PERFORMANCE EVALUATION AND STANDARDIZATION OF PLANTING TIME IN CARROT (*Daucus carota* L.)

By

BASAVARAJ VITTHAL SIMPI

(2012-12-118)

THESIS

Submitted in partial fulfillment of the

requirement for the degree of

Master of Science in Horticulture

Faculty of Agriculture

Kerala Agriculture University

DEPARTMENT OF OLERICULTURE

COLLEGE OF HORTICULTURE

VELLANIKKARA, THRISSUR-680 656

KERALA, INDIA

2016

DECLARATION

I hereby declare that the thesis entitled **"Performance evaluation and standardization of planting time in carrot (*Daucus carota* L.)"** is a bonafide record of research work done by me during the course of research and the thesis has not been previously formed the basis for the award to me any degree, diploma, fellowship or other similar title, of any other University or Society.

Vellanikkara
Date: 20/08/2016

Mr. Basavaraj Vitthal Simpi
(2012-12-118)

CERTIFICATE

Certified that thesis entitled **"Performance evaluation and standardization of planting time in carrot (*Daucus carota* L.)"** is a bonafide record of research work done independently by Basavaraj Vitthal Simpi (2012-12-118) under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, associateship or fellowship to him.

Sarah T George

Vellanikkara
Date: 20/08/2016

Dr. Sarah T. George
Chairperson, Advisory Committee
Professor
Department of Olericulture
College of Horticulture, Vellanikkara

CERTIFICATE

We undersigned, members of the advisory committee of Mr. Basavaraj Vitthal Simpi, a candidate for the degree of Master of Science in Horticulture, agree that the thesis entitled **"Performance evaluation and standardization of planting time in carrot (*Daucus carota* L.)"** may be submitted by Mr. Basavaraj Vitthal Simpi in partial fulfillment of the requirement of the degree.

Sarah T. George

Dr. Sarah T. George
Chairperson, Advisory Committee
Professor,
Department of Olericulture
College of Horticulture, Vellanikkara

20/8/16

Dr. Salikutty Joseph
Member, Advisory Committee
Professor and Head,
Department of Olericulture
College of Horticulture, Vellanikkara

20/8/16

Dr. P. Indira
Member, Advisory Committee
Professor,
Department of Olericulture
College of Horticulture, Vellanikkara

S. K. 20/8/16

Dr. S. Krishnan
Member, Advisory Committee
Professor and Head,
Department of Agricultural Statistics
College of Horticulture, Vellanikkara

P. 20/8/16

EXTERNAL EXAMINER
Dr. P. JANSIRANI
Professor and Head,
Department of Vegetable Crops
Horticulture College and Research
Institute, Periyakulam

ACKNOWLEDGEMENT

And so comes the time to look back on the path traversed during the endeavor and to remember the faces and spirits behind the action with a sense of gratitude. Nothing of significance can be accomplished without the acts of assistance, words of encouragement and gestures of helpfulness from the other members of the society.

First, and foremost, I bow my head before the **God** *who enabled me to successfully complete the thesis work on time.*

It is with immense pleasure I avail this opportunity to express my deep sense of whole hearted gratitude and indebtedness to my major advisor **Dr. Sarah T. George,** *Professor, Department of Olericulture, College of Horticulture, Vellanikkara for her expert advice, inspiring guidance, valuable suggestions, constructive criticisms, constant encouragement, affectionate advice and above all, the extreme patience, understanding and wholehearted co-operation rendered throughout the course of my study. I really consider it my greatest fortune in having her guidance for my research work and my obligation to her lasts forever.*

I consider it as my privilege to express my deep-felt gratitude to **Dr. Salikutty Joseph,** *Professor and Head, Department of Olericulture for her constant support, valuable*

suggestions, cooperation throughout the research programme and critical scrutiny of the manuscript.

I am deeply obliged to ***Dr. P. Indira,*** *Professor, Department of Olericulture, College of Horticulture and member of my advisory committee for her support and enthusiasm, relevant suggestions during the investigation and preparation of thesis.*

I express my heartfelt thanks to ***Dr. S. Krishnan,*** *Professor and Head, Department of Agricultural Statistics, for his relentless support in resolving the statistical intricacies and valuable suggestions for my research programme.*

Words are inadequate to express my sincere gratitude to ***Dr. T. E. George,*** *Professor & former Head, Department of Olericulture for his constant support, expert and valuable advice and whole hearted co-operation and guidance extended throughout the investigation.*

I would like to acknowledge the help extended by each of the teaching and non-teaching staff.

