Effect of varieties and nutrient levels on growth, yield and quality in knolkhol (*Brassica oleracea* var. *gongylodes* L.)

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by

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CERTIFICATE- I

This is to certify that the thesis entitled **"Effect of varieties and nutrient levels on growth, yield and quality in knolkhol (*Brassica oleracea var. gongylodes* L.)"** submitted in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE** in **Vegetable Science** of Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior is a record of the bonafide research work carried out by Mr. **Gopal Nagar** under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee and the Director of Instruction.

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

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This is to certify that the thesis entitled **"Effect of varieties and nutrient levels on growth, yield and quality in knolkhol (*Brassica oleracea var. gongylodes* L.)"** submitted by Mr. **Gopal Nagar** to the Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior in partial fulfilment of the requirements for the degree of Master of Science in **HORTICULTURE** in the Department of **Vegetable Science** has been accepted after evaluation by the External Examiner and approved by the Student's Advisory Committee after an oral examination on the same.

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Place – Mandsaur

Date - (Gopal Nagar)

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List of symbols/Abbreviations

Symbol	Abbreviation	Stands for
/	-	Per
@	-	At the rate of
%	-	Per cent
^{0}C	-	Degree Celsius
&	-	And
-	ANOVA	Analysis of variance
-	CD	Critical difference
-	Cm	Centimeter
-	CV	Coefficient of variance
-	cv.	Cultivar
-	DAT	Days After Sowing
-	Df	Degree of freedom
-	DAP	Dai Ammonium Phosphate
-	Eg	For example
-	*et al.*	and others
-	Fig.	Figure
-	G	Gram
-	Ha	Hectare
-	*i.e.*	That is
-	K	Potassium
-	Kg/ha	Kilogram per hectare
-	M	Meter
-	m^2	Meter square
-	Max.	Maximum
-	Mg	Milli Gram
-	Min.	Minimum
-	MOP	Muriate of potash
-	M.S.S.	Mean sum of square
-	mT	Metric ton
-	No.	Number
-	NS	Non significant
-	P	Phosphorus
-	RDF	Recommended dose of fertilizer
-	R.H.	Relative humidity
-	q/ha	Quintal per hectare
-	RVSKVV	Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya
-	S.Em	Standard Error of Mean
-	spp.	Species
-	*Viz.*	Videlicet (Namely)

CHAPTER- I

INTRODUCTION

Chapter- I
INTRODUCTION

Knolkhol (*Brassica oleracea var. gongylodes*) is a cool season crop. It is also known as kohlrabi, German turnip, cabbage turnip, Navalkol, Gunth Gobhi, and Ganth gobhi.The name kohlrabi comes from the *German* word *Kohl* means "cabbage" plus *Rübe ~ Rabi* (*Swiss German* variant) means "*turnip*", because the swollen stem resembles the latter. The bulb like swollen edible portion is stem known as knob, which arises from thickening of stem tissues above the cotyledon. Leaves are attached on this bulb like swollen structure. Knob is green or violet, and generally, round to flat round in shape. The fleshy turnip-like enlargement of the stem, called knob, develops entirely above the ground. This knob is harvested for human consumption as raw or cooked vegetable, though in some parts, young leaves are also used. One hundred gram of edible portion of knolkhol contains 92.7 g moisture, 1.1 g protein, 0.2g fat, 0.7g minerals, 1.5g fiber, 3.8g carbohydrates, 25 cal. Energy, 20 mg calcium, 18 mg magnesium, 10 mg oxalic acid, 35mg phosphorus, 0.4 mg iron, 0.12mg sodium, 37 mg potassium, 0.09 mg copper, 143 mg sulphur, 36 I.U. vitamin A, 0.12 mg riboflavin, 0.5 mg nicotinic acid, 0.05mg Thiamin, and 85 mg Vitamin c.

Comparing to cabbage and cauliflower, knolkhol is not much popular in India. Knolkhol is mainly cultivated in Maharashtra, Assam, Uttar Pradesh, Madhya Pradesh, Himachal Pradesh, Punjab, Haryana, West Bengal and Jammu and Kashmir. It is more popular in Kashmir. Besides it is also cultivated in some parts of southern states. Among the cole crops grown in our country, the demand for knolkhol is now increasing especially in parts of West Bengal, Kashmir and part of southern Karnataka.

Plants require food for growth and development in the form of proper doses of NPK. Knolkhol is a heavy feeder and shows good response to fertilizer application (Shalini *et al*., 2002). Nitrogen plays an essential role for plant production (Marschner, 1995). It is a part of chlorophyll molecule, amino acid, proteins, nucleic acid and pigments. Adequate supply of nitrogen favours

the transformation of carbohydrates into proteins and promotes the formation of protoplasm and since protoplasm is highly hydrated, the plant becomes more succulent. Normal metabolic activities can continue only in the presence of optimum level of nitrogen. The addition of nitrogen enhances vegetative growth and its deficiency leads to stunted growth with small yellow leaves and low production (Haque and Jakhro, 1996). The optimum N-form and application rate must be determined for Kohlrabi to produce maximum yield and optimum product quality. Increasing the use of mineral-N causes environmental problems due to the excessive accumulation of nitrate in the edible portions (Parente *et al*., 2006) and leaching of harmful elements to the ground water (Ju *et al*., 2007). Therefore, N fertilization in vegetable field has to take into account not only form farming economics point of view but also the environment and human health (Schenk, 2006). Now vegetable consumers are extremely health conscious and their preference is high quality (rich in vitamins and minerals) and chemical residue-free (nitrate and heavy metals) products (Heyes and Bycroft, 2002)

Phosphorus plays a vital in several key physiological processes, viz. photosynthesis, respiration, energy storage and transfer, cell division and cell enlargement. Phosphorus is an important structural component of many biochemical's viz. nucleic acids (DNA, RNA} co-enzymes, nucleotides, phospholipids and sugar phosphate. It stimulates root growth, blooming, fruit setting and seed formation (Memon, 1996).

Potassium is considered essential in photosynthesis, sugar translocation, nitrogen metabolism, enzyme activation, stomatal opening, water relation and growth of meristematic tissues. It acts as chemical traffic policeman, root booster, stalk strengthener, protein builder, and breathing regulator and retards the diseases. But it is not effective without its co-efficient such as N and P (Chandra, 1989). Deficiency of potassium may hamper various physiological processes such as, respiration, photosynthesis, chlorophyll development, and may reduce water content of leaves which is directly related to plant growth and yield. The cost of inorganic fertilizers is very high and sometimes it is not available in the market. Consequently, the

farmers fail to apply inorganic fertilizer to the crop field in the optimum dose (Haque, 2000).

The actual yield of kohlrabi is very low against the potential yield. This big gap between the actual and potential yield can be bridged up by adopting modern agronomic techniques like planting methods, use of fungicides, controlled irrigation and increased nutritional status of the soil. The available literature regarding the fertilizer response indicates that NPK application to kohlrabi improved the yield considerably (Ahmed *et al*., 2003).

Sharof and Wier (1994) studied the minimum amount of N required for vegetable crops including kohlrabi in relation to components of N balance in the soil and calculated that N requirement values were invariably lower than values from field trials. Gianguinlo and borin (1996) reported that the stem size and homogeneity for kohlrabi crop were best grown in peaty-clay soil with 100 kg N+50 kg P_2O_5 +104 kg K_2O ha^{-1} as mineral fertilizer. Choudhuri and Som (1969) studied the response of kohlrabi (White Vienna) to different levels of N and P and obtained best highest yield with 100.7 kg N and 60 kg P/ha.

Keeping the above facts in view, an experiment entitled “Effect of varieties and nutrient levels on growth, yield and quality in knolkhol was conducted at Research field, Department of Vegetable Science, College of Horticulture, Mandsaur (M.P.) with the following objectives:

1. To find out the effect of nutrient levels on growth, yield and quality.
2. To find out the performance of different varieties.
3. To find out the interactive effect of varieties and nutrient levels on growth, yield and quality.
4. To work out the economics of different treatments.

CHAPTER - II

REVIEW OF LITERATURE

Chapter- II
REVIEW OF LITERATURE

The literature pertinent to the various aspects of the present investigation entitled **"Effect of varieties and nutrient levels on growth, yield and quality in knolkhol (*Brassica oleracea* var. *gongylodes* L.)"** is reviewed under the following heads:

1. **Effect of nutrient levels**
2. **Effect of varieties**
3. **Combined effect of nutrient levels and varieties**

2.1 Effect of nutrient levels

Knolkhol is a heavy feeder and shows good response to fertilizer application. Plants require food for growth and development in the form of proper doses of NPK. Nitrogen is a part of chlorophyll molecule, amino acid, proteins, nucleic acid and pigments. Adequate supply of nitrogen favours the transformation of carbohydrates into proteins and promotes the formation of protoplasm and since protoplasm is highly hydrated, the plant becomes more succulent. Normal metabolic activities can continue only in the presence of optimum level of nitrogen. The addition of nitrogen enhances vegetative growth and its deficiency leads to stunted growth with small yellow leaves and low production (Haque and Jakhro, 1996). Phosphorus plays a vital role in several key physiological processes, viz. photosynthesis, respiration, energy storage and transfer, cell division and cell enlargement. Phosphorus is an important structural component of many biochemicals viz, nucleic acid (DNA, RNA), co-enzymes, nucleotides, phospholipids and sugar phosphate. It stimulates root growth, blooming, fruit setting and seed formation (Memon, 1996). The available literature regarding the fertilizer response indicates that NPK application to Kohlrabi improved the yield considerably.

Khan *et al* (2002) conducted an experiment to evaluate the influence of N_2, P_2O_5 on the growth and marketable yield of cabbage. All three nutrients were given in five different combinations with or without FYM. Results showed that N_2, P_2O_5 and K_2O @ 160:90:60 kg ha^{-1} alone with FYM @ 15-20 t ha^{-1} gave the maximum total weight of 1641 g in T_5 followed of T_4 as 1459 g given

N_2, P_2O_5, K_2O @ 120:90:0 kg ha^{-1} with FYM @ 15-20 t ha^{-1}, whereas in the control treatment, no fertilizer it was found 1004. As far as weight of edible portion is concern it was significant amount all treatments, in T_5 it was found as 1099 g followed by T_4 as 929 g, the minimum weight of edible portion was obtained in control treatment, with no fertilizers as 597 g. Although, plant with maximum height was found in T_5, but it was found non-significant among all treatments. Data on the girth indicates that it was significant among all treatments. Maximum girth was obtained in T_5 as 41.69, followed as 39.46 in T_3. On the whole it was observed that application of N, P_2O_5 and K_2O@ 160:90:60 along with FYM @15-20 t ha^{-1} gave the desirable results in term of growth and marketable yield of cabbage.

Shalini *et al.* (2002) studied the effect of two organic manures (FYM and vermicompost) along with inorganic N fertilizer with and without Azospirillum. It was found that both the organic manures had significant effect in increasing growth and yield as well as in maintaining the fertility of red sandy clay soil. Application of 50 per cent N through urea + 50 per cent N (VC) + Azospirillum resulted in higher availability and uptake of nutrient by knolkhol and thus produced the maximum yield (37 t/ha).

Ahmed *et al.* (2003) investigated the effect of seven different NPK levels on the growth and yield of kohlrabi. Nitrogen, phosphorous and potassium were applied alone as well as in various combinations and had a significant effect on various plant growth and yield parameters. Maximum tuber weight (430.80 g), tuber diameter (10.23 cm), number of leaves per plant (14.38) and tuber yield (25850 kg per ha) was recorded in plots fertilized with 160-120 -160 kg NPK per ha. They concluded that NPK @ 160-120-60 kg per ha was found to be the best fertilizer dose for the higher yield of kohlrabi.

Westerveld *et al*. (2003) evaluated nitrogen application rates of 0, 85, 170, 255, and 340 kg ha^{-1} were applied 75% pre plant and 25% side dress to Atlantis, a mid-season cultivar. Total yield, marketable yield, weight per head, head density, and head size were assessed at harvest. In 2001, total yield showed a peak at 265 kg N ha^{-1} while in 2001 no significant effect was recorded. Head size and weight per head increased with increasing N rate only in 2000, reflecting differences in yield. Cabbage density was generally

unaffected by N rate. Days to maturity decreased with increasing N rate reaching a minimum at 245 and 226 kg ha^{-1} in 2000 and 2001, respectively. Nitrogen rates above current recommended levels are beneficial in maximizing cabbage yields in wet years and minimizing days to maturity.

Pervez *et al.* (2004) studied 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. The experiment was laid out according to randomized complete block design in factorial arrangement with three replications. Application of 200kg N ha^{-1} recorded superiority over other N levels with regard to plant height, number of leaves, root length, root diameter, total biomass per plant as well as root yield per hectare.

Bilekudari *et al.* (2005) reported that higher fertilizer level (130:55:55 NPK/ha) significantly increased the plant height (124cm), number of branches per plant (9.47), seed yield per plant (12.3g), per hectare (5.13 q) and test weight (9.9g) compared to recommended dose of fertilizer.

Krezel and Kolota (2008) stated that nitrogen was supplied in a single pre-plant dose in the amounts of 50, 100, 150, 200 $kgha^{-1}$ or in a split application: 100+50 or 100+50+50 $kgha^{-1}$, with top dressing conducted 2 and 4 weeks after planting. The results of the study did not show any significant response of Chinese cabbage yield to higher nitrogen rates. The level of nitrogen raised from 50 to 150 kg ha^{-1} was favorable for vitamin C and total sugars content, while the application of 200 kg ha^{-1} had a negative effect on accumulation of these constituents. Split application of 150 and 200 kg N ha^{-1} resulted in decreased vitamin C and dry matter contents in comparison to single pre-plant doses of nitrogen used in the same amounts. Plant heavily supplied with nitrogen contained the highest level of nitrates.

Kachari and Korla (2009) conducted an experiment with three levels of inorganic fertilizers, NPK (100, 75 and 50 per cent of recommended dose of NPK 125: 75: 65 kg/ha), inoculation of four bio-fertilizers (viz., Azotobacter, Azospirillum, vesicular arbuscular mycorrhizae, PSB1), recommended dose of FYM, i.e. @ 25 t/ha and their combinations. Observations were recorded on the different aspects of the plant like growth and development characters (plant height, leaf length, leaf width, leaf area, number of leaves, leaf weight, stalk length, root biomass, days to curd formation), yield attributing characters

(curd size, curd height, gross curd weight, net curd weight and yield per hectare). Though the treatments performed differently during both the years of the studies, nitrogen and potassium gave consistent results during both the years with respect to growth and yield attributing characters.

Prasad *et al.* (2009) assessed the performance of two fertilizers in different doses for growth, yield and quality of Chinese cabbage. Analysis of variance showed significant differences among the treatments for all the traits. The maximum number of outer leaves, head length, head width, total head weight, net head weight and head yield were obtained with the application of 120kg N/ha and 100kg P/ha. Whereas the maximum plant height, plant spread, leaf area and head diameter were recorded with the application of 140kgN/ha and 120kgP/ha. From the experiment, suggested that the application of 120kg nitrogen /ha and 100kg P/ha is best for obtaining higher production in chinese cabbage in the Gangetic plains of West Bengal.

Jilani *et al.* (2010) evaluated five N levels (50, 100, 150, 200 and 250 kg/ha) along with a control (no nitrogen. The results showed that higher N levels gave better results for all parameters studied. 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.

Hossain *et al*. (2011) studied the response of cabbage variety Autumn Queen to added N, P, K and S nutrients in respect of growth, dry matter production and yield, nutrient contents in loose and heading leaves of the crop. Treatment receiving 240 kg N,45 kg P,180 kg K and 45 kg S/ha performed best in recording plant height, root length, number of loose and heading leaves, leaf length and breadth, thickness and diameter of head and yield. However, the optimum doses of N, P, K and S for maximum number of heading leaves (85.41/plant) and yield (87.09 t/ha) were 232.50, 35.85, 165.80 and 35.35 kg/ha and 202.30, 36.16, 69.17 and 34.18 kg/ha, respectively. Treatment receiving 320 kg N, 45 kg P, 180 kg k and 30kg s/ha performed best in recording nitrogen content both in loose (7.36%) and heading (5.80%). Nitrogen, phosphorus, potassium and sulphur contents in

loose leaves were the highest in treatments receiving 240kg N, 60 kg P, 180 kg K, 30 kg S; 240 kg N, 45 kg P, 240 kg K, 30 kg S and 240 kg N, 45 kg P,180 kg K, 60 kg S/ha, respectively.

Katiyar *et al*. (2011) conducted an experiment to find out the interaction and economics of nitrogen and phosphorus on crop growth of broccoli variety green head. Randomized Block Design was selected with four levels of nitrogen (30, 60, 90, 120 kg/ha) and three levels of phosphorus (30, 60, 90 kg/ha) with its basal dose of K2O @ 60kg/ha. As regards the yield of broccoli, nitrogen & phosphorus both showed direct response more pronouncely at the 90 kg/ha of fertilization. The results revealed significantly increase in the head yield of broccoli (nitrogen 170.15 and phosphorus 160.38 q/ha., respectively). The significant result was found in the interaction of nitrogen and phosphorus 175.70 q/ha. The maximum cost – benefit ratio was found 1:2.1.

Thapa and Prasad (2011) determined the response of Chinese cabbage to different doses of nitrogen and phosphorus levels. The study revealed that with the increase in the nitrogen levels from 80-140 kg/ha and phosphorus levels from 60-100 kg/ha there was increasing tendency in most of the characters. The maximum number of outer leaves, head length, head width, total head weight, net head weight and head yield were obtained with the application of 120 kg N/ha and 100 kg P/ha and the maximum plant height, plant spread, leaf area and head diameter were recorded with the application of 140 kg N/ha and 120 kg P/ha significantly. From the experiment, it may be concluded that the application of 120 kg nitrogen/ha and 100 kg P/ha is the best for obtaining higher production of Chinese cabbage in the Gangetic plains of West Bengal.

Choudhary *et al.* (2012) evaluated the effect of different organic sources and fertility levels on the growth, yield, quality and economics of sprouting broccoli under semi-arid conditions of Rajasthan. Significant increase in plant height, number of leaves, leaf area, volume and diameter of head, total head yield, crude protein and chlorophyll content in head was recorded under various levels of organic sources and fertility levels. Growth, yield and quality attributes were recorded maximum under treatment combination of vermi-compost 5.0 t ha^{-1} along with 125% recommended dose

of fertilizers (NPK 100, 80 and 60 kg/ha), which was at par with poultry manure 5.0 t ha^{-1} and 100% recommended dose of fertilizers, respectively. Furthermore, it also registered maximum net return and B:C ratio (4.09) than rest of the treatments.

Sultana *et al.* (2012) studied the effects of cow dung and potassium on growth and yield of kohlrabi. The experiment consisted of three levels of cow dung (0, 20 and 40 t/ha) and four levels of potassium (0, 20, 50, 80 kg/ha). All the parameters were significantly influenced by application of cow dung and potassium. The highest plant height (44.65 cm), number of leaves per plant (12.11), length of largest leaf (37.54 cm), and breadth of largest leaf (18.66 cm) were obtained from the highest dose of cow dung and potassium applied (40 t cow dung + 80 kg K/ha) while the lowest plant height (33.64 cm), number of leaves (9.01), length of largest leaf (27.94 cm), and breadth of largest leaf (11.00 cm) were obtained from control treatment combination. The highest fresh weight of leaves (49.33 g), fresh weight of knob (328.66 g) and fresh weight of roots (66.55 g) per plant were also recorded under the treatment combination of 40 t cow dung + 80 kg K/ha, while the lowest fresh weight of leaves (22.11 g), fresh weight of knob (136.00 g) and fresh weight of roots (23.33 g) were obtained from control treatment combination. Similarly, the dry weight of leaves (19.34%), knob (15.19%) and roots (32.75%) were highest under the same treatment combination of 40 t cow dung + 80 kg K/ha and the lowest dry weight of leaves (11.71%), dry weight of knob (7.38%) and dry weight of roots (15.29%) were obtained from control treatment combination C0K0. The marketable yields of knob per plot (7.86 kg) and per hectare (39.58 tons) were also the highest under the treatment combination 40 t cow dung/ha and 80 kg potassium per hectare.

Yadav *et al.* (2012) evaluated the effect of nitrogen and biofertilizers on growth of cabbage (*Brassica oleracea* var. *capitata* L.) var. Pride of India. The experiment consist of T_7 treatment viz., four levels of nitrogen (control, 100 kg, 125 kg and 150 kg) and three doses of biofertilizers (Azotobacter, Azospirillium and PSB) in combination with nitrogen levels and one is absolute control was laid out in simple RBD with three replications. The treatment T_{16} (150 kg N + PSB) was recorded maximum plant height (24.64 cm), plant spread(42.87 cm), number of open leaves (20.67), leaf area

(247.43 cm^2), maximum days taken to head maturity (110.00), diameter of stem (17.51mm), yield of head per hectare (432.92 q ha^{-1}). However, it was statistically at par with 150 kg N + Azospirillium and 150 kg N + Azotobacter inoculation.

Kumar and Sahu (2013) tested 25 combinations involving 5 irrigation levels (Furrow irrigation at 1.2 IW/CPE, drip irrigation at 100, 80, 60 & 40 per cent PE) and 5 nitrogen levels (50, 75, 100, 125 & 150 per cent of recommended dose of nitrogen) through fertigation. Results indicated that all the growth parameters were significantly influenced by irrigation and fertigation with nitrogen levels. Higher plant height and more number of leaves $plant^{-1}$ were observed with drip irrigation at 100 per cent PE and fertigation applied @ 150 per cent of recommended dose of nitrogen. Increasing the irrigation and nitrogen levels increased the yield significantly and highest yield (30.60 ton ha^{-1}) was obtained with drip irrigation at 100 per cent PE and fertigation with 150 per cent of recommended dose of nitrogen (29.71 t ha^{-1}). Total uptake of nitrogen (287.93 kg ha^{-1}), phosphorus (25.30 kg ha^{-1}) and potassium (297.11 kg ha^{-1}) were maximum at drip irrigation at 100 per cent PE. Similarly the maximum uptake of nitrogen (296.22 kg ha-^{1}), Phosphorus (26.90 kg ha^{-1}) and potassium (309.74 kg ha^{-1}) were observed at fertigation with 150 per cent of recommended dose of nitrogen. Water use efficiency (WUE) was found higher under drip irrigation at 40 per cent PE (9.80 q ha^{-1} cm^{-1}) over furrow irrigation at 1.2 IW/CPE (8.08 q ha^{-1} cm^{-1}).

Saleh *et al*. (2013) studied the response of kohlrabi plants (*Brassica oleracea var. gongylodes* L.) to different fertilizer sources and application rates of nitrogen (N). Three fertilizer sources, i.e., mineral-N fertilizer (control) as ammonium nitrate (33.5% N), organic-N as chicken manure (3.4% N) and combined application of 50% mineral-N (ammonium nitrate) + 50% organic-N (chicken manure) were assigned to the main-plots, while three N rates, i.e., 50, 75 and 100 kg N/fedden (4200 m^2) were randomized and occupied the sub-plots. The data showed that increasing the application rate of N within the range of 50 up to 100 kg N/fedden increased all studied plant growth characters, chlorophyll content and tuber yield, but the differences within application rate of 75 and 100 were not great enough to be significant. It could be concluded that, the economical and useful fertilizer source and application

rate of N for the best growth, productivity and tuber quality of kohlrabi plants is the combined source of 50% organic-N with 50% mineral-N at application rate of 75 kg N/feddan (4200 m^2).

Talukder *et al.* (2013) conducted experiment to determine optimum dose of N, P, K and S for yield maximization of knolkhol during the Rabi season. Treatments comprising four levels of N (0, 50, 100, 150 kg ha^{-1}), P (0, 25, 50, 75 kg ha^{-1}), K (0, 40, 80, 120 kg ha^{-1}) and S (0, 10, 20, 30 kg ha^{-1}) along with a blanket dose of zinc 5 kg, boron 1 kg and cow dung 5 t ha^{-1} were arranged in a randomized complete block design with three replications. The combined effect of NPKS significantly increased yield and yield attributes of knolkhol. The highest edible stem yield of 25.08 t ha^{-1} showing 291% increased over control during 2010-11 and of 34.23 t ha^{-1} showing 184% increased over control during 2011-12 was obtained from T_3 (N100 P50 K80 S20 kg ha^{-1}) treatment. From the regression analysis, it was observed that nitrogen 106.36 kg, phosphorous 57.86 kg, potassium 78.78 kg and sulphur 22.14kg during 2010-11 and nitrogen 105.20 kg, phosphorous 53.14 kg, potassium 80.25 kg and sulphur 20.92 kg per hectare during 2011-12 was found optimum for knolkhol production in Grey Terrace Soil of Gazipur.

Mishra *et al*. (2014) evaluated the eleven treatments out of these seven comprised of 100 per cent NPK with or without organic nutrient supplements, two treatments with 50 per cent NPK + organic nutrient supplements, one treatment with no nutrients (T_1 – control), and one treatment with only biofertilizers. The T_7 which comprised of 100 per cent NPK (@150-38-63 kg NPK ha^{-1}) application along with vermicompost (@ 2.5 tha^{-1}), biofertilizer @2 kg ha^{-1} each of Azotobacter, Azospirillum and PSB) recorded significantly higher values for total dry weight per plant (77.8 g), yield (420.0 q ha^{-1}), chlorophyll content (56.96%) TSS (3.1°Brix), ascorbic acid content (55.2 mg/ 100g) and protein content (44.2 g/100g) followed by T_6. The treatment T_6 had same nutrients as T_7 except, FYM instead of vermicompost. But the T_6 proved to be most economical treatment with a benefit: cost ratio of 2.7

Parwaiz *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 used in a randomized complete block design (RCBD) replicated three

times on radish (*Raphanus sativus L*.) cv. Early Long White). Phosphorus and potassium were used at constant rates of 75 and 100 kg ha^{-1} in the form of di-ammonium phosphate and potassium sulphate, respectively. 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 1 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.

Roni *et al*. (2014) conducted experiment to determine optimum level of nitrogen and spacing for improving the nutritional quality of broccoli. There were 15 treatments in the experiment comprising five levels of N viz., 0, 80, 120,160, and 200 kg/ha and three plant spacing's viz., 60cm x 60cm, 60cm × 45cm, and 60cm × 30cm. The results revealed that the highest ascorbic acid content (50.38 mg/100g) was obtained from $S_{60X30}N_0$ and the highest β-carotene content (50.67 IU/100g) was found in $S_{60X60}N_0$. Maximum Ca (0.556%) was found in $S_{60X60}N_0$ whereas maximum Fe (159.002 ppm) was in $S_{60X60}N_{200}$. The maximum P content (0.081%) was observed in $S_{60X60}N_{160}$ and maximum K content (0.854%) was found in $S_{60X45}N_{120}$.

Talat *et al.* (2014) carried out an experiment in split split plot design with three levels of organic manures (farmyard manure @ 10 t $ha^{-1,}$ vermicompost @ 5 t ha^{-1} and control), and two levels of biofertilizers (un-inoculated, inoculated with Azospirillum) as sub plot treatments and four levels of nitrogen (0, 100, 150, 200 kg ha^{-1}) as main plot treatments. The results revealed that the quality parameters viz., crude protein, vitamin A, vitamin C, reducing sugars, TSS and chlorophyll significantly increased with the application of nitrogen levels. Inoculation of Azospirillum showed significant results over control.

Dadhich *et al.* (2015) studied the influence of levels of nitrogen and zinc on yield attributes and economics of Early White Vienna variety of knolkhol. Results indicated that application of Nitrogen up to 100% RDN and Zinc up to 4 kg ha^{-1} $ZnSO_4$ significantly improved yield attributes and also maximum net returns of Rs. 223597 and 221617 were recorded. While highest benefit cost ratio of 4.81:1 and 4.82:1, were recorded under the

treatment of nitrogen @ 125 percent of RDN and zinc @ 6kg ha^{-1}, respectively.

