage with fertility level F₁ (NPK-00:00:00 kg/ha)

Combined effect of varieties and fertility levels had non- significant influence on dry weight of root at harvesting stage.

Table 10: Effect of varieties, fertility levels and their interaction on dry weight of roots (g/plant) of turnip

Varieties (V)	Dry weight of roots (g/plant)					
	Fertility levels (F)					MEAN
	F ₁	F ₂	F ₃	F ₄	F ₅	
V ₁	7.03	8.69	10.03	10.34	11.04	9.42
V ₂	9.08	10.45	11.73	13.13	14.05	11.69
MEAN	8.06	9.57	10.88	11.73	12.55	

Treatment	Varieties	Fertility levels	Interaction
S.Em±	0.347	0.549	0.78
CD at 5%	1.032	1.632	NS



4.1.6 Fresh weight of leaves (g/plant)

Fresh weight of leaves (g/plant) was recorded at harvesting stage exhibited significant effect of varieties and fertility levels. The results on fresh weight of leaves (g/plant) as influenced with varieties and fertility levels are presented in Table 11 and depicted in Fig. 8.

The findings showed significant effect of varieties on fresh weight of leaves at harvesting stage. Maximum fresh weight of leaves (120.57 g/plant) was found in variety V₂ (Purple Top White Globe) at harvesting stage. The minimum fresh weight of leaves (110.59 g/plant) was recorded in case of variety V₁ (Pusa Sweti) at harvesting stage.

Fresh weight of leaves showed significant influence of fertility levels. Maximum fresh weight of leaves (128.07 g/plant) was observed with fertility level F₅ (NPK-100:60:50 kg/ ha) followed by F₄ > F₃ > F₂ in descending order *i.e.* 120.30, 114.83 and 110.28 g/plant at harvesting stage. Minimum fresh weight of leaves (104.40 g/plant) was recorded in case of fertility levels F₁ (NPK-00:00:00 kg/ha) at harvesting stage.

Combined effect of varieties and fertility levels showed non - significant influence on fresh weight of leaves at harvesting stage in turnip.

Table 11: Effect of varieties, fertility levels and their interaction on fresh weight of leaves (g/plant) of turnip

Varieties (V)	Fresh weight of leaves (g/plant)					
	Fertility levels (F)					MEAN
	F ₁	F ₂	F ₃	F ₄	F ₅	
V ₁	102.67	105.67	109.00	115.60	120.00	110.59
V ₂	106.13	114.90	120.67	125.00	136.13	120.57
MEAN	104.40	110.28	114.83	120.30	128.07	

Treatment	Varieties	Fertility levels	Interaction
S.Em±	3.326	5.258	7.44
CD at 5%	9.881	15.623	NS

Fig.8(a): Effect of varieties of fresh weight of leaves (g/plant)

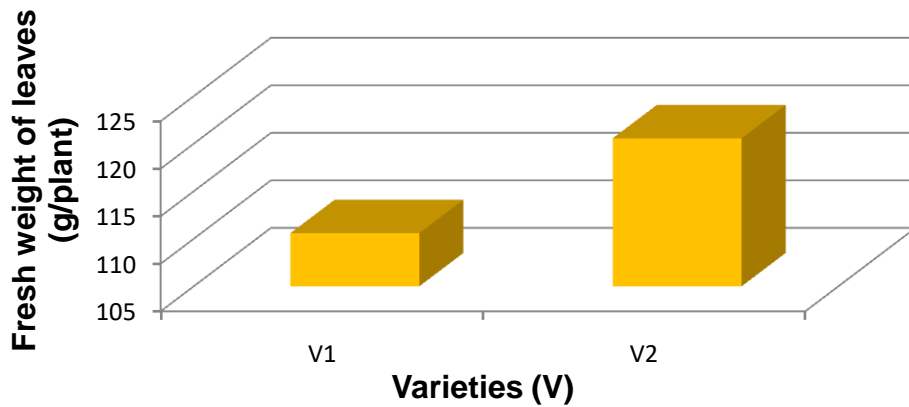


Fig.8(b): Effect of fertility levels of fresh weight of leaves (g/plant)

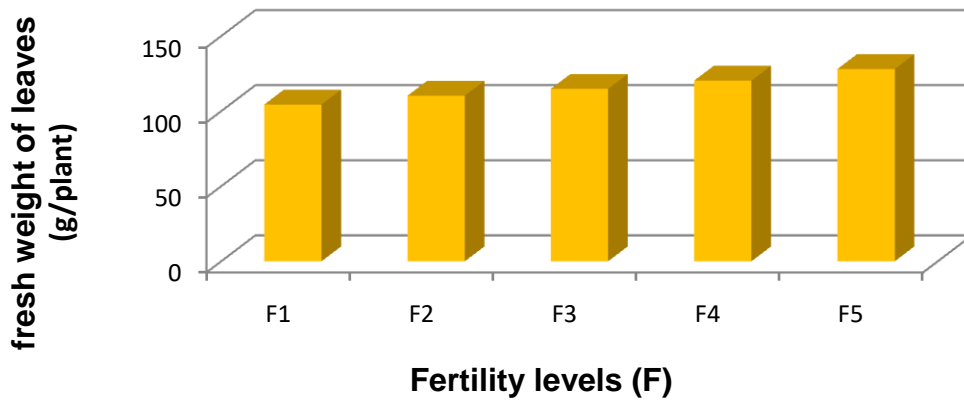
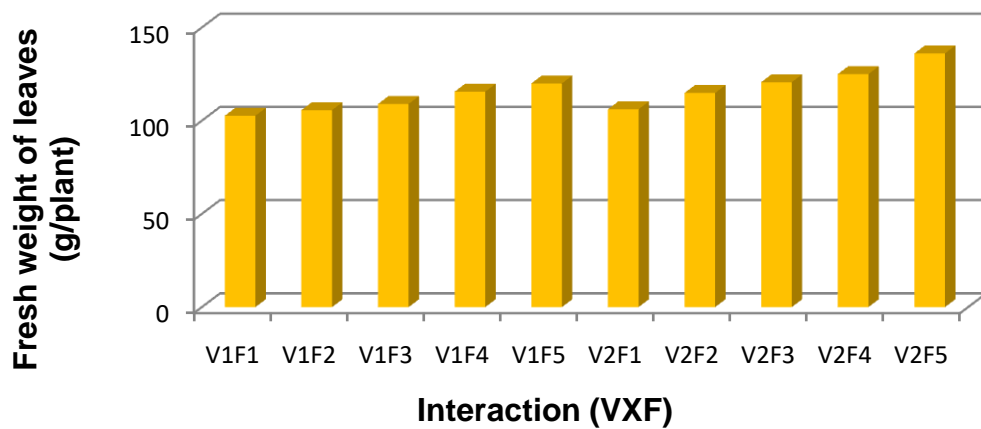


Fig.8(c): Interaction effect of varieties and fertility levels on fresh weight of leaves (g/plant)



4.1.7 Dry weight of leaves (g/plant)

The results pertaining to dry weight of leaves (g/plant) was significantly influenced with varieties and fertility levels are presented in Table 12 and Fig. 9. Interaction effect of varieties and fertility levels had non- significant influence on dry weight of leaves (g/plant) in turnip.

The data revealed significant effect of varieties on dry weight of leaves. Variety V₂ (Purple Top White Globe) found maximum dry weight of leaves (9.06 g/plant) as compared to minimum dry weight of leaves (6.34 g/plant) was recorded in case of variety V₁ (Pusa Sweti) at harvesting stage.

Fertility levels exerted significant influence on dry weight of leaves in turnip. highest dry weight of leaves (10.00 g/plant) was recorded with fertility level F₅ (NPK-100:60:50 kg/ha) followed by F₄> F₃> F₂ in descending order *i.e.* 8.53, 7.22 and 6.67 g/plant at harvesting stage. Lowest dry weight of leaves (6.07 g/plant) was recorded at harvesting stage with fertility levels F₁ (NPK- 00:00:00 kg/ha)

Combined effect of varieties and fertility levels had non- significant influence on dry weight of leaves at harvesting stage.

Table 12: Effect of varieties, fertility levels and their interaction on dry weight of leaves (g/plant) of turnip

Varieties (V)	Dry weight of leaves (g/plant)					
	Fertility levels (F)					MEAN
	F ₁	F ₂	F ₃	F ₄	F ₅	
V ₁	5.03	5.48	6.12	7.06	8.00	6.34
V ₂	7.10	7.86	8.33	10.00	12.00	9.06
MEAN	6.07	6.67	7.22	8.53	10.00	

Treatment	Varieties	Fertility levels	Interaction
S.Em±	0.279	0.442	0.62
CD at 5%	0.830	1.312	NS

Fig.9(a) : Effect of varieties on dry weight of leaves (g/plant)

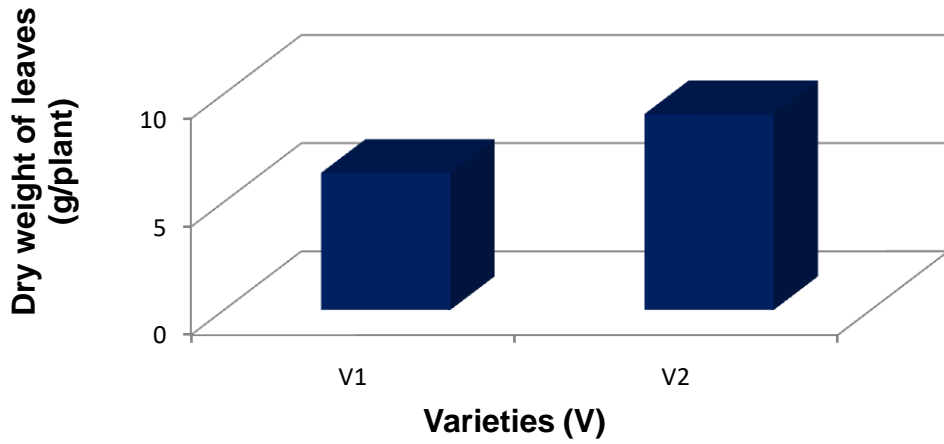


Fig.9(b): Effect of fertility levels of dry weight of leaves (g/plant)

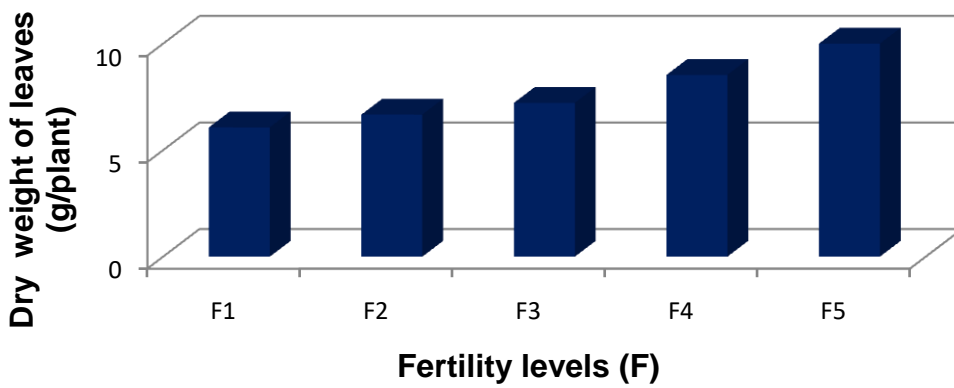
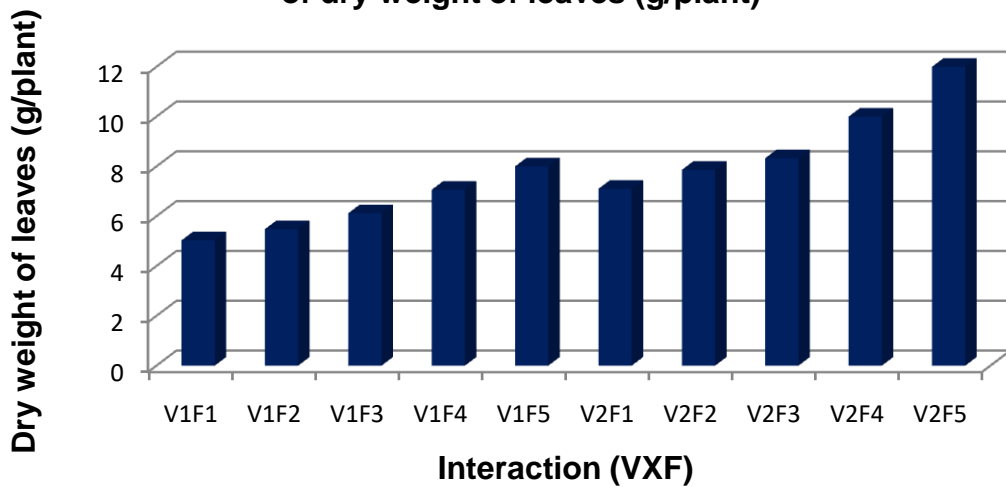


Fig.9(c) : Interaction effect of varieties and fertility levels of dry weight of leaves (g/plant)



4.1.8 SPAD value

The results on SPAD value as influenced by varieties and fertility levels are presented in Table 13 and fig. 10. SPAD value of plant was recorded at 30, 45 and 60 DAS exhibited significant effect of varieties and fertility levels.

The data revealed significant effect of varieties on SPAD value at all the growth stages. Maximum SPAD value (39.49, 42.10 and 51.48) was found in variety V_2 (Purple Top White Globe) at 30, 45 and 60 DAS, respectively. Variety V_1 (Pusa Sweti) recorded minimum SPAD value *i.e.* 37.49, 39.46 and 47.77 at 30, 45 and 60 DAS, respectively.

SPAD value recorded at 30, 45 and 60 DAS was significantly affected by different fertility levels. The highest SPAD value was recorded at 30, 45 and 60 DAS *i.e.* 41.26, 43.97 and 52.37 under the fertility level F_5 (NPK-100:60:50 kg/ha). It was followed by fertility levels $F_4 > F_3 > F_2$ in descending order at all the growth stages. Minimum SPAD value was recorded in under the fertility level F_1 (NPK-00:00:00 kg/ha) *i.e.* 36.43, 37.50 and 46.17, at 30, 45 and 60 DAS, respectively.

Combined effect of varieties and fertility levels showed non-significant influence on SPAD value at all the growth stage in turnip.