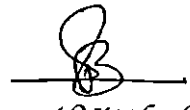
I am deeply indebted to my ***Parents*** *and* ***Family members*** *without whose moral support, blessing and affection this would not have been a success. I once again express my heartfelt thanks to all those who helped me in completing this work.*

I am genuinely indebted to my seniors Vikram, Divya, Pramod, Ajay, Subbareddy, Ningaraju, Naveen, Ravindra,

Harikumar, Siddesh and Amaranath for valuable assistance and guidance during the entire period of my research.

Let me express my sincere thanks to my batch mates friends Mahsuma, Shanthi, Yashwant, Datta, Avadumbar, Sachin Yogesh, Ramanarayan, Vemaraju, Shreeram, Minnu, Maheshwari, Surya, Aswini, Teena, Sharath, Sangameshwar Ajithkumar, Veeresh, Deepak and Shoba for their timely help and co-operation.

I thank my juniors Rahul, Arun Kumar Anand, Harsha, Jeevan, Naresh, Ramesh, Sanjay, Ningappa, Charan, Darshan, Reddy, Shridhar, Umesh, Akhila and Shilpa for their sincere help, support and encouragement.



Basavaraj Vitthal Simpi

LIST OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

Abbreviations

AOAC - Association of Official Agricultural Chemists

^{0}B – Degree brix

TSS – Total soluble solids

cm – Centimeter

% - Per cent

g – Gram

mg – Milligram

kg – Kilo gram

m – Meter

E-W – East-West

N-S – North-South

r – Residual value

viz. – Namely

INTRODUCTION

1. INTRODUCTION

Carrot (*Daucus carota* L.) is a popular cool season root vegetable belonging to family Umbelliferae. It is grown throughout the world, in temperate countries mainly during spring and summer season, while in tropical regions, during winter season. Area under carrot in India is reported to be 22540 ha with an annual production of 4.15 lakh tons. Carrot roots are used as salad, cooked vegetable and used in the preparation of soup, halwa and pickles. Fresh carrot is exported from India to countries like Kuwait and Sharjah.

It is a major source of vitamin A and has a high carotene, a provitamin that is converted by the body into vitamin A and contains appreciable quantities of thiamine and riboflavin (Arthey, 1975; Tindall *et al.*, 1986; Gopalan *et al.*, 1989; Tweneboah, 1997). Carrot is an aromatic herb with diuretic and digestive properties, useful to stimulate uterus with anti-cancer properties and it increases the flow of urine, improves eyesight as well as skin health due to its rich source of β carotene (Ageless, 2009).

Vegetables are so common in human diet that a meal without a vegetable is supposed to be incomplete in any part of the world. India is the second largest producer of vegetables in the world, next to China. These are grown in about six million hectares forming 3% of the total cropped area. Our country is gifted with a wide range of agro climatic conditions which enables the production of vegetables throughout the year in one part of the country or the other, thus maintaining a continuous supply of fresh vegetables.

In India, about 40 vegetable crops of varying significance are grown. These include solanaceous, cucurbitaceous, leguminous and cruciferous vegetables, root crops, bulb crops and leaf vegetables. Major vegetable crops grown in the country are tomato, potato, onion, brinjal, cabbage, cauliflower, okra, cucurbits and peas.

Root crops include a number of vegetables grown for their enlarged, edible storage root. They are hardy, cool season crops with a long storage life. While they belong to several unrelated plant families, these crops have similar cultural requirements. Root vegetables were an essential part of the diet during the early evolution of humankind. Among root vegetables carrot is very important crop because of its nutritional value.

They are characterised by relatively moderate requirements for climate and soil. Carrot originated in Southwest Asia and later spread throughout China and the Mediterranean basin. The colour was yellow in the 17th century and mutated to become orange (De Lannoy, 2000). It is a biennial but grown as an annual which has a hollow, erect, very short stem and quadripinnate leaves which can grow up to 30 cm in length. Carrot has a main tap-root which becomes tuberous with absorbent hairs but without secondary roots. The roots may grow up to 20 cm in length and attain a diameter of 3-4cm. It is made up of a central cylinder (core) which is more or less fibrous and an external part (cortex) which is tender and of a deeper colour than the inner core (De Lannoy, 2000).

Essential oils extracted from carrot may be used as a body purifier which has the potential to boost the functions of the liver and the digestive system, and also assist in the formation of red blood corpuscles and slowing down ageing process. They have been used to control ulcers, eczema, boil and are used in cosmetic preparations to fight wrinkles (Ageless, 2009).