Filho *et al.* (2015) evaluated five P doses (0, 80, 160, 240, and 320 kg ha^{-1} P_2O_5) on cauliflower and broccoli. For each experiment, *Brassica,* the experimental design was a randomized complete block with four replications. At the beginning inflorescence stage, the P level in the leaves was verified to be significantly influenced by P dose only in cauliflower plants. Cauliflower (35 970 kg ha^{-1}) and broccoli (11425 kg ha^{-1}) maxima productivities resulted from the respective doses of 245 and 320 kg ha^{-1} P_2O_5. In both experiments, after harvest of cauliflower and broccoli, significant effects of P doses were observed in soil P content, mass and diameter of the inflorescence, and productivity. The broccoli and cauliflower crops respond positively to P doses even in P-rich soils and that they demand different amounts of phosphorus to reach maximum productivity and inflorescence diameter and mass.

Mankar *et al.* (2015) stated that different levels of nitrogen (N_0-0, N_1 - 50 kg N/ha, N_2-100 kg N/ha, N_3-150 kg N/ha and N_4-200 kg N/ha) and microbial inoculants (M_0-0, M_1-Azospirillum, M_2-Azotobacter) were used to show the performance of these treatments on vegetative growth and yield of cabbage. Among all the treatments the combination of microbial inoculants M_1 (Azospirillum) and nitrogen level of N_3 (150 kg N/ha) provided the best result and recorded maximum head yield (668.27q/ha). In terms of yield contributing parameters the above treatment combination was also found significant differences in respect of plant height (55.13 cm), diameter of head (21.41 cm), depth of head (19.11 cm) and weight of head (1.653 kg) per plant. The next best treatment was microbial inoculants M_1 (Azospirillum) at nitrogen level of N_4 (200 kg N/ha).

Neethu *et al.* (2015) tested four levels of nitrogen viz. 80 (N_1), 120 (N_2), 160 (N_3) and 200 (N_4) kg N ha^{-1} and three levels of phosphorus viz. 40 (P_1), 60 (P_2) and 80 (P_3) kg P_2O_5 ha^{-1} in FRBD to find out the suitable doses of N and P for higher growth and yield of broccoli. There were twelve treatments replicated three times. Application of 160 kg N ha^{-1} (N_3) as well as 80 kg P_2O_5 ha^{-1} ($P_{3)}$ reported significantly higher (14.30 and 13.84 t ha^{-1}, respectively) flower head yield of broccoli which were found at par with N4 (200 kg N ha^{-1}) and P_2 (60 kg P_2O_5 ha^{-1}) levels. Similar trend was also observed in respect to

different growth parameters viz. plant height, number of leaves plant^{-1}, leaf area, along with size of flower head as well as fresh and dry yield of different parts of the crop.

Sharma and Kumar (2015) assessed the response of three levels of nutrients, i.e. F_1 (125% of recommended dose of NPK), F_2 (100% recommended dose of NPK) and F_3 (75% of recommended dose of NPK). Results revealed that a comparison of data among nutrient levels indicated that leaf N contents increased consistently with nutrient levels. Among nutrient levels, uptake of N, P and K increased under F_1 which was at par with F_2 and increased significantly over F_3 and increased to the tune of 41.5-44.4, 41.8-44.8 and 41.4-44.1% under F_1 and F_2 over F_3, respectively. A comparison among nutrient levels revealed foliage weight to the tune of 44.3 and 41.9% higher under F_1 and F_2, respectively over F_3. Curd weight and curd yield increased significantly with increasing nutrient levels (Table 4).The nutrient level F_1 (125% of recommended dose of nutrients) registered highest curd weight and curd yield (695.7g plant^{-1} and 231.9 q ha^{-1}), which were at par with F_2 (675.4 g plant^{-1} and 225.1 q ha^{-1}) and increased over F_3 (489.9 g plant^{-1} and 163.3 q ha^{-1}) to the tune of 37.8-42.0%.

Singh *et al.* (2015) studied seven different treatments including control to examine the optimum doses of NPK and boron for broccoli. The results revealed significant response on growth and yield of broccoli for different treatments. Application of 120 kg N+60 kg P_2O_5+40 kg K_2O+15 kg B ha^{-1} gave maximum plant height plant^{-1} (65.33 cm), number of leaves plant^{-1} (18.26), length of longest leaf (52.99 cm), width of longest leaf (17.98 cm), spread of plant (55.53 cm) and stem diameter (4.47 cm), whereas in control was minimum pronounced plant height plant^{-1} (58.66 cm), number of leaves plant^{-1} (12.33), length longest leaf (42.70 cm) width of longest leaf (14.18 cm), spread of plant and stem diameter (3.04 cm). Similar, pattern on the curd diameter (13.69 cm), length of curd (16.33 cm), weight of curd plant^{-1} (286.89 g), weight of sprout plant^{-1} (126.89 g), weight of curd and sprout plant^{-1} (0.390 kg) and total yield Curd + sprout (148.51 q ha^{-1}) was recorded with the application of 120 kg N+60 kg P_2O_5+40 kg K_2O+15 kg B ha^{-1} and minimum was under control treatment.

Verma and Nawange (2015) observed the response of cabbage cultivar to different levels of nitrogen and sulphur on growth, yield, and quality. Nitrogen application 150 kg/ha and sulphur application 60 kg/ha produced significantly higher plants height, plant spread, stem diameter, width of head, higher weight of head per plant and yield of cabbage. Sulphur application 80 kg/ha contributed significantly more protein percentage over rest of the applications of sulphur. The maximum yield recorded under treatment combination 150 kg N/ha and 60 kg S/ha.

2.2 Effect of varieties

Genetic makeup of a plant has a great influence on its performance**.** Interaction of genetic makeup and environmental factors determines the performance of a variety at a place thereby its suitability.

Arin *et al.* (2003) assessed the possibility of growing kohlrabi (*Brassica oleraceae var. gongylodes L.*) under Trakya (Turkey) conditions during the spring and fall growing periods. In each period, three kohlrabi cultivars (Express Forcer, Neckar, Lahn), two seedling ages (four or six weeks old) and three planting dates (at two week intervals in April, May for spring and in September, October for fall), with respect to yield and quality characteristics, were evaluated. Cultivars Neckar and Express Forcer had higher yield and quality than Lahn in both seasons. Higher yield was obtained from six weeks old seedlings in the spring, while a period of four weeks was sufficient for growing seedlings in fall.

El-Bassiony *et al.* (2014) studied the effect of two varieties and foliar spray of yeast, amino acid and chitosan on growth, yield and chemical content of Kohlrabi plants. Obtained results show that the highest plant height was found by cv. Delikatess weisser with foliar spray of chitosan. Meanwhile, the highest values of dry weight of leaves and tubers were found by Delicates wiser with foliar spray of yeast. Furthermore, the highest values of leaves number, tuber height and diameter and fresh weight of tubers as well as total yield of tubers of Kohlrabi plants were recorded by cv. Burble Vienna with foliar spray of chitosan. Furthermore, the highest amount of N, P and K% in leaves and N% in tubers of Kohlrabi were found by cv. Burble Vienna with foliar spray of chitosan.

Chaudhari *et al.* (2015) determined the growth of knolkhol as influenced by different planting date and varieties. The study was conducted with three planting date *viz.,* 1st November, 15th November and 1st December at four varieties *viz.,* White Vienna (V1) Palam Tender Knob (V2) Early White Vienna (V3) and Purple Vienna(V4). Among the planting dates, 15th November planting significantly increased plant height, plant spread, East-West and North-South and leaf area. Amongst varieties Purple Vienna achieved higher growth parameters.

2.3. Interactive effect of nutrient levels and varieties

Plant requires nutrients for manufacturing their food**.** Generally high yielding varieties need more nutrients as compared to low yielding ones. Hence, application of nutrients has great influence on the performance of a variety.

Akoumianakis *et al.* (2011) investigated the effect of four levels of N application (0, 150, 300 and 450 mg l^{-1} N) on three radish cultivars (Saxa, Red Fuoko and White Ghiaccio) grown in pots in autumn/winter (from mid-October to mid-January) and spring (from mid-February to early May). The number of leaves per plant and mean leaf area increased with N rates of up to 300 mg l^{-1} in the autumn/winter and 150 mg l^{-1} in the spring. Mean root fresh weight increased with N application up to 300 mg l^{-1} (cv. Red Fuoko and White Ghiaccio) or 450 mg l^{-1} (cv. Saxa) in the autumn/winter crop, but only up to 150 mg N l^{-1} weight of cv. White Ghiaccio in both seasons. Increasing N, however, caused a reduction in percent root dry matter and root firmness, even from as low as 150 mg l^{-1} N. The occurrence of hollowness within the roots was particularly high in White Ghiaccio, followed by Red Fuoko, whereas cv. Saxa was resistant to this defect. Red Fuoko showed a higher percentage of roots with hollow centres with increasing N levels during the winter. They conclude that although N application (up to 300 mg l^{-1} in the autumn/winter and 150 mg l^{-1} in the spring) increases yield. It may adversely affect root quality by reducing firmness.

Giri *et al.* (2013) determined the optimum rate of nitrogen (N) fertilizer for effective growth and yield of two varieties of broccoli in southern plain of Nepal. The experiment was laid out with two-factorial completely random

block design (RCBD) comprising two varieties of broccoli (Calabrese and Green Sprouting) and five N rates (0, 50, 100, 150 and 200 kg ha^{-1}) with three replications. The effects of variety and N rate on total curd yield were significant but the interaction effect was non-significant. Green Sprouting produced 11% higher total curd than Calabrese. Similarly, curd production increased N rate up to 200 kg ha^{-1} reaching a maximum of 14.47 t $ha^{-1.}$ This indicated that optimum level of N could be beyond the rates tested in this study, which needs further experimentation.

Zaki *et a*l. (2015) studied the effect of different rates of potassium fertilizer (20, 40 and 60 kg K_2O/fed.) on growth, production and quality of three broccoli cultivars, i.e., Calabrese American, Calabrese France and Southern Star Hybrid in sandy soil under drip irrigation system. Results indicate that Southern Star Hybrid cultivar was superior in its vegetative growth; i.e., leaves number, fresh weight of spears and total plant; main spear yield; physical head quality, (mean head weight and head diameter); chemical head quality (vitamin C); N% in leaves and stems; P% in stems and spears as well as K% in stems and spears followed by Calabrese France and Calabrese American, respectively. On the other hand, Calabrese American were the tallest plants, heaviest leaves and stems fresh weight, highest leaves and spears dry weight and best TSS but Southern Star hybrid heads were the best vitamin C content and Calabrese France cultivar gave the highest values of branches number, stem dry weight and protein percentage. Potassium levels differed statistically in their effect on the vegetative growth of broccoli plants (plant height, leaves numbers per plant, fresh weight of leaves, stems and spears; dry weight of leaves, stems and spears; main spear yield; physical heads quality (weight, height and diameter); chemical head quality (TSS, vitamin C and protein percentage); N, P and K% of leaves, stems and heads. The highest vegetative growth was obtained by adding 40 kg K_2O/fed., followed by 60 kg K_2O/fed., which came in the second order. The lowest values of vegetative growth; main head yield; physical heads quality and N, P and K of broccoli leaves, stems and heads were obtained by 20 kg K_2O/fed. The results indicated that combined effect of cultivars and mineral potassium levels caused statistical increases in vegetative growth, yield, physical heads quality; N% in stems and K% leaves of broccoli. The highest vegetative

growth, yield and chemical contents were obtained by the combined effect of Southern Star Hybrid cultivar with 40 units K_2O/fed.

CHAPTER-III

MATERIAL AND METHODS

Chapter- III

MATERIAL AND METHODS

This chapter comprises of the material used and methodology adopted during the present investigation entitled **"Effect of varieties and nutrient levels on growth, yield and quality in knolkhol (*Brassica oleracea* var. *gongylode* L.)".** The methods employed during the course of investigation and materials utilized have great significance in the research programme. The details of the material and methods are being given under the following heads:

3.1 Location of the experiment

The present study was carried out at the Vegetable Research Field, College of Horticulture, Mandsaur, (M.P), during 2015-16. Mandsaur is situated in Malwa plateau in western part of Madhya Pradesh at North latitude of $23^0$45' to $24^0$13' North and longitude of $74^0$44' to $75^0$18' East at an altitude of 435.20 m above mean sea level. The topography of the experimental field is plain.

3.2 Climate of the region

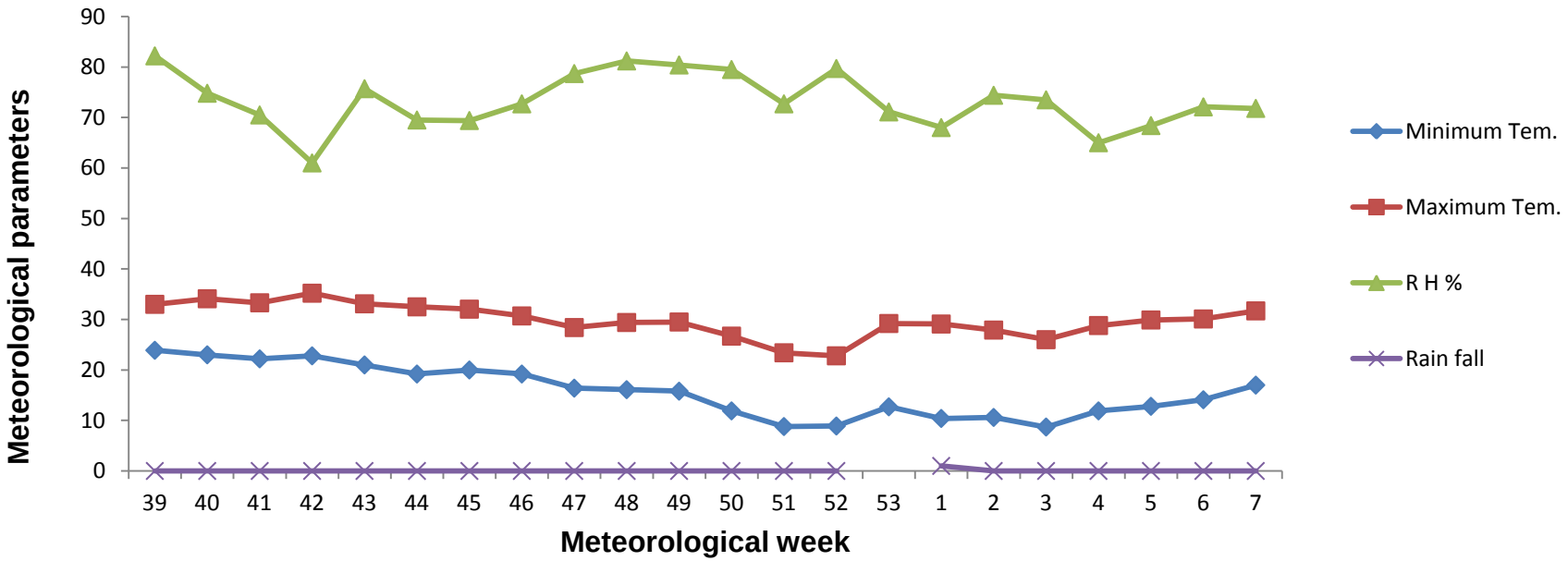
Mandsaur belongs to sub tropical and semi arid climatic conditions having a temperature range of minimum 8.7^{0}C and maximum 35.2^{0}C in winter and summer, respectively. In this area maximum rainfall is received during mid June to September. The average annual rainfall is 744.8 mm. South-west monsoon brings major part of annual precipitation. Meteorological data recorded during the period of investigation are presented in Table 3.1

Table 3.1: Meteorological parameters recorded during the period of Investigation (25th September 2015 to 22th February2016)

Standard meteorological weekly	Average weekly Temperature		Relative humidity (%)	Weekly rainfall (mm)
	Minimum ^{0}C	Maximum ^{0}C		
39	23.9	33.	82.2	-
40	23.0	34.1	74.8	-
41	22.2	33.3	70.5	-
42	22.8	35.2	61.0	-
43	21.0	33.1	75.7	-
44	19.2	32.5	69.5	-
45	20.0	32.04	69.4	-
46	19.2	30.7	72.7	-
47	16.4	28.4	78.7	-
48	16.1	29.4	81.2	-
49	15.8	29.5	80.4	-
50	11.9	26.7	79.5	-
51	8.8	23.4	72.7	-
52	8.9	22.8	79.7	-
53	12.7	29.2	71.1	
1	10.4	29.1	68.0	1
2	10.6	27.9	74.4	-
3	8.7	26.0	73.5	-
4	11.9	28.8	65.0	-
5	12.8	29.9	68.4	-
6	14.1	30.1	72.1	-
7	17.0	31.7	71.8	-

Source: Meteorological observatory of the College of Horticulture, Mandsaur

Fig.1: Meteorological parameters recorded during the period of Investigation (25th September 2015 to 22th Ferbruary 2016



3.3 Soil of the experimental field

The soil of the experimental field was light alluvial having sandy loam texture with uniform topography. Soil samples of the field up to a depth of 15 cm were taken randomly from the field, with the help of soil auger. 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 of field soil samples are presented in Table 3.2

Table 3.2: Physical and chemical composition of the soil

S. No.	Composition			Method
	Physical	**Content**	**Category**	
1.	Sand (%)	55	-	Bouyoucos Hydrometer
2.	Silt (%)	35	-	Bouyoucos Hydrometer
3.	Clay (%)	10	-	Bouyoucos Hydrometer
	Chemical	**Content**	**Category**	
4.	Soil pH	7.4	Neutral	Glass electrode pH meter
5.	Electrical conductivity (dSm^{-1})	0.80	Normal	By conductivity bridge at 25^0C
6.	Available nitrogen (kg/ha)	280.0	Medium	Rapid titration method (Walkley and Black ,1934)
7.	Available phosphorus (kg/ha)	16.00	Medium	Olson's extraction method (Olson *et al.*, 1954)
8.	Available potassium (kg/ha)	572.00	High	Flame photometer

Table 3.3: Previous year crop history of the experimental field

Year	Crops grown	
	***Kharif* Season**	***Rabi* Season**
2013-14	fallow	Cauliflower
2014-15	fallow	Summer squash
2015-16	fallow	-

3.4 Experimental details

3.4.1 Experimental details and layout

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

Name of crop : Knolkhol (*Brassica oleracea var. gongylodes* L.)

Season : *Rabi* season 2015-16

Design : Factorial Randomized Block Design

Number of replication : 3

Treatments-

1. Varieties : 2
2. Nutrient levels : 6

Treatment combination : 12

Total number of plots : 36

Plant spacing : 30 cm x 20 cm

Plot size : 400cm x 90cm

Date of sowing : 25th September 2015

Date of transplanting : 9th November 2015

Date of harvesting : 22th December 2015 to 24th February 2016

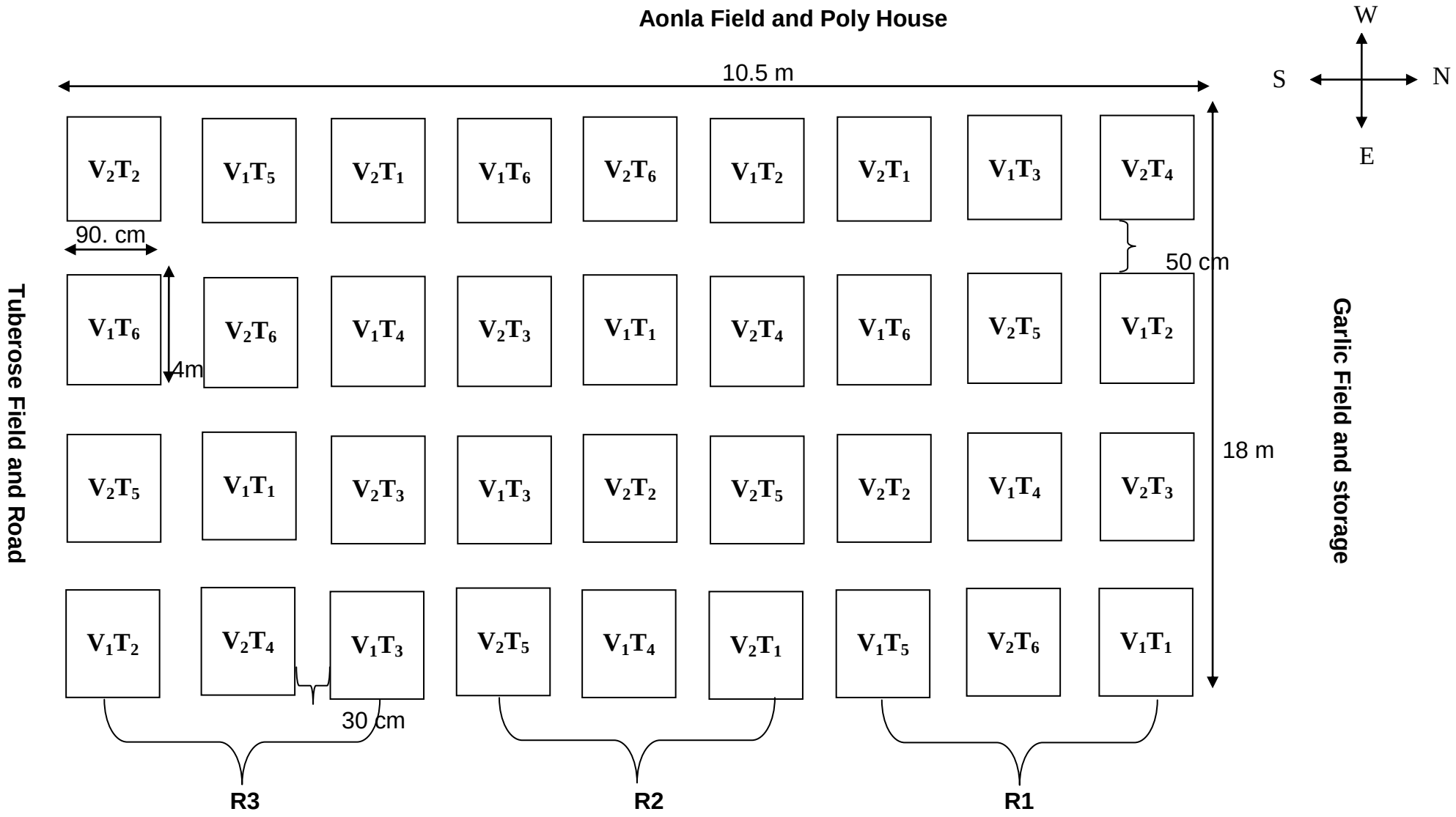


Fig. 2: Layout of the experimental Fiel

Plate 1:- A Panoramic view of experimental field at knob initiation stage of knolkhol

3.4.2 Treatment details

The experiment was conducted with varieties and growing condition as given below along with their notations.

1. **Varieties**

   V_1 – Pusa Virat

   V_2 – White Vienna

2. **Nutrient levels :**

   T_1 – 60 kg N + 45 kg P_2O_5 + 50 kg K_2O per hectare

   T_2 – 60 kg N + 60 kg P_2O_5 + 50 kg K_2O per hectare

   T_3 – 80 kg N + 45 kg P_2O_5 + 50 kg K_2O per hectare

   T_4 – 80 kg N + 60 kg P_2O_5 + 50 kg K_2O per hectare

   T_5 –100 kg N + 45 kg P_2O_5 + 50 kg K_2O per hectare

   T_6 –100 kg N + 60 kg P_2O_5+ 50 kg K_2O per hectare

Table 3.4: Treatment combinations

Treatment	Treatment details	Symbol
T_1	Pusa Virat+60kgN+45kgP_2O_5+50kgK_2O/ha	V_1T_1
T_2	Pusa Virat+60kgN+60kgP_2O_5+50kgK_2O/ha	V_1T_2
T_3	Pusa Virat+80kgN+45kgP_2O_5+50kgK_2O/ha	V_1T_3
T_4	Pusa Virat+80kgN+60kgP_2O_5+50kgK_2O/ha	V_1T_4
T_5	Pusa Virat+100kgN+45kgP_2O_5+50kgK_2O/ha	V_1T_5
T_6	Pusa Virat+100kgN+60kgP_2O_5+50kgK_2O/ha	V_1T_6
T_7	White Vienna+60kgN+45kgP_2O_5+50kgK_2O/ha	V_2T_1
T_8	White Vienna +60kgN+60kgP_2O_5+50kgK_2O/ha	V_2T_2
T_9	White Vienna +80kgN+45kgP_2O_5+50kgK_2O/ha	V_2T_3
T_{10}	White Vienna +80kgN+60kgP_2O_5+50kgK_2O/ha	V_2T_4
T_{11}	White Vienna +100kgN+45kgP_2O_5+50kgK_2O/ha	V_2T_5
T_{12}	White Vienna +100kgN+60kgP_2O_5+50kgK_2O/ha	V_2T_6

3.5 Agronomical operations

3.5.1 Nursery raising

After selection of the site, the soil was ploughed to a good tilth. All weed plants, stones and other undesirable materials were collected and removed from the field. A nursery bed of 1.0 m wide and 30 cm high from ground level was prepared for raising seedlings. Before sowing, seed was treated with mancozeb @ 2.0 g/kg + carbendazim @ 1.0 g/kg of seed to avoid damage of seedlings from disease. The seeds were sown in well prepared beds in lines 2-3 cm deep spaced 5 cm apart then covered well with fine soil and mulched with dry grass (doob grass) to facilitate early and uniform germination. Immediately, then light irrigation was given. Sowing was done on the 25th September 2015.

3.5.2. After care of seedlings

After sowing of seeds, the seedlings were regularly irrigated till the seedlings were ready for transplanting. Weeding and plant protection measures were taken as and when required.

3.5.3 Field preparation

The field was ploughed thoroughly to a fine tilth. There after field was leveled properly with heavy wooden plank by tractor and beds were prepared. The size of bed was 90 cm in width and 30 cm high from ground level.

3.5.4 Nutrient management

(a) Fertilizer: The calculated quantities of fertilizers were applied to the respective plot. The sources of nutrients were nitrogen (Urea), phosphorus (DAP) and potash (MOP). Half dose of nitrogen and full dose of phosphorus and potash were applied as basal dose. While the rest dose of nitrogen was given in knolkhol, at 20 days after transplanting. Other intercultural operations and crop management practices were carried out in accordance with the recommended package of practices.

3.5.5 Transplanting and gap filling

Thirty eight days old seedlings of uniform height were selected and transplanted in the field with the spacing of 30 cm row to row and 20 cm plant to plant. Gap filling was carried out 5 days after transplanting.

3.5.6 Irrigation

Optimum soil moisture was maintained in the field through drip irrigation system. Irrigation was given at the intervals according to weather conditions.

3.5.7 Weeding

Two hand weedings with shallow hoeing were done at 20 and 40 days after transplanting.

3.5.8 Earthing up

An earthing up was done at 20 and 30 days after transplanting and at knob initiation stage for root aeration, weed check as well as mixing of fertilizers.

3.5.9 Plant protection measures

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

3.5.10 Harvesting

The harvesting of knolkhol was started from 22th December 2015 and continues up to 24th February 2016. Knolkhol was harvested when the knob attained proper size.

3.6 Observations recorded during course of investigation

The observations were recorded on 5 randomly selected plants in each plot and their mean values were worked out on the following traits:

3.6.1 Growth parameters

I. Plant height (cm)

Height of the five randomly selected and tagged plants was measured at knob initiation and knob harvesting time. The plant height was measured from soil surface up to the tip with the help of measuring scale and average was worked out.

II. Number of leaves

The number of fully grown leaves was counted, while small leaves attached inside the whorl were left out in five randomly selected and tagged plants at knob initiation and knob harvesting time.

III Fresh weight of plant (g)

The fresh weight of five randomly selected plants (including vegetative parts and knob) at knob initiation and harvesting stage was determined using weighing balance. The fresh weight of plant was expressed in grams/plant.

VI. Dry weight of plant (g)

After taking fresh weight, plants were dried in hot air oven at 65^{o} C temperature till constant weight. The dry weight of plant (including vegetative parts and knob) was expressed in grams/plant.

V Leaf area

The leaf area of five randomly selected plants in each experimental plot was measured with systronics leaf area meter (Model Licor 211) at knob initiation after transplanting. Thereafter, averages were worked out at each stage.

VI 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 20, 30 and 45 days after transplanting.

VI I Days to 50% knob initiation (days)

The date on which 50% plants had got knob initiation was noted thereafter, days taken for 50% knob initiation were worked out from the date of transplanting.

VIII Days to knob harvesting (days)

The date on which 50% knobs attained maturity was recorded and days to marketable maturity of knob were worked out from the date of transplanting

3.6.2 Yield parameters and yield

I Knob length (cm)

The knob length was recorded as average of five randomly marketable knobs from base to tip of knob.