Table 13: Effect of varieties, fertility levels and their interaction on SPAD value of turnip

Treatments	SPAD value		
	30 DAS	45 DAS	60 DAS
Varieties (V)			
V ₁	37.49	39.46	47.77
V ₂	39.49	42.10	51.48
S.Em±	0.608	0.750	0.872
CD at 5%	1.806	2.227	2.591
Fertility levels (F)			
F ₁	36.43	37.50	46.17
F ₂	37.37	39.07	47.83
F ₃	38.05	41.00	50.73
F ₄	39.35	42.37	51.03
F ₅	41.26	43.97	52.37
S.Em±	0.961	1.185	1.379
CD at 5%	2.856	3.521	4.097
Interaction (VXF)			
V ₁ F ₁	35.62	36.00	44.20
V ₁ F ₂	36.07	38.00	46.00
V ₁ F ₃	37.00	39.33	48.80
V ₁ F ₄	38.26	41.67	49.27
V ₁ F ₅	40.53	42.30	50.60
V ₂ F ₁	37.23	39.00	48.13
V ₂ F ₂	38.67	40.13	49.67
V ₂ F ₃	39.11	42.67	52.67
V ₂ F ₄	40.43	43.07	52.80
V ₂ F ₅	42.00	45.63	54.13
S.Em±	1.36	1.68	1.95
CD at 5%	NS	NS	NS

Fig.10(a) : Effect of varieties on SPAD value

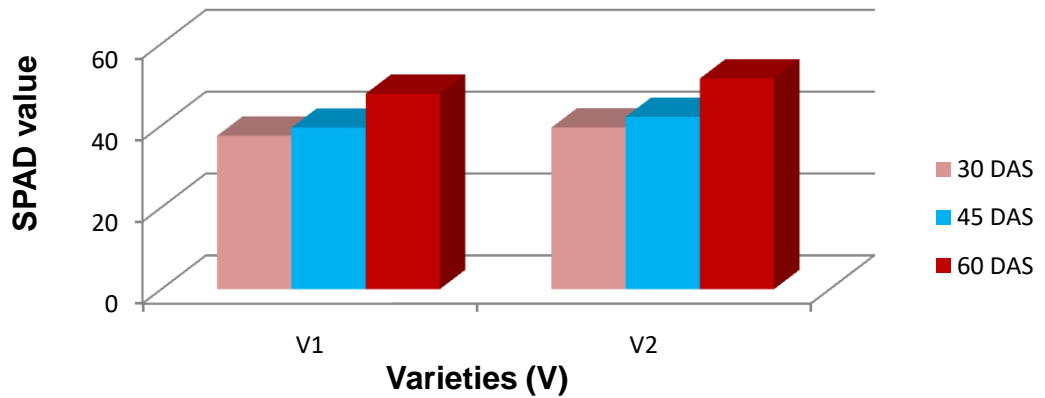


Fig.10(b): Effect of fertility levels of SPAD value

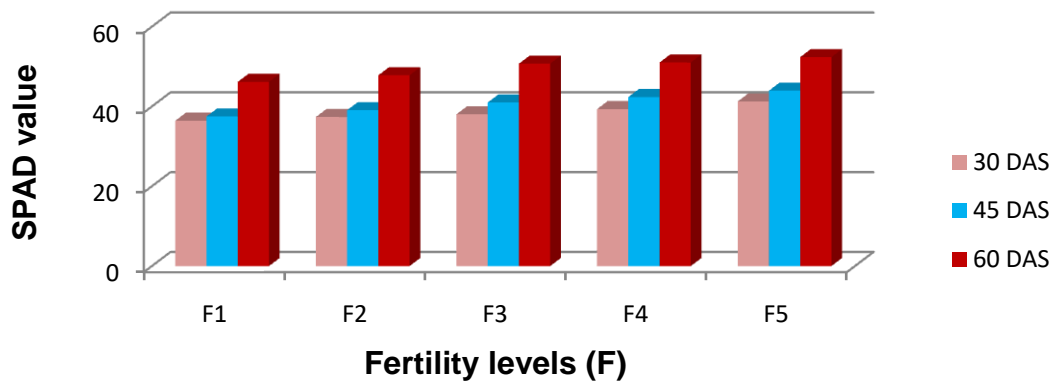
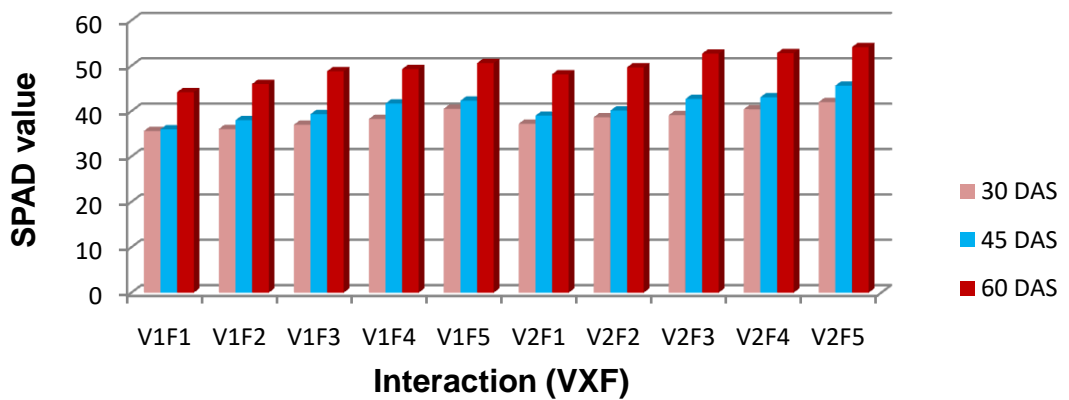


Fig.10(c) : Interaction effect of varieties and fertility levels of SPAD value



4.2 Yield parameters

4.2.1 Root length (cm)

Length of root as presented in Table 14 and depicted in Fig.11 exhibited significant effect of varieties and fertility levels. Combined effect of varieties and fertility levels had no remarkable influence on root length in turnip.

Root length was significantly influenced by different varieties. Among the varieties V₂ (Purple Top White Globe) recorded longest root length (18.05 cm) root length of turnip. Smallest root length (15.88 cm) was observed in variety V₁ (Pusa Sweti).

Application of fertilizers exhibited positive effect on root length. Fertility level F₅ (NPK-100:60:50 kg/ha) observed maximum root length (18.58 cm). It was followed by F₄> F₃> F₂ in descending order. Minimum root length (15.38 cm) was observed under fertility level F₁ (NPK-00:00:00 kg/ha).

Combined effect of varieties and fertility levels had non- significant influence on root length in turnip.

Table 14: Effect of varieties, fertility levels and their interaction on root length (cm) of turnip

Varieties (V)	Root length (cm)					
	Fertility levels (F)					MEAN
	F ₁	F ₂	F ₃	F ₄	F ₅	
V ₁	14.10	15.29	16.03	16.33	17.67	15.88
V ₂	16.67	17.50	18.27	18.33	19.50	18.05
MEAN	15.38	16.39	17.15	17.33	18.58	

Treatment	Varieties	Fertility levels	Interaction
S.Em±	0.366	0.579	0.82
CD at 5%	1.088	1.720	NS

Fig.11(a): Effect of varieties on root length (cm)

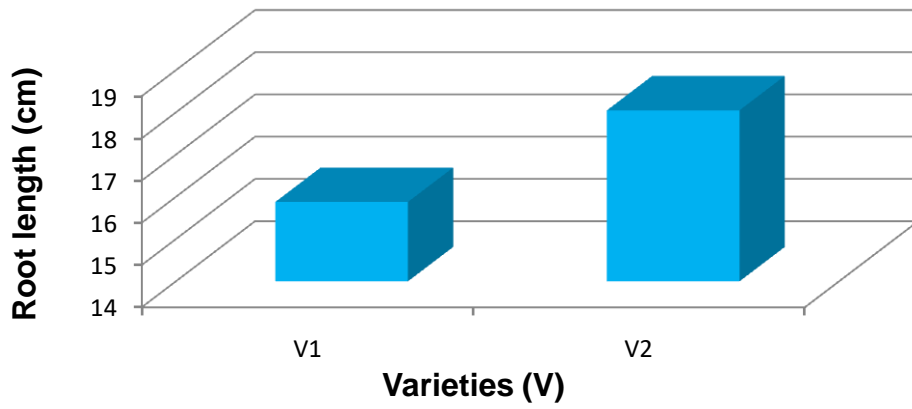


Fig.11(b): Effect of fertility levels of root length (cm)

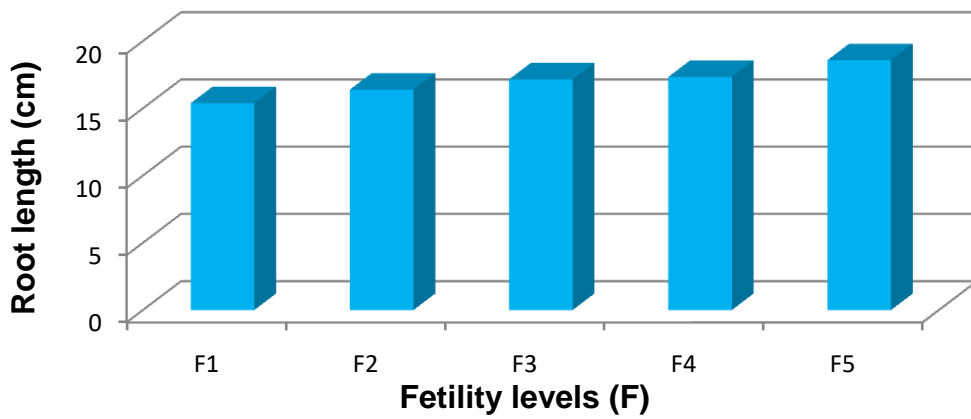


Fig.11(c): Interaction effect of varieties and fertility levels of root length (cm)

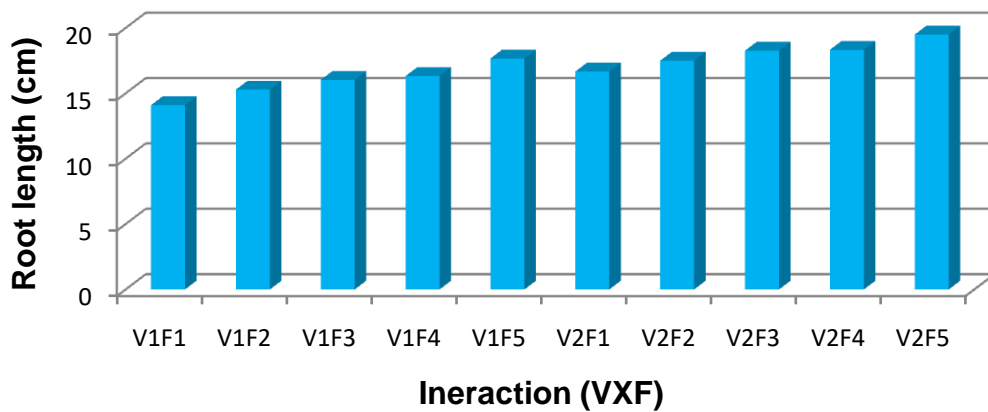




Plate 2:- Roots of different varieties of turnip

4.2.2 Diameter of root (cm)

The data presented in table 15 and depicted in Fig.12 revealed that root diameter was significantly influenced by varieties and fertility levels, whereas combined effect of varieties and fertility levels did not show any remarkable influence on root diameter in turnip.

The maximum root diameter (6.93 cm) was found with variety V₂ (Purple Top White Globe). Minimum root diameter (6.40 cm) was recorded with variety V₁ (Pusa Sweti) in turnip.

Fertility levels showed significant effect on diameter of root in turnip. Maximum root diameter (7.64 cm) was recorded with fertility level F₅ (NPK-100:60:50 kg/ha). It was followed by F₄ > F₃ > F₂ in descending order, while minimum root diameter (5.90 cm) was observed under fertility level F₁ (NPK-00:00:00 kg/ha)

Combined effect of varieties and fertility levels had non- significant influence on root diameter in turnip.

Table 15: Effect of varieties, fertility levels and their interaction on root diameter (cm) of turnip

Varieties (V)	Root diameter (cm)					
	Fertility levels (F)					MEAN
	F ₁	F ₂	F ₃	F ₄	F ₅	
V ₁	5.73	6.23	6.40	6.63	7.01	6.40
V ₂	6.07	6.33	6.80	7.17	8.27	6.93
MEAN	5.90	6.28	6.60	6.90	7.64	

Treatment	Varieties	Fertility levels	Interaction
S.Em±	0.100	0.158	0.22
CD at 5%	0.297	0.470	NS

Fig.12(a): Effect of varieties on root diameter (cm)

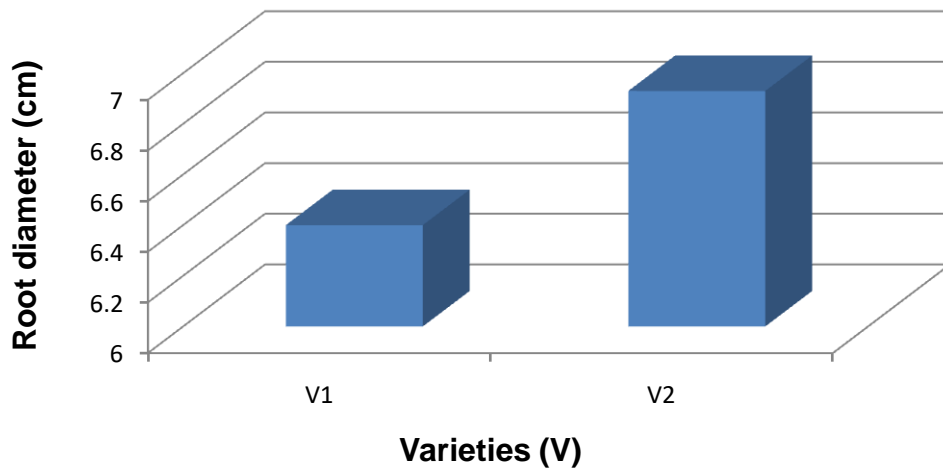


Fig.12(b): Effect of fertility levels on root diameter (cm)

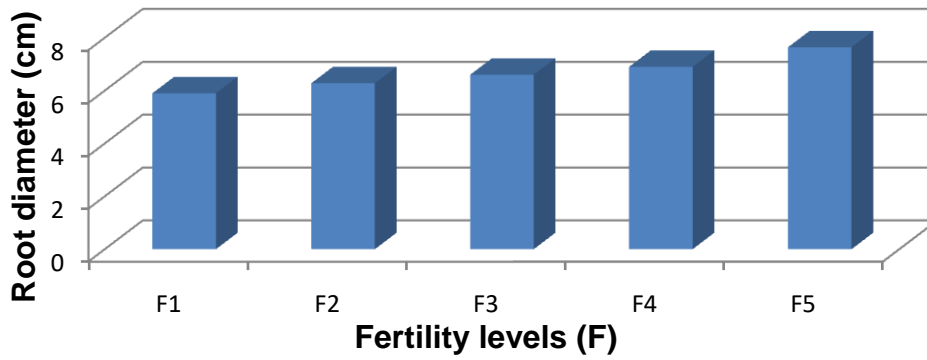
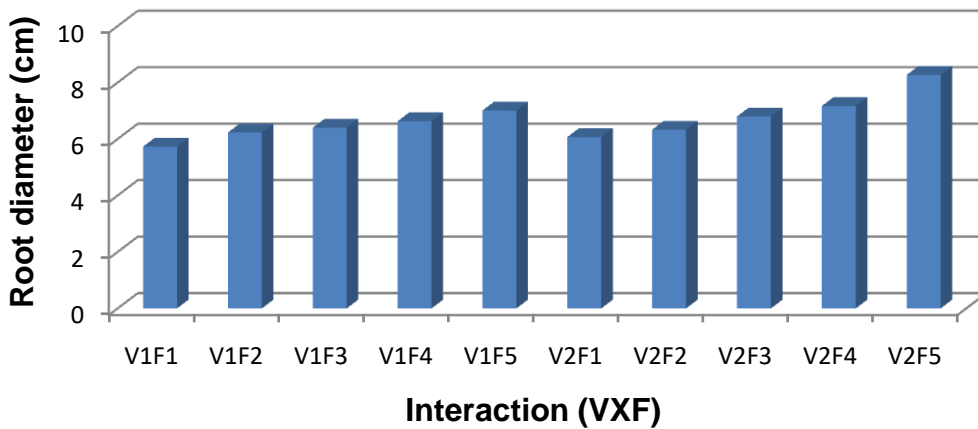


Fig.12(c): Interaction effect of varieties and fertility levels of root diameter (cm)



4.2.3 Root yield per plot (kg)

Root yield per plot as presented in Table 16 and Fig.13 revealed significant influence of varieties and fertility levels. Combined effect of varieties and fertility levels showed non-significant influence on root yield per plot (kg) of turnip.

Average root yield per plot (3.62 kg) was found higher with variety V₂ (Purple Top White Globe) root yield per plot in turnip. Lower root yield per plot (2.95 kg) was observed under variety V₁ (Pusa sweti).

Increase in root yield per plot was noted with each increase in fertility level. Highest root yield per plot (3.69 kg) was obtained with the application of fertility level F₅ (NPK-100:60:50 kg/ha) followed by F₄> F₃> F₂ in descending order *i.e.* 3.33, 3.22 and 3.14 kg, respectively. Minimum root yield per plot (3.04 kg) was obtained under fertility level F₁ (NPK-00:00:00 kg/ ha) in turnip.

Combined effect of varieties and fertility levels show non- significant influence on root yield per plot of turnip.