Productivity and quality parameters of carrot root yield depend on cultivar, climate, soil, and agronomic factors (Kaack *et al.* 2001 and Gajewski *et al.* 2007).

There are many reasons for its low productivity in India. Raising quality roots is very difficult. There is excessive forking and splitting of roots, if crop is grown very early in season. Also the method of sowing has significant effect on the quality of root

and yield. Extension of carrot cultivation in a diverse variety of soils and environmental conditions is needed to increase carrot production in the country. (Dahiya *et al.*, 2007).

A number of varieties have been evolved under Asiatic and European types and from cross between two. Varieties suitable for the plains of Kerala are yet to be identified.

In Kerala generally cool season vegetables are mainly grown in high altitude regions of Idukki, Wayanad and Palakkad districts where mild subtropical climate prevails. With the development of tropical varieties in cool season vegetables, their cultivation is spreading towards non-traditional areas as well. Popularization of carrot cultivation in the plains will help to minimize truckloads of pesticide loaded carrot coming from the neighbouring states. This will also help to increase the overall vegetable production of the state.

In this study an attempt was made to evaluate the performance of fifteen carrot varieties in the plains and to understand the influence of sowing time on quality and growth characters.

In this background, the present study was undertaken with following objectives:

- To identify ideal carrot varieties for cultivation in the plains of Kerala
- To study the influence of planting time on the qualitative and quantitative traits of carrot.
- To select the suitable planting time for successful cultivation of carrots in the plains of Kerala.

REVIEW OF LITERATURE

2. REVIEW OFLITERATURE

Carrot (*Daucus carota* L.) is a cool season vegetable crop, performing well under cooler weather (10 to 25°C) (Joubert *et al.*, 1994; Rubatzky *et al.*, 1999). Carrots have been cultivated under different temperatures and in different soils influencing the growth, yield and quality in different ways. Temperature is the most important climatic factor affecting the production of carrots. It has an effect on plant growth mainly on the rate of chemical reactions, and consequently the usage of photosynthetic products (Rubatzky *et al.*, 1999; Suojala, 2000; Joubert *et al.* 1994) indicated that a yield of 30 to 40 tons ha^{-1} is regarded as a good average, although successful farmers often achieve 60 tons and more.

2.1 Climate requirements

Nortje and Henrico (1986) stated that climatic factors influencing carrot production include temperature, rainfall, moisture, and to a lesser extent, day length and light intensity.

Rubatzky *et al.* (1999) showed that climate has the most important influence on crop production. Sustainable production of carrots can only be attained under favourable climate conditions.

2.1.1 Effect of temperature

Krickl (1963) found that roots grew to a cylindrical form at a temperature of 18°C while they became more pointed as the temperature dropped, particularly in temperature sensitive varieties.

Quagliotti (1967) reported an increase in carrot vegetative growth at 20 ^{0}C and 26°C compared to that at 14°C. Manosa (2011) however, reported that growth during the early development stage of root crops such as carrot and radish was reduced when plants were subjected to warmer temperatures a week after seeding, indicating that there is a sensitive period to warm temperature in the early growth stage.

Carrots belong to the moderately hardy group of vegetables that are not sensitive to winter cold and frost. Carrots in the seedling phase will endure frosts and temperatures as low as -7 ^{0}C. The top growth is slow at temperatures below 4 ^{0}C, and consecutive severe frosts will leads to leaf death (Joubert *et al.*, 1994).

Carrots can be grown throughout the year, except in extremely cold areas, where there is almost no growth during winter and in very hot regions. In summer it is difficult to attain a good stand (Joubert *et al.*, 1994; Rubatzky *et al.*, 1999).

Optimum temperature for growing carrots is between 15 and 20 °C (Joubert *et al.*, 1994; Rubatzky *et al.*, 1999; Kluepfel and Smith, 2002).

The yield and quality of carrots are reduced when mean temperatures are above 25 °C and /or below 10 °C. Temperatures as low as 4 °C also influence quality characteristics such as root length, diameter and shape. The brittleness of carrot roots increases with cooler soil temperatures, and the roots crack. Nantes carrot types, largely because they do not have strong central core development, split or crack more easily in extremely cold weather than other carrot types. Once the soil freeze, crown damage occurs as small hairlines and horizontal splits on the surface of the storage root (Manosa, 2011).

Temperature above 28°C and below 10°C during the early vegetative stage reduces foliage