II Knob diameter (cm)

Knob diameter of five randomly selected plants at knob harvesting stage was measured using vernier caliper and expressed in centimeters.

III Knob weight (g)

Weight of five knobs at edible maturity stage was recorded using electronic weighing balance. The average knob weight was expressed in grams.

VI Marketable (knobs) yield (q/ha)

Marketable knobs were weighed on electronic balance and marketable knobs yield per plot was recorded in kilogram which was converted into quintal per hectare as given below:

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

V. Total (knobs +leaves) yield (q/ha)

Total knobs were weighed on electronic balance and total **(**knobs +Leaves) yield per plot was recorded in kilogram which was converted into quintal per hectare as given below:

$$\text{Total (knobs +leaves) yield (q/ha)} = \frac{\text{Total (knobs +leaves) yield (kg/plot) X } 10{,}000}{\text{Net plot area } (m^2) \times 100}$$

3.6.3 Quality parameters

I. Dry matter (%)

A portion of knob from randomly marked five plants from each treatment was taken. After recording fresh weight, chopping was done. The samples were oven dried at 60 ±5 ºC till constant weight. Oven dried samples were again weighed and dry matter was expressed in percentage.

$$\text{Dry matter content (\%)} = \frac{\text{Dried weight of sample} \times 100}{\text{Fresh weight of sample}}$$

II. Ascorbic acid (mg/100g)

The ascorbic acid content in knolkhol was estimated by using the method given by Ranganna (1977).

A. Reagents

1. 3% meta phosphoric acid (HPO_3): Prepared by dissolving the pellets of HPO_3 in glass distilled water.
2. Ascorbic acid standard: Weigh accurately 100 mg of l-ascorbic acid and make up to 100 ml with 3% HPO_3. Dilute 10 ml to 100 ml with 3% HPO_3 (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 200ml.

B. Standardization of dye

C. Take 5 ml of standard ascorbic acid solution and add 5 ml of HPO_3. 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 knolkhol, blend with 3% HPO_3 and make up to 100 ml with HPO_3. Filter or centrifuge the sample before titration.

E. Procedure

Take an aliquot 10 ml of the HPO_3 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:

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

III. Total soluble solids (^{0}Brix):

All the fruits of each knob 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 ^{0}Brix by hand

refractometer. Few drops of juice were placed on the surface of prism. The hinged part was placed back. The refractometer was then placed against the sun. The reading was noted by revolving the eyepiece at room temperature (A.O.A.C., 1970).

3.6.4 Economics of the Treatments:

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

3.7 Statistical analysis

The data obtained on various observations for each treatment were subject to "Analysis of variance" as recommended by Panse and Sukhatme (1985). The skeleton of ANOVA as per design is as follows:

Table 3.5: Skeleton of analysis of variance (ANOVA)

(ANOVA)					
Source of variation (S.V.)	Degree of freedom (df)	Sum of square (SS)	Mean sum of squares (MSS)	"F" value (Calculated) (F_{cal})	"F" value (Table) at 5% level of significance (F_{tab})
Replication	(r-1) = 2	SSR	MSR	MSR/ MSE	3.44
Variety(V)	(v-1) = 1	SSW	MSW	MSW/ MSE	4.30
Nutrient levels (N)	(n-1) = 5	SSV	MSV	MSV /MSE	2.66
Interaction (V x N)	(v-1)x(n-1) = 5	SSVW	MSVW	MSVW /MSE	2.66
Error	{totalDF-(r+v+rn)} = 22	SSE	MSE		
Total	(vnr-1) = 35	SST			

The significant differences between different treatments were evaluated 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) S.Em ± for V = $\sqrt{\frac{\text{EMS}}{\text{No. of replication X Levels of N}}}$

(b) S.Em ± for N = $\sqrt{\frac{\text{EMS}}{\text{No. of replication X Levels of V}}}$

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

(ii) Critical difference (CD)

(a) CD for V = SEm± (V) $x\sqrt{2} \times t_{5\% \text{ (edf)}}$

(b) CD for N = SEm± (N) $\times \sqrt{2} \times t_{5\% \text{ (edf)}}$

(c) CD for VxN = SEm± (VxN) $x\sqrt{2} \times t_{5\% \text{ (edf)}}$

Where,

r = Number of replication

V = Number of varieties

N = Number of nutrient levels

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

CHAPTER-IV

RESULTS

Chapter-IV

RESULTS

This chapter deals with the analysis of data recorded during the experiment entitled **"Effect of varieties and nutrient levels on growth, yield and quality in knolkhol (*Brassica oleracea var. gongylodes* L.)".** The results of various observations recorded during experiment were statistically analysed 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

Growth of knolkhol was studied with respect to plant height, number of leaves, fresh weight of plant at knob initiation and harvesting stage, dry weight of plant at knob initiation and harvesting stage, leaf area, SPAD value, days to 50% knob initiation and days to knob harvesting.

4.1.1 Plant height (cm)

Plant height was recorded at knob initiation and knob harvesting stage. The data presented in Table 4.1 and Fig. 3 (a,b,c) revealed significant effect of varieties and treatment levels on plant height at knob initiation and harvesting stages.

The data revealed significant effect of varieties on plant height of knolkhol at knob initiation and knob harvesting stage. Variety V_2 (White Vienna) recorded more plant height (27.02 cm) as compared to V_1 at knob initiation stage. At harvesting stages, maximum plant height of 45.62 cm was found in variety V_1 (Pusa Virat).

Nutrient levels exerted significant influence on plant height. Maximum plant height of 26.33 and 48.00 cm was recorded with nutrient level T_6 followed by $T_4 > T_5 > T_3 > T_2$ in descending order at both the growth stages.

T_1V_1

T_2V_1

T_3V_1

T_4V_1

T_5V_1

T_6V_1

Plate 2(a):- Knolkhol knobs along with leaves under different treatments

T_1V_2

T_2V_2

T_3V_2

T_4V_2

T_5V_2

T_6V_2

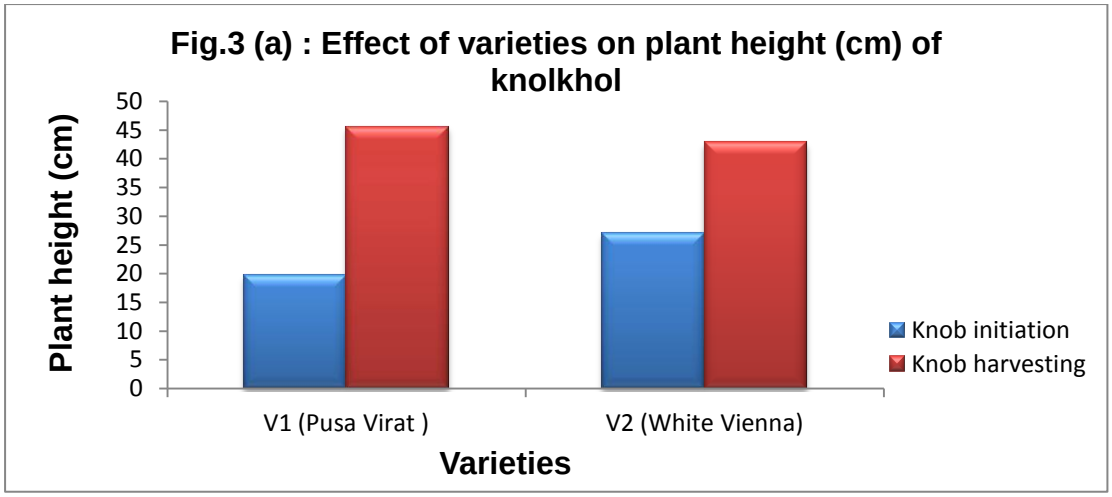
Plate 2(b):- Knolkhol knobs along with leaves under different treatments

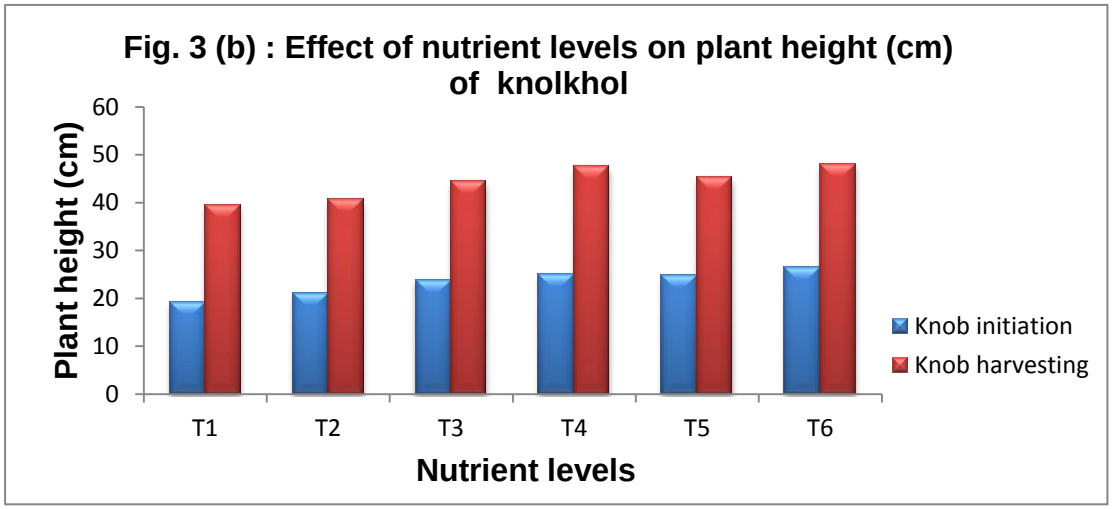
Minimum plant height of 19.72 and 39.50 cm was recorded in case of T_1 at both the growth stages.

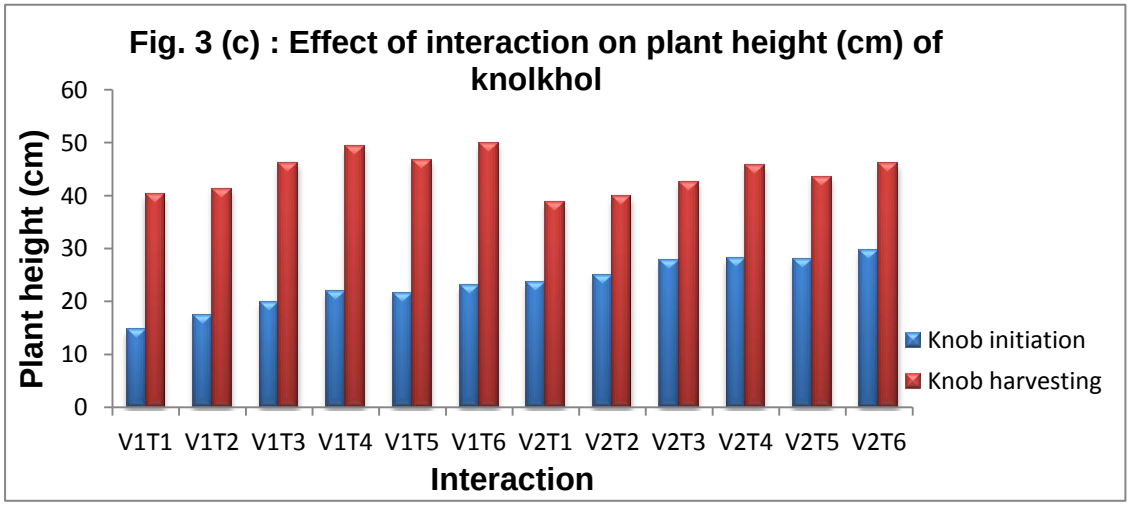
Combined effect of varieties and nutrient levels had non significant influence on plant height at knob initiation and harvesting stage after transplanting.

Table 4.1: Effect of varieties, nutrient levels and their interaction on plant height (cm) of knolkhol

Treatment	**Plant height (cm)**	
	Knob initiation	**Knob harvesting**
Varieties (V)		
V_1 (Pusa Virat)	19.72	45.62
V_2 (White Vienna)	27.02	42.79
S.Em±	**0.67**	**0.77**
CD at 5%	**1.99**	**2.25**
Nutrient levels (T)		
T_1	19.20	39.50
T_2	21.07	40.57
T_3	23.87	44.40
T_4	25.00	47.60
T_5	24.75	45.17
T_6	26.33	48.00
S.Em±	**1.17**	**1.32**
CD at 5%	**3.44**	**3.87**
Interaction (V x T)		
V_1T_1	14.73	40.20
V_1T_2	17.27	41.33
V_1T_3	19.93	46.20
V_1T_4	21.87	49.33
V_1T_5	21.47	46.80
V_1T_6	23.07	49.87
V_2T_1	23.67	38.80
V_2T_2	24.87	39.80
V_2T_3	27.80	42.60
V_2T_4	28.13	45.87
V_2T_5	28.03	43.53
V_2T_6	29.60	46.13
S.Em±	**1.66**	**1.87**
CD at 5%	**NS**	**NS**







4.1.2 Number of leaves per plant

Number of leaves per plant was recorded at knob initiation and knob harvesting stage. The findings of the present study as depicted in Table 4.2 and Fig. 4 (a,b,c) revealed significant effect of varieties and nutrient levels on number of leaves per plant at both knob initiation and harvesting stages.

The data showed significant effect of varieties on number of leaves of knolkhol at knob initiation and knob harvesting stage. At knob initiation, Variety V_2 (White Vienna) recorded maximum number of leaves (8.20). Whereas at harvesting stage maximum number of leaves (17.79) was observed with V_1 (Pusa Virat). Minimum number of leaves of 6.94 and 15.68 was recorded in case of V_2 (White Vienna) at knob initiation and V_1 (Pusa Virat) at harvesting stages respectively. The difference between V_1 and V_2 was significant at both the growth stages.

Nutrient levels exerted significant influence on number of leaves. Maximum number of leaves of 8.35 and 18.53 cm was recorded with nutrient level T_6 followed by $T_4>T_5>T_3>T_2$ in descending order at both the growth stages. Minimum number of leaves of 6.33 and 15.23 cm was recorded in case of T_1 at knob initiation and knob harvesting stage respectively.

Combined effect of varieties and nutrient levels had non significant influence on number of leaves at both knob initiation and knob harvesting stages.

Table 4.2: Effect of varieties, nutrient levels and their interaction on number of leaves of knolkhol

Treatment	Number of leaves	
	Knob initiation	**Knob harvesting**
Varieties (V)		
V_1 (Pusa Virat)	6.94	17.79
V_2 (White Vienna)	8.20	15.68
S.Em±	**0.23**	**0.40**
CD at 5%	**0.68**	**1.19**
Nutrient levels (T)		
T_1	6.33	15.23
T_2	6.60	15.57
T_3	7.98	16.60
T_4	8.13	17.67
T_5	8.03	16.80
T_6	8.35	18.53
S.Em±	**0.40**	**0.70**
CD at 5%	**1.19**	**2.07**
Interaction (V x T)		
V_1T_1	5.80	16.13
V_1T_2	6.00	16.67
V_1T_3	7.27	17.13
V_1T_4	7.47	19.07
V_1T_5	7.33	17.40
V_1T_6	7.80	20.33
V_2T_1	6.87	14.33
V_2T_2	7.20	14.47
V_2T_3	8.70	16.07
V_2T_4	8.80	16.27
V_2T_5	8.73	16.20
V_2T_6	8.90	16.73
S.Em±	**0.57**	**0.99**
CD at 5%	**NS**	**NS**

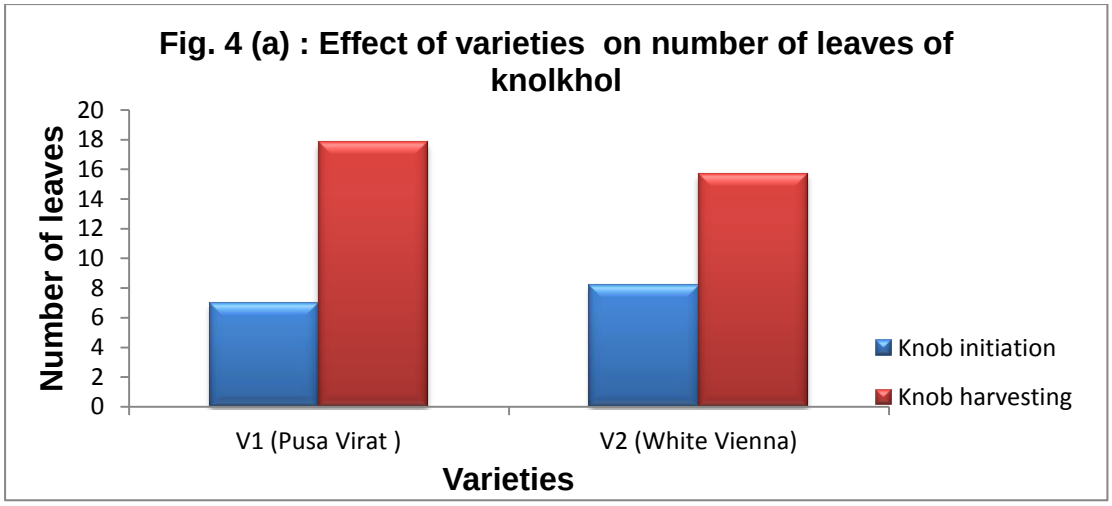


Fig. 4 (a) : Effect of varieties on number of leaves of knolkhol
Number of leaves
20
18
16
14
12
10
8
6
4
2
0
V1 (Pusa Virat)
V2 (White Vienna)
Varieties
Knob initiation
Knob harvesting

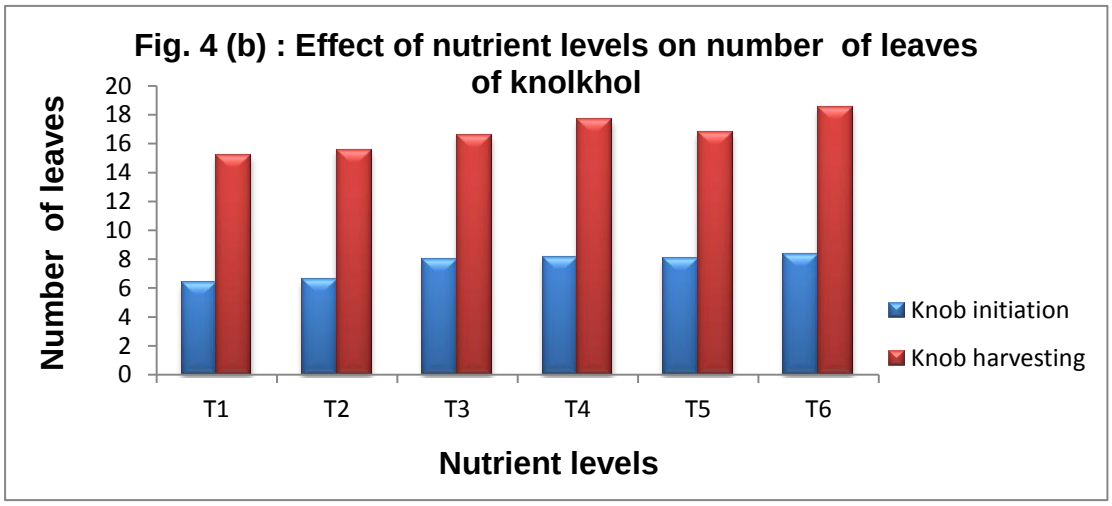


Fig. 4 (b) : Effect of nutrient levels on number of leaves of knolkhol
Number of leaves
20
18
16
14
12
10
8
6
4
2
0
T1
T2
T3
T4
T5
T6
Nutrient levels
Knob initiation
Knob harvesting

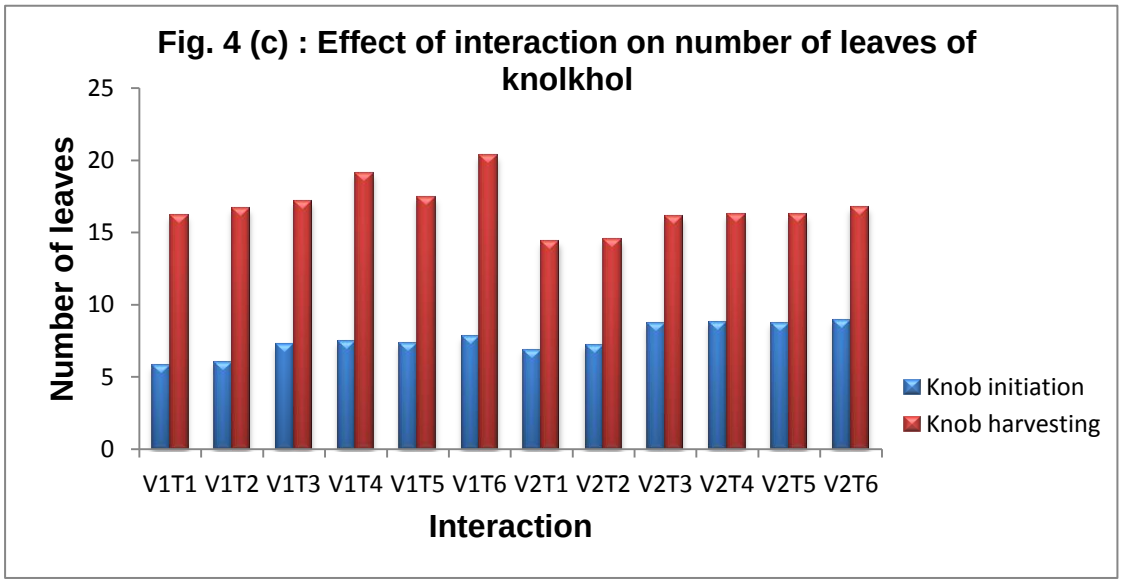


Fig. 4 (c) : Effect of interaction on number of leaves of knolkhol
Number of leaves
25
20
15
10
5
0
V1T1 V1T2 V1T3 V1T4 V1T5 V1T6 V2T1 V2T2 V2T3 V2T4 V2T5 V2T6
Interaction
Knob initiation
Knob harvesting

4.1.3 Fresh weight (g) per plant

The results pertaining to fresh weight of plant (g) as influenced with varieties and nutrient levels are presented in Table 4.3 and Fig. 5 (a,b,c) Fresh weight of plant was recorded at knob initiation and knob harvesting stage revealed significant effect of varieties and nutrient levels.

The findings indicated significant effect of varieties on fresh weight of plant (g) at both knob initiation and knob harvesting stages. Maximum fresh weight of plant i.e. 72.31g and 640.22 g were found in case of variety V_1 (Pusa Virat) at knob initiation and harvesting stages, respectively. Minimum fresh weight of plant i.e. 29.06 g and 339.69 g were recorded in case of V_2 (White Vienna) at knob initiation and harvesting stages, respectively. The difference between V_1 and V_2 was significant at both the growth stages.

Nutrient levels exerted significant influence on fresh weight of plant (g). Maximum fresh weight of plant i.e. 61.92g and 571.67g was recorded with nutrient level T_6 followed by $T_4 > T_5 > T_3 > T_2$ in descending order at both the growth stages. Minimum fresh weight of plant i.e. 38.92g and 400.33 g was observed in case of T_1 at both the growth stages.

Combined effect of varieties and nutrient levels had exerted significant influence on fresh weight of plant (g) at both knob initiation as well as knob harvesting stages. Maximum fresh weight of plant 92.67g and 760.67g was found with treatment combination V_1T_6 at knob initiation and harvesting stages, respectively. Minimum fresh weight of plant i.e. 26.17g and 300.67g was recorded in case of V_2T_1 (White Vienna) at knob initiation and harvesting stages, respectively. The difference between V_1T_6 and V_2T_1 was significant at both the growth stages.

Table 4.3: Effect of varieties, nutrient levels and their interaction on fresh weight (g) per plant of knolkhol

Treatment	Fresh weight (g) per plant	
	Knob initiation	**Knob harvesting**
Varieties (V)		
V_1 (Pusa Virat)	72.31	640.22
V_2 (White Vienna)	29.06	339.69
S.Em±	**1.31**	**11.49**
CD at 5%	**3.85**	**33.71**
Nutrient levels (T)		
T_1	38.92	400.33
T_2	44.08	444.17
T_3	48.42	500.58
T_4	57.42	518.42
T_5	53.33	504.58
T_6	61.92	571.67
S.Em±	**2.27**	**19.91**
CD at 5%	**6.66**	**58.38**
Interaction (V x T)		
V_1T_1	51.67	500.00
V_1T_2	60.00	567.33
V_1T_3	68.17	663.00
V_1T_4	84.67	686.00
V_1T_5	76.67	664.33
V_1T_6	92.67	760.67
V_2T_1	26.17	300.67
V_2T_2	28.17	321.00
V_2T_3	28.67	338.17
V_2T_4	30.17	350.83
V_2T_5	30.00	344.83
V_2T_6	31.17	382.67
S.Em±	**3.21**	**28.15**
CD at 5%	**9.42**	**82.57**

Fig. 5 (a) : Effect of varieties on fresh weight (g) per plant of knolkhol

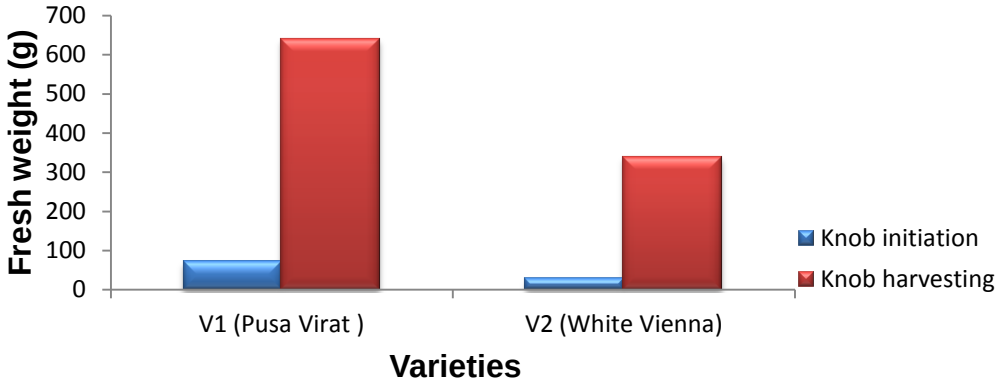


Fig. 5 (b) : Effect of nutrient levels on Fresh weight (g) per plant of knolkhol

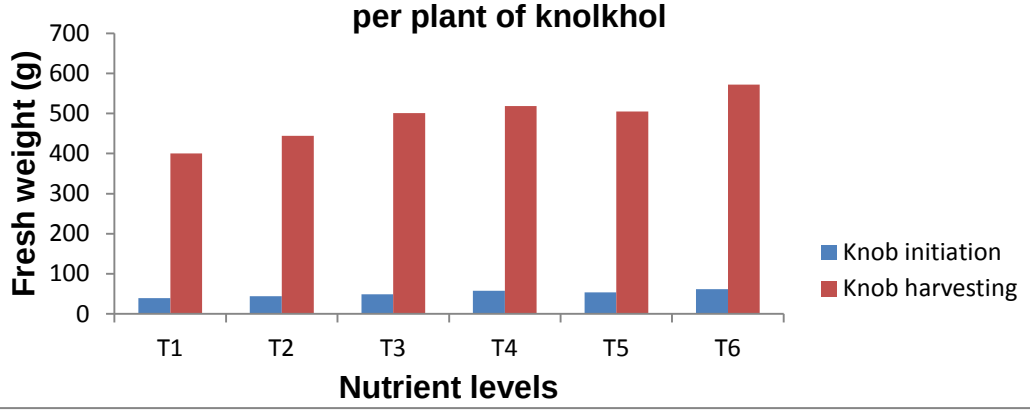
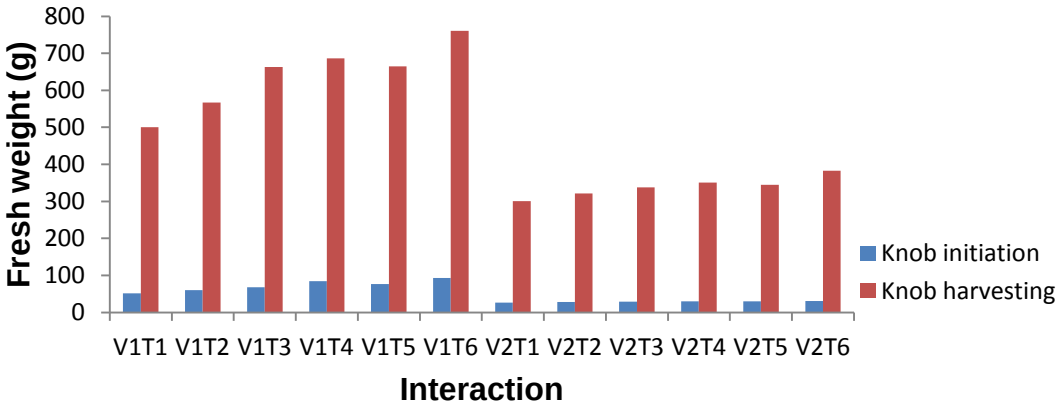


Fig. 5 (c) : Effect of interaction on Fresh weight (g) per plant of knolkhol



4.1.4 Dry weight (g) of plant

The data with respect to dry weight (g) of plant as influenced with varieties and nutrient levels are presented in Table 4.4 and Fig. 6 (a,b,c) Dry weight of plant, was recorded at knob initiation and knob harvesting stages, showed significant effect of varieties and nutrient levels.