Table 16: Effect of varieties, fertility levels and their interaction on root yield per plot (kg) of turnip

Varieties (V)	Root yield per plot (kg)					
	Fertility levels (F)					MEAN
	F ₁	F ₂	F ₃	F ₄	F ₅	
V ₁	2.73	2.83	2.90	3.00	3.28	2.95
V ₂	3.35	3.45	3.54	3.66	4.09	3.62
MEAN	3.04	3.14	3.22	3.33	3.69	

Treatment	Varieties	Fertility levels	Interaction
S.Em±	0.065	0.103	0.15
CD at 5%	0.193	0.305	NS

Fig.13(a): Effect of varieties on root yield per plot (kg)

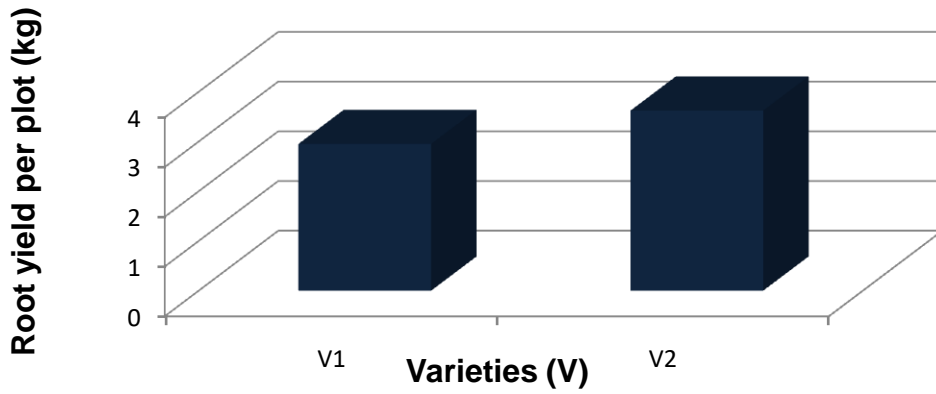


Fig.13(b): effect of fertility levels on root yield per plot (kg)

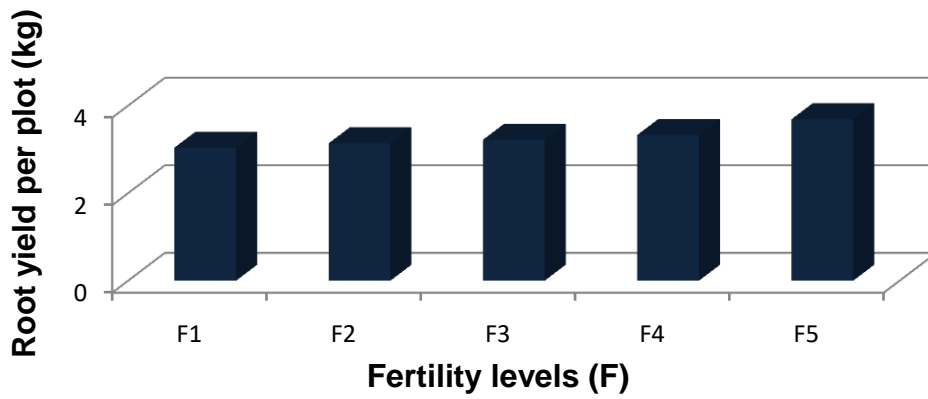
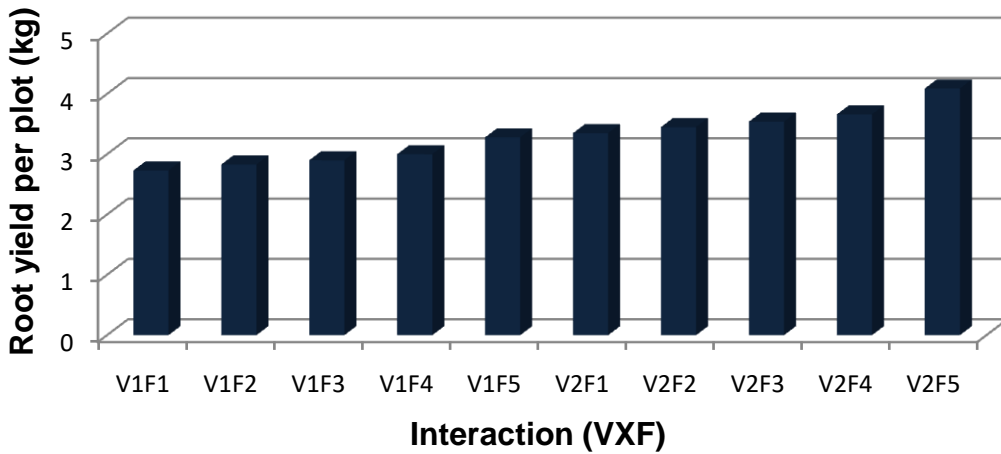


Fig13(c): Interaction effect of varieties and fertility levels of root yield per plot (kg)



4.2.4 Root yield (q/ha)

Root yield (q/ha) as presented in Table 17 and depicted in Fig.14 revealed significant influence of varieties and fertility levels. Combined effects varieties and fertility levels showed non- significant effect on root yield (q/ ha).

Maximum root yield (464.07 q/ha) was found in variety V₂ (Purple Top White Globe) in turnip. Lowest root yield (378.04 q/ha) was observed under variety V₁ (Pusa Sweti) in turnip.

Fertility levels also had exerted significant effect on root yield (q/ha). There was increase in root yield with increasing fertility levels. Maximum root yield (472.89 q/ha) was observed with fertility level F₅ (NPK-100:60:50 kg/ha). It was followed by F₄> F₃> F₂ in descending order. The lowest root yield (389.72 q/ha) was observed in case of fertility level F₁ (NPK-00:00:00 kg/ha).

Combined effect of varieties and fertility levels had no remarkable influence on root yield per hectare in turnip.

Table 17: Effect of varieties, fertility levels and their interaction on root yield (q/ha) of turnip

Varieties (V)	Root yield (q/ha)					
	Fertility levels (F)					MEAN
	F ₁	F ₂	F ₃	F ₄	F ₅	
V ₁	350.00	362.44	372.22	384.44	421.11	378.04
V ₂	429.44	442.89	454.44	468.89	524.67	464.07
MEAN	389.72	402.67	413.33	426.67	472.89	

Treatment	Varieties	Fertility levels	Interaction
S.Em±	8.317	13.150	18.60
CD at 5%	24.710	39.069	NS

Fig.14(a): Effect of varieties on root yield (q/ha)

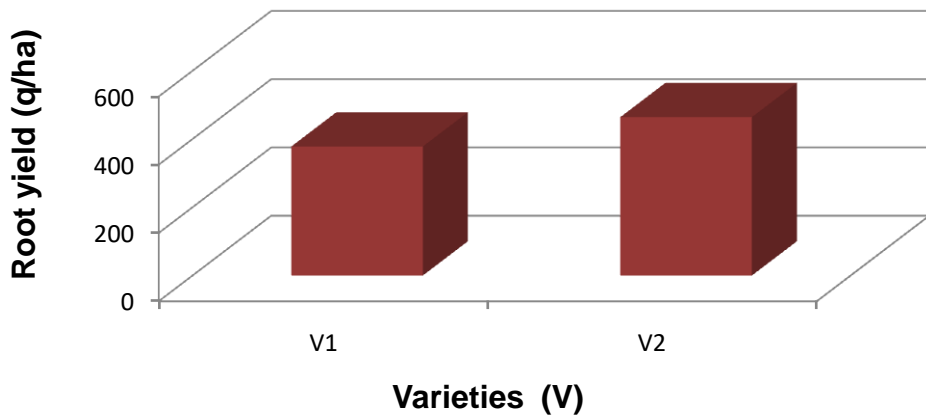


Fig.14 (b): Effect of fertility levels on root yield (q/ha)

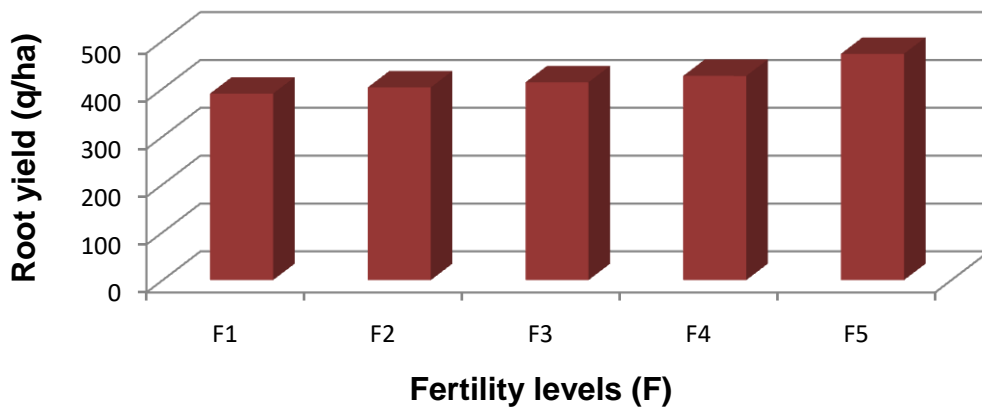


Fig.14 (c): Interaction effect of varieties and fertility levels on root yield (q/ha)

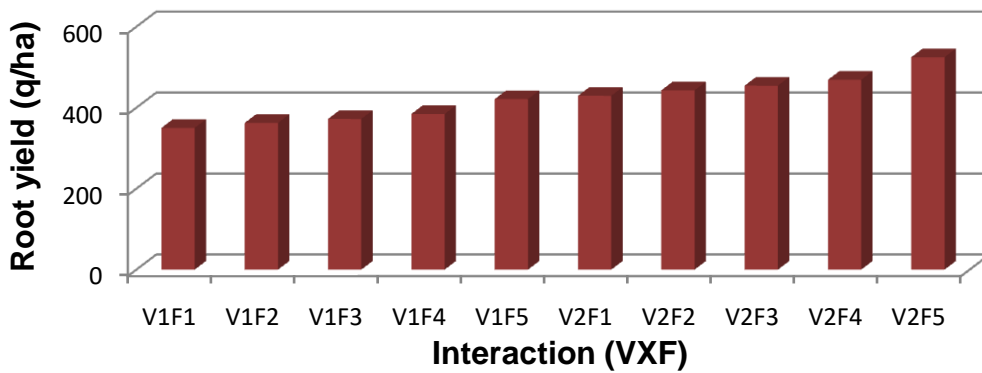




Plate 3(a):- Roots of different treatments of turnip

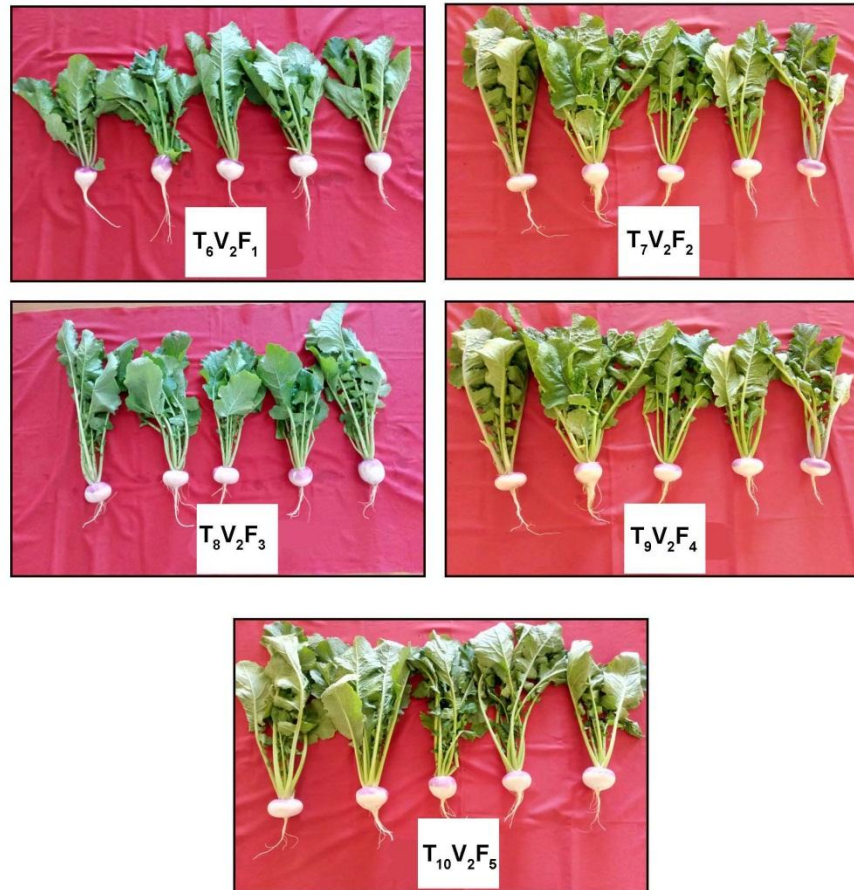


Plate 3 (b) :- Roots of different treatments of turnip

4.3 Quality parameters

4.3.1 TSS (°Brix)

The results on TSS content as significantly influenced by varieties and fertility levels presented in Table 18 and Fig.15. Interaction effect of varieties and fertility levels was found non- significant on total soluble solids in turnip.

Among the varieties, maximum TSS content (35.65°Brix) was determined with variety V₂ (Purple Top White Globe). Minimum TSS content (33.53°Brix) was noted in case of variety V₁ (Pusa Sweti) in turnip.

Application of fertility levels exhibited significant effect on TSS content. Maximum TSS content (7.40 °Brix) was recorded with fertility level F₅ (NPK-100:60:50 kg/ha) which was significantly superior over other fertility levels. F₅ was followed by F₄> F₃> F₂ with a TSS content of 6.91, 6.79 and 6.61°Brix, respectively, While minimum TSS content 6.15 °Brix was observed under fertility level F₁ (NPK-00:00:00 kg/ha).

Combined effect of varieties and fertility levels showed non- significant influence on TSS content in turnip.

Table 18: Effect of varieties, fertility levels and their interaction on TSS (°Brix) in roots of turnip

Varieties (V)	Total Soluble Solids (°Brix)					
	Fertility levels (F)					MEAN
	F ₁	F ₂	F ₃	F ₄	F ₅	
V ₁	6.01	6.53	6.70	6.81	7.03	6.62
V ₂	6.30	6.69	6.88	7.00	7.77	6.93
MEAN	6.15	6.61	6.79	6.91	7.40	

Treatment	Varieties	Fertility levels	Interaction
S.Em±	0.103	0.164	0.23
CD at 5%	0.307	0.486	NS

Fig.15(a): Effect of varieties on TSS (°Brix)

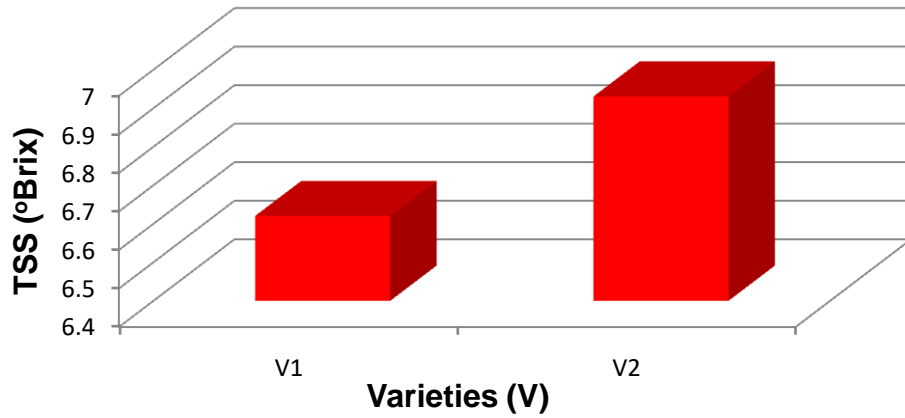


Fig.15(b): Effect of fertility levels on TSS (°Brix)

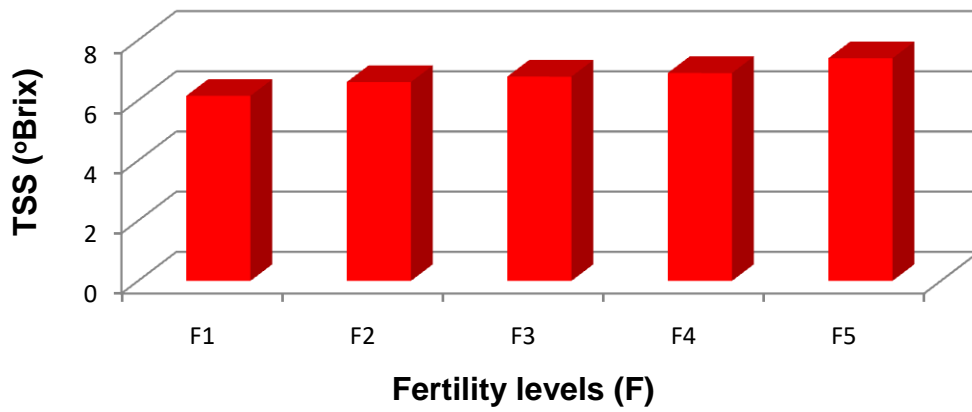
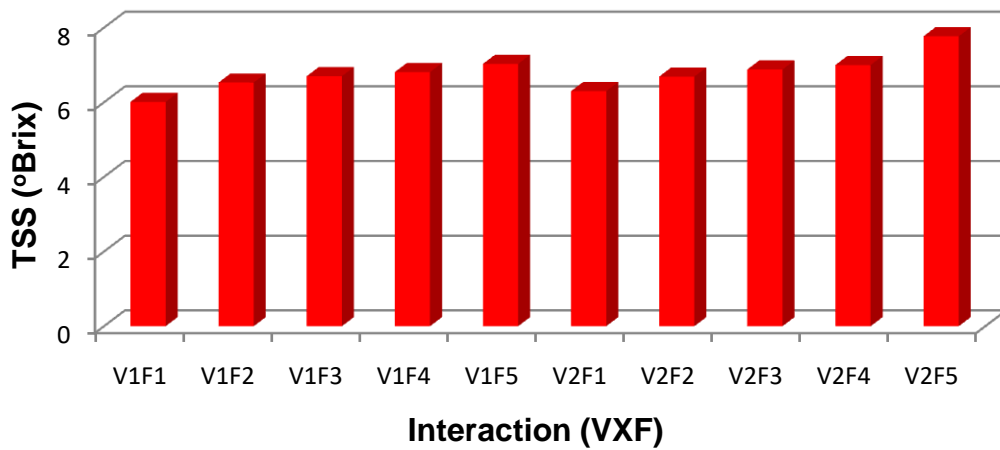


Fig.15(c): Interaction effect of varieties and fertility levels on TSS (°Brix)



4.3.2 Vitamin-C content of root (mg/100 g)

The findings of the present experiment showed in Table 19 and depicted in Fig.16. denoted significant effect of varieties and fertility levels. Interaction effect of varieties and fertility levels was found non- significant on Vitamin-C content of root in turnip.