The findings revealed significant effect of varieties on dry weight of plant (g) at both knob initiation and knob harvesting stages. Maximum dry weight of plant i.e. 5.94 g and 56.67g was found with variety V_1 (Pusa Virat) at knob initiation and harvesting stages, respectively. Minimum dry weight of plant 3.17 g and 28.24 g was recorded in case of V_2 (White Vienna) at knob initiation and harvesting stages, respectively. The difference between V_1 and V_2 was significant at both the growth stages.

Nutrient levels exerted significant influence on dry weight of plant (g). Maximum dry weight of plant 5.92 g and 52.25 g was recorded with nutrient level T_6 followed by $T_4>T_5>T_3>T_2$ in descending order at all the growth stages. Minimum dry weight of plant i.e. 3.58 g and 33.50 g was recorded in case of T_1 at both the growth stages.

Combined effect of varieties and nutrient levels had significant influence on dry weight of plant (g) at both knob initiation and knob harvesting stages. Maximum dry weight of plant 8.0 g and 69.33 g was found with treatment combination V_1T_6 at knob initiation and harvesting stages, respectively. It was followed by $V_1T_4>V_1T_5>V_1T_3>V_1T_2>V_1T_1>V_2T_6>V_2T_4>V_2T_5>V_2T_3>V_2T_2$. Minimum dry weight of plant 2.5 g and 23.83 g was recorded in case of treatment combination V_2T_1 at knob initiation and harvesting stages, respectively. The treatment combination V_1T_6 was significantly superior over all other combinations at both the growth stages.

Table 4.4 : Effect of varieties, nutrient levels and their interaction on dry weight (g) per plant of knolkhol

Treatment	Dry weight(g)	
	Knob initiation	Knob harvesting
Varieties (V)		
V_1 (Pusa Virat)	5.94	56.67
V_2 (White Vienna)	3.17	28.24
S.Em±	**0.12**	**0.99**
CD at 5%	**0.36**	**2.91**
Nutrient levels (T)		
T_1	3.58	33.50
T_2	4.00	37.00
T_3	4.25	42.75
T_4	5.03	45.88
T_5	4.55	43.33
T_6	5.92	52.25
S.Em±	**0.21**	**1.72**
CD at 5%	**0.63**	**5.04**
Interaction (V x T)		
V_1T_1	4.66	43.17
V_1T_2	5.16	48.50
V_1T_3	5.50	58.67
V_1T_4	6.50	61.50
V_1T_5	5.83	58.83
V_1T_6	8.00	69.33
V_2T_1	2.50	23.83
V_2T_2	2.83	25.50
V_2T_3	3.00	26.83
V_2T_4	3.56	30.27
V_2T_5	3.26	27.83
V_2T_6	3.83	35.17
S.Em±	**0.30**	**2.43**
CD at 5%	**0.89**	**7.12**

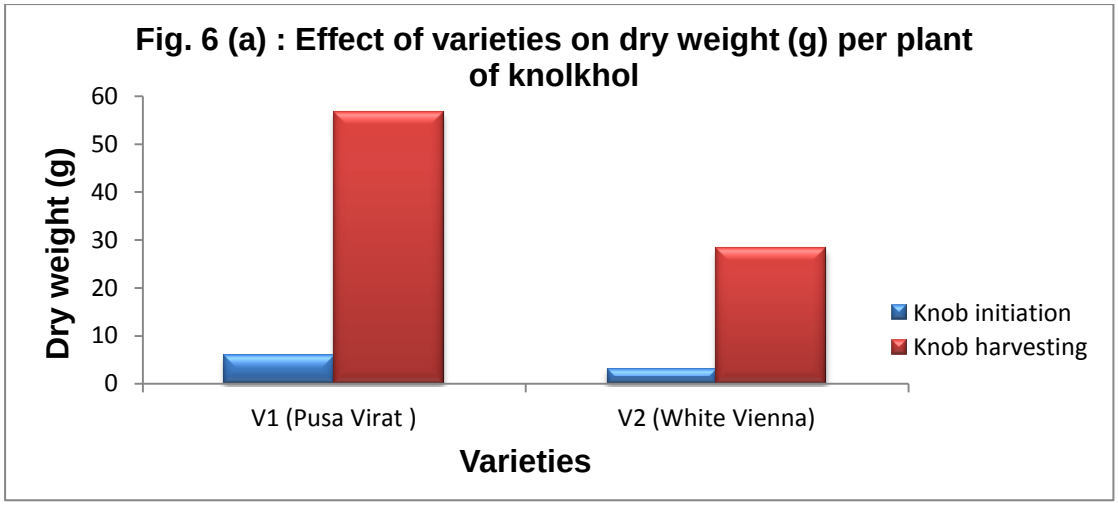


Fig. 6 (a) : Effect of varieties on dry weight (g) per plant of knolkhol
Dry weight (g)
60
50
40
30
20
10
0
V1 (Pusa Virat)
V2 (White Vienna)
Varieties
Knob initiation
Knob harvesting

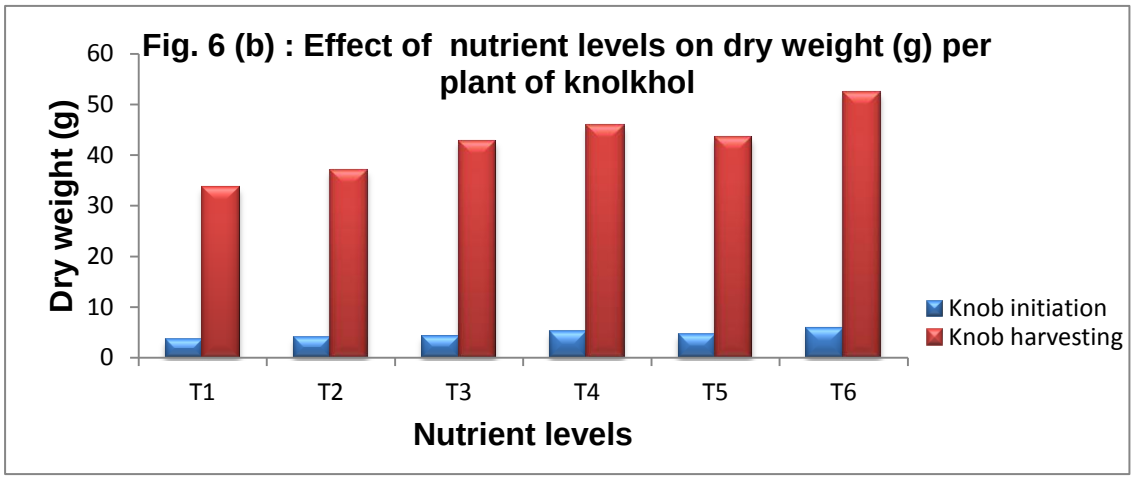


Fig. 6 (b) : Effect of nutrient levels on dry weight (g) per plant of knolkhol
Dry weight (g)
60
50
40
30
20
10
0
T1
T2
T3
T4
T5
T6
Nutrient levels
Knob initiation
Knob harvesting

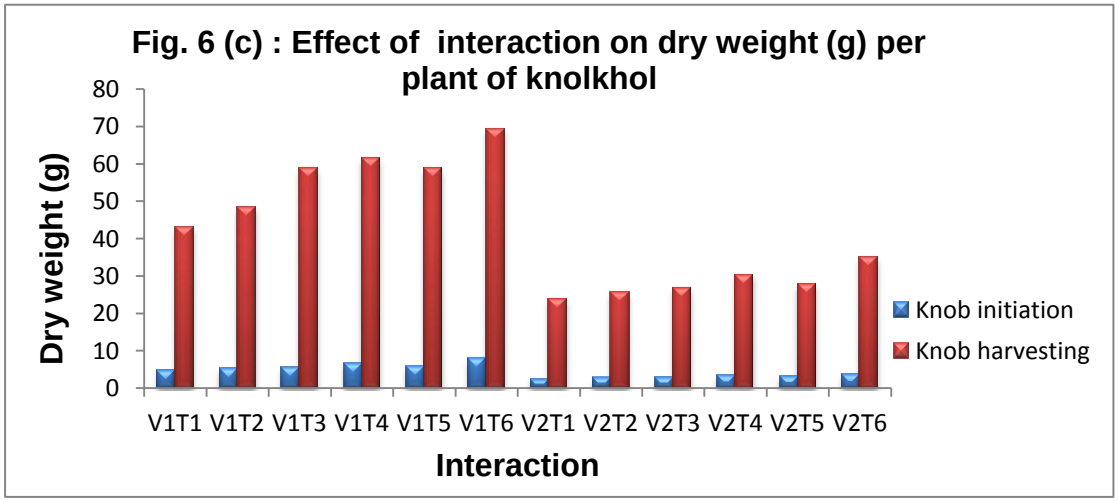


Fig. 6 (c) : Effect of interaction on dry weight (g) per plant of knolkhol
Dry weight (g)
80
70
60
50
40
30
20
10
0
V1T1 V1T2 V1T3 V1T4 V1T5 V1T6 V2T1 V2T2 V2T3 V2T4 V2T5 V2T6
Interaction
Knob initiation
Knob harvesting

4.1.5 Leaf area (cm^2) per plant

Leaf area (cm^2) per plant was measured at knob initiation stage. Perusal of data presented in Table 4.5 and Fig. 7 (a,b,c) indicated significant effect of varieties and nutrient levels on leaf area (cm^2) per plant at knob initiation.

Variety V_1 (Pusa Virat) recorded maximum leaf area per plant i.e. 826.97 cm^2 at knob initiation. Minimum leaf area per plant i.e.436.56 cm^2 was found with variety V_2 (White Vienna). The difference between V_1 and V_2 was significant.

Nutrient levels exerted significant effect on leaf area per plant (cm^2). Nutrient level T_6 recorded maximum leaf area per plant i.e.733.42 cm^2 at knob initiation. It was followed by $T_4>T_5>T_3>T_2$ under study. The difference between T_6 and T_4 was non significant. Minimum leaf area of 533.78 cm^2 per plant was found with T_1 at knob initiation.

Combined effect of varieties and nutrient levels showed significant effect on leaf area per plant at knob initiation. Treatment combination V_1T_6 recorded maximum leaf area per plant i.e. 826.97 cm^2 at knob initiation after transplanting. It was at par to V_1T_4 but significantly superior to all other treatment combinations.

Minimum leaf area per plant was observed under V_2T_1.

Table 4.5: Effect of varieties, nutrient levels and their interaction on leaf area at knob initiation per plant in knolkhol

Varieties	leaf area at knob initiation						
	Nutrient levels						MEAN
	T_1	T_2	T_3	T_4	T_5	T_6	
V_1	670.17	733.77	810.77	946.60	813.60	986.93	**826.97**
V_2	397.40	411.93	415.87	458.37	455.37	479.90	**436.56**
MEAN	**533.78**	**572.85**	**613.32**	**702.48**	**634.75**	**733.42**	

	V	T	Interaction
S.Em ±	**16.23**	**28.10**	**39.74**
$CD_{5\%}$	**47.59**	**82.42**	**116.56**

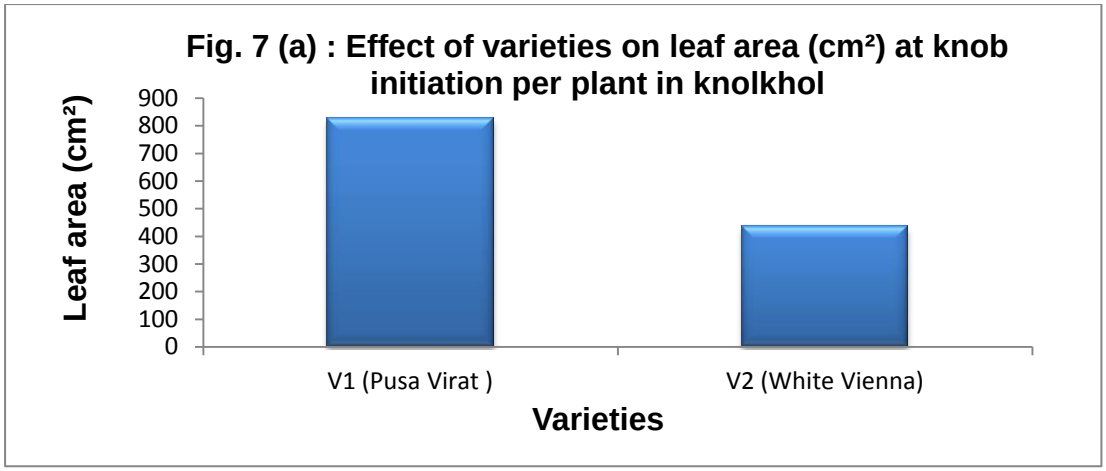


Fig. 7 (a) : Effect of varieties on leaf area (cm²) at knob initiation per plant in knolkhol
Leaf area (cm²)
900
800
700
600
500
400
300
200
100
0
V1 (Pusa Virat)
V2 (White Vienna)
Varieties

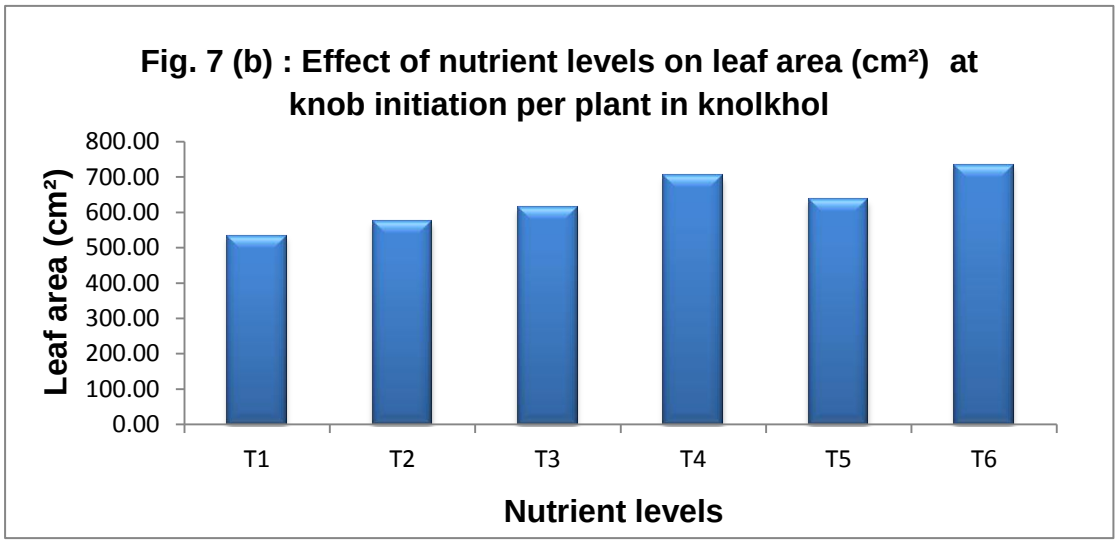


Fig. 7 (b) : Effect of nutrient levels on leaf area (cm²) at knob initiation per plant in knolkhol
Leaf area (cm²)
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
T1
T2
T3
T4
T5
T6
Nutrient levels

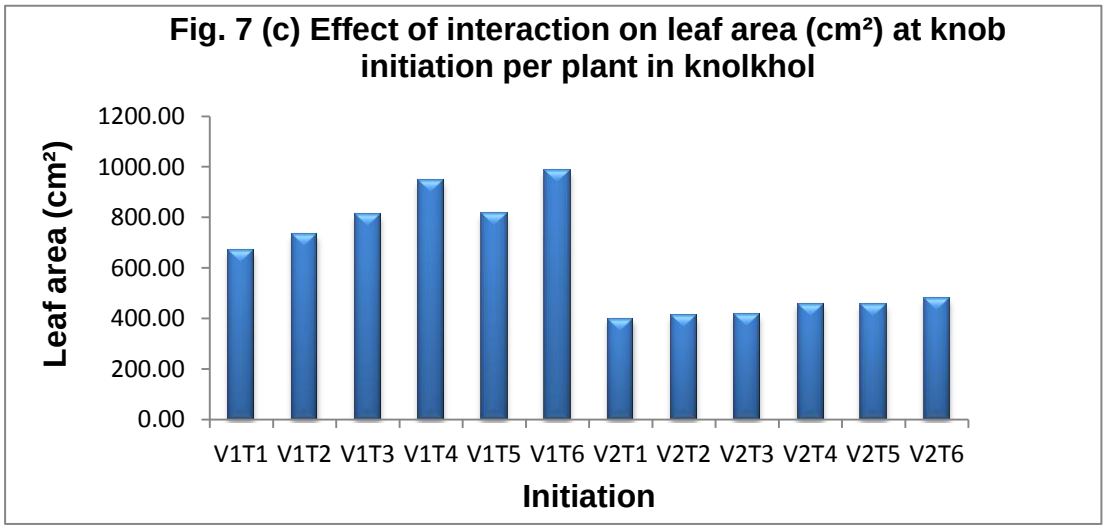


Fig. 7 (c) Effect of interaction on leaf area (cm²) at knob initiation per plant in knolkhol
Leaf area (cm²)
1200.00
1000.00
800.00
600.00
400.00
200.00
0.00
V1T1 V1T2 V1T3 V1T4 V1T5 V1T6 V2T1 V2T2 V2T3 V2T4 V2T5 V2T6
Initiation

4.1.6 SPAD value

SPAD value in leaves was determined at 20, 30 and 45 days after transplanting. Perusal of data as given in Table 4.6 and Fig. 8 (a,b,c) revealed significant influence of varieties and nutrient levels at all the stages of study. Combined effect showed non significant influence on SPAD value all the stages.

Among the varieties, maximum SPAD value was found in case of V_1 (Pusa Virat). Lowest SPAD value was observed under V_2 (White Vienna) at all the stages. In general, there was linear increase in SPAD value up to 45 days after transplanting. Variety V_1 had recorded a SPAD value of 50.55, 54.03 and 59.65 while V_2 as 47.75, 50.45 and 56.67 at 20, 30 and 45 days after transplanting, respectively.

Nutrient levels exerted significant effect on SPAD value at all the three growth stages. Nutrient level T_6 recorded maximum SPAD value of plant 52.49, 55.12 and 61.16 at 20, 30 and 45 days after transplanting, respectively. It was followed by T_4>T_5> T_3 > T_2 at all the growth stages under study. Minimum SPAD value of 45.13, 49.03 and 54.93 were found with N_1 at 20, 30 and 45 days after transplanting, respectively.

Combined effect of varieties and nutrient levels had non significant effect on SPAD value at all the stages of crop growth under study. However, numerically treatment combination V_1T_6 had highest SPAD value among the combinations i.e. 54.71, 57.24 and 63.56 at 20, 30 and 45 days after transplanting, respectively. While, treatment combination V_2T_1 had lowest SPAD value of 43.89, 47.64 and 53.57 at 20, 30 and 45 days after transplanting.

Table 4.6: Effect of varieties, nutrient levels and their interaction on SPAD value of knolkhol

Treatment	SPAD Value		
	20 DAT	**30 DAT**	**45 DAT**
Varieties (V)			
V_1 (Pusa Virat)	50.55	54.03	59.65
V_2 (White Vienna)	47.75	50.45	56.67
S.Em±	**0.68**	**0.70**	**0.72**
CD at $_{5\%}$	**1.99**	**2.05**	**2.11**
Nutrient levels (T)			
T_1	45.13	49.03	54.96
T_2	47.62	51.11	56.13
T_3	48.35	52.34	58.56
T_4	51.16	53.26	59.12
T_5	50.15	52.58	59.03
T_6	52.49	55.12	61.16
S.Em±	**1.18**	**1.21**	**1.25**
CD at $_{5\%}$	**3.45**	**3.56**	**3.65**
Interaction (V x T)			
V_1T_1	46.37	50.41	56.35
V_1T_2	48.57	52.06	57.67
V_1T_3	49.18	54.41	59.79
V_1T_4	52.27	55.51	60.34
V_1T_5	52.19	54.56	60.22
V_1T_6	54.71	57.24	63.56
V_2T_1	43.89	47.64	53.57
V_2T_2	46.67	50.17	54.59
V_2T_3	47.51	50.28	57.34
V_2T_4	50.05	51.01	57.89
V_2T_5	48.11	50.60	57.83
V_2T_6	50.27	52.99	58.77
S.Em±	**1.66**	**1.72**	**1.76**
CD at $_{5\%}$	**NS**	**NS**	**NS**

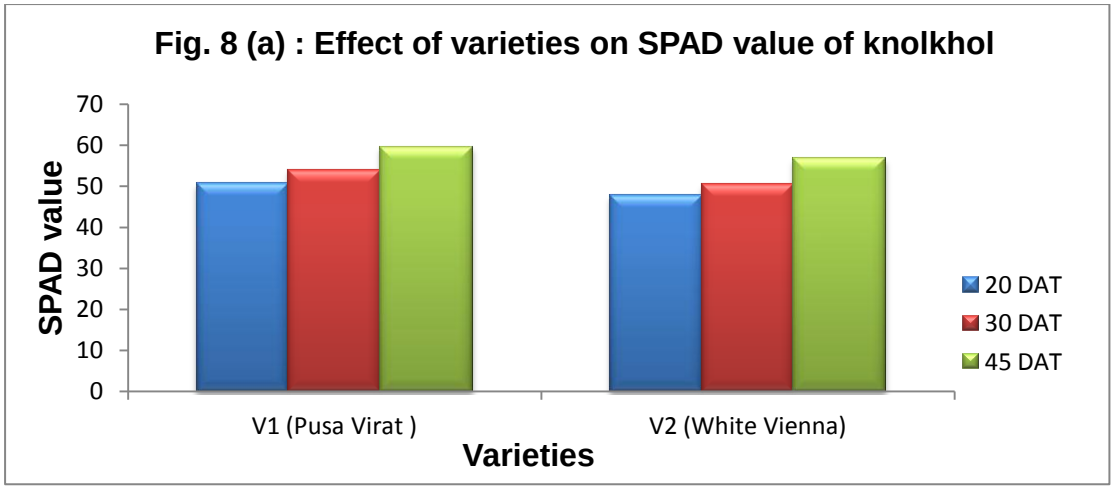


Fig. 8 (a) : Effect of varieties on SPAD value of knolkhol
SPAD value
70
60
50
40
30
20
10
0
V1 (Pusa Virat)
V2 (White Vienna)
Varieties
20 DAT
30 DAT
45 DAT

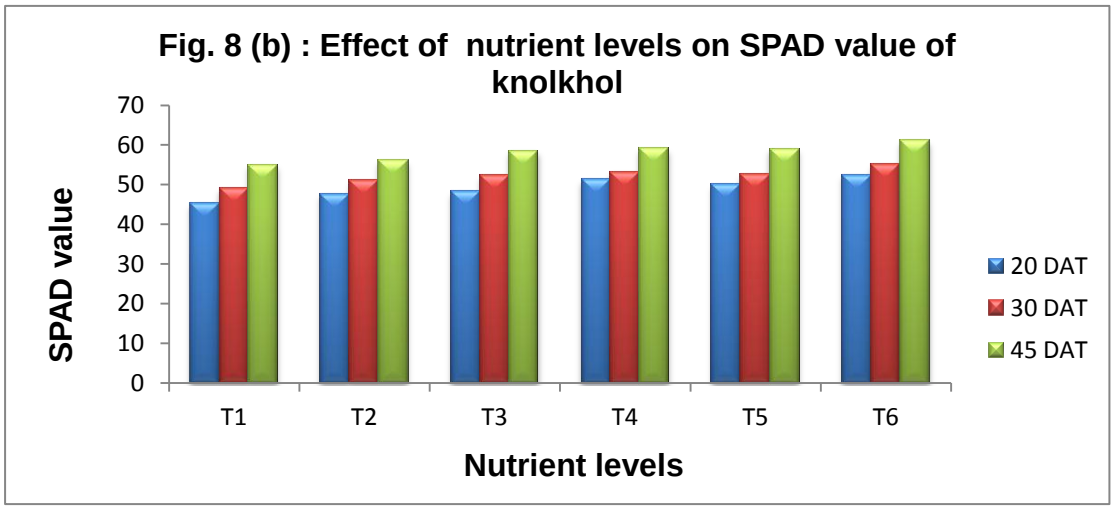


Fig. 8 (b) : Effect of nutrient levels on SPAD value of knolkhol
SPAD value
70
60
50
40
30
20
10
0
T1
T2
T3
T4
T5
T6
Nutrient levels
20 DAT
30 DAT
45 DAT

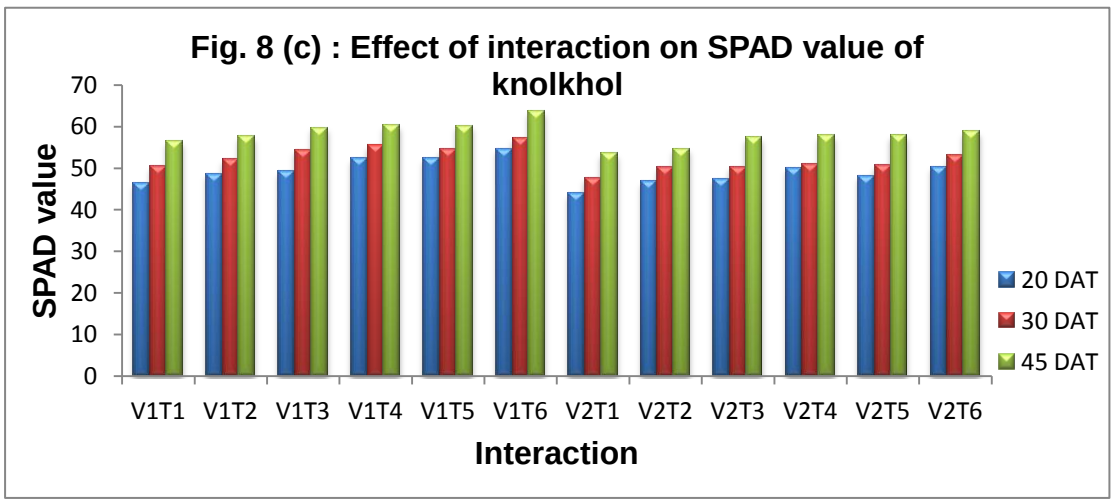


Fig. 8 (c) : Effect of interaction on SPAD value of knolkhol
SPAD value
70
60
50
40
30
20
10
0
V1T1
V1T2
V1T3
V1T4
V1T5
V1T6
V2T1
V2T2
V2T3
V2T4
V2T5
V2T6
Interaction
20 DAT
30 DAT
45 DAT

4.2 Phenological parameters

4.2.1. Days to 50% knob initiation

Data presented in Table 4.7 and Fig. 9 (a,b,c) showed significant influence of varieties as well as nutrient levels on days to 50% knob initiation. The combined effect of varieties and nutrient level was non significant.

Maximum days to 50% knob initiation 43.94 days were taken by variety V_1 (Pusa Virat). Variety V_2 (White Vienna) had recorded earliest knob initiation. It had taken 25.56 days to 50% knob initiation. There was significant difference between V_1 and V_2 with respect to knob initiation.

Application of nutrient levels imposed significant influence on days to 50% knob initiation. Maximum days to 50% knob initiation (37.00) were taken under T_5 nutrient level. It was followed by T_6>T_3 > T_4 and T_1 i.e. 35.17, 35.00, 34.67, and 33.36 days, respectively. Minimum days to 50% knob initiation i.e. 33.00 days were taken in case of nutrient level T_2.The difference between T_5 and T_6 and T_6 and T_4 was non significant.

Table 4.7: Effect of varieties, nutrient levels and their interaction on days to 50% knob initiation in knolkhol

Varieties	Days to 50% knob initiation						
	Nutrient levels						MEAN
	T_1	T_2	T_3	T_4	T_5	T_6	
V_1	42.67	42.00	44.00	43.67	47.00	44.33	**43.94**
V_2	24.67	24.00	26.00	25.67	27.00	26.33	**25.61**
MEAN	**33.67**	**33.00**	**35.00**	**34.67**	**37.00**	**35.17**	

	V	T	Interaction
S.Em ±	**0.43**	**0.74**	**1.05**
$CD_{5\%}$	**1.26**	**2.18**	**NS**

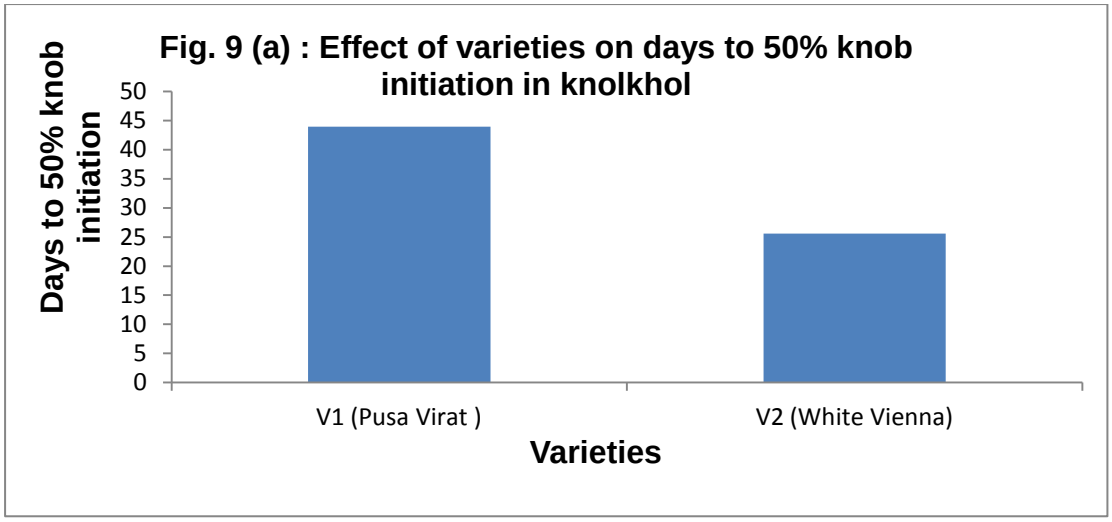


Fig. 9 (a) : Effect of varieties on days to 50% knob initiation in knolkhol
Days to 50% knob initiation
50
45
40
35
30
25
20
15
10
5
0
V1 (Pusa Virat)
V2 (White Vienna)
Varieties

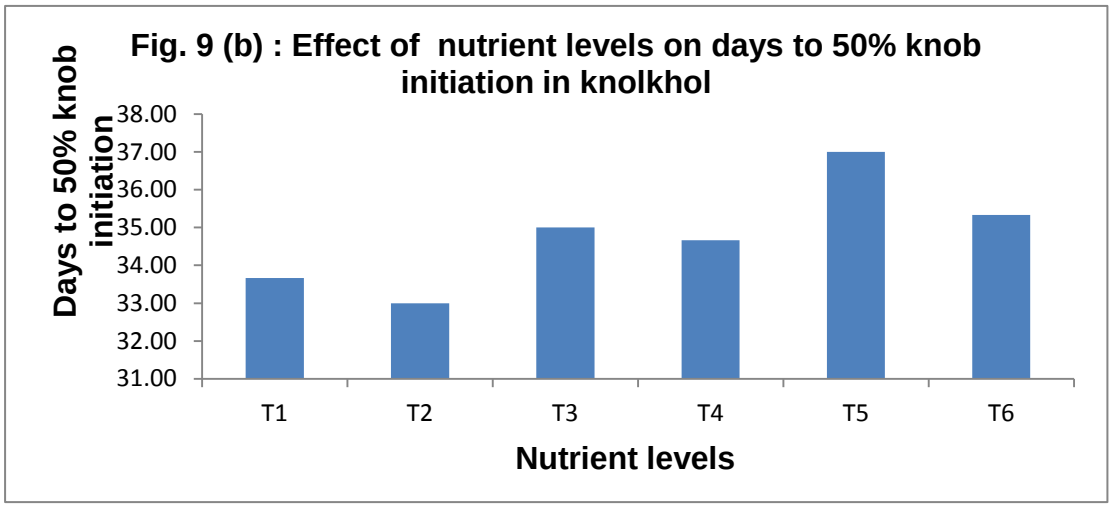


Fig. 9 (b) : Effect of nutrient levels on days to 50% knob initiation in knolkhol
Days to 50% knob initiation
38.00
37.00
36.00
35.00
34.00
33.00
32.00
31.00
T1
T2
T3
T4
T5
T6
Nutrient levels

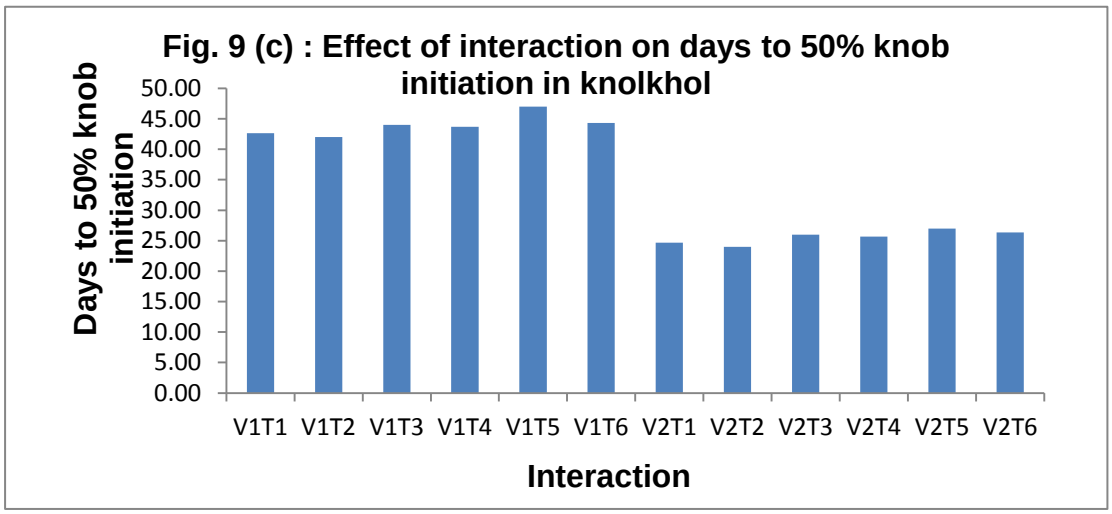


Fig. 9 (c) : Effect of interaction on days to 50% knob initiation in knolkhol
Days to 50% knob initiation
50.00
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
V1T1
V1T2
V1T3
V1T4
V1T5
V1T6
V2T1
V2T2
V2T3
V2T4
V2T5
V2T6
Interaction

4.2.2 Days to knob harvesting

The findings presented in Table 4.8 and depicted in Fig. 10 (a,b,c) registered significant effect of varieties and nutrient levels on days to knob harvesting in knolkhol.

Maximum days to knob harvesting 77.72 days were taken by variety V_1 (Pusa Virat). Variety V_2 (white Vienna) had recorded earliest harvesting. It had taken 59.50 days to knob harvesting. The difference between V_1 and V_2 with respect to days to knob harvesting was significant.

Application of nutrient levels caused significant influence on days to knob harvesting. Maximum days to knob harvesting 72.50 days were taken under T_5 nutrient level. It was followed by T_6>T_3 > T_4> T_1 with 69.67, 69.00, 67.67 and 67.33 days, respectively. Minimum days to knob harvesting (65.50) were taken under nutrient level T_2.

Combined effect of varieties and nutrient levels had non significant effect on days to knob harvesting in knolkhol.

.

Table 4.8: Effect of varieties, nutrient levels and their interaction on days to knob harvesting in knolkhol

Varieties		Days to knob harvesting					MEAN
		Nutrient levels					
	T_1	T_2	T_3	T_4	T_5	T_6	
V_1	76.00	74.00	78.00	76.33	83.00	79.00	**77.72**
V_2	58.67	57.00	60.00	59.00	62.00	60.33	**59.50**
MEAN	**67.33**	**65.50**	**69.00**	**67.67**	**72.50**	**69.67**	

	V	T	Interaction
S.Em ±	**0.80**	**1.39**	**1.97**
$CD_{5\%}$	**2.36**	**4.09**	**NS**

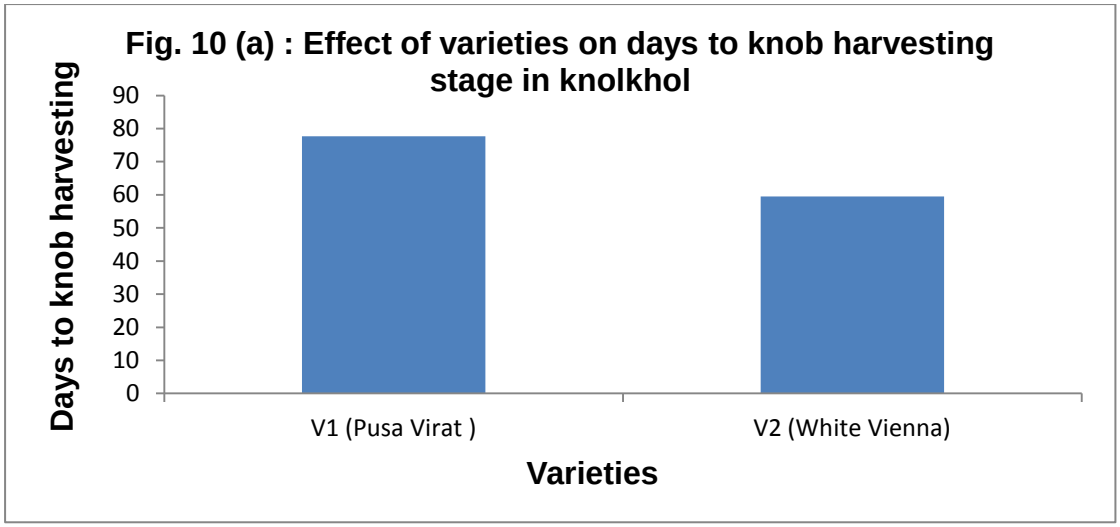


Fig. 10 (a) : Effect of varieties on days to knob harvesting stage in knolkhol
Days to knob harvesting
90
80
70
60
50
40
30
20
10
0
V1 (Pusa Virat)
V2 (White Vienna)
Varieties

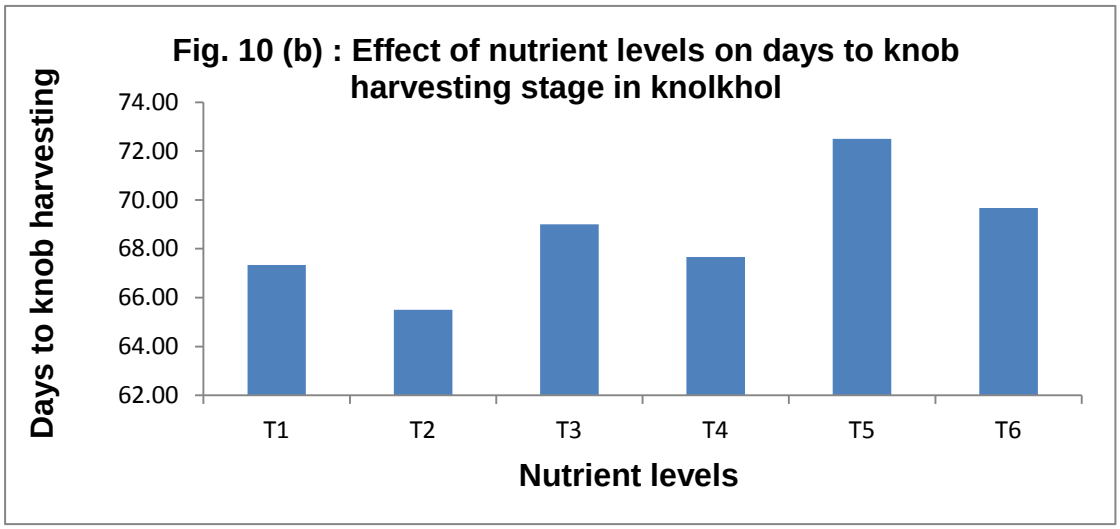


Fig. 10 (b) : Effect of nutrient levels on days to knob harvesting stage in knolkhol
Days to knob harvesting
74.00
72.00
70.00
68.00
66.00
64.00
62.00
T1
T2
T3
T4
T5
T6
Nutrient levels

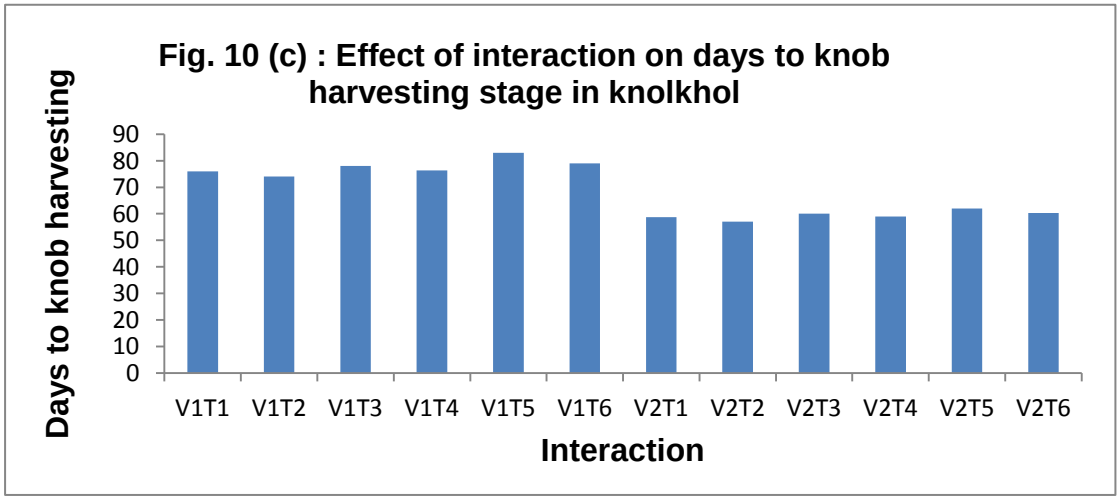


Fig. 10 (c) : Effect of interaction on days to knob harvesting stage in knolkhol
Days to knob harvesting
90
80
70
60
50
40
30
20
10
0
V1T1
V1T2
V1T3
V1T4
V1T5
V1T6
V2T1
V2T2
V2T3
V2T4
V2T5
V2T6
Interaction

4.3 Yield parameters and yield

4.3.1 Knob Length (cm)

The data given in Table 4.9 and Fig. 11(a,b,c) revealed that knob length (cm) was affected significantly with varieties and nutrient levels. Combined effect of varieties and nutrient levels had significant effect on length of knob in knolkhol.

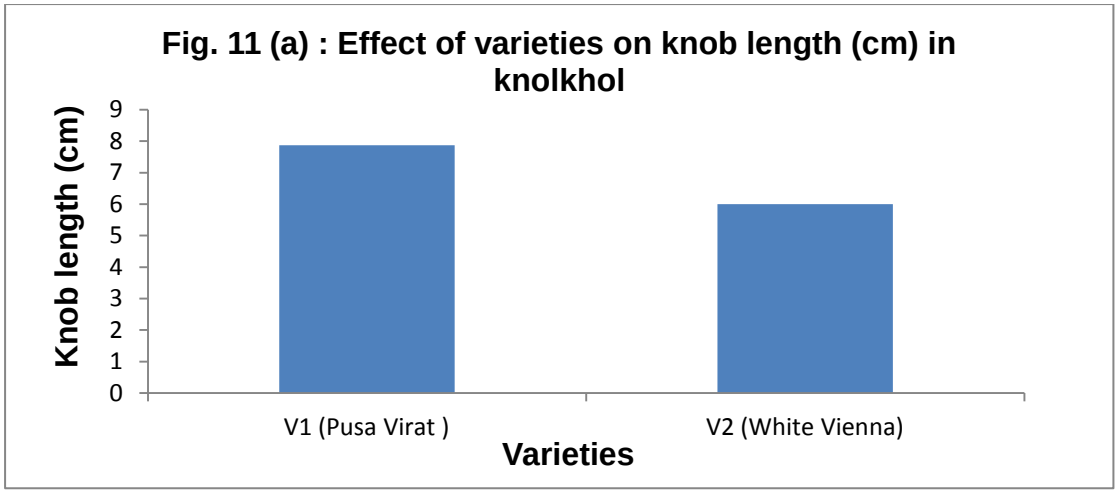
Among the varieties, maximum knob length of 7.87 cm was measured with variety V_1 (Pusa Virat) which was significantly superior over other one. Minimum length of knob 6.0cm was measured in case of variety V_2 (white Vienna).

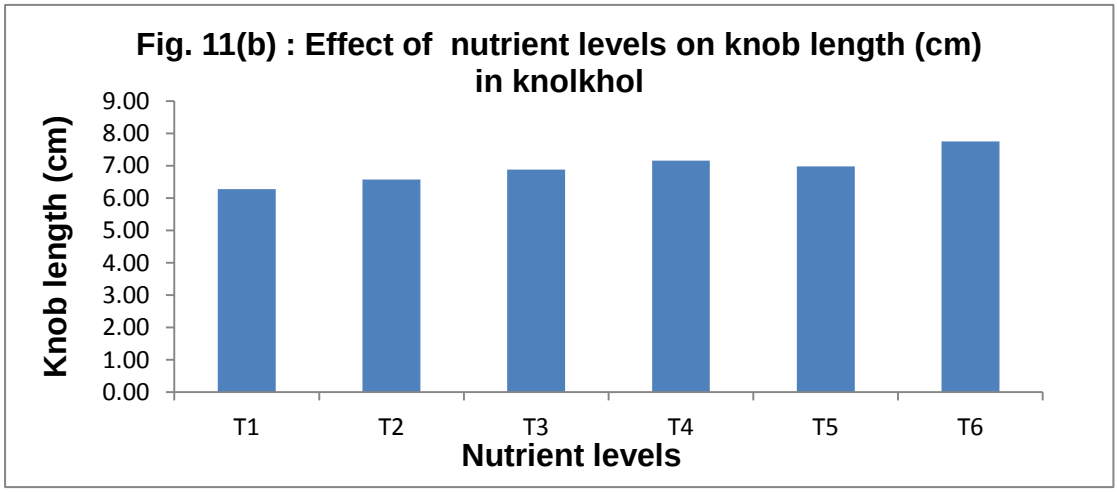
Application of nutrient exhibited positive effect on knob length. Maximum knob length of 7.75 cm was recorded with nutrient level T_6 which is significantly superior over all the nutrient levels. It was followed by $T_4 > T_5 > T_3 > T_2$ with a knob length of 7.15, 6.98, 6.88 and 6.57 cm, respectively. While minimum knob length 6.27 cm was observed under nutrient level T_1.

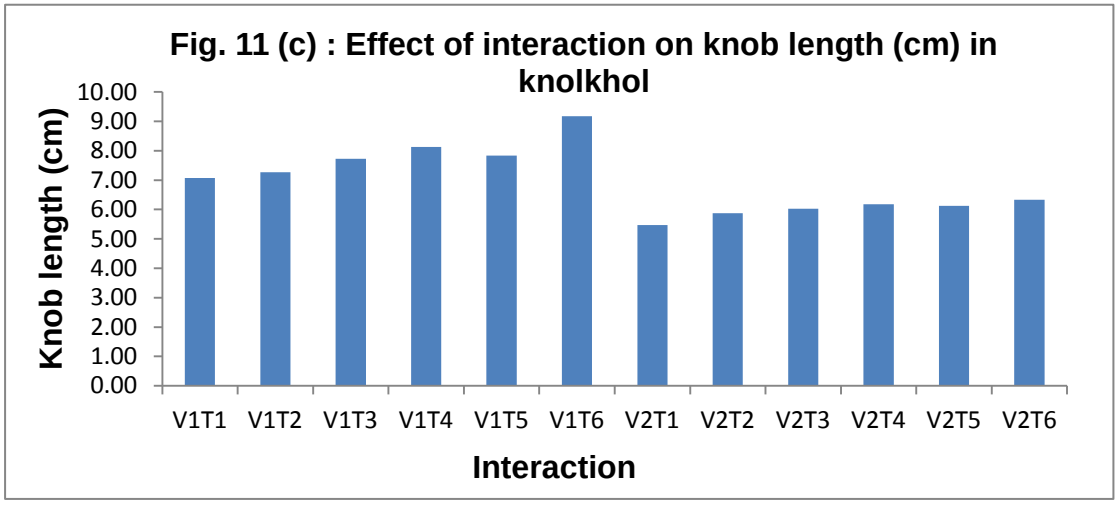
Combined effect of varieties and nutrient levels had significant effect on knob length in knolkhol. Maximum knob length of 9.17cm was found in case of treatment combination V_1T_6 at knob harvesting stage. Minimum knob length of 5.47cm was recorded with treatment combination V_2T_1 at knob harvesting stage.

Table 4.9: Effect of varieties, nutrient levels and their combinations on knob length (cm) in knolkhol

Varieties	knob length (cm)						
	Nutrient levels						MEAN
	T_1	T_2	T_3	T_4	T_5	T_6	
V_1	7.07	7.27	7.73	8.13	7.84	9.17	**7.87**
V_2	5.47	5.87	6.03	6.18	6.12	6.33	**6.00**
MEAN	**6.27**	**6.57**	**6.88**	**7.15**	**6.98**	**7.75**	
	V	**T**	**Interaction**				
S.Em ±	**0.09**	**0.16**	**0.22**				
$CD_{5\%}$	**0.27**	**0.46**	**0.65**				







4.3.2 Knob diameter (cm)

Knob diameter was measured at knob harvesting stage. The findings presented in Table 4.10 and Fig. 12 (a,b,c) revealed significant effect of varieties and nutrient levels on knob diameter at the harvesting stage.

Amongst varieties, maximum knob diameter of 8.23 cm was measured with variety V_1 (Pusa Virat) which was significantly superior over V_1. Minimum knob diameter of 7.49 cm was measured in case of variety V_2 (White Vienna).

Application of nutrients exerted positive effect on knob diameter. Maximum knob diameter of 8.65 cm was recorded with nutrient level T_6 which is significantly superior over all the nutrient levels. It was followed by $T_4 > T_5 > T_3 > T_2$ with a knob diameter of 8.23, 8.04, 7.96 and 7.38 cm, respectively. While minimum knob diameter of 6.88 cm was observed under nutrient level T_1.

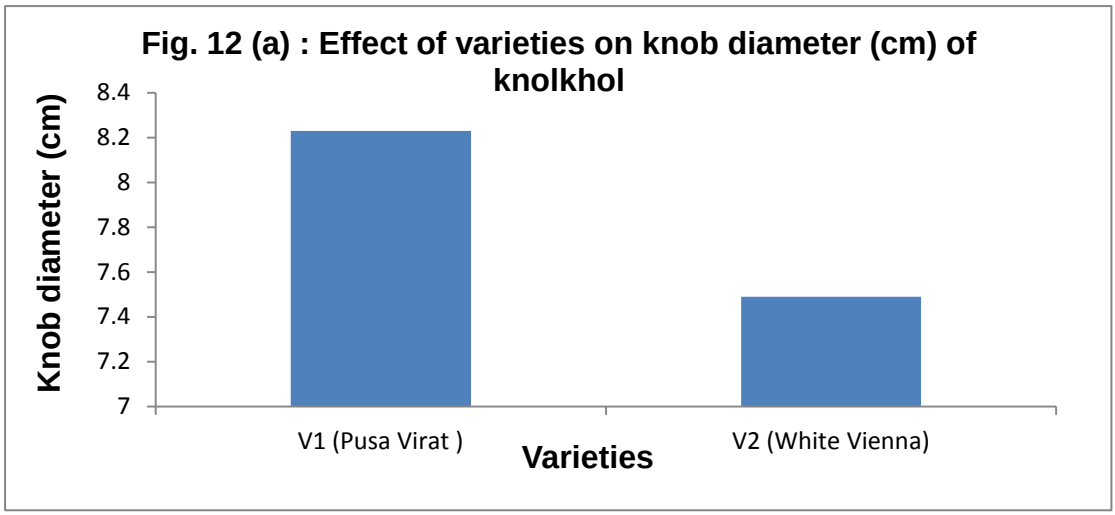
Combined effect of varieties and nutrient levels had non significant effect on knob diameter in knolkhol.

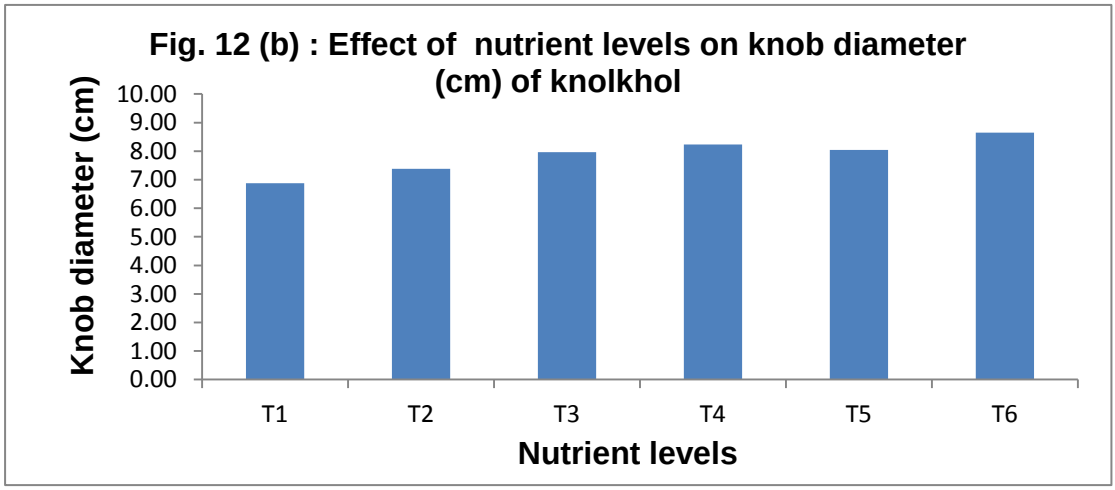
.

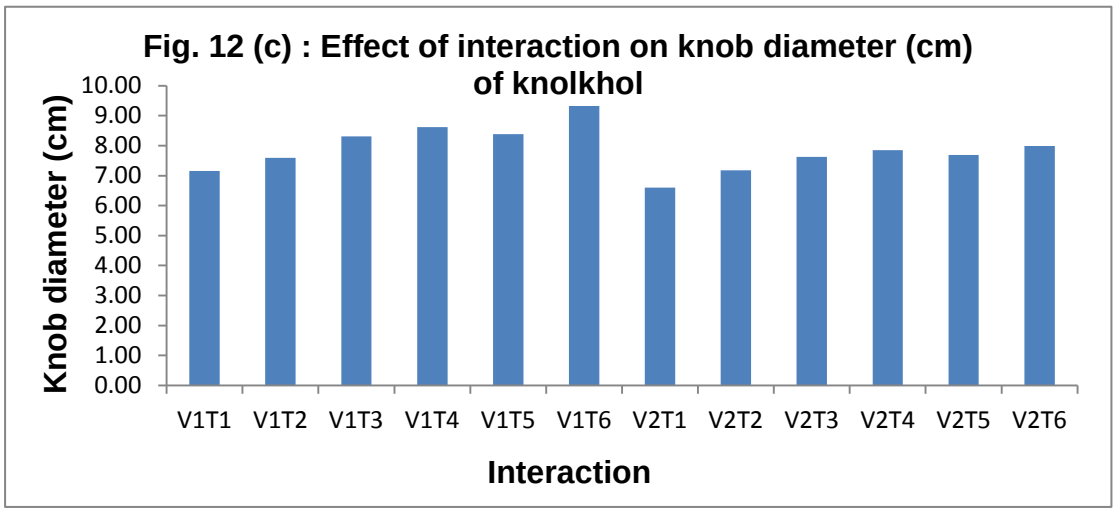
Table 4.10: Effect of varieties, nutrient levels and their combinations on knob diameter (cm) in knolkhol

Varieties	Knob diameter (cm)						
	Nutrient levels						MEAN
	T_1	T_2	T_3	T_4	T_5	T_6	
V_1	7.15	7.59	8.31	8.62	8.38	9.32	**8.23**
V_2	6.60	7.18	7.62	7.85	7.69	7.98	**7.49**
MEAN	**6.88**	**7.38**	**7.96**	**8.23**	**8.04**	**8.65**	

	V	T	Interaction
S.Em ±	**0.11**	**0.19**	**0.27**
$CD_{5\%}$	**0.32**	**0.55**	**NS**







4.3.3 Knob weight (g)

The average weight of knob was recorded at harvesting stage. The data presented in Table 4.11 and Fig. 13 (a,b,c) indicated significant effect of varieties and nutrient levels on weight of knob. The interaction effect of varieties and nutrient levels was significant.