Among the varieties, maximum Vitamin-C content of (35.65 mg/100 g) was determined with variety V₂ (Purple Top White Globe). Minimum Vitamin-C content (33.53 mg/100 g) was noted in case of variety V₁ (Pusa Sweti). There was significant difference between variety V₁ and V₂.

Fertility levels showed positive effect on Vitamin -C content. Maximum Vitamin-C content of (36.97 mg/100 g) was recorded with fertility level F₅ (NPK-100:60:50 kg/ha) which was significantly superior over all the fertility levels. It was followed by F₄> F₃> F₂ with a Vitamin-C content of 35.52, 34.75 and (33.62 mg/100 g), respectively. While minimum Vitamin -C content 32.10 (mg/100 g) was observed under fertility level F₁ (NPK-00:00:00 kg/ha).

Combined effect of varieties and fertility level showed non- significant influence on Vitamin-C content in turnip roots.

Table 19: Effect of varieties, fertility levels and their interaction on vitamin- C content of root (mg/100 g) of turnip

Varieties (V)	Vitamin-C content of root (mg/100 g)					
	Fertility levels (F)					MEAN
	F ₁	F ₂	F ₃	F ₄	F ₅	
V ₁	30.60	32.33	33.73	34.67	36.33	33.53
V ₂	33.60	34.90	35.77	36.37	37.60	35.65
MEAN	31.10	33.62	34.75	35.52	36.97	

Treatment	Varieties	Fertility levels	Interaction
S.Em±	0.667	1.055	1.49
CD at 5%	1.982	3.134	NS

Fig.16(a): Effect of varieties on Vitamin- C content of root (mg/100 g)

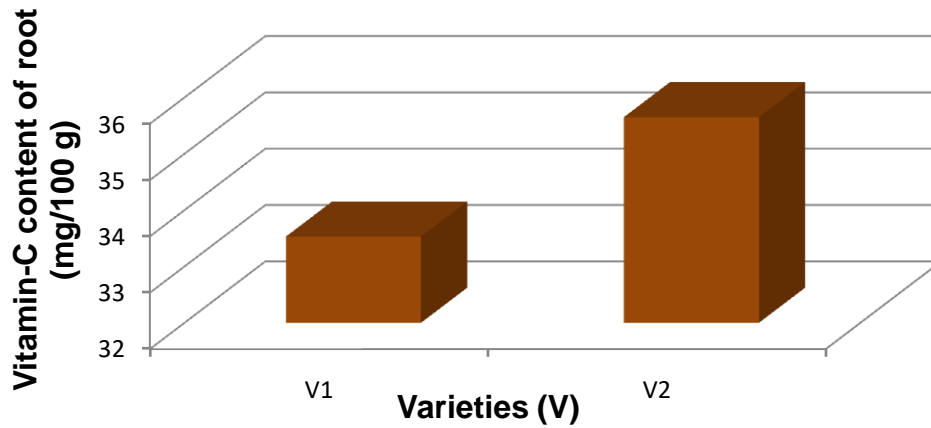


Fig.16(b): Effect of fertility levels on Vitamin- C content of root (mg/100 g)

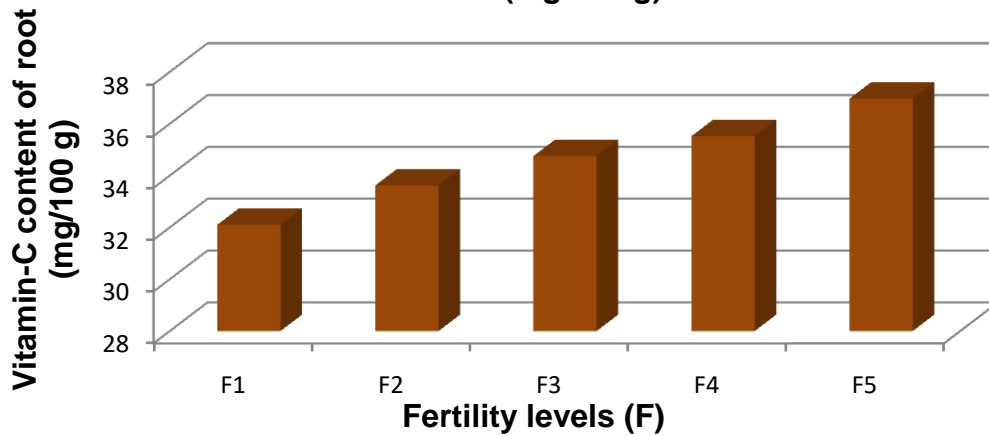
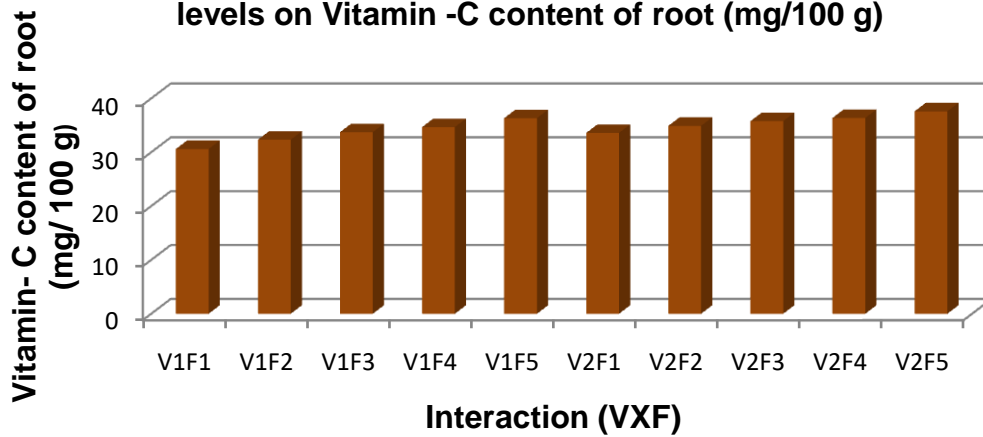


Fig.16(c): Interaction effect of varieties and fertility levels on Vitamin -C content of root (mg/100 g)



4.4 Soil and plant analysis

4.4.1 NPK content in plant at harvesting stage

The findings of the present experiment as showed in Table 20 and depicted in Fig.17 denoted significant effect of fertility levels on post harvest NPK content in plant. Varieties and interaction effect of varieties and fertility levels had showed non significant influence on post harvest NPK content in plant.

Application of fertility exhibited significant effect on nitrogen content in plant. Maximum post harvest nitrogen content (1.83%) in plant was recorded with fertility level F_5 (NPK-100:60:50 kg/ha) which was significantly superior over all other fertility levels. It was followed by $F_4 > F_3 > F_2$ in descending order with a post harvest nitrogen content in plant of *i.e.* 1.75, 1.72 and 1.70 %, respectively. Whereas application of fertility level F_1 (NPK-00:00:00 kg/ha) resulted in minimum post harvest nitrogen content (1.60 %) in plant.

Interaction effect of varieties and fertility levels was found non-significant on nitrogen content in plant of harvesting stage.

The findings showed that phosphorus content in the plant increased with increasing fertility levels. Maximum post harvest phosphorus content (0.21 %) in plant was recorded with fertility level F_5 (NPK- 100:60:50 kg/ha) which was significant superior over all other fertility levels. It was followed by $F_4 > F_3 > F_2$ in descending order. Minimum post harvest phosphorus content (0.14 %) in plant was determined with application of fertility level F_1 (NPK-00:00:00 kg/ha).

Interaction effect of varieties and fertility levels showed non- significant on phosphorus content in plant of harvesting stage.

There was significant effect of fertility levels on post harvest potassium content in the plant. Highest post harvest potassium content (2.58 %) in plant was recorded with fertility level F_5 (NPK-100:60:50 kg/ha) which was significantly superior over all other fertility levels. It was followed by $F_4 > F_3 > F_2$. Lowest post harvest potassium content (2.13 %) in plant was found with application of fertility level F_1 (NPK-00:00:00 kg/ha).

Table 20: Effect of varieties, fertility levels and their interaction on NPK content in plant (%) at harvesting stage

Treatments	NPK content in plant (%) at harvesting stage		
	Nitrogen	Phosphorus	Potassium
Varieties (V)			
V ₁	1.70	0.17	2.31
V ₂	1.74	0.18	2.36
S.Em±	0.028	0.007	0.062
CD at 5%	NS	NS	NS
Fertility levels (F)			
F ₁	1.60	0.14	2.13
F ₂	1.70	0.15	2.25
F ₃	1.72	0.18	2.32
F ₄	1.75	0.20	2.39
F ₅	1.83	0.21	2.58
S.Em±	0.044	0.011	0.099
CD at 5%	0.132	0.031	0.293
Interaction (VXF)			
V ₁ F ₁	1.53	0.13	2.07
V ₁ F ₂	1.69	0.14	2.21
V ₁ F ₃	1.71	0.18	2.34
V ₁ F ₄	1.74	0.20	2.41
V ₁ F ₅	1.81	0.21	2.52
V ₂ F ₁	1.67	0.14	2.18
V ₂ F ₂	1.71	0.17	2.29
V ₂ F ₃	1.73	0.18	2.31
V ₂ F ₄	1.75	0.19	2.36
V ₂ F ₅	1.85	0.21	2.65
S.Em±	0.06	0.01	0.14
CD at 5%	NS	NS	NS

Fig. 17(a) : Effect of varieties on NPK content in plant (%) at harvesting stage

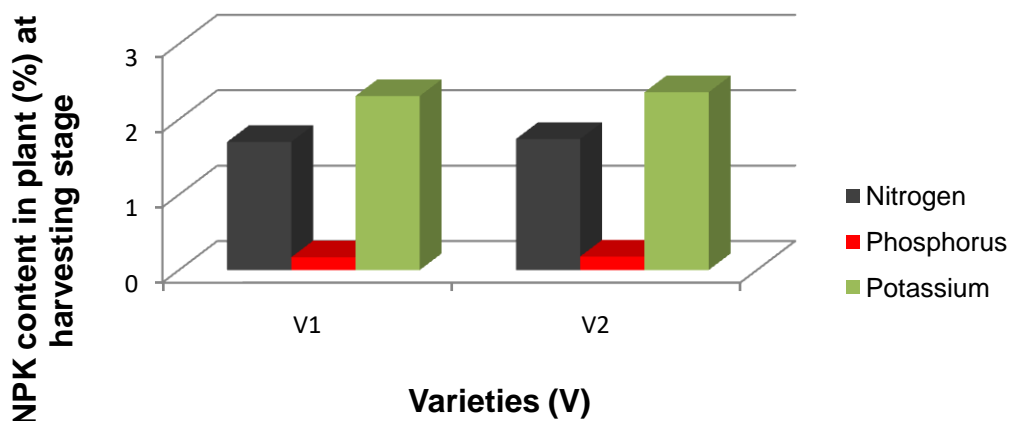


Fig.17(b) : Effect of fertility levels on NPK content in plant (%) at harvesting stage

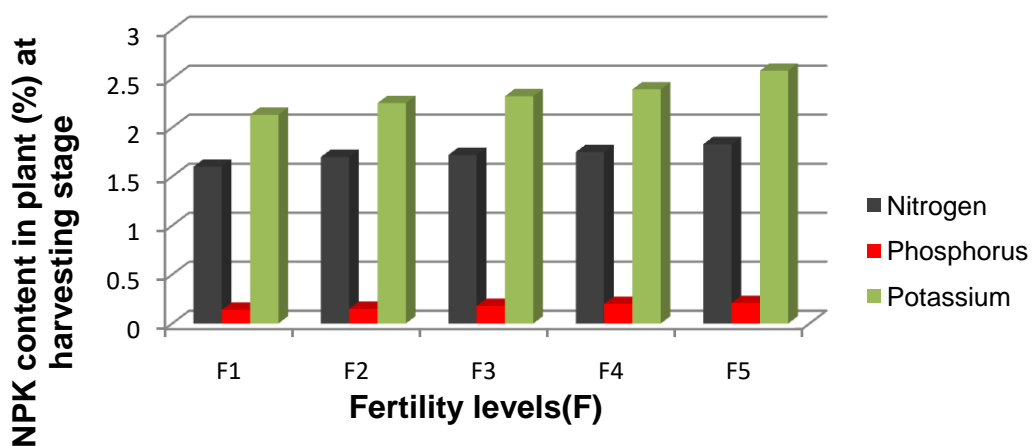
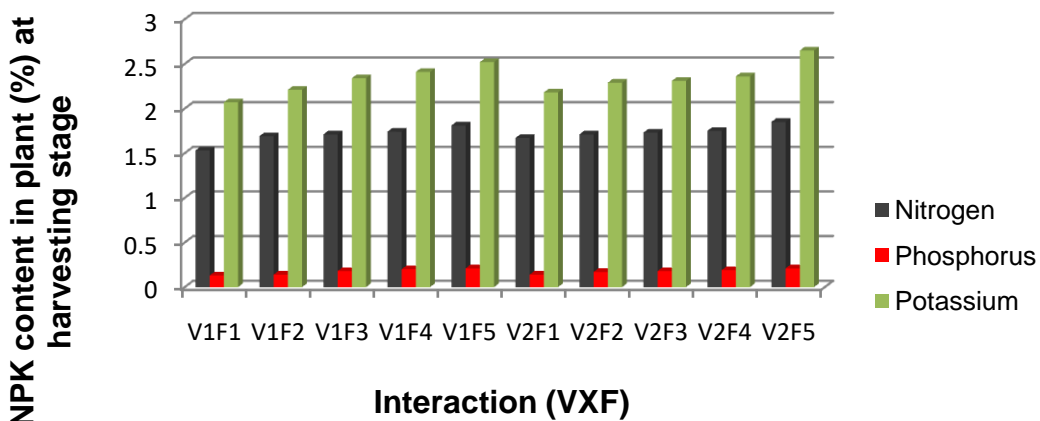


Fig.17(c) : Interaction effect of varieties and fertility levels on NPK content in plant (%) at harvesting stage



Interaction effect of varieties and fertility levels showed non- significant on potassium content in plant of harvesting stage.

4.4.2 NPK content in soil at harvesting stage

The findings of the present experiment presented in Table 21 and Fig.18 denoted significant effect of varieties and fertility levels on post harvest available NPK in soil. Interaction effect of varieties and fertility was found non-significant on post harvest available NPK content in soil.

There was significant effect of varieties on available nitrogen content in soil. Highest available nitrogen content (158.73 kg/ha) in soil was estimated with variety V₂ (Purple Top White Globe). It was significantly superior over V₁ (Pusa Sweti) *i.e.* 131.26 kg/ha.

Application of fertility levels imposed positive effect on post harvest available nitrogen in soil. Maximum post harvest available nitrogen (169.40 kg/ha) in soil was recorded with fertility levels F₅ (NPK-100:60:50 kg/ha) which was significantly superior over all the fertility level. It was followed by F₄> F₃> F₂ with available nitrogen of 154.82, 144.17 and 135.38 kg/ha, respectively while minimum post harvest available nitrogen content (121.20 kg/ha) in soil was observed under fertility level F₁ (NPK-00:00:00 kg/ha).

There was significant effect of varieties on available phosphorus content in soil. Highest available phosphorus (37.00 kg/ha) in soil was estimated with variety V₂ (Purple Top White Globe). It was significant superior over V₁ (Pusa Sweti) *i.e.* 34.47 kg/ha.