Among the varieties, maximum weight of knob 308.17g was recorded with variety V_1. Minimum weight of knob 214.65g was observed in case of variety V_2.

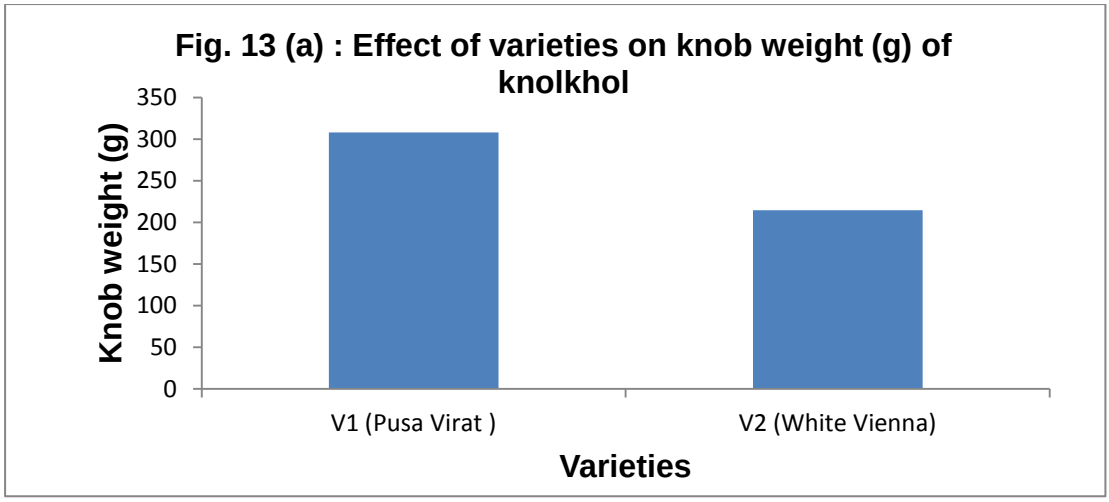
Nutrient levels exerted significant effect on knob weight at harvesting stage. Maximum weight of knob 311.03g was recorded with application of Nutrient level T_6. It was followed by $T_4 > T_5 > T_3 > T_2$ under study. Minimum knob weight 207.65 was found with T_1 at harvesting stage.

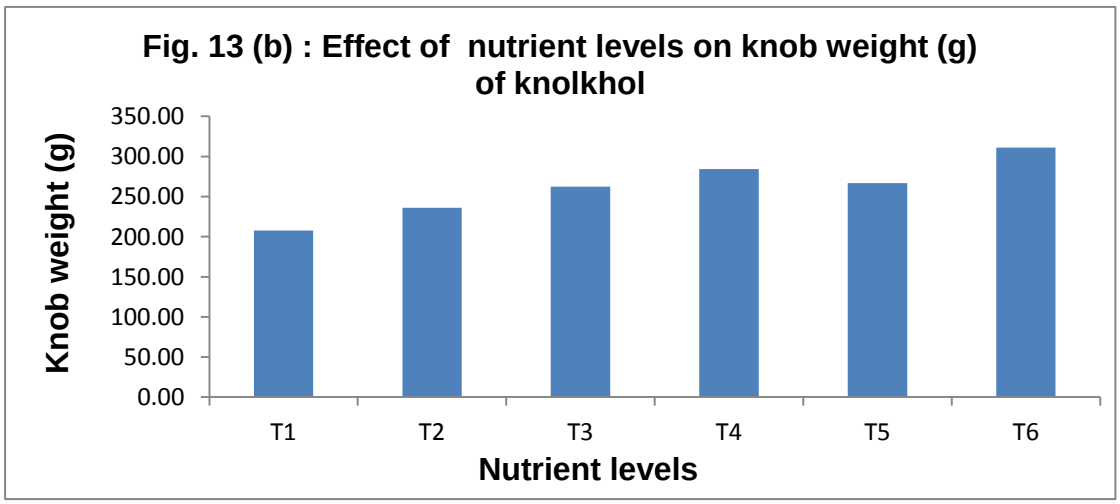
Combined effect of varieties and nutrient levels had significant effect on knob weight of knolkhol. Maximum weight of knob 388.53g was found in case of treatment combination V_1T_6 at knob harvesting stage. Minimum weight of knob 185.57g was recorded in case of treatment combination V_2T_1 at knob harvesting stage.

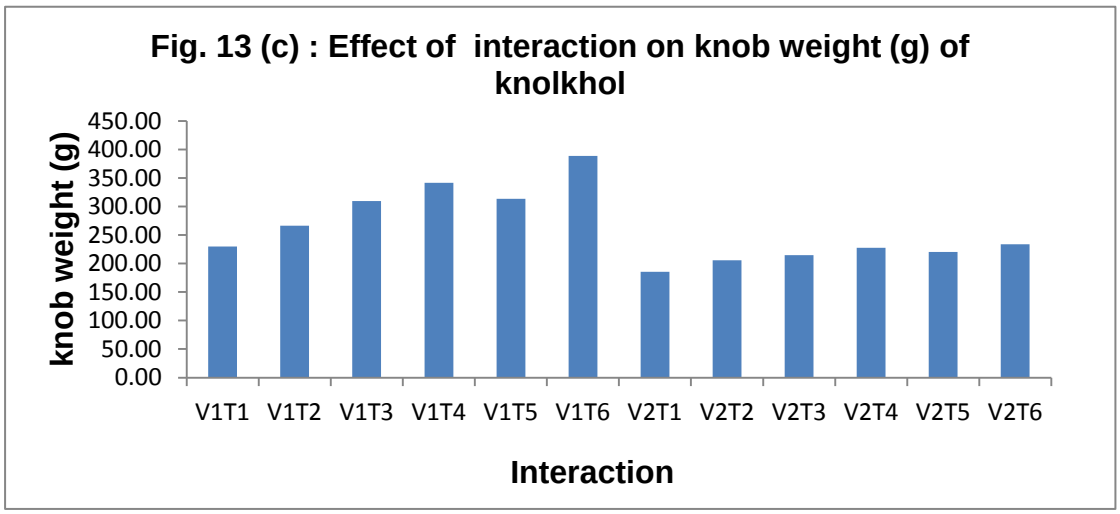
Table 4.11: Effect of varieties, nutrient levels and their interaction on knob weight (g) of knolkhol.

Varieties	Knob weight (g) per plant						
	Nutrient levels						MEAN
	T_1	T_2	T_3	T_4	T_5	T_6	
V_1	229.73	266.47	309.67	341.27	313.33	388.53	**308.17**
V_2	185.57	205.80	214.93	227.70	220.37	233.53	**214.65**
MEAN	**207.65**	**236.13**	**262.30**	**284.48**	**266.85**	**311.03**	

	V	T	Interaction
S.Em ±	**6.52**	**11.28**	**15.96**
$CD_{5\%}$	**19.11**	**33.09**	**46.80**







4.3.4 Marketable knobs yield (q/ha)

The findings presented in Table 4.12 and depicted in Fig. 14(a,b,c) showed the marketable knobs yield as influenced by varieties and nutrient levels at harvesting stage. It is evident from results that individual effect of varieties and nutrient levels on marketable knobs yield at the harvesting stage was significant.

Variety V_1 recorded maximum marketable knobs yield 338.52 q/ha. Minimum marketable knobs yield of 276.34q/ha was found in case of variety V_2.

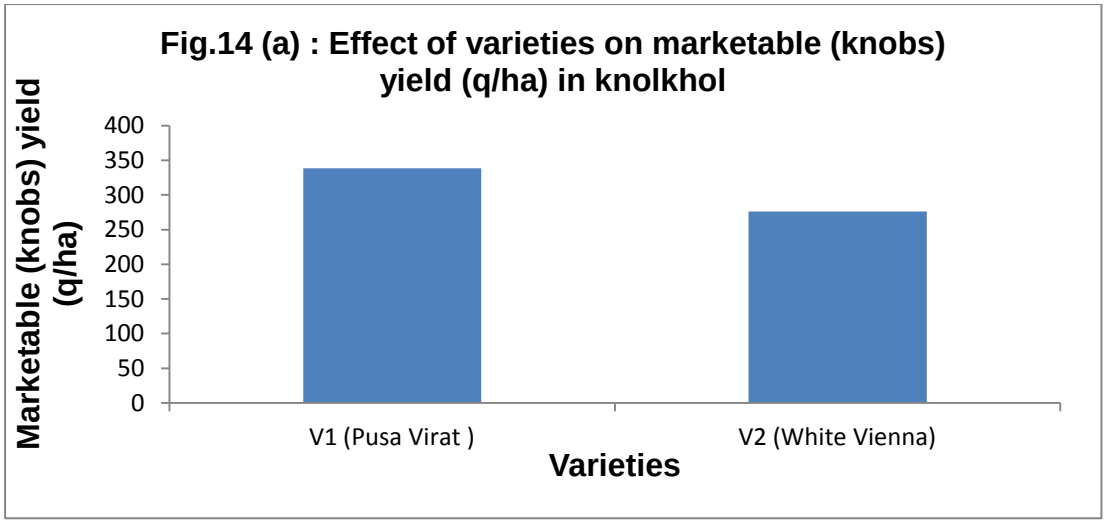
Application of nutrients exhibited positive effect on marketable knobs yield. Maximum marketable knobs yield of 373.37q/ha was recorded with nutrient level T_6 which is significantly superior over all the nutrient levels. It was followed by T_4>T_5> T_3 > T_2 with a marketable knob yield of 342.33, 328.62, 314.42 and 255.65 q/ha, respectively. While minimum marketable knobs yield (230.22 q/ha) was observed under nutrient level T_1.

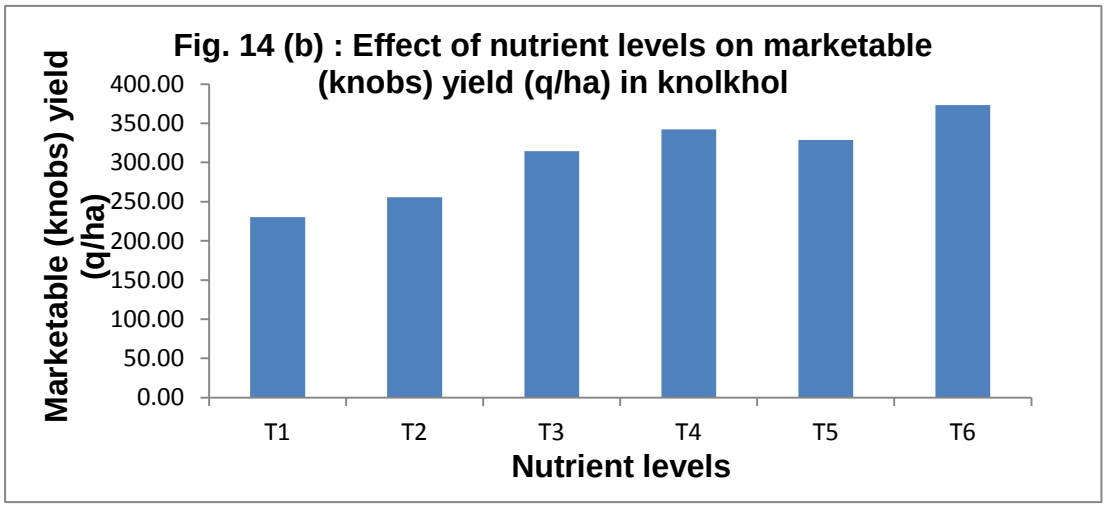
Combined effect of varieties and nutrient levels indicated significant influence on marketable knobs yield in the present study. Highest marketable knobs yield (435.27q/ha) was obtained with treatment combination V_1T_6. It was significantly superior over all other treatment combinations. Combination V_2T_1 recorded lowest marketable knob yield which was at par to V_2T_2.

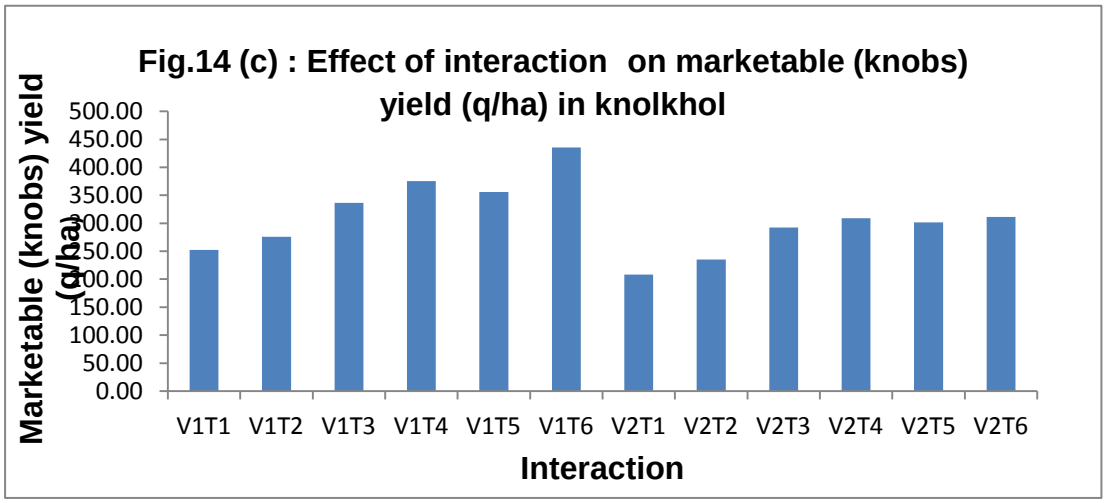
Table 4.12: Effect of varieties, nutrient levels and their combinations on marketable (knobs) yield (q/ha) in knolkhol

Varieties	Marketable (knobs) yield (q/ha)						
	Nutrient levels						MEAN
	T_1	T_2	T_3	T_4	T_5	T_6	
V_1	252.20	275.97	336.27	375.53	355.90	435.27	**338.52**
V_2	208.23	235.33	292.57	309.13	301.33	311.47	**276.34**
MEAN	**230.22**	**255.65**	**314.42**	**342.33**	**328.62**	**373.37**	

	V	T	Interaction
S.Em ±	**5.58**	**9.67**	**13.67**
$CD_{5\%}$	**16.37**	**28.35**	**40.09**







4.3.5 Total (knobs+ leaves) yield (q/ha)

The findings given in Table 4.13 and Fig. 15 (a,b,c) showed the total (knobs+ leaves) yield as influenced by varieties and nutrient levels at harvesting stage. It is evident from the results that the individual effect of varieties and nutrient levels on total (knobs+ leaves) yield q/ha at the harvesting stage was statistically significant.

The data showed that variety V_1 recorded highest total (knobs+ leaves) yield (538.89 q/ha). Minimum total (knobs+ leaves) yield 459.06 q/ha was recorded in case of variety V_2. The difference between V_1 and V_2 was significant.

Application of nutrients exhibited positive effect on total (knobs+ leaves) yield. Maximum total (knobs+ leaves) yield 592.30 q/ha was recorded with nutrient level T_6 which is significantly superior over all the nutrient levels. It was followed by $T_4 > T_5 > T_3 > T_2$ with a total (knobs+ leaves) yield of 531.25, 516.27, 492.63 and 451.12 q/ha, respectively. While minimum total (knobs+ leaves) yield 410.28q/ha was observed under nutrient level T_1.

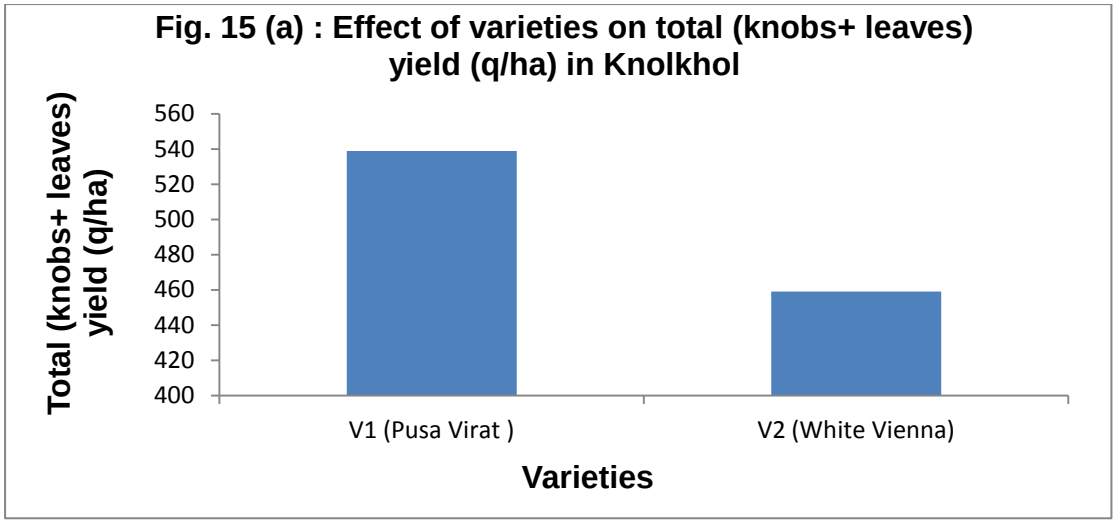
Combined effect of varieties and treatment level indicated significant influence on total (knobs+ leaves) yield in the present study. Highest total (knobs+ leaves) yield was found with V_1T_6 which was significantly superior over all other treatment combinations. It was followed by $V_1T_4 > V_1T_5 > V_1T_3 > V_2T_6 > V_2T_4$. Lowest total (knobs+ leaves) yield was recorded in case of V_2T_1

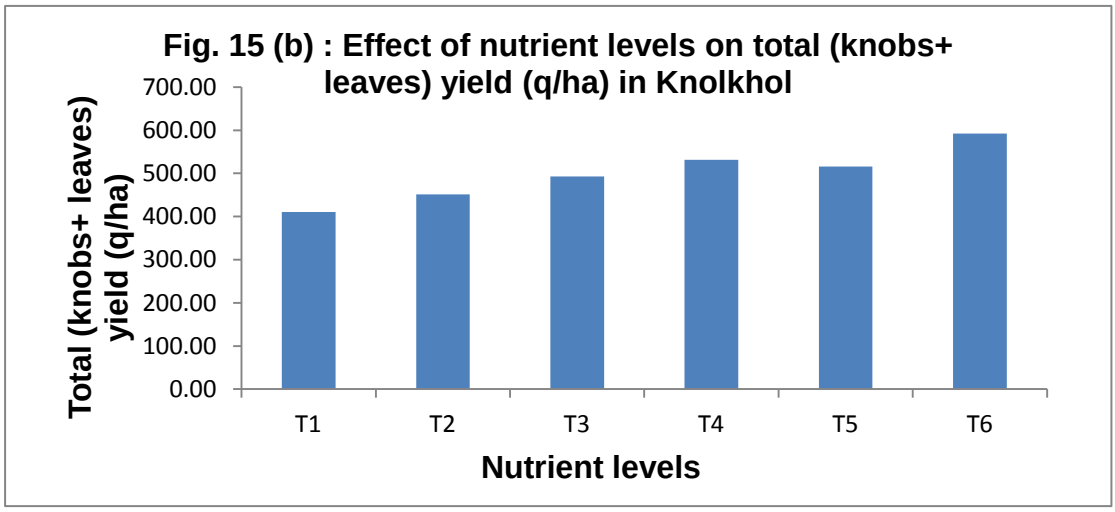
Table 4.13: Effect of varieties, nutrient levels and their combinations on total (knobs+ leaves) yield (q/ha) in knolkhol

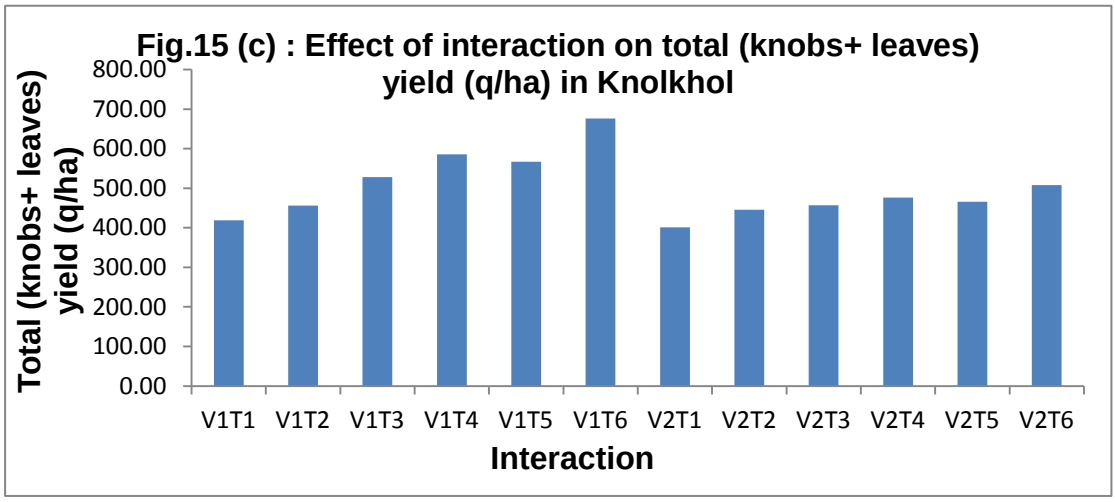
Varieties	Total (knobs+ leaves) yield (q/ha)

	Nutrient levels						MEAN
	T_1	T_2	T_3	T_4	T_5	T_6	
V_1	419.33	456.53	527.90	585.87	567.03	676.70	**538.89**
V_2	401.23	445.70	457.37	476.63	465.50	507.90	**459.06**
MEAN	**410.28**	**451.12**	**492.63**	**531.25**	**516.27**	**592.30**	

	V	T	Interaction
S.Em ±	**10.57**	**18.30**	**25.88**
$CD_{5\%}$	**30.99**	**53.67**	**75.91**







4.4 Quality parameters

4.4.1 Dry matter (%)

The findings of the present experiment (Table 4.14 and Fig. 16 (a,b,c)) revealed significant effect of varieties as well as nutrient levels on dry matter content in knolkhol plant at both knob initiation and knob harvesting stages.

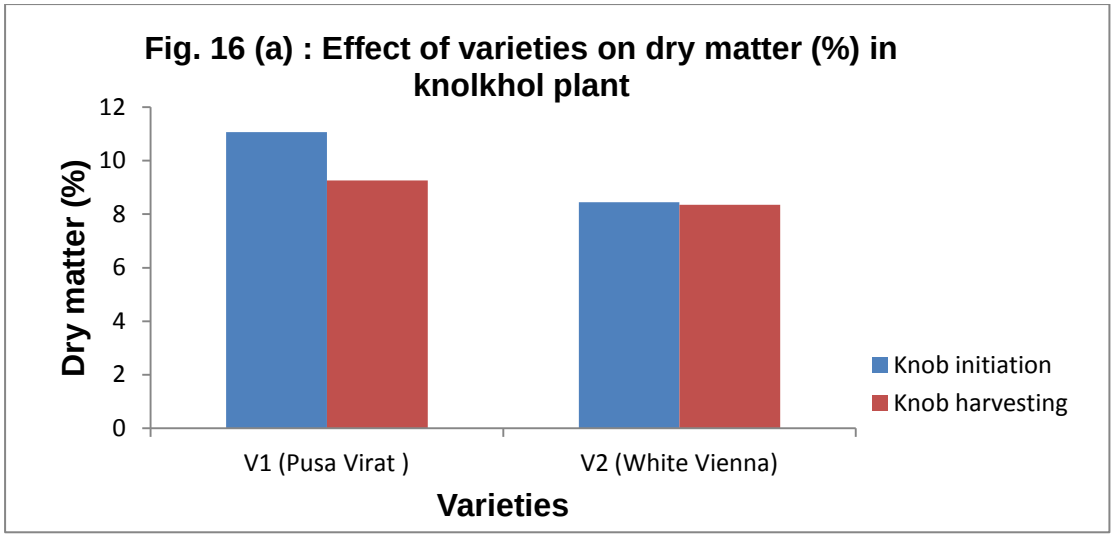
Among the varieties, maximum dry matter content of 11.06 and 9.26% was determined with V_1 at knob initiation and knob harvesting stage, respectively. Variety V_2 registered minimum dry matter content of 8.45 and 8.35% at knob initiation and knob harvesting stage, respectively.

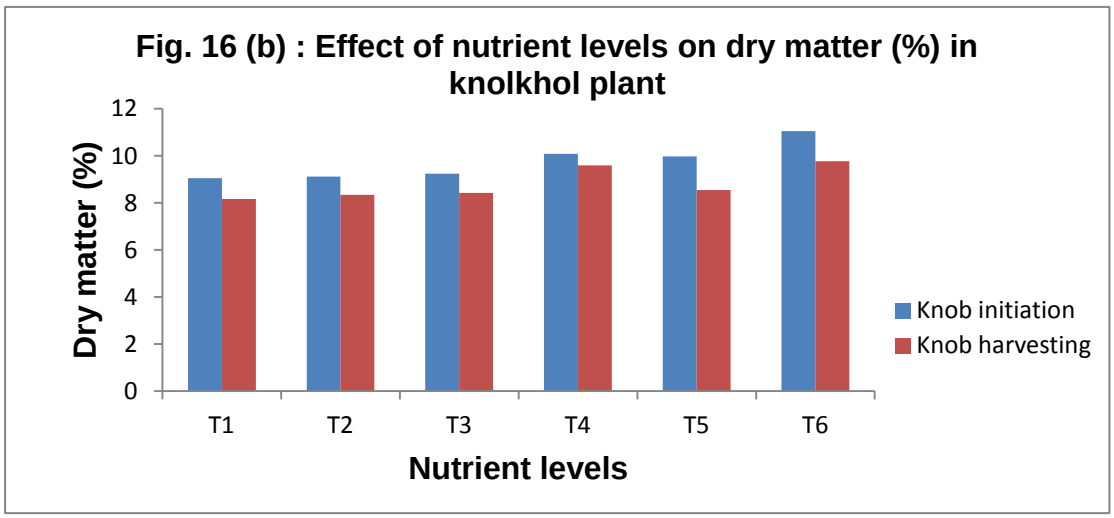
Application of nutrients exhibited positive effect on dry matter (%). Maximum dry matter content of 11.05% at knob initiation and 9.77 % at knob harvesting was recorded with nutrient level T_6 which is significantly superior over all the nutrient levels. It was followed by $T_4 > T_5 > T_3 > T_2$ with a dry matter content of 10.09, 9.97, 9.24, 9.12% at knob initiation and 9.59, 8.55, 8.42, 8.34% at knob harvesting stage, respectively. While minimum dry matter content of 9.05 and 8.17% was observed under nutrient level T_1 at knob initiation and knob harvesting stage, respectively.

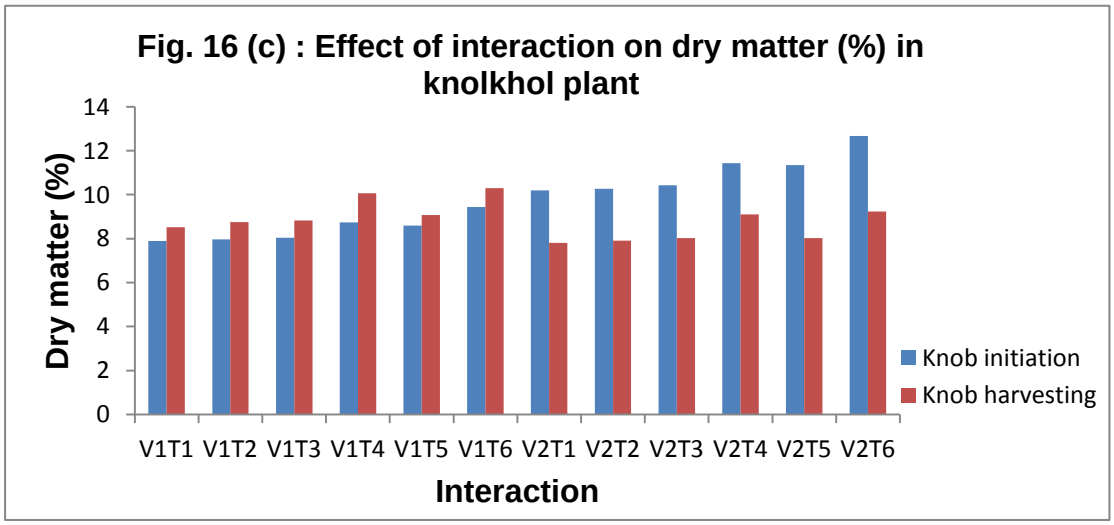
Combined effect of varieties and nutrient levels showed non significant influence on dry matter content (%) in knolkhol at both knob initiation and knob harvesting stages.

Table 4.14: Effect of varieties, nutrient levels and their interaction on dry matter (%) in knolkhol plant

Treatment	Dry matter (%)	
	Knob initiation	Knob harvesting
Varieties (V)		
V_1 (Pusa Virat)	11.06	9.26
V_2 (White Vienna)	8.45	8.35
S.Em±	**0.57**	**0.22**
CD at 5%	**1.67**	**0.64**
Nutrient levels (T)		
T_1	9.05	8.17
T_2	9.12	8.34
T_3	9.24	8.42
T_4	10.09	9.59
T_5	9.97	8.55
T_6	11.05	9.77
S.Em±	**0.40**	**0.38**
CD at 5%	**1.18**	**1.12**
Interaction (V x T)		
V_1T_1	7.90	8.52
V_1T_2	7.96	8.76
V_1T_3	8.04	8.82
V_1T_4	8.74	10.07
V_1T_5	8.59	9.07
V_1T_6	9.44	10.29
V_2T_1	10.20	7.81
V_2T_2	10.27	7.91
V_2T_3	10.43	8.02
V_2T_4	11.44	9.10
V_2T_5	11.34	8.03
V_2T_6	12.67	9.24
S.Em±	**0.57**	**0.54**
CD at 5%	**1.67**	**1.58**







4.4.2 Ascorbic acid (mg/100g)

The findings of the present experiment (Table 4.15 and Fig. 17(a,b,c)) denoted significant effect of varieties, nutrient levels as well as interaction effect of varieties and nutrient levels on ascorbic acid content in knob at harvesting stage.

Among the varieties, maximum ascorbic acid content of 40.80 mg/100g was determined with V_2. Minimum ascorbic acid content of 39.45 mg/100g was noted in case of variety V_1. There was significant difference between V_1 and V_2.

Application of nutrients exhibited positive effect on ascorbic acid content (mg/100g). Maximum ascorbic acid content 44.13 mg/100g was recorded with nutrient level T_6 which was significantly superior over all the nutrient levels. It was followed by $T_4 > T_5 > T_3 > T_2$ with a ascorbic acid content of 42.42, 40.90, 39.42 and 37.40 mg/100g, respectively. While minimum ascorbic acid content (36.48 mg/100g) was observed under nutrient level T_1.

Combined effect of varieties and nutrient level showed non significant influence on ascorbic acid content in knob.

Table 4.15: Effect of varieties, nutrient levels and their interaction on ascorbic acid (mg/100g) in knob

Varieties	ascorbic acid (mg/100g) in knob harvesting stage						
	Nutrient levels						MEAN
	T_1	T_2	T_3	T_4	T_5	T_6	
V_1	35.13	36.47	39.33	41.50	40.80	43.47	**39.45**
V_2	37.83	38.33	39.50	43.33	41.00	44.80	**40.80**
MEAN	**36.48**	**37.40**	**39.42**	**42.42**	**40.90**	**44.13**	

	V	T	Interaction
S.Em ±	**0.37**	**0.65**	**0.92**
$CD_{5\%}$	**1.09**	**1.90**	**NS**

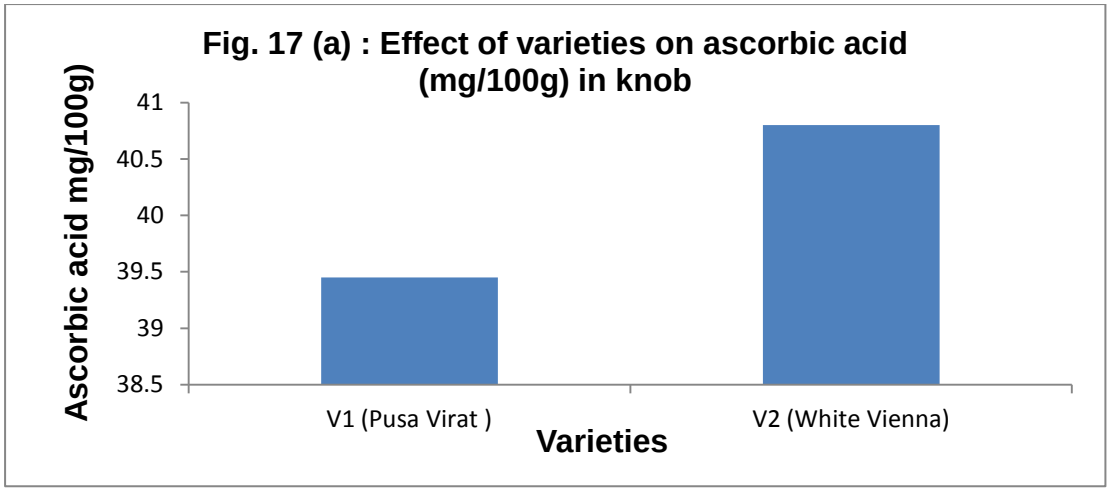


Fig. 17 (a) : Effect of varieties on ascorbic acid (mg/100g) in knob
Ascorbic acid mg/100g)
41
40.5
40
39.5
39
38.5
V1 (Pusa Virat)
V2 (White Vienna)
Varieties

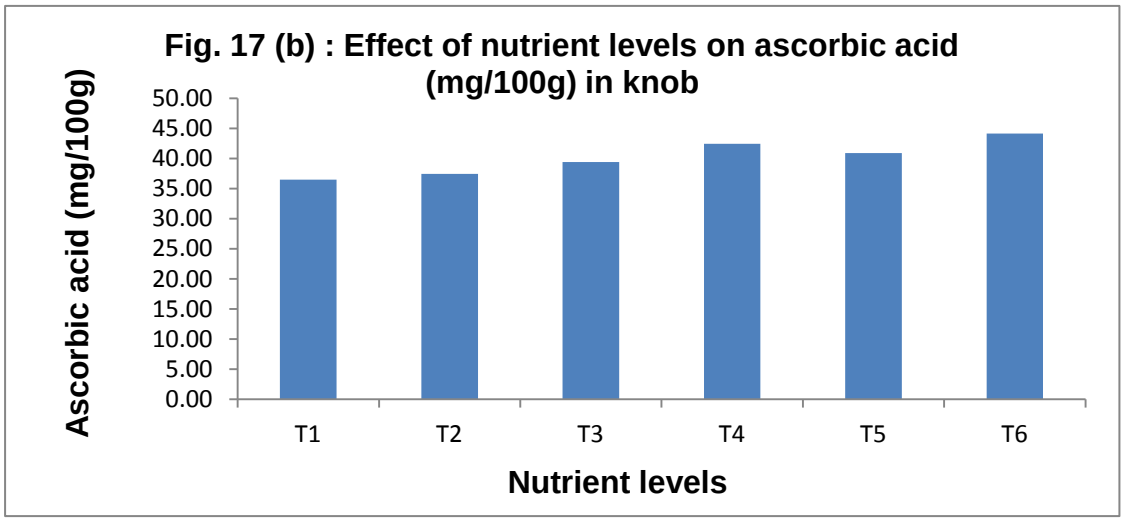


Fig. 17 (b) : Effect of nutrient levels on ascorbic acid (mg/100g) in knob
Ascorbic acid (mg/100g)
50.00
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
T1
T2
T3
T4
T5
T6
Nutrient levels

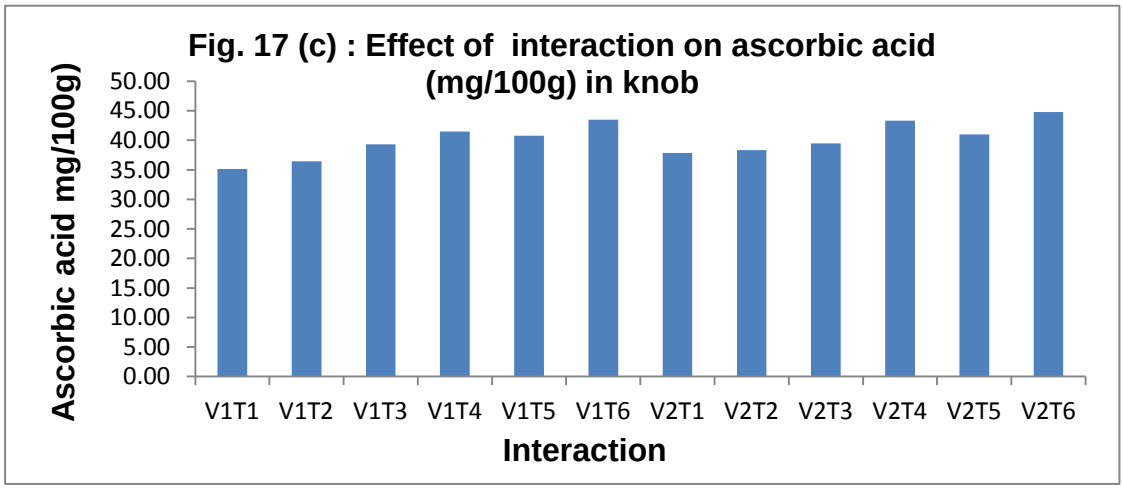


Fig. 17 (c) : Effect of interaction on ascorbic acid (mg/100g) in knob
Ascorbic acid mg/100g)
50.00
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
V1T1
V1T2
V1T3
V1T4
V1T5
V1T6
V2T1
V2T2
V2T3
V2T4
V2T5
V2T6
Interaction

4.4.3 TSS (°Brix)

The findings of the present experiment (Table 4.16 and Fig. 18(a,b,c)) denoted significant effect of varieties, nutrient levels as well as interaction effect of varieties and treatment levels on TSS content in knob.

Among the varieties, maximum TSS content of 7.02°Brix was determined with V_1. Minimum TSS content of 6.79°Brix was noted in case of variety V_2.

Application of nutrients exhibited positive effect on TSS content. Maximum TSS content 7.22°Brix was recorded with nutrient level T_6 which was significantly superior over T_2 and T_1 nutrient levels. N_6 was followed by T_4 >T_5 > T_3 > T_2 with a TSS content of 7.17, 7.08, 6.97 and 6.58°Brix, respectively. While minimum TSS content of 6.42°Brix was observed under nutrient level T_1.

Combined effect of varieties and nutrient levels showed non significant influence on TSS content in knob.

Table 4.16: Effect of varieties, nutrient levels and their interaction on TSS in knob

Varieties	TSS content in knob at harvesting stage.						
	Nutrient levels						MEAN
	T_1	T_2	T_3	T_4	T_5	T_6	
V_1	6.60	6.67	7.10	7.27	7.17	7.30	**7.02**
V_2	6.23	6.50	6.83	7.07	7.00	7.13	**6.79**
MEAN	**6.42**	**6.58**	**6.97**	**7.17**	**7.08**	**7.22**	

	V	T	Interaction
S.Em ±	**0.07**	**0.12**	**0.17**
$CD_{5\%}$	**0.20**	**0.34**	**NS**

Fig. 18. (a) : Effect of varieties on TSS (°Brix) in knob

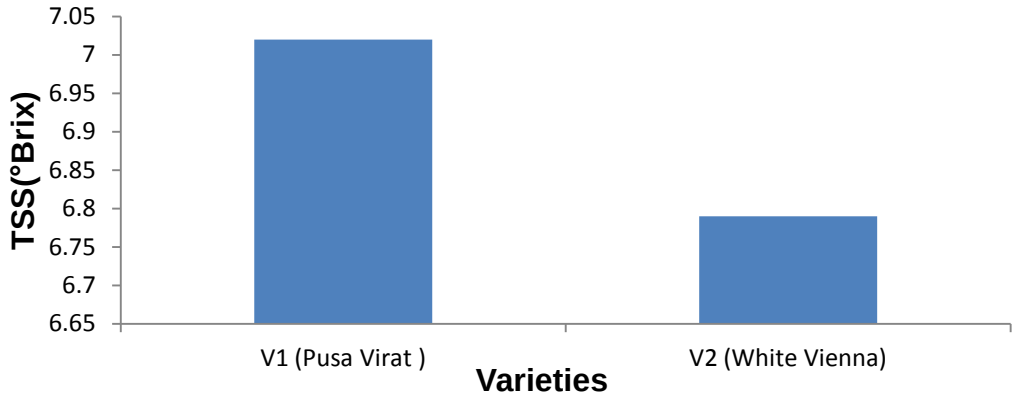


Fig. 18. (b) : Effect of nurtient level onTSS(°Brix) in knob

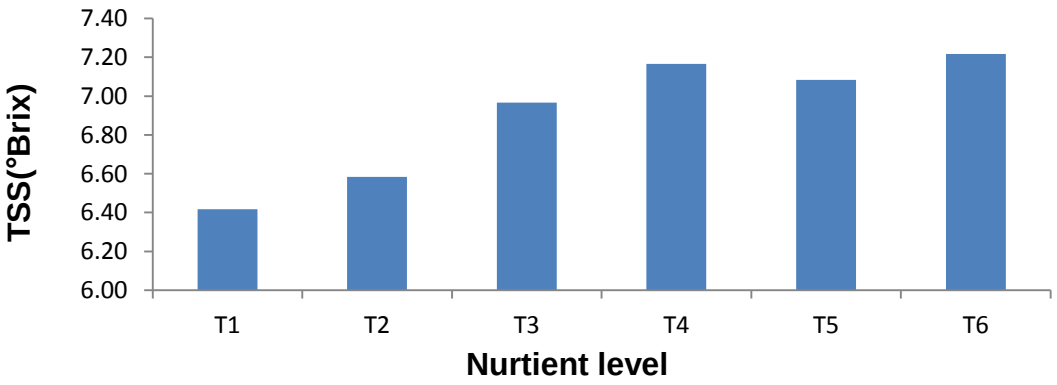
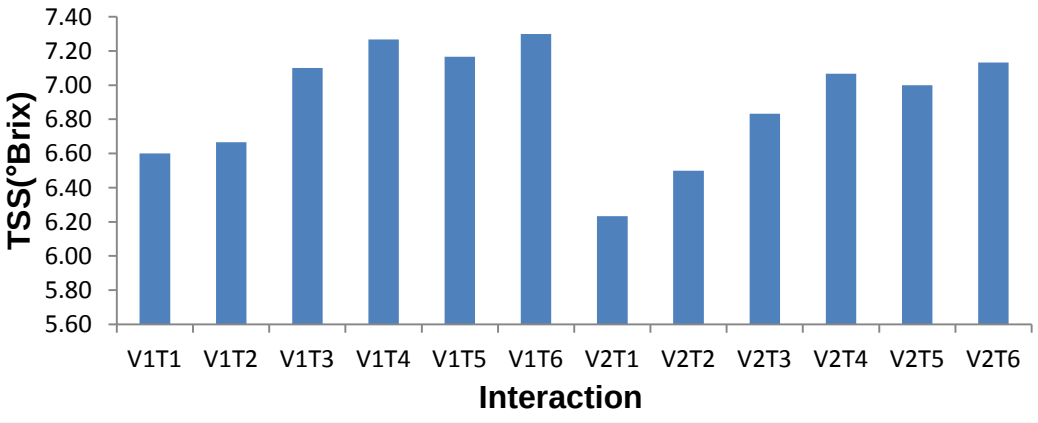


Fig. 18. (c) : Effect of interaction on TSS(°Brix) in knob



4.5 Economics of the different treatments for knolkhol production

The data presented in Table 4.17 showed that cost of cultivation was influenced with nutrient levels. Application of T_6 recorded the highest cost of cultivation followed by $T_4>T_2>T_5>T_3$. While minimum cost of cultivation was found under the nutrient level T_1.

Among the treatment combinations V_1T_6 recorded highest gross income of Rs. 435266.67/ha which was followed by $V_1T_4> V_1T_5> V_1T_3> V_2T_6> V_2T_4> V_2T_5$. Lowest gross income was obtained with V_2T_1.

Highest net return (Rs. 36,3263.1) was realized in case of treatment combination V_1T_6, while lowest net return was found under V_2T_1 (Rs.137230.6) treatment combination. Maximum C: B ratio (1:4.97) was found with V_1T_6 treatment combination followed by $V_1T_4 >V_1T_5> V_1T_3> V_2T_6>V_2T_4$ in descending order. While the minimum C:B ratio (1:1.90) was obtained with V_2T_1 combination.

Table 4.17 : Economics of different treatments

Treatment combination	Common Expenditure (Rs.)	Treatment cost (Rs.)	Total cost of cultivation (Rs./ha)	Yield (q/ha)	Gross income (Rs.)	Net income (Rs.)	C:B Ratio
V_1T_1	67050	3952.73	71002.3	252.20	252200.00	181197.3	1:2.50
V_1T_2	67050	4697.92	71747.9	275.97	275966.67	204218.7	1:2.80
V_1T_3	67050	4080.59	71130.5	336.27	336266.67	265136.1	1:3.67
V_1T_4	67050	4825.98	71875.9	375.53	375533.33	303657.4	1:4.17
V_1T_5	67050	4208.39	71258.3	355.90	355900.00	284641.6	1:3.93
V_1T_6	67050	4953.58	72003.5	435.27	435266.67	363263.1	1:4.97
V_2T_1	67050	3952.73	71002.7	208.23	208233.33	137230.6	1:1.90
V_2T_2	67050	4697.92	71747.9	235.33	235333.33	163585.4	1:2.23
V_2T_3	67050	4080.59	71130.5	292.57	292566.67	221436.1	1:3.07
V_2T_4	67050	4825.98	71875.9	309.13	309133.33	237256.4	1:3.27
V_2T_5	67050	4208.39	71258.3	301.33	301333.33	230074.9	1:3.20
V_2T_6	67050	4953.58	72003.5	311.47	311466.67	239463.1	1:3.30

Fig. 19 Effect of interaction on gross income and net income of knolkhol

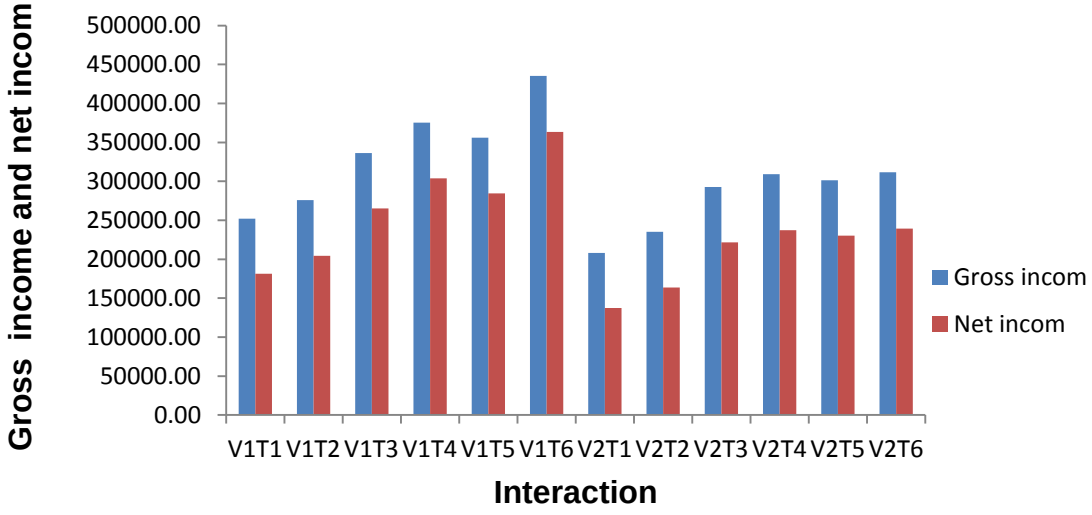
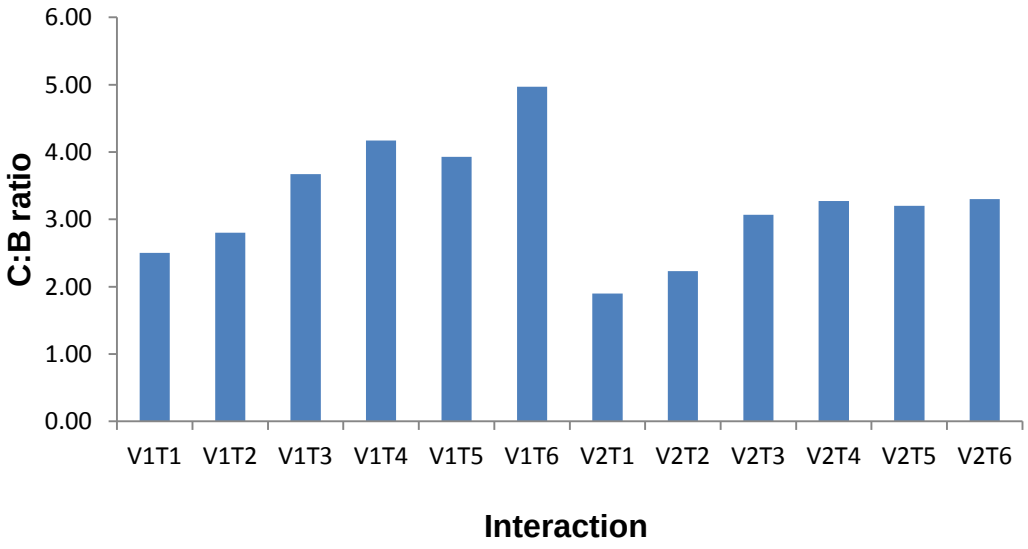


Fig. 20 : Effect of interaction on C:B ratio of knolkhol



CHAPTER- V

DISCUSSION

Chapter- V

DISCUSSION

The results of the present experiment entitled **"Effect of varieties and nutrient levels on growth, yield and quality in knolkhol (*Brassica oleracea var. gongylodes* L.)"** carried out at Vegetable Research Field, College of Horticulture, Mandsaur during 2015-16 are discussed and illustrated, keeping in view the findings of previous workers, under following headings:

5.1 Growth parameters

Growth attributes of knolkhol viz., plant height (cm), number of leaves per plant, fresh weight of plant (g) and dry weight of plant (g) were recorded at knob initiation and knob harvesting stages. SPAD value was observed at 20, 30 and 45 DAT (days after transplanting). Leaf area (cm^2) was noted at knob initiation stage. The results showed significant effect of varieties and nutrient levels on all the growth parameters. While combined effect had influenced fresh weight and dry weight of plant both at knob initiation and harvesting stages and leaf area at knob initiation significantly.

There was increase in plant height with advancement of growth period. The results showed that increase in plant height between knob initiations was rapid as compared to knob harvesting stage.

Among varieties V_2 (White Vienna) recorded more plant height as compared to V_1 at knob initiation stage. It was found to be fast growing. At harvesting stage, maximum plant height of was found in variety V_1 (Pusa Virat). The observed differences in plant height of cultivars are mainly due to the genotype of each cultivar. Similar findings have been also found by Giri *et al.* (2013) and Zaki *et al.* (2015) in broccoli and EI- Bassiony *et al.* (2014) and Chaudhari *et al.* (2015) in kohlrabi.

Nutrient level T_6 has registered maximum plant height at both the growth stages. It was followed by $T_4 > T_5 > T_3 > T_2$, while the minimum plant

height was observed in case of nutrient level T_1. The maximum growth under higher supply of nitrogen might be due to increasing the photosynthetic rates and the assimilation rates, which lead to increase in the plant height of Kohlrabi. These findings are in agreement with those reported by Saleh *et al.* (2013), Shalini *et al.* (2002), Sultana *et al*. (2012) in knolkhol, Thapa and Prasad (2011) in chinese cabbage, Katiyar *et al.* (2011) in broccoli.

Combined effect of varieties and nutrient levels had non significant influence on plant height at both knob initiation and harvesting stages.

Number of leaves varied significantly among the knolkhol varieties. At knob initiation, variety V_2 (White Vienna) recorded maximum number of leaves per plant. Whereas, at harvesting stage, highest number of leaves was observed with V_1 (Pusa Virat). Minimum number of leaves was recorded in case of V_2 (White Vienna) at knob initiation and V_1 (Pusa Virat) at harvesting stages, respectively. The difference between V_1 and V_2 was significant at both the growth stages. This difference in cultivars could be attributed to their genotypes. These results are in line with Arin *et al.* (2003) and EI- Bassiony *et al.* (2014) in kohlrabi, Giri *et al.* (2013) and Zaki *et al.* (2015) in broccoli.

Nutrient levels, had exhibited significant effect on number of leaves per plant. Highest number of leaves per plant was reported under nutrient level T_6 followed by T_4>T_5 >T_3 and T_2. Lower number of leaves per plant was reported under nutrient level T_1. Nitrogen is an integral part of chlorophyll. It is a constituent of all proteins and promotes vigorous vegetative growth and deep colour, while phosphorus and potassium play a vital role in several key physiological processes viz., photosynthesis, respiration, energy storage, cell division and cell enlargement. Therefore the increased number of leaves per plant may be due to balanced fertilization of the crop. Similar results have been reported by Ahmed *et al. (*2003), Talukder *et al*. (2013), Gupta *et al.* (2010), Sultana *et al*. (2012), Saleh *et al.* (2013).

Combined effect of varieties and nutrient levels had non significant influence on number of leaves at both knob initiation and knob harvesting stages.

Among the varieties, maximum leaf area per plant was observed in variety V_1 (Pusa Virat). Minimum leaf area per plant was observed with variety V_2 (White Vienna). Similar results have been found by Arin *et al.* (2003) and Chaudhari *et al*. (2015).

Nutrient levels had exhibited significant effect on leaf area per plant. Highest leaf area per plant was reported under nutrient level T_6 followed by T_4> T_5>T_3>T_2. Lower leaf area per plant was reported in nutrient level T_1. These findings are corroborated with those of Prasad *et al.* (2009), Gupta *et al*. (2010) and Neethu *et al.* (2015).

Combined effect of varieties and nutrient levels showed significant effect on leaf area per plant. Treatment combination V_1T_6 had recorded maximum leaf area per plant. It was at par to V_1T_4 but significantly superior to all other treatment combinations. Minimum leaf area per plant was observed under V_2T_1.

There was increase in SPAD value with advancement of growth period. Among varieties V_1 (Pusa Virat) recorded maximum SPAD value at all the stages of growth. Minimum SPAD value was observed with V_2 (White Vienna).

Nutrient level T_6 has registered maximum SPAD value at all the growth stages. It was followed by T_4>T_5 >T_3 >T_2, while the minimum SPAD value was observed in case of nutrient level T_1. The higher availability of nutrients might have increased chlorophyll content thereby SPAD value under these treatments. These findings are corroborated with those of Saleh *et al.* (2013) and Mishra *et al.* (2014) in knolkhol.

Combined effect of varieties and nutrient levels showed non significant effect on SPAD value in knolkhol.