The findings showed that phosphorus content in the soil increased with increasing fertility levels. Maximum available phosphorus content (38.83 kg/ha) in soil was recorded with fertility level F₅ (NPK-100:60:50 kg/ha) which was significantly superior over all the fertility levels. It was followed by F₄> F₃> F₂ with available phosphorus of 37.00, 35.00 and 34.33 kg/ha, respectively. While minimum available phosphorus (33.50 kg/ha) in soil was observed under fertility level F₁ (NPK-00:00:00 kg/ha).

There was significant effect of varieties on available potassium content in soil. Highest available potassium (374.20 kg/ha) in soil was estimated with

variety V₂ (Purple Top White Globe). It was significantly superior over V₁ (Pusa Sweti) *i.e.* 337.13 kg/ha.

The findings showed that potassium in the soil increased with increasing fertility levels. Maximum post harvest available potassium content (383.00kg/ha) in soil was recorded with fertility level F₅ (NPK-100:60:50 kg/ha) which was significantly superior over all the fertility levels. It was followed by F₄> F₃> F₂ with a post harvest available potassium of 374.50, 361.50 and 344.00 kg/ha, respectively. While minimum potassium content (315.33 kg/ha) in soil was observed under fertility level F₁ (NPK-00:00:00 kg/ha).

Lowest effect of varieties and fertility levels showed non- significant effect on available NPK content in soil at after harvesting of turnip.

Table 21: Effect of varieties, fertility levels and their interactions on available NPK content (kg/ha) in soil at harvesting

Treatments	NPK content in soil (kg/ha) at harvesting stage		
	Nitrogen	Phosphorus	Potassium
Varieties (V)			
V ₁	131.26	34.47	337.13
V ₂	158.73	37.00	374.20
S.Em±	4.965	0.767	8.334
CD at 5%	14.753	2.279	24.761
Fertility levels (F)			
F ₁	121.20	33.50	315.33
F ₂	135.38	34.33	344.00
F ₃	144.17	35.00	361.50
F ₄	154.82	37.00	374.50
F ₅	169.40	38.83	383.00
S.Em±	7.851	1.213	13.177
CD at 5%	23.326	3.604	39.150
Interaction (VXF)			
V ₁ F ₁	103.33	31.67	286.67
V ₁ F ₂	126.00	33.00	324.33
V ₁ F ₃	137.67	33.67	341.67
V ₁ F ₄	141.30	35.33	358.33
V ₁ F ₅	148.00	38.67	374.67
V ₂ F ₁	139.07	35.33	344.00
V ₂ F ₂	144.77	35.67	363.67
V ₂ F ₃	150.67	36.33	381.33
V ₂ F ₄	168.33	38.67	390.67
V ₂ F ₅	190.80	39.00	391.33
S.Em±	11.10	1.72	18.63
CD at 5%	NS	NS	NS

Fig.18(a): Effect of varieties on available NPK content in soil (kg/ha) at harvesting stage

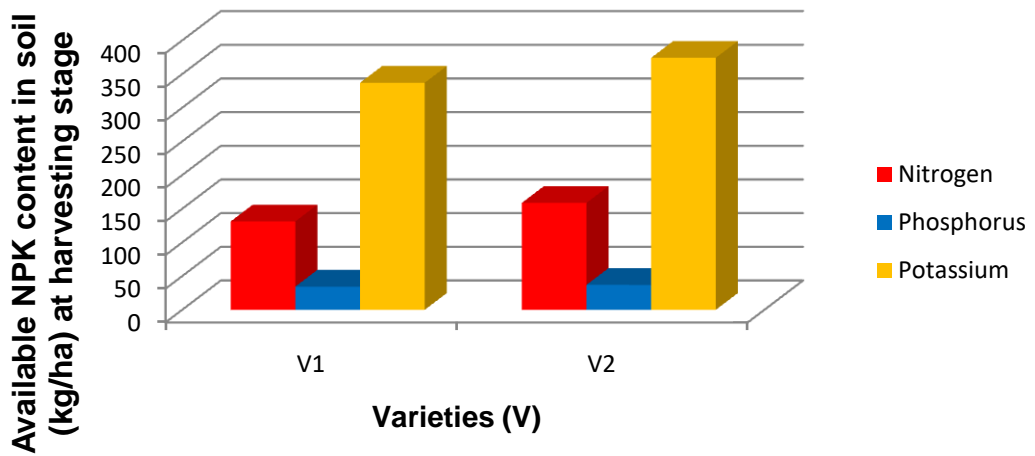


Fig.18(b): Effect of fertility levels on available NPK content in soil (kg/ha) at harvesting stage

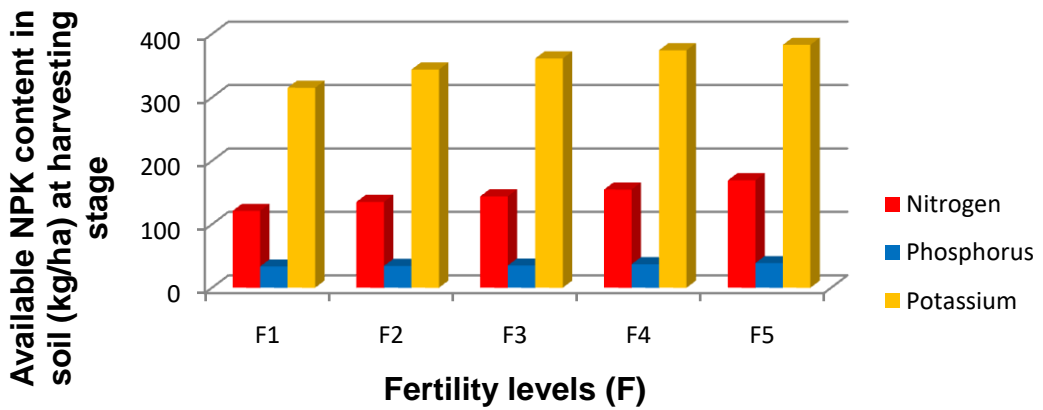
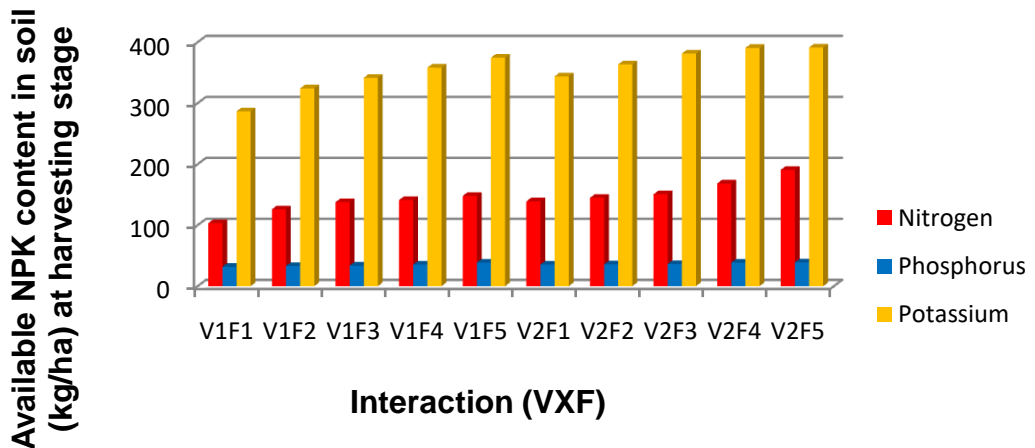


Fig.18(c): Interaction effect of varieties and fertility levels on available NPK content in soil (kg/ha) at harvesting stage



4.5 Economics of different treatments for turnip production

Data presented in Table 22 and depicted in Fig.19 to 21 revealed significant effect of varieties and fertility levels on gross income, net income and B:C ratio, while interaction effect of varieties and fertility levels had non-significant effect on gross income, net income and B:C ratio in turnip.

Highest gross income (185627.20 Rs./ha), net income (150464.96 Rs./ha), and B:C ratio (4.36) was recorded in variety V_2 (Purple Top White Globe). Lowest gross income (151217.33 Rs./ha), net income (116055.10 Rs./ha) and B:C ratio (3.30) was noted in variety V_1 (Pusa Sweti).

Fertility levels exerted significant effect on gross income, net income and B:C ratio. Maximum gross income (189155.33 Rs./ha), net income (151354.67 Rs./ha) and B:C ratio (4.22) was recorded with fertility level F_5 (NPK-100:60:50 kg/ha) which was significantly higher over other fertility levels. It was followed by fertility level $F_4 > F_3 > F_2$ in descending order. While minimum gross income (155889.33 Rs./ha), net income (124289.33 Rs./ha) was recorded under F_1 (NPK-00:00:00 kg/ha) and B:C ratio (3.65) was calculated under fertility level F_4 (NPK-80:50:40 kg/ha).

Interactive effect of varieties and fertility levels had exerted non – significant influence on gross income, net income and B:C ratio. But numerically highest gross income (209866.67 Rs./ha), net income (172066.01 Rs./ha) and B:C ratio (5.00) was realized in case of treatment combination V_2F_5 , while lowest gross income (140000.00 Rs./ha), net income (108400.00 Rs./ha) and F_4 (NPK-80:50:40 kg/ha) B:C ratio (3.19) was found under V_1F_1 treatment combination.

Table 22: Effect of varieties, fertility levels and their interaction on gross income (Rs./ha), net income (Rs./ha) and B:C ratio.

Treatments	Gross income (Rs./ha)	Net income (Rs./ha)	B:C ratio
Varieties (V)			
V ₁	151217.33	116055.10	3.30
V ₂	185627.20	150464.96	4.36
S.Em±	3326.710	3326.710	0.084
CD at 5%	9884.164	9884.164	0.250
Fertility levels (F)			
F ₁	155889.33	124289.33	3.93
F ₂	161066.67	126647.14	3.68
F ₃	165333.33	130023.28	3.68
F ₄	170666.67	133985.72	3.65
F ₅	189155.33	151354.67	4.22
S.Em±	5259.991	5259.991	0.133
CD at 5%	15628.235	15628.235	0.395
Interaction (VXF)			
V ₁ F ₁	140000.00	108400.00	3.43
V ₁ F ₂	144977.33	110557.80	3.21
V ₁ F ₃	148888.00	113577.95	3.21
V ₁ F ₄	153777.33	117096.38	3.19
V ₁ F ₅	168444.00	130643.34	3.45
V ₂ F ₁	171778.67	140178.67	4.43
V ₂ F ₂	177156.00	142736.47	4.14
V ₂ F ₃	181778.67	146468.62	4.14
V ₂ F ₄	187556.00	150875.05	4.11
V ₂ F ₅	209866.67	172066.01	5.00
S.Em±	7438.75	7438.75	0.19
CD at 5%	NS	NS	NS

Fig.19(a): Effect of varieties on gross income (Rs./ha)

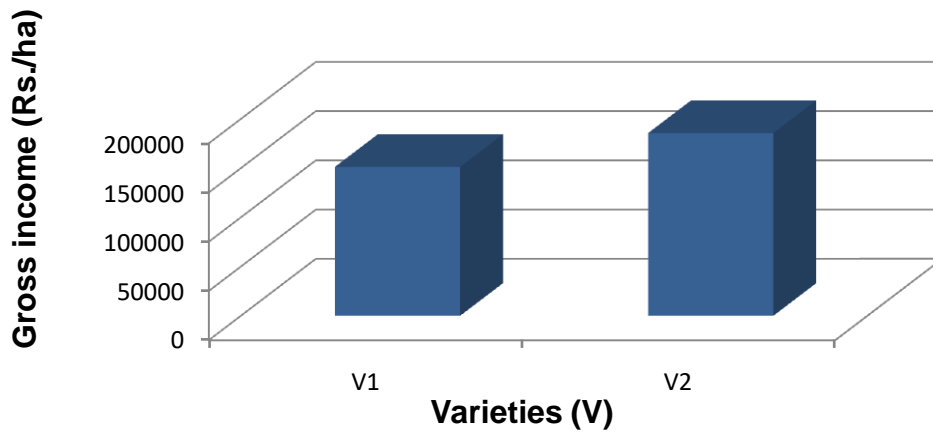


Fig.19(b): Effect of fertility levels on gross income (Rs./ha)

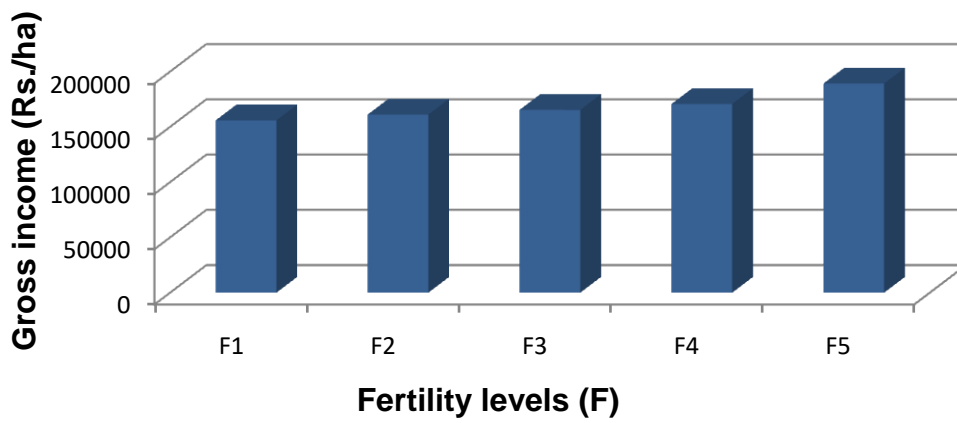


Fig.19(c): Interaction effect of varieties and fertility levels on gross income (Rs./ha)

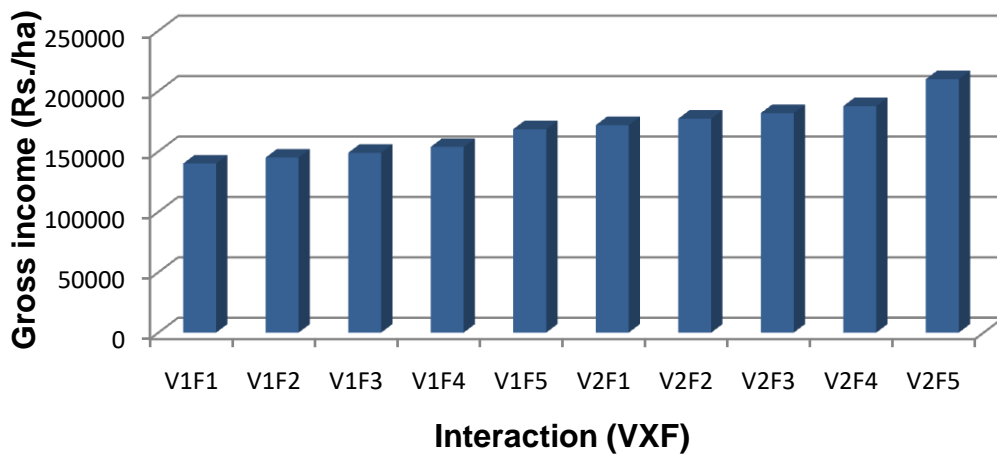


Fig.20(a): Effect of varieties on net income (Rs./ha)

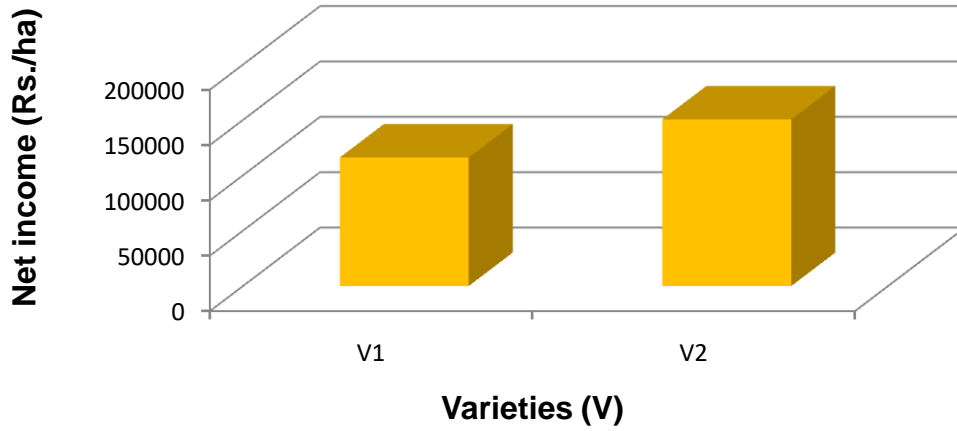


Fig.20(b): Effect of fertility level on net income (Rs./ha)

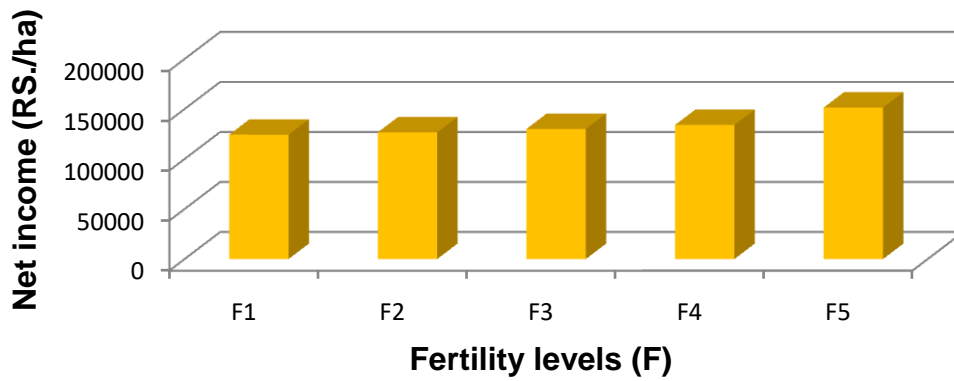


Fig.20(c): Interaction effect of varieties and fertility levels on net income (Rs./ha)

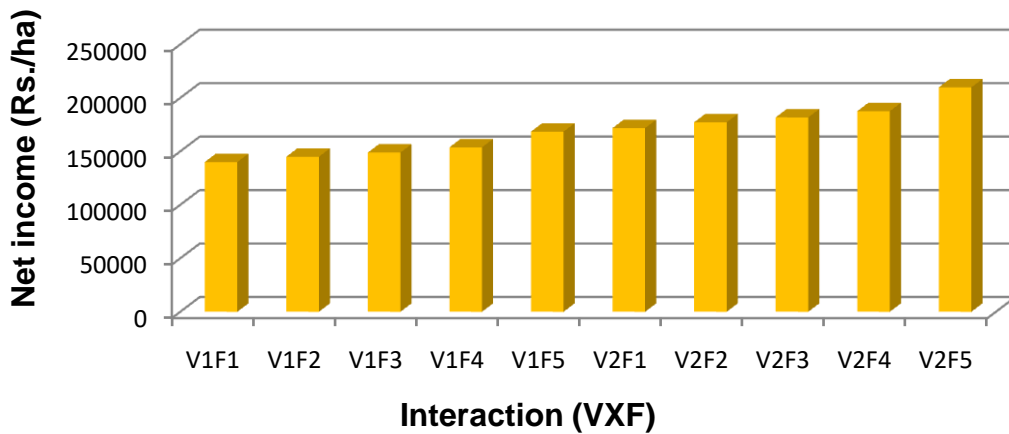


Fig.21(a): Effect of varieties on B:C ratio

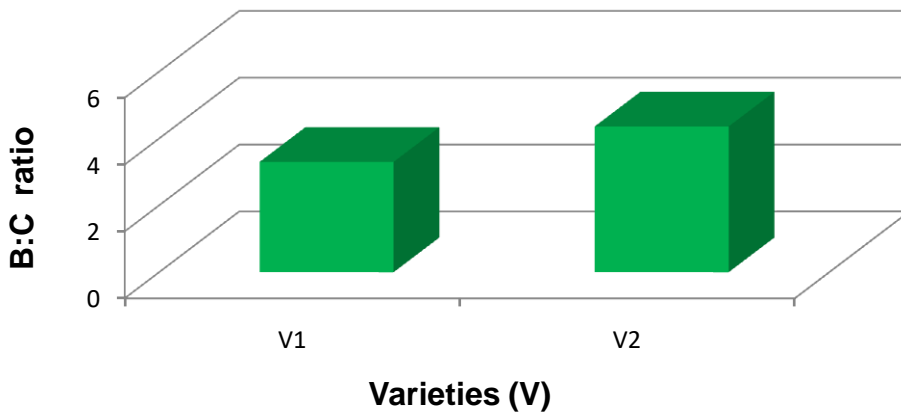


Fig.21(b): Effect of fertility levels on B:C ratio

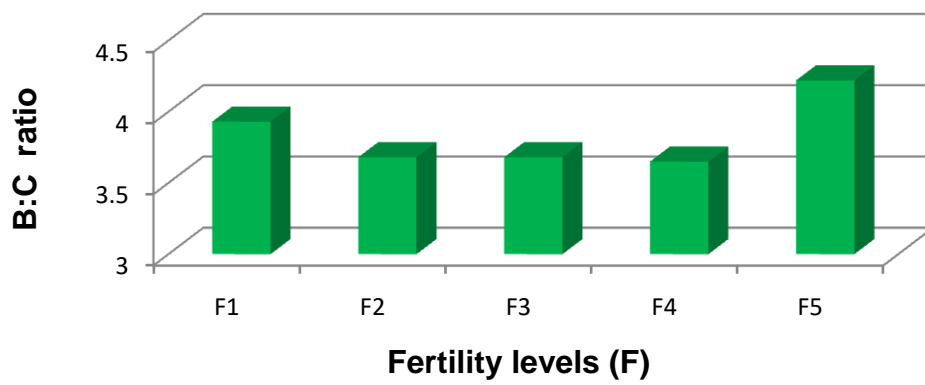
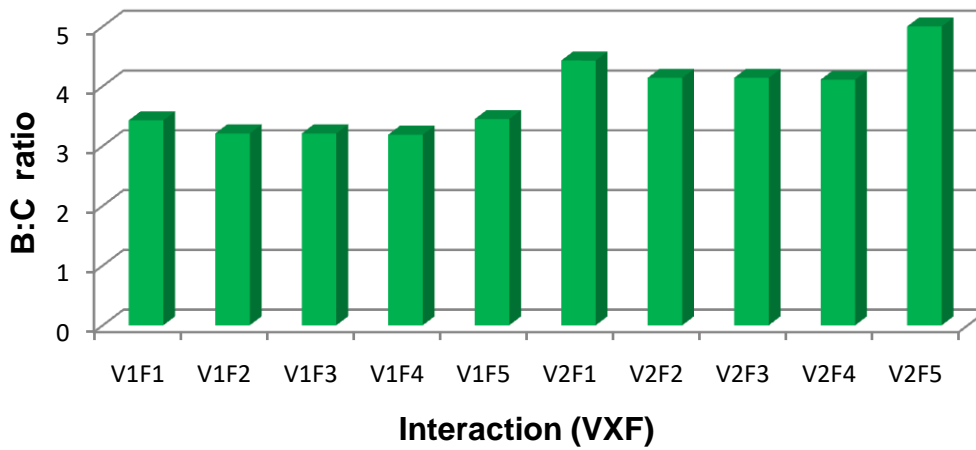


Fig.21(c): Interaction effect of varieties and fertility levels of B:C ratio





CHAPTER- V
DISCUSSION

Chapter-V

DISCUSSION

The results of the present experiment entitled “Effect of varieties and fertility levels on growth, yield and quality of turnip (*Brassica rapa* L.)” are discussed and illustrated keeping in view the findings of earlier workers, here under following headings:

5.1 Growth Parameters

Growth parameters of turnip viz., plant height (cm), number of leaves per plant, leaf area per plant (cm²), fresh and dry weight of roots (g/plant), fresh and dry weight of leaves, SPAD value were recorded during the present investigation. There was significant influence of varieties and fertility levels on all these growth parameters. Whereas, combined effect of varieties and fertility levels was found non - significant in case of all growth parameters.

There was an increase in plant height (cm) with advancement of growth period. The data revealed significant effect of varieties on plant height of turnip at all the growth stages. Maximum plant height was found in variety V₂ (Purple Top White Globe) at 30, 45 and 60 DAS. Minimum plant height was recorded in case of Variety V₁ (Pusa Sweti) at 30, 45 and 60 DAS. These variations in relation to height of plants for various radish cultivars might be affected by the environment to the great extent besides genetic potential (Ola *et al.*, 2018). Similar results have been reported by Dongarwar *et al.* (2018), Nargave *et al.* (2018) in radish.

Fertility levels exerted significant influence on plant height (cm) in turnip at all the growth stages. Maximum plant height was recorded with fertility levels F₅ (NPK-100:60:50 kg/ha) at 30, 45 and 60 DAS. It was followed by F₄> F₃> F₂ in descending order. Minimum plant height was found in case of fertility level F₁ (NPK-00:00:00 kg/ha) *i.e.* at 30, 45 and 60 DAS. The positive influence of the nutrients on plant height clearly supports the fact that higher application of nitrogen has a vital role in betterment of plant physiological process such as cell division, cell elongation along with timely metabolic processes and also favoured the greater assimilation of photosynthates

(Satari *et al.*, 2020). These results are in conformity with the findings of Tripathi *et al.* (2017) and Baloch *et al.* (2014) in radish.

Combined effect of varieties and fertility had non-significant influence on plant height of turnip at all the growth stages under study in turnip.

Varieties had exerted significant effect on number of leaves per plant at 30, 45 and 60 DAS harvesting stage in turnip. Among varieties, V₂ (Purple Top White Globe) counted maximum number of leaves per plant followed by variety V₁ (Pusa Sweti) at all the growth stages studied. There was a linear increase in number of leaves per plant with advancement of growth stage. The significant differences thereafter could be attributed to the requirement of developing plants for more quantum of carbohydrates, which might have forced the plants of these varieties to produce more number of leaves (Dongarwar *et al.* 2018). The variation in number of leaves among different varieties was also reported by Bhattarai *et al.* (2015) in turnip, Singh *et al.* (2018) and Ola *et al.* (2018) in radish.

Each increasing dose of fertility levels enhanced the number of leaves per plant at 30, 45 and final 60 DAS. Maximum number of leaves per plant was recorded with fertility levels F₅ (NPK- 100-60-50 kg/ha) followed by F₄>F₃>F₂ in descending order at 30, 45 and 60 DAS. Minimum number of leaves per plant was recorded in case of fertility levels F₁ (NPK-00:00:00 kg/ha) at 30, 45 and 60 DAS, respectively. The positive role of nitrogen increment on number of leaves may be explained as nitrogen accelerated the synthesis of proteins, chlorophyll, enzymes and consequently carbohydrate synthesis is also enhanced (Nawaz *et al.*, 2020). The increase in number of leaves per plant could be attributed to the enhanced availability of nutrients at the appropriate time, which might have resulted in increased photosynthetic rate and accumulation of metabolites in plants (Satari *et al.*, 2020). These results are in line with the observations made by Wahocho *et al.* (2016) in turnip and Lakra *et al.* (2017) in radish.

Combined effect of varieties and fertility levels had non-significant influence on number of leaves per plant at 30, 45 and 60 DAS at harvesting stage in turnip.

The data indicates significant influence of varieties and fertility levels on leaf area of turnip. Maximum leaf area was found in variety V₂ (Purple Top White Globe) while minimum leaf area was observed under variety V₁ (Pusa Sweti) at harvesting stages. These variations in leaf area between varieties of radish 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).

Fertility levels had showed significant influence on leaf area in turnip. Maximum leaf area was recorded with fertility level F₅ (NPK- 100- 60-50 kg/ha) harvesting stage. It was followed by F₄>F₃>F₂ in descending order. Minimum leaf area was recorded in fertility level F₁ (NPK-00:00:00 kg/ha) at harvesting stage. Similar results have been reported by Sulfab *et al.* (2017).

Combined effect of varieties and fertility levels had non-significant influence on leaf area at harvesting stage in turnip.

The findings showed significant effect of varieties on fresh weight of root at harvesting stage. The highest fresh weight of root was found in variety V₂ (Purple Top White Globe) at harvesting stage. The lowest fresh weight of root was recorded in case of variety V₁ (Pusa Sweti) at harvesting stage. The variation in the weight of root might be due to the genetic variation. Increase in leaf area, root diameter, plant height might be reflected in the increases in the root weight (Dongarwar *et al.*, 2017). The higher root weight per plant were due to more number of leaves and leaf area for photosynthesis and efficient utilization of these photosynthates, might have enhanced the weight of root (Ladumor *et al.*, 2020). Similar results have been reported by Pervez *et al.* (2003), Semba *et al.* (2019) and Singh *et al.* (2019) in radish.

Fresh weight of plant showed significant influence of fertility levels. Maximum fresh weight of root was observed with fertility level F₅ (NPK- 100:60:50 kg/ha) followed by F₄> F₃> F₂ in descending order at harvesting stage. Minimum fresh weight of root was recorded in case of fertility level F₁ (NPK-00:00:00 kg/ha) at harvesting stage. The increase in fresh weight of root

could be due to higher uptake and accumulation of greater amount of photosynthates leading to increase in number of leaves, plant size and fresh bio mass, which in turn yields higher dry matter content (Satari *et al.*, 2020). Similar results have been quoted by Baloch *et al.* (2014) and Nargave *et al.* (2018) in radish, Ali *et al.* (2006) and Moniruzzaman *et al.* (2013) in carrot.

Combined effect of varieties and fertility levels showed non-significant influence on fresh weight of root at harvesting stage in turnip.

The data revealed significant effect of varieties on dry weight of root. Variety V₂ (Purple Top White Globe) found maximum dry weight of root (g/plant) at harvesting stage. Minimum dry weight of root was recorded in case of variety V₁ (Pusa Sweti) at harvesting stage. These findings are in agreement with those reported by Semba *et al.* (2019) in radish and Kushwah *et al.* (2019) in carrot.

Fertility levels exerted significant influence on dry weight of root in turnip. Maximum dry weight of root was recorded with fertility level F₅ (NPK-100:60:50 kg/ha) followed by F₄ > F₃ > F₂ in descending order at harvesting stage. Minimum dry weight of root was recorded at harvesting stage with fertility level F₁ (NPK-00:00:00 kg/ha). Similar results were obtained by Inam *et al.* (2011) in turnip and Satari *et al.* (2020) in radish.

Combined effect of varieties and fertility levels had non- significant influence on dry weight of root at harvesting stage.

The findings showed significant effect of varieties on fresh weight of leaves at harvesting stage. Maximum fresh weight of leaves was found in variety V₂ (Purple Top White Globe) at harvesting stage. The minimum fresh weight of leaves was recorded in case of variety V₁ (Pusa Sweti) at harvesting stage. The factors influencing the weight of leaves are leaf length and leaf size or even the nutrient content in the leaves. So the phenotypic and genotypic features of leaf are an important feature in determining the weight of the leaves among different genotypes (Semba *et al.*, 2019). Similar findings have been reported by Pervez *et al.* (2003) and Dongarwar *et al.* (2017) in radish.

Fresh weight of leaves showed significant influence of fertility levels. Maximum fresh weight of leaves was observed with fertility level F₅ (NPK-100-60-50 kg/ ha) followed by F₄> F₃> F₂ in descending order at harvesting stage. Minimum fresh weight of leaves was recorded in case of fertility levels F₁ (NPK-00:00:00 kg/ha) at harvesting stage. The presence of adequate amount of nitrogen along with balanced quantities of phosphorus and potassium might be the major cause of enhancing the fertility level of soil that promoted plant growth. The positively continuous plant grown therefore, increased the leaves weight per plant. Addition of different nitrogen treatments significantly affects leaf fresh weight per plant (Baloch *et al.*, 2014). Increase in fresh weight of turnip due to application of inorganic fertilizers at higher rates was also observed in previous studies (Ziaf *et al.*, 2020; El-Sherbeny *et al.*, 2012; Sadia *et al.* 2013a & b) in turnip.

Combined effect of varieties and fertility levels showed non - significant influence on fresh weight of leaves at harvesting stage in turnip.

The data revealed significant effect of varieties on dry weight of leaves. Variety V₂ (Purple Top White Globe) found maximum dry weight of leaves as compared to minimum dry weight of leaves was recorded in case of variety V₁ (Pusa Sweti) at harvesting stage. These differences in the dry weight of the leaves may be due to the dissimilarities in phenotypic and genotypic differences among the varieties (Semba *et al.*, 2019). These results are in agreement with those of Kushwah *et al.* (2019) in carrot.

Fertility levels exerted significant influence on dry weight of leaves in turnip. Highest dry weight of leaves was recorded with fertility level F₅ (NPK-100:60:50 kg/ha) followed by F₄> F₃> F₂ in descending order at harvesting stage. Lowest dry weight of leaves was recorded at harvesting stage with fertility levels F₁ (NPK- 00:00:00 kg/ha). These findings are agreement with Ziaf *et al.* (2020), (El-Sherbeny *et al.* (2012) and Sadia *et al.* (2013a&b) in turnip.

Combined effect of varieties and fertility levels had non- significant influence on dry weight of leaves at harvesting stage.

The data revealed significant effect of varieties on SPAD value at all the growth stages. Maximum SPAD value was found in variety V₂ (Purple Top White Globe) at 30, 45 and 60 DAS. Variety V₁ (Pusa Sweti) recorded minimum SPAD value, respectively. Chlorophyll content of leaves was might be varied according to leaf area and types of leaves and genotypic character (Dongarwar *et al.*, 2018).

SPAD value recorded at 30, 45 and 60 DAS was significantly affected by different fertility levels. The highest SPAD value was recorded at 30, 45 and 60 DAS under the fertility level F₅ (NPK-100: 60:50 kg/ha). It was followed by fertility levels F₄> F₃> F₂ in descending order at all the growth stages. Minimum SPAD value was recorded in under the fertility level F₁ (NPK-00:00:00 kg/ha) at 30, 45 and 60 DAS, respectively. The increase in chlorophyll content could be attributed to increased N content in the leaves, which is a constituent of chlorophyll pigment. The increase in N content of the leaves is due to the better uptake of nitrogen (Satari *et al.*, 2020). The present findings are in conformity with the work done by Ziaf *et al.* (2020) in turnip.

Combined effect of varieties and fertility levels showed non-significant influence on SPAD value at all the growth stage in turnip.

5.2 Yield parameters

Yield attributes viz., root length (cm), root diameter (cm), root yield per plot (kg), root yield (q/ha) showed significant influence of varieties and fertility levels. Whereas, combined effect of varieties and fertility levels had non significant effect on yield attributes.

Root length was significantly influenced by different varieties. Among the varieties V₂ (Purple Top White Globe) recorded longest root length of turnip. Smallest root length was observed in variety V₁ (Pusa Sweti). Environmental and genetic factors strongly effect on root length. So cultivars with more number of leaves have more root length (Pervez *et al.*, 2003). Also, up take of more nutrients and rate of photosynthesis was higher than other plants so that vegetative growth was increased and the carrot roots were rich in carbohydrate (Ladumor *et al.*, 2020). The present findings are in conformity with the work done by Dongarwar *et al.* (2018) on radish crop.

Application of fertilizers exhibited positive effect on root length. Fertility level F₅ (NPK-100:60:50 kg/ha) observed maximum root length. It was followed by F₄ > F₃ > F₂ in descending order. Minimum root length was observed under fertility level F₁ (NPK-00:00:00 kg/ha). This increased root length with nitrogen increment can be ascribed as efficient acquisition of absorbed nutrients by roots and enriched nutrition through nitrogen application (Nawaz *et al.*, 2020). An increase in root length might be due to effect of environment, soil texture and on time and balanced manuring practices. More numbers along with greater size of leaves per plant might also be one of the growth characteristics that influenced on the size of roots (Baloch *et al.* 2014). Increase in root length with higher level of N may be attributed to the increase in number of leaves. More the number of leaves more will be the assimilation of photosynthate by the process of photosynthesis which is further utilized for root cell differentiation and elongation (Shrestha *et al.*, 2018). Similar results were observed by Ziaf *et al.* (2020) Sadia *et al.* (2013a&b) in turnip, Nahar *et al.* (2014) and Haque *et al.* (2019) in carrot.

Combined effect of varieties and fertility levels had non- significant influence on root length in turnip.

The maximum root diameter was found with variety V₂ (Purple Top White Globe). Minimum root diameter was recorded with variety V₁ (Pusa Sweti) in turnip. Root diameter depends upon environmental factors, soil conditions and genetic makeup (Pervez *et al.*, 2003). The results of the present investigation are similar to Dongarwar *et al.* (2018) and Nargave *et al.* (2018) in radish.

Fertility levels showed significant effect on diameter of root in turnip. Maximum root diameter was recorded with fertility level F₅ (NPK-100:60:50 kg/ha). It was followed by F₄ > F₃ > F₂ in descending order, while minimum root diameter was observed under fertility level F₁ (NPK-00:00:00 kg/ha). Highest level of fertilizer had favorable effect on vegetative growth and carbohydrate synthesis. Which had enhanced the yield attributes and consequently root diameter (Nargave *et al.*, 2020). Similar effect of NPK on root diameter was

also found by Ziaf *et al.* (2020) Sadia *et al.* (2013a&b) in turnip, Jilani *et al.* (2010) and Baloch *et al.* (2014) in radish.

Combined effect of varieties and fertility levels had non-significant influence on root diameter in turnip.

Average root yield per plot was found higher with variety V₂ (Purple Top White Globe) root yield per plot in turnip. Lower root yield per plot was observed under variety V₁ (Pusa Sweti). As the varieties which have shown superior performance in yield have significantly more number of vigorous leaves on it and more plant height, which could have synthesized more food material and supplied to the roots, that might have resulted in increasing the weight and diameter of roots and ultimately resulted in getting higher root yield in these varieties (Dongarwar *et al.*, 2018). Present results are in conformity with Pervez *et al.* (2003) Ola *et al.* (2018) in radish, Ladumor *et al.* (2020) in carrot.

Increase in root yield per plot was noted with each increase in fertility level. Highest root yield per plot was obtained with the application of fertility level F₅ (NPK-100:60:50 kg/ha) followed by F₄> F₃> F₂ in descending order, respectively. Minimum root yield per plot was obtained under fertility level F₁ (NPK-00-00-00 kg/ ha) in turnip. It is well understood that yield is a parameter that is highly and positively affected by length, size, weight of root and total number of survived plants per plot (Baloch *et al.*, 2014). Similar findings have been reported by Sadia *et al.* (2013a&b) and Khetran *et al.* (2016) in turnip

Combined effect of varieties and fertility levels show non-significant influence on root yield per plot of turnip.

Maximum root yield per hectare was recorded in variety V₂ (Purple Top White Globe) in turnip. Lowest root yield was observed under variety V₁ (Pusa Sweti) in turnip. It was noticed that, the genotypes which performed better in a unit area were likely to perform better on large scale as the yield per hectare was calculated by multiplying yield per plot with hectare factor. Similar results were reported by Bhattarai *et al.* (2015) in turnip, Sharma *et al.* (2020), Sharma and Singh (2018) in carrot, Ola *et al.* (2018) in radish.

Fertility levels also had exerted significant effect on root yield (q/ha). There was increase in root yield with increasing fertility levels. Maximum root

yield was observed with fertility level F_5 (NPK-100:60:50 kg/ha). It was followed by $F_4 > F_3 > F_2$ in descending order. The lowest root yield was observed in case of fertility level F_1 (NPK-00:00:00 kg/ha). The increase in yield of carrot root might be attributed to higher individual root weight, higher number of leaves per plant, higher dry matter content of root (Ali *et al.* 2006). These findings are in line with Ziaf *et al.* (2020) in turnip, Kushwah *et al.* (2019) in carrot and Nargave *et al.* (2018) in radish.

Combined effect of varieties and fertility levels had no remarkable influence on root yield per hectare in turnip.

5.3 Quality parameters

The results on TSS content were significantly influenced by varieties. Among the varieties, maximum TSS content was determined with variety V_2 (Purple Top White Globe). Minimum TSS content was noted in case of variety V_1 (Pusa Sweti) in turnip. The variation in the TSS content in root, might be due to the genetic make-up of varieties and it also might be due to the effect of soil and climatic conditions wherein that variety grown (Dongarwar *et al.*, 2017). These results are in conformity with Nargave *et al.* (2018) in radish, Kushwah *et al.* (2019) and Ladumor *et al.* (2020) in carrot.

Application of fertility levels exhibited significant effect on TSS content. Maximum TSS content was recorded with fertility level F_5 (NPK-100:60:50 kg/ha) which was significantly superior over other fertility levels. F_5 was followed by $F_4 > F_3 > F_2$, while minimum TSS content was observed under fertility level F_1 (NPK-00:00:00 kg/ha). Similar results were reported by Lakra *et al.* (2017) and Nargave *et al.* (2018) in radish, Kadam *et al.* (2018) in beet root.

Combined effect of varieties and fertility levels showed non-significant influence on TSS content in turnip.

Among the varieties, maximum Vitamin-C content of roots was determined with variety V_2 (Purple Top White Globe). Minimum Vitamin-C content was noted in case of variety V_1 (Pusa Sweti). There was significant difference between variety V_1 and V_2 . It might be due to the fact that, genetic cause or responses of the particular genotype to the soil and climatic

conditions might be reflected in such characters (Dongarawar *et al.*, 2017). Similar findings have been reported by Bhattarai *et al.* (2015) in turnip, Nargave *et al.* (2018) in radish.

Fertility levels showed positive effect on Vitamin-C content. Maximum Vitamin-C content of was recorded with fertility level F₅ (NPK-100:60:50 kg/ha) which was significantly superior over all the fertility levels. It was followed by F₄> F₃> F₂ with a Vitamin-C content, while minimum Vitamin-C content was observed under fertility level F₁ (NPK-00:00:00 kg/ha). Boskovic–Rakocevic *et al.* (2012) in carrot and Nargave *et al.* (2018) in radish also reported the similar results.

Combined effect of varieties and fertility level showed non-significant influence on Vitamin-C content in turnip roots.

5.4 Post harvest analysis of NPK in Soil and plant

5.4.1 NPK content in plant at harvesting stage

The findings of the present experiment denoted significant effect of fertility levels on post harvest NPK content in plant. Varieties and interaction effect of varieties and fertility levels had showed non significant influence on post harvest NPK content in plant.

Application of fertility exhibited significant effect on nitrogen content in plant. Maximum post harvest nitrogen content in plant was recorded with fertility level F₅ (NPK-100:60:50 kg/ha) which was significantly superior over all other fertility levels. It was followed by F₄> F₃> F₂ in descending order. Whereas application of fertility level F₁ (NPK-00:00:00 kg/ha) resulted in minimum post harvest nitrogen content in plant. These results are in line with the results of Roni *et al.* (2014), Neethu *et al.* (2015), Ukai *et al.* (2016) and Ziaf *et al.* (2020).

Interaction effect of varieties and fertility levels was found non-significant on nitrogen content in plant of harvesting stage.

The findings showed that phosphorus content in the plant increased with increasing fertility levels. Maximum post harvest phosphorus content in plant was recorded with fertility level F₅ (NPK-100:60:50 kg/ha) which was significant superior over all other fertility levels. It was followed by F₄> F₃> F₂

in descending order. Minimum post harvest phosphorus content in plant was determined with application of fertility level F₁ (NPK-00:00:00 kg/ha). These results are in agreement with Yanthan *et al.* (2012), Misgina *et al.* (2016) and Ziaf *et al.* (2020).

Interaction effect of varieties and fertility levels showed non- significant on phosphorus content in plant of harvesting stage.

There was significant effect of fertility levels on post harvest potassium content in the plant. Highest post harvest potassium content in plant was recorded with fertility level F₅ (NPK-100:60:50 kg/ha) which was significantly superior over all other fertility levels. It was followed by F₄> F₃> F₂. Lowest post harvest potassium content in plant was found with application of fertility level F₁ (NPK-00:00:00 kg/ha). Potassium uptake varied significantly among different fertility levels, perhaps due to variation in dry matter yield. Higher K content at higher level of K application together with higher dry matter production resulted in higher K uptake (Singh and Lal, 2012). Similar effect with higher nutrient levels was observed by Lakshmi *et al.* (2012) and Misgina *et al.* (2016).

Interaction effect of varieties and fertility levels showed non- significant on potassium content in plant of harvesting stage.

5.4.2 NPK content in soil at harvesting stage

There was significant effect of varieties on available nitrogen content in soil. Highest available nitrogen content in soil was estimated with variety V₂ (Purple Top White Globe). It was significantly superior over V₁ (Pusa Sweti). It indicated that the variety which yielded more has taken up more nitrogen from the soil resulting in more depletion of available nitrogen in soil (Jatav *et al.*, 2018). These findings are corroborated by those of Singh and Kushwah *et al.* (2006).

Application of fertility levels imposed positive effect on post harvest available nitrogen in soil. Maximum post harvest available nitrogen in soil was recorded with fertility levels F₅ (NPK-100:60:50 kg/ha) which was significantly superior over all the fertility level. It was followed by F₄> F₃> F₂ with available nitrogen of respectively while minimum post harvest available nitrogen content

in soil was observed under fertility level F_1 (NPK-00:00:00 kg/ha). This may be due to lower yield in this treatment. These results are in agreement of Abdel-Motagally and Attia (2009) and Yanthan *et al.* (2012).

There was significant effect of varieties on available phosphorus content in soil. Highest available phosphorus in soil was estimated with variety V_2 (Purple Top White Globe). It was significant superior over V_1 (Pusa Sweti). Higher uptake of phosphorus due to higher yield may be the reason for these findings (Jatav *et al.*, 2017).

The findings showed that phosphorus content in the soil increased with increasing fertility levels. Maximum available phosphorus content in soil was recorded with fertility level F_5 (NPK-100:60:50 kg/ha) which was significantly superior over all the fertility levels. It was followed by $F_4 > F_3 > F_2$ with available phosphorus of respectively. While minimum available phosphorus in soil was observed under fertility level F_1 (NPK-00:00:00 kg/ha). The observed increase in soil available PK in response to the increased application of PK fertilizer could be explained by the fact that some of the applied PK in the soil has not been utilized by the plant and hence remained in the soil reported by (Misgina, 2016). Similar findings have been reported by Abdel-Motagally and Attia (2009) and Yanthan *et al.* (2012).

There was significant effect of varieties on available potassium content in soil. Highest available potassium in soil was estimated with variety V_2 (Purple Top White Globe). It was significantly superior over V_1 (Pusa Sweti).

The findings showed that potassium in the soil increased with increasing fertility levels. Maximum post harvest available potassium content in soil was recorded with fertility level F_5 (NPK-100:60:50 kg/ha) which was significantly superior over all the fertility levels. It was followed by $F_4 > F_3 > F_2$ with a post harvest available potassium of respectively. While minimum potassium content in soil was observed under fertility level F_1 (NPK-00:00:00 kg/ha). These findings are in agreement with those reported by Lakshmi *et al.* (2012).

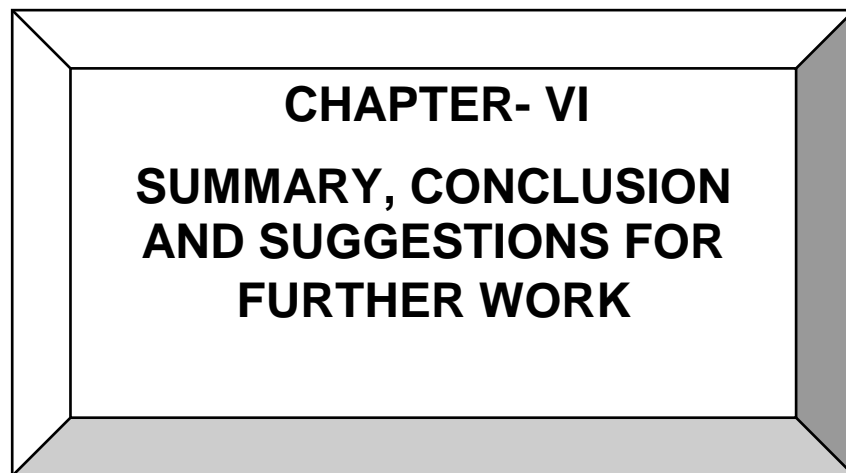
Combined effect of varieties and fertility levels showed non- significant effect on available NPK content in soil at after harvesting of turnip.

5.5 Economics of different treatments for turnip production

Highest gross income, net income and B:C ratio was recorded in variety V_2 (Purple Top White Globe). Lowest gross income, net income and B:C ratio was noted in variety V_1 (Pusa Sweti). Higher yield, long sized roots and earliness are some of the characters which might be responsible for increase in profit of carrot growing farmers. These results are in line with results of Bhattarai *et al.* (2015) in turnip, Sharma and Singh (2018), Kushwah *et al.* (2019) and Sharma *et al.* (2020) in carrot.

Fertility levels exerted significant effect on gross income, net income and B:C ratio. Maximum gross income, net income and B:C ratio was recorded with fertility level F_5 (NPK-100:60:50 kg/ha) which was significantly higher over other fertility levels. It was followed by fertility level $F_4 > F_3 > F_2$ in descending order. While minimum gross income, net income (Rs./ha) was recorded under F_1 (NPK-00:00:00 kg/ha) and B:C ratio was calculated under fertility level F_4 (NPK-80:50:40 kg/ha). Similar results were also reported by Kumar *et al.* (2015) and Nawaz *et al.* (2020) in turnip, Kushwah *et al.* (2019) in carrot.

Interactive effect of varieties and fertility levels had exerted non-significant influence on gross income, net income and B:C ratio. But numerically highest gross income, net income and B:C ratio was realized in case of treatment combination V_2F_5 , while lowest gross income, net income and B:C ratio was found under V_1F_1 treatment combination.



CHAPTER- VI
SUMMARY, CONCLUSION
AND SUGGESTIONS FOR
FURTHER WORK

Chapter-VI

SUMMARY, CONCLUSION AND SUGGESTIONS FOR FURTHER WORK

6.1 Summary

An investigation entitled “Effect of varieties and fertility levels on growth, yield and quality of turnip (*Brassica rapa* L.)” was conducted at Vegetable Research Field, College of Horticulture, Mandsaur (MP) during *Rabi* season, 2019-20. Ten treatment combination comprising of two varieties (V₁- Pusa Sweti and V₂-Purple Top White Globe) and five fertility levels (F₁- 00:00:00 NPK kg/ha, F₂-40:30:20 kg/ha, F₃-60:40:30 kg/ha, F₄-80:50:40 kg/ha, F₅-100:60:50 kg/ha) were evaluated in factorial randomized block design with three replication. Growth parameters viz., plant height (cm), number of leaves per plant and leaf area per plant (cm²), fresh and dry weight of roots (g/plant), fresh and dry weight of leaves and SPAD value, Yield parameters *i.e.* root length (cm), root diameter (cm), root yield per plot (kg), root yield (q/ha) and post harvest analysis NPK content in plant and soil, economics of treatments were studied. The findings obtained from the study have been summarized as follows:

6.1.1 Effect of varieties

The results of the experiment with respect to growth parameters of turnip revealed significant effect of varieties on plant height (cm), number of leaves per plant and leaf area per plant (cm²), fresh and dry weight of roots (g/plant), fresh and dry weight of leaves, SPAD value. Maximum plant height (cm), number of leaves per plant and SPAD value was observed in V₂ (Purple Top White Globe) as compared to V₁ (Pusa Sweti) at 30, 45 and 60 DAS. Leaf area per plant (cm²), fresh and dry weight of roots (g/plant), fresh and dry weight of leaves was recorded maximum with variety V₂ (Purple Top White Globe) which was significantly superior over V₁ (Pusa Sweti) at harvesting stage.

Yield parameters indicated significant effect of varieties in turnip. Highest root length (cm), root diameter (cm), root yield per plot (kg), root yield

per hectare were recorded with variety V₂ (Purple Top White Globe) while, the lowest value of all these yield parameters was found under the variety V₁ (Pusa Sweti).

Quality parameters of turnip viz., TSS (^oBrix), Vitamin-C content of root (mg/100 g) had significantly influenced by varieties and fertility levels. Highest TSS (^oBrix) content in root was observed in case of varieties V₂ (Purple Top White Globe). Minimum TSS (^oBrix) was noted in case of variety V₁ (Pusa Sweti). Maximum Vitamin-C content of root (mg/100 g) of turnip root was found under V₂ (Purple Top White Globe). Minimum Vitamin-C content of root (mg/100 g) was found in variety V₁ (Pusa Sweti).

Varieties had exerted non significant influence on post harvest NPK content in plant. But significant effect of varieties was observed on available NPK in soil after harvest. Highest post harvest available NPK in soil was recorded determined with V₂ (Purple Top White Globe) which was significantly superior over V₁ (Pusa Sweti).

Maximum gross return (Rs./ha), net return (Rs./ha) and benefit: cost ratio for was obtained in case of V₂ (Purple Top White Globe). While minimum gross return (Rs./ha), net return (Rs./ha) and benefit: cost ratio was recorded under variety V₁ (Pusa Sweti) of turnip.

6.1.2 Effect of fertility levels

The findings of the investigation with respect to growth characters of turnip indicated significant effect of fertility levels. Amongst fertility levels F₅ (NPK- 100:60:50 kg/ha) had recorded maximum plant height (cm), number of leaves per plant, SPAD value at 30, 45 and 60 DAS. Effect of rest of the fertility levels on growth parameters under study was in order of F₄> F₃> F₂. Minimum plant height (cm), number of leaves per plant, SPAD value was observed in case of fertility level F₁ (NPK- 00:00:00 kg/ha). Highest value for leaf area per plant (cm²), fresh and dry weight of roots (g/plant), fresh and dry weight of leaves were recorded under fertility levels F₅ (NPK- 100:60:50 kg/ha) and lowest values was recorded under fertility level F₁ (NPK- 00:00:00 kg/ha) at harvesting stage.

Yield attributes viz., root length (cm), root diameter (cm), root yield per plot (kg), root yield (q/ha) revealed significant impact of fertility levels in turnip. Highest root length (cm), root diameter (cm), root yield per plot (kg), root yield (q/ha) was recorded under F₅ (NPK- 100:60:50 kg/ha) fertility levels. It was followed by F₄> F₃> F₂ in descending order. While the lowest value of all these yield parameters was observed under the fertility levels F₁ (NPK- 00:00:00 kg/ha).

Result showed significant effect on quality attributes of fertility levels on TSS (°Brix), Vitamin-C content of root (mg/100 g) in turnip. Highest TSS (°Brix), Vitamin-C content of root (mg/100 g) in root was recorded with fertility levels F₅ (NPK- 100:60:50 kg/ha) which was significantly superior over other fertility levels. It was followed by F₄> F₃> F₂ in descending order. Minimum TSS (°Brix), Vitamin-C content of root (mg/100 g) was recorded with fertility levels F₁ (NPK- 00:00:00 kg/ha).

Post harvest analysis viz., NPK content in plant, and post harvest available NPK in soil revealed significant influence of fertility levels in turnip. Highest post harvest NPK content in plant was determined under fertility levels F₅ (NPK- 100:60:50 kg/ha). It was followed by F₄> F₃> F₂ in descending order. While lowest NPK content in plant was observed with fertility levels F₁ (NPK- 00:00:00 kg/ha). Maximum post harvest available NPK in soil was recorded under F₅ (NPK-100:60:50 kg/ha) fertility levels. It was followed by F₄> F₃> F₂ in descending order. While minimum post harvest available NPK in soil was observed with fertility levels F₁ (NPK- 00:00:00 kg/ha).

Highest gross income (Rs./ha), net income (Rs./ha) and benefit: cost ratio was recorded with fertility levels F₅ (NPK- 100:60:50 kg/ha) which was significantly superior over other fertility levels. While minimum gross income (Rs./ha) and net income (Rs./ha) was recorded with fertility levels F₁ (NPK- 00:00:00 kg/ha), while under fertility level F₄ (NPK-80:50:40 kg/ha), it was observed minimum B:C ratio.

6.1.3 Combined effect of varieties and fertility levels

Combined effect of varieties and fertility levels showed non significant influence on all growth parameters, yield parameters, quality parameters and post harvest NPK content in plant and soil, economics.

6.2 Conclusion

It may be concluded from the findings of the present study that among the different varieties of turnip, variety V₂ (Purple Top White Globe) recorded superior performance for growth attributes, yield attributes and quality attributes. Among the fertility levels, application of F₅ (NPK-100:60:50 kg/ha) showed highest growth attributes, yield attributes, quality attributes and yield in turnip. Besides, highest NPK content in plant and soil, economics was recorded with application of F₅ (NPK- 100:60:50 kg/ha).

6.3 Suggestions for further work

- The experiment may be repeated for one or two years for confirmation of the results.
- In the repeated experiment more varieties and fertility levels may be tested.
- Integration of organic manures and biofertilizers may be tested along with chemical fertilizers.



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APPENDICES

APPENDIX-I: Analysis of variance for plant height (cm) at different growth stages

Source of variation	D.F.	Mean Sum of Square		
		Plant height (cm)		
		30 DAS	45 DAS	60 DAS
Replication (R)	2	6.129	1.249	3.049
Varieties (V)	1	10.502	357.765	69.403
Fertility level (F)	4	35.192	102.255	69.380
Interaction (VxF)	4	1.133	5.575	0.347
Error	18	2.071	4.978	6.367
CV		9.038	8.533	7.917

APPENDIX-II: Analysis of variance for 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
Replication (R)	2	0.394	0.329	1.209
Varieties (V)	1	1.541	6.627	4.485
Fertility level (F)	4	2.636	5.249	7.604
Interaction (VxF)	4	0.152	0.384	0.780
Error	18	0.288	0.230	0.389
CV		8.121	6.008	5.532

APPENDIX-III: Analysis of variance for leaf area per plant (cm²), fresh weight of roots (g/plant) and dry weight of roots (g/plant) at different growth stages

Source of variation	D.F.	Mean Sum of Square		
		Leaf area per plant (cm ²)	Fresh weight of roots (g/plant)	Dry weight of roots (g/plant)
Replication (R)	2	544.717	630.685	5.216
Varieties(V)	1	180842.194	4994.880	38.397
Fertility level (F)	4	77086.718	2212.780	19.021
Interaction (VxF)	4	4716.974	53.828	0.544
Error	18	5920.014	1680.709	1.811
CV		13.639	7.650	12.749

APPENDIX-IV: Analysis of variance for fresh weight of leaves (g/plant) and dry weight of leaves (g/plant) at different growth stages

Source of variation	D.F.	Mean Sum of Square	
		Fresh weight of leaves (g/plant)	Dry weight of leaves(g/plant)
Replication (R)	2	26.250	2.830
Varieties (V)	1	747.003	55.570
Fertility level (F)	4	497.700	14.909
Interaction (VxF)	4	31.510	0.931
Error	18	165.897	1.171
CV		11.144	14.057

APPENDIX-V: Analysis of variance for SPAD value at different growth stages

Source of variation	D.F.	Mean Sum of Square		
		SPAD value		
		30 DAS	45 DAS	60 DAS
Replication (R)	2	17.709	12.987	22.682
Varieties (V)	1	29.800	52.272	103.045
Fertility level (F)	4	21.203	39.622	38.848
Interaction (VxF)	4	0.311	1.082	0.052
Error	18	5.544	8.428	11.406
CV		6.117	7.119	6.805

APPENDIX-VI: Analysis of variance for root length (cm) and root diameter (cm) at different growth stages

Source of variation	D.F.	Mean Sum of Square	
		Root length (cm)	Root diameter (cm)
Replication (R)	2	0.720	0.393
Varieties (V)	1	35.295	2.070
Fertility level (F)	4	8.426	2.602
Interaction (VxF)	4	0.115	0.290
Error	18	2.010	0.150
CV		8.355	5.816

APPENDIX-VII: Analysis of variance for root yield per plot (kg) and root yield (q/ha) at different growth stages

Source of variation	D.F.	Mean Sum of Square	
		Root yield per plot (kg)	Root yield (q/ha)
Replication (R)	2	0.213	3503.797
Varieties (V)	1	3.377	55498.559
Fertility level (F)	4	0.374	6146.599
Interaction (VxF)	4	0.009	149.522
Error	18	0.063	1037.472
CV		7.650	7.650

APPENDIX-VIII: Analysis of variance for TSS (^oBrix) and Vitamin-C content of root (mg/100g) at different growth stages

Source of variation	D.F.	Mean Sum of Square	
		TSS (^o Brix)	Vitamin- C content of root (mg/100 g)
Replication (R)	2	0.280	5.187
Varieties (V)	1	0.724	33.496
Fertility level (F)	4	1.234	20.521
Interaction (VxF)	4	0.088	0.707
Error	18	0.161	6.675
CV		5.919	7.469

APPENDIX-IX: Analysis of variance for NPK in plant at different growth stages

Source of variation	D.F.	Mean Sum of Square		
		NPK in plant		
		N	P	K
Replication (R)	2	0.005	0.002	0.200
Varieties (V)	1	0.015	0.000	0.016
Fertility level (F)	4	0.041	0.006	0.172
Interaction (VxF)	4	0.004	0.000	0.011
Error	18	0.012	0.001	0.058
CV		6.340	14.730	10.348

APPENDIX-X: Analysis of variance for NPK in soil at different growth stages

Source of variation	D.F.	Mean Sum of Square		
		NPK in soil		
		N	P	K
Replication (R)	2	259.412	2.233	1033.233
Varieties (V)	1	5658.133	48.133	10304.533
Fertility level (F)	4	2027.012	28.050	4348.083
Interaction (VxF)	4	220.729	2.550	322.950
Error	18	369.814	8.826	1041.752
CV		13.263	8.314	9.075

APPENDIX-XI: Effect of varieties, fertility levels and their interaction on gross income (Rs.), net income (Rs.), and B:C ratio

Source of variation	D.F.	Mean Sum of Square		
		Gross income (Rs.)	Net income (Rs.)	B:C ratio
Replication (R)	2	560685792.533	560685792.533	0.031
Varieties (V)	1	8880291930.133	8880291930.133	8.532
Fertility level (F)	4	983427244.800	693934536.609	0.366
Interaction(VxF)	4	23920204.800	23920204.800	0.110
Error	18	166005034.015	166005034.015	0.106
CV		7.650	9.669	8.509

APPENDIX-XII: General cost of turnip cultivation excluding the cost of treatments (Rs./ha)

Sr. No.	Cultural practices	Cost ha ⁻¹ (Rs.)
1	Seed (4 kg)	1000
2	Field preparation	2200
3	Bed preparation	2400
4	Sowing	3200
5	Thinning	3800
6	Insecticide	2000
7	Irrigation	3000
8	Harvesting	14000
	Total	31600

APPENDIX-XIII: Treatment cost of turnip

Symbol	Treatment levels	Amount (Rs.)
F ₁	00:00:00 kg/ha	0000
F ₂	40:30:20 kg/ha	2819.53
F ₃	60:40:30 kg/ha	3710.05
F ₄	80:50:40 kg/ha	5080.95
F ₅	100:60:50 kg/ha	6200.66

APPENDIX-XIV: Economics of different treatments of turnip

Treatment combination	Common cost (RS.)	Treatment cost (Rs.)	Total cost of cultivation (Rs./ha)	Yield (q/ha)	Gross* income (Rs.)	Net income (Rs.)	B:C Ratio
V ₁ F ₁	31600	0	31600.00	350.00	140000	108400.00	3.43
V ₁ F ₂	31600	2819.53	34419.53	362.44	144976	110526.47	3.21
V ₁ F ₃	31600	3710.05	35310.05	372.22	148888	113577.95	3.21
V ₁ F ₄	31600	5080.95	36680.95	384.44	153776	117095.05	3.19
V ₁ F ₅	31600	6200.66	37800.66	421.11	168444	130643.34	3.45
V ₂ F ₁	31600	0	31600.00	429.44	171776	140176.00	4.43
V ₂ F ₂	31600	2819.53	34419.53	442.89	177156	142736.47	4.14
V ₂ F ₃	31600	3710.05	35310.05	454.44	181776	146465.95	4.14
V ₂ F ₄	31600	5080.95	36680.95	468.89	187556	150875.05	4.11
V ₂ F ₅	31600	6200.66	37800.66	524.67	209868	172067.34	4.55

*Sale price of turnip roots are 400/quintal

VITA

The author of this thesis **Ms. Diksha Rathore, D/o Kailash Rathore** was born on 11th April 1994 at Sehore, Tq.- Sehore & Dt.- Sehore (Madhya Pradesh). She passed high school in the year 2009 from Govt. M.L.B. Girls High Secondary School, Sehore, Tq.-Sehore & Dt.- Sehore with 51.33%, and passed Higher Secondary School in the year 2011 from Govt. Higher Secondary Excellence School No.1, Sehore, Tq.- Sehore & Dt.- Sehore (Madhya Pradesh) with 64.4 %.

She joined R.A.K. College of Agriculture, Sehore (M.P.) in 2012 and completed B.Sc. (Agriculture) in the year 2016 with securing an OGPA of 6.64 on 10 point scale.

After graduation, she joined M.Sc. (Ag.) Horticulture in College of Horticulture, Mandsaur (M.P.) for specialization in Vegetable Science. She has completed the entire course requirement for the above said Master's Degree in the year 2021 with an OGPA of 71.80 on a 10 point scale.

She was allotted an interesting research problem entitled “**Effect of varieties and fertility levels on growth, yield and quality of turnip (*Brassica rapa* L.)**” of her choice for thesis work, which has been duly completed by her and presented in the form of this thesis.

Permanent Address:

Diksha Rathore

D/O Shri Kailash Rathore

Near Mantri Petrol Pump, Indore Naka, Sehore (M.P.)

Tq.- Sehore

Dist.- Sehore

PIN- 466001

Contact number :- 8659826094

diksharathore836@gmail.com

(Diksha Rathore)