Maximum fresh weight of plant was found in case of variety V_1 (Pusa Virat) at both knob initiation and harvesting stages. Minimum fresh weight of plant was recorded in case of V_2 (White Vienna) at both the stages. The difference between V_1 and V_2 was significant at both the growth stages. The variation in fresh weight of plant under cultivars may be attributed to their genetic architecture. These finding are corroborated with those reported by EI- Bassiony *et al.* (2014) in kohlrabi and Zaki *et al.* (2015) in broccoli.

Application of nutrient level T_6 resulted in maximum fresh weight of plant which was followed by T_4 >T_5>T_3 >T_2 in descending order. While, minimum fresh weigh of plant was found under T_1 at both the stages of crop growth. Similar results were reported by Mishra *et al.* (2014) and Dadhich *et al.* (2015) in knolkhol.

Combined effect of varieties and nutrient levels had exerted significant influence on fresh weight of plant (g) at both knob initiation as well as knob harvesting stages. Maximum fresh weight of plant was found with treatment combination V_1T_6 at both knob initiation and harvesting stages. Minimum fresh weight of plant was recorded in case of V_2T_1 at both the stages under study. The difference between V_1T_6 and V_2T_1 was significant at both the growth stages.

The findings indicated significant effect of varieties on dry weight of plant (g) at both knob initiation and knob harvesting stages. Maximum dry weight of plant was found in case of variety V_1 (Pusa Virat) at both knob initiation and harvesting stages. Minimum dry weight of plant was recorded in case of V_2 (White Vienna) at knob initiation and harvesting stages. The difference between V_1 and V_2 was significant at both the growth stages. These results are in agreement with the findings of EI- Bassiony *et al.* (2014) in kohlrabi and Zaki *et al.* (2015) in broccoli.

Maximum dry weight of plant was observed with nutrient level T_6, followed by $T_4 > T_5 > T_3 > T_2$ in descending order. While, minimum dry weight of plant was found under T_1 at both the stages of crop growth. These findings are supported with those reported by Gupta *et al*. (2010), Saleh *et al.* (2013), Mishra *et al.* (2014) and Dadhich *et al.* (2015).

Combined effect of varieties and nutrient levels had significant influence on dry weight of plant (g) at both knob initiation and knob harvesting stages. Maximum dry weight of plant was found with treatment combination V_1T_6 at both knob initiation and harvesting stages. It was followed by V_1T_4>V_1T_5>V_1T_3>V_1T_2>V_1T_1>V_2T_6>V_2T_4>V_2T_5>V_2T_3>V_2T_2. Minimum dry weight of plant was recorded in case of treatment combination V_2T_1 at both

knob initiation and harvesting stages. The treatment combination V_1T_6 was significantly superior over all other combinations at both the growth stages.

5.2 Phenological parameters

Phenological parameters viz., days to 50% knob initiation and days to knob harvesting were recorded under the study.

There was significant difference between V_1 and V_2 with respect to knob initiation. Maximum days to 50% knob initiation were taken by variety V_1 (Pusa Virat). Variety V_2 (White Vienna) had recorded earliest knob initiation. Similar findings have been reported by Hossain *et al.* (2011).

Application of nutrient levels exerted significant influence on days to 50% knob initiation. Maximum days to 50% knob initiation were taken under T_5 nutrient level. It was followed by T_6>T_3 >T_4 and T_1 respectively. Minimum days to 50% knob initiation days were taken in case of nutrient level T_2. The difference between T_5 and T_6 and T_6 and T_4 was non significant. Higher dose of nitrogen might have been the reason for delay in knob initiation. These findings could be supported with the results of Hossain *et al.* (2011), Mankar *et al.* (2015) and Singh *et al.* (2015).

Combined effect of varieties and nutrient levels had imposed non significant influence on days to knob initiation in knolkhol.

The difference between V_1 and V_2 with respect to days to knob harvesting was significant. Maximum days to knob harvesting were taken by variety V_1 (Pusa Virat). Variety V_2 (White Vienna) had recorded earliest harvesting. Delay in knob initiation consequently resulted in delay in harvesting which could be attributed to genetic makeup of the varieties.

Application of nutrient levels caused significant influence on days to knob harvesting. Maximum days to knob harvesting were taken under T_5 nutrient level. It was followed by T_6>T_3 >T_4>T_1. Minimum days to knob harvesting were taken under nutrient level T_2. Delay in knob initiation as a result of higher dose of nitrogen might have increased the days to harvesting.

Combined effect of varieties and nutrient levels had non significant effect on days to knob harvesting in knolkhol.

5.3 Yield parameters and yield

Yield parameters viz., knob length (cm), knob diameter (cm), knob weight (g), marketable (knobs) yield (q/ha) and Total yield (knobs + leaves) showed significant influence of varieties and nutrient levels.

Variety V_1 (Pusa Virat) had recorded maximum knob length (cm). Minimum knob length (cm) was observed with variety V_2 (White Vienna). The observed difference in knob length of cultivars may be due to the genotypes of cultivars. These results are similar to those reported by Giri *et al.* (2013) and EI- Bassiony *et al.* (2014).

Nutrient levels exhibited significant effect on knob length (cm) in knolkhol. Maximum knob length (cm) was found with application of nutrient level T_6. It was followed by T_4 >T_5 >T_3 and T_2 in descending order. Minimum knob length (cm) was observed with application of nutrient level T_1. These findings are in agreement with Prasad *et al.* (2009), Singh *et al.* (2012), Talukder *et al.* (2013) and Verma and Nawange (2015).

Combined effect of varieties and nutrient levels had significant effect on knob length in knolkhol. Maximum length of knob was found in case of treatment combination V_1T_6 at knob harvesting stage. Minimum knob length was recorded with treatment combination V_2T_1 at knob harvesting stage.

Among varieties V_1 (Pusa Virat) recorded maximum knob diameter (cm). Minimum knob diameter (cm) was found in case of variety V_1 (White Vienna). These findings are in line with Arin *et al.* (2003), Giri *et al.* (2013), EI-Bassiony *et al.* (2014) and Zaki *et al.* (2015).

Nutrient level T_6 had registered maximum knob diameter (cm) followed by T_4 >T_5 >T_3 and T_2. Lowest knob diameter (cm) was observed in case of nutrient level T_1. Nutrient level T_1 might have not provided sufficient nutrients that reduced the knob diameter (cm) in knolkhol. It is a fact that the presence of all the three major elements in a suitable combination enhanced the vegetative growth of the plants. The plants grown under T_6 nutrient level had maximum number of leaves that might have enhanced the photosynthetic activities and prepared sufficient food for the plant growth and knob enlargement. Similar results have been reported by Ahmed *et al.* (2003), Gupta *et al.* (2010), Hossain *et al.* (2011) and Singh *et al.* (2015).

Combined effect of varieties and nutrient levels showed non significant effect on knob diameter in knolkhol.

Among the varieties, maximum weight of knob was recorded with variety V_1. Minimum weight of knob was observed in case of variety V_2. These findings are in line with Arin *et al.* (2003) and EI-Bassiony *et al.* (2014).

Nutrient levels exerted significant effect on knob weight. Maximum weight of knob was recorded with application of nutrient level T_6. It was followed by T_4> T_5>T_3>T_2 under study. Minimum knob weight was found with T_1 at harvesting stage. Higher dose of nutrients enhanced synthesis and accumulation of food thereby resulted in higher knob weight. These results are corroborated with those obtained by Ahmed *et al* (2003), Prasad *et al*. (2009), Gupta *et al* (2010), Talukder *et al* (2013), Dadhich *et al* (2015) and Verma and Nawange (2015).

Combined effect of varieties and nutrient levels had significant effect on knob weight of knolkhol. Maximum weight of knob was found in case of treatment combination V_1T_6. Minimum weight of knob was recorded in case of treatment combination V_2T_1.

Variety V_1 recorded maximum marketable knobs yield. Minimum marketable knobs yield (q/ha) was found in case of variety V_2. Higher growth and yield attributes under V_1 ultimately resulted in higher knob yield. Similar findings were reported by Arin *et al.* (2003) and EI-Bassiony *et al.* (2014).

Application of nutrients exhibited positive effect on marketable knobs yield. Maximum marketable knobs yield was recorded with nutrient level T_6 which is significantly superior over all the nutrient levels. It was followed by T_4>T_5>T_3 >T_2. While minimum marketable knobs yield was observed under nutrient level $N_{1.}$ Application of nutrients enhanced the growth and yield parameters thereby marketable knobs yield. These findings are in agreement with Shalini *et al.* (2002), Westerveld *et al*. (2003), Krezel and Kolota (2008), Sultana *et al*. (2012) and Dadhich *et al.* (2015).

Combined effect of varieties and nutrient levels indicated significant influence on marketable knobs yield in the present study. Highest marketable knobs yield was obtained with treatment combination V_1T_6. It was significantly

superior over all other treatment combinations. Combination V_2T_1 recorded lowest marketable knob yield which was at par to V_2T_2.

Among varieties, V_1 (Pusa Virat) recorded maximum total (knobs + leaves) yield. While, lowest total yield was obtained with variety V_2 (White Vienna). These findings are supported with those of Arin *et al.* (2003) and EI-Bassiony *et al.* (2014).

Nutrient levels exerted significant influence on total (knobs + leaves) yield. Highest total yield (knobs + leaves) was found with application of the nutrient level T_6. It was followed by $T_4 > T_5 > T_3$ and T_2. Minimum total yield (knobs + leaves) was observed in case of nutrient level T_1. Similar results have been reported by Shalini *et al.* (2002), Ahmed *et al.* (2003), Biesiada (2008), Sultana *et al*. (2012), Talukder *et al* (2013) and Dadhich *et al.* (2015).

Combined effect of varieties and nutrient levels revealed significant influence on total yield (knobs + leaves). Maximum total yield (knobs + leaves) was found with V_1T_6. Minimum total yield (knobs + leaves) was noted with treatment combination V_2T_1.

5.4 Quality parameters

Quality parameters viz., dry matter content (%), ascorbic acid and TSS were determined to study the effect of varieties and nutrient levels.

Among the varieties, maximum dry matter content was determined with V_1 at both knob initiation and knob harvesting stages. Variety V_2 registered minimum dry matter content at both knob initiation and knob harvesting stages. These findings are in agreement with Zaki *et al*. (2015).

Maximum dry matter content was recorded with application of nutrient level T_6 at both knob initiation and knob harvesting stages which was significantly superior over all the nutrient levels. It was followed by $T_4>T_5>T_3>T_2$. While minimum dry matter content was observed under nutrient level T_1 at both stages of study. Similar results have been reported by Biesiada (2008), Krezel and Kolota (2008), Gupta *et al*. (2010), Saleh *et al. (*2013) and Roni *et al*. (2014).

Combined effect of varieties and nutrient levels showed non significant influence on dry matter content (%) in knolkhol at both knob initiation and knob harvesting stages.

The findings of the present experiment exhibited significant effect of varieties on ascorbic acid content in knob. Among the varieties, maximum ascorbic acid was determined with V_2. Minimum ascorbic acid content was noted in case of variety V_1. It could be attributed to the genetic makeup of these varieties. These results have parity with Zaki *et al* (2015).

Nutrient levels exerted significant influence on ascorbic acid content. Highest ascorbic acid content was taken under the nutrient level T_6. It was followed by T_4>T_5>T_3 and T_2. Minimum ascorbic acid content was observed in case of nutrient level T_1. Similar results have been reported by Gupta *et al*. (2010), Saleh *et al*. (2013), Mishra *et al*. (2014), Roni *et al.* (2014) and Mankar *et al.* (2015).

Combined effect of varieties and nutrient levels showed non significant influence on ascorbic acid content in knolkhol knobs.

There was significant difference among varieties with respect to TSS content in knob. Maximum TSS content was determined with V_1 Pusa Virat). Minimum TSS content was noted in case of variety V_2 (White Vienna).

Application of nutrients exhibited positive effect on TSS content. Maximum TSS content was recorded with nutrient level T_6 which was significantly superior over T_2 and T_1 nutrient levels. T_6 was followed by T_4 >T_5>T_3 >T_2. While minimum TSS content of was observed under nutrient level T_1.

Combined effect of varieties and nutrient levels showed non significant influence on TSS content in knob.

5.6 Economics of the different treatments for knolkhol production

Application of T_6 recorded the highest cost of cultivation followed by T_4>T_2>T_5>T_3. While minimum cost of cultivation was incurred under the nutrient level N_1.

Among the treatment combinations V_1T_6 recorded highest gross income which was followed by V_1T_4>V_1T_5>V_1T_3>V_2T_6>V_2T_4>V_2T_5. Lowest gross income was obtained with V_2T_1.

Highest net return was realized in case of treatment combination V_1T_6, while lowest net return was found under V_2T_1 treatment combination. Maximum C: B ratio was found with V_1T_6 treatment combination followed by V_1T_4 >V_1T_5> V_1T_3>V_2T_6>V_2T_4 in descending order. While the minimum C: B ratio was obtained with V_2T_1 combination.

CHAPTER- VI

SUMMARY, CONCLUSION AND SUGGESTIONS FOR FURTHER WORK

Chapter- VI

SUMMARY, CONCLUSION AND SUGGESTION FOR FURTHER WORK

6.1 Summary

A field investigation entitled **"Effect of varieties and nutrient levels on growth, yield and quality in knolkhol (*Brassica oleracea* var. *gongylodes* L.)"** was carried out during 2015-16 at Vegetable Research Field, College of Horticulture, Mandsaur (M.P.). Twelve nutrient combinations comprising of 2 varieties and 6 nutrient levels were tested in factorial randomized block design with three replications. The findings of the experiment have been summarized under following headings:

6.1.1 Effect of varieties

Varieties indicated significant differences for growth attributes under the experiment. Maximum plant height was found in variety V_2 (White Vienna) at knob initiation and V_1 at knob harvesting stage. Minimum plant height was recorded in case of variety V_1 (Pusa Virat) at knob initiation and V_2 (White Vienna) at knob harvesting stage. Maximum number of leaves per plant were counted with variety V_2 (White Vienna) at knob initiation and V_1 (Pusa Virat) at knob harvesting stage. Minimum number of leaves per plant was found with variety V_1 (Pusa Virat) at knob initiation and V_2 (White Vienna) at knob harvesting stage. Among the varieties, maximum leaf area per plant was determined with variety V_1 (Pusa Virat) at knob initiation. Lowest leaf area per plant was determined under the variety V_2 (white Vienna). Variety V_1 (Pusa Virat) had taken maximum fresh weight and dry weight of plant at knob initiation and knob harvesting stage. Minimum fresh weight and dry weight of plant were taken by variety V_2 (White Vienna) Maximum SPAD value was found in variety V_1 (Pusa Virat) at 20, 30 and 45 days. Minimum SPAD value was recorded in case of variety V_2 (White Vienna).

The findings related to phenological parameters viz., days to 50% knob initiation and days to harvesting had indicated significant influence of varieties. Variety V_1 (Pusa Virat) had taken maximum days to 50% knob

initiation and days to harvesting. Earliest 50% knob initiation and knob harvesting was commenced in variety V_2 (White Vienna).

Yield attributes viz., knob length (cm), knob diameter (cm), knob weight (g), marketable (knobs) (q/ha) and total yield (knobs + leaves) (q/ha) showed significant effect of varieties in knolkhol. Highest knob length (cm) was found with variety V_1 (Pusa Virat). Lowest knob length (cm) was observed in case of Variety V_2 (White Vienna). Maximum knob diameter (cm) was measured with variety V_1 (Pusa Virat). Minimum knob diameter (cm) was observed in case of variety V_2 (White Vienna). Maximum knob weight was found with variety V_1 (Pusa Virat), which was significantly superior over other varieties. Minimum knob weight was observed in case of variety V_2 (White Vienna). Highest marketable yield (knobs) (q/ha) and total yield (knobs + leaves) (q/ha) were recorded with variety V_1 (Pusa Virat), which was significantly superior over other variety. Lowest marketable yield (knobs) (q/ha) and total yield (knobs + leaves) (q/ha) was observed under variety V_2 (White Vienna).

Quality of knolkhol was studied with respect to dry matter (%) content, ascorbic acid and TSS. Maximum dry matter (%) was found with variety V_1 (Pusa Virat) at both the stages of study. Lowest dry matter (%) was noted in case of variety V_2 (White Vienna). Maximum ascorbic acid was found with variety V_2 (White Vienna). Lowest ascorbic acid was observed in case of variety V_1 (Pusa Virat). Highest TSS was observed in case of variety V_1 (Pusa Virat), which was significantly superior over other varieties. Minimum TSS in knob was noted in case of variety V_2 (White Vienna).

6.1.2 Effect of nutrient levels

The findings of the trial with respect to growth characters of knolkhol indicated significant effect of nutrient levels. Amongst nutrient levels T_6 had recorded maximum plant height, number of leaves at knob initiation and knob harvesting stage, SPAD value at 20, 30, 45 days, per plant at knob initiation. Rest of the nutrients was in order of T_4>T_5> T_3>T_2. Minimum plant height, number of leaves, SPAD value at 20, 30, 45 days and leaf area per plant were observed in case of nutrient level T_1. Nutrient level T_5 had found maximum fresh weight and dry weight of plant at knob initiation and knob harvesting

stage. It was followed by T_4>T_5> T_3 and T_2 in descending order. Minimum fresh weight and dry weight of plant were taken by nutrient level T_1.

Nutrient levels had exhibited significant influence on phenological parameters viz., days to 50% knob initiation and days to harvesting. Earliest first knob initiation and knob harvesting was commenced under nutrient level T_2. It was followed by T_1>T_4> T_3 and T_6. It was delayed with increase nutrient levels and took maximum days with T_5 nutrient level.

Yield attributes viz., knob length, knob diameter, knob weight, marketable knobs (q/ha) and total (knobs + leaves) yield (q/ha) revealed significant impact of nutrient levels in knolkhol. There was increase in knob length with increase in nutrient levels. Highest knob length was recorded under T_6 nutrient level. It was followed by T_4 >T_5 >T_3 and T_2. Lowest knob length was observed with T_1 nutrient level. Nutrient level exhibited significant effect on knob diameter and knob weight. There was linear increase in knob diameter with every increased nutrient level. Maximum knob diameter and knob weight was found under T_6 nutrient level, which was followed by T_4 > T_5 >T_3 and T_2. Minimum knob diameter and knob weight was found under T_1 nutrient level. Nutrient level exhibited significant impact on marketable knobs (q/ha) and total (knobs + leaves) yield (q/ha). Maximum marketable knobs (q/ha) and total (knobs + leaves) yield (q/ha) were found with T_6 nutrient level, which was higher than T_4 >T_5>T_3> T_2 nutrient level under the study. Minimum marketable knobs (q/ha) and total (knobs + leaves) yield (q/ha) were observed under T_1 nutrient level.

Results showed significant effect on quality attributes of nutrient levels on dry matter (%) content, ascorbic acid and TSS in knob of knolkhol. There was increase in dry matter (%) content with increased nutrient levels. Maximum dry matter (%) content was noted in case of T_6 nutrient level which was significantly higher than T_4>T_5>T_3>T_2. While minimum dry matter (%) content was recorded under T_1 nutrient level. Maximum ascorbic acid was observed under T_6 nutrient level, which was followed by T_4>T_5>T_3> T_2. While minimum ascorbic acid was recorded with T_1 nutrient level. Highest TSS content in knob was recorded with T_6 nutrient level, which was significantly superior over other nutrient level. It was followed by T_4>T_5>T_3>T_2. While

minimum TSS was recorded with T_1 nutrient level. All the TSS content in knob differed significantly to each other with respect to TSS content in knob.

6.1.3 Combined effect of varieties and nutrient levels

Combined effect of varieties and nutrient levels on plant height, number of leaves, knob diameter(cm), SPAD value at 20, 30, 45 days, days to 50% knob initiation, days to knob harvesting, dry matter (%), ascorbic acid, TSS was non significant. It indicates that interaction effect of varieties and nutrient levels in the present investigation was non significant and had exerted no remarkable influence on these parameters. Interaction effect of varieties and nutrient levels revealed statistically significant influence on leaf area, fresh weight and dry weight, knob length (cm), marketable knobs (q/ha) and total (knobs + leaves) yield (q/ha) under the investigation. Highest leaf area, fresh weight and dry weight per plant, knob length (cm), marketable knobs (q/ha) and total (knobs + leaves) yield (q/ha) were recorded with treatment combination V_1T_6.

6.2 Conclusion

It may be concluded from the findings of the present study that among the different varieties of knolkhol, variety V_1 (Pusa Virat) recorded superior performance of growth attributes, yield attributes, yield and quality attributes. Among the nutrient levels, application of T_6 (100-60-50 kg/ha NPK) showed highest growth, yield, quality parameters and yield of knolkhol. Among the combinations application of V_1T_6 showed superior performance for growth and yield parameters. It also recorded highest net income and B:C ratio.

6.3 Suggestions for further work

- The investigation should be repeated for confirmation of the results.
- Integration of organic manures and biofertilizers may be tested along with chemical fertilizers.
- In the future studies nutrient levels along with more varieties may be tested.

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APPENDICES

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)	
		Knob initiation	Knob harvesting
Replication (R)	**2**	13.08	0.90
Varieties (V)	**1**	481.07	71.68
Nutrient levels (N)	**5**	43.70	75.02
Interaction (V × N)	**5**	1.54	1.68
Error	**22**	8.20	10.54
CV		**12.24**	**7.34**

APPENDIX- II: Analysis of variance for number of leaves at different growth stages

Source of variation	D.F.	Mean Sum of Square	
		Number of leaves	
		Knob initiation	Knob harvesting
Replication (R)	**2**	0.25	0.33
Varieties (V)	**1**	13.93	40.11
Nutrient levels (N)	**5**	4.46	9.29
Interaction (V × N)	**5**	0.05	1.41
Error	**22**	1.02	2.99
CV		**13.35**	**10.33**

APPENDIX- III: Analysis of Variance for fresh weight (g) per plant at different growth Stages

Source of variation	D.F.	Mean Sum of Square	
		Fresh weight (g)	
		Knob initiation	Knob harvesting
Replication (R)	**2**	15.75	877.68
Varieties (V)	**1**	16835.06	812852.50
Nutrient levels (N)	**5**	438.84	21530.91
Interaction (V × N)	**5**	279.22	6398.95
Error	**22**	30.93	2377.49
CV		**10.97**	**9.95**

APPENDIX- IV: Analysis of variance for dry weight (g) per plant at different growth stages

Source of variation	D.F.	Mean Sum of Square	
		Dry weight (g)	
		Knob initiation	Knob harvesting
Replication (R)	**2**	0.03	6.50
Varieties (V)	**1**	69.44	7273.24
Nutrient levels (N)	**5**	4.11	262.20
Interaction (V × N)	**5**	0.79	51.35
Error	**22**	0.27	17.69
CV		**11.47**	**9.90**

APPENDIX- V: Analysis of variance for leaf area per plant at knob initiation growth stages

Source of variation	D.F.	Mean Sum of Square
		Leaf area
		Knob initiation
Replication (R)	**2**	620.69
Varieties (V)	**1**	1371787.5
Nutrient levels (N)	**5**	34505.73
Interaction (V × N)	**5**	12840.96
Error	**22**	4738.70
CV		**10.896**

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

Source of variation	D.F.	Mean Sum of Square		
		SPAD value		
		20 DAT	30 DAT	45DAT
Replication (R)	**2**	0.36	2.67	5.87
Varieties (V)	**1**	70.50	115.56	80.28
Nutrient levels (N)	**5**	42.45	25.25	30.25
Interaction (V × N)	**5**	2.05	1.56	1.27
Error	**22**	8.29	8.82	9.31
CV		**5.85**	**5.68**	**5.24**

APPENDIX- VII: Analysis of variance for days to 50% knob initiation and days to knob harvesting.

Source of variation	D.F.	Mean Sum of Square	
		days to 50% knob initiation	days to knob harvesting
		Knob initiation	Knob harvesting
Replication (R)	**2**	3.25	2.69
Varieties (V)	**1**	3043.36	3006.69
Nutrient levels (N)	**5**	11.45	33.82
Interaction (V × N)	**5**	0.96	3.16
Error	**22**	3.31	11.87
CV		**5.23**	**5.02**

APPENDIX- VIII: Analysis of variance for knob length and knob weight at harvesting stages

Source of variation	D.F.	Mean Sum of Square	
		Knob length (cm)	Knob weight(g)
Replication (R)	**2**	0.24	1041.60
Varieties (V)	**1**	31.43	78708.30
Nutrient levels (N)	**5**	1.55	7865.14
Interaction (V × N)	**5**	0.39	2309.55
Error	**22**	0.14	763.90
CV		**5.53**	**10.57**

APPENDIX- IX: Analysis of variance for knob diameter at harvesting stages

Source of variation	D.F.	Mean Sum of Square
		Knob diameter(cm)
Replication (R)	**2**	0.20
Varieties (V)	**1**	4.9
Nutrient levels (N)	**5**	2.40
Interaction (V × N)	**5**	0.15
Error	**22**	0.21
CV		**5.85**

APPENDIX- X: Analysis of variance for marketable (knobs) yield q/ha and total yield (knobs+ leaves) q/ha

Source of variation	D.F.	Mean Sum of Square	
		Marketable (knobs) yield q/ha	Total yield (knobs+ leaves) q/ha
Replication (R)	**2**	671.39	1471.04
Varieties (V)	**1**	34794.68	57368.23
Nutrient levels (N)	**5**	17647.97	24296.49
Interaction (V × N)	**5**	1503.08	5372.64
Error	**22**	560.48	2009.40
CV		**7.70**	**8.98**

APPENDIX- XI: Analysis of variance for dry matter (%) per plant

Source of variation	D.F.	Mean Sum of Square	
		dry matter (%) per plant	
		Knob initiation	Knob harvesting
Replication (R)	**2**	0.09	0.12
Varieties (V)	**1**	61.44	7.3
Nutrient levels (N)	**5**	3.61	2.85
Interaction (V × N)	**5**	0.19	0.02
Error	**22**	0.97	0.86
CV		**10.12**	**10.58**

APPENDIX- XII: Analysis of variance for ascorbic acid and TSS in knolkhol knob.

Source of variation	D.F.	Mean Sum of Square	
		ascorbic acid	TSS
Replication (R)	**2**	5.42	0.10
Varieties (V)	**1**	16.40	0.4
Nutrient levels (N)	**5**	51.73	0.60
Interaction (V × N)	**5**	1.51	0.01
Error	**22**	2.51	0.08
CV		**3.95**	**4.20**

Appendix – XII. General cost of knolkhol cultivation excluding the cost of the treatment inputs (Rs/ha).

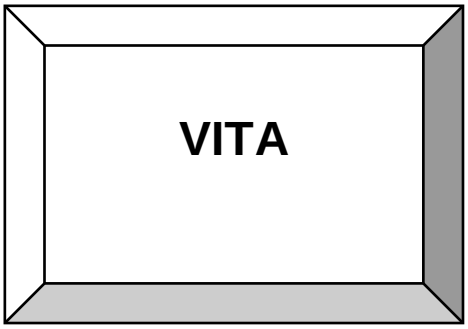
Cultural practices		Cost ha^{-1} (Rs)
1	Seed (1.5 kg)	3,500
2	Field preparation	2,000
3	Bed preparation	4,000
4	Transplanting	8750
5	Irrigation	28,000
6	Insecticide + Fungicide	8,400
7	Labour charges for weeding & spray	6,900
8	Harvesting cost	5,500
	Total	**67,050**

Cost of treatments

Treatment levels		Amount (Rs)
T_1	60:45:50 NPK kg/ha	3952.73
T_2	60:60:50 NPK kg/ha	4697.92
T_3	80:45:50 NPK kg/ha	4080.59
T_4	80:60:50 NPK kg/ha	4825.98
T_5	100:45:50 NPK kg/ha	4208.39
T_6	100:60:50 NPK kg/ha	4953.58

Sale price of produce

Knolkhol knobs were sold @ Rs.1000/q.


VITA

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The author of this thesis, Mr. **Gopal Nagar** s/o Shri Mohan Lal Nagar and Smt Kanti Bai was born on the 11th day of July 1988 at Ujjain in Madhya Pradesh. He passed his higher secondary school examination from Govt. Higher Secondary School, Runija (M.P.) with 43.33 % in the year 2007.

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For the partial fulfilment of the master's degree "**Effect of varieties and nutrient levels on growth, yield and quality in knolkhol (*Brassica oleracea var. gongylodes* L.)"** under Mandsaur condition. Which was successfully conducted by his and being submitted in the form of this thesis?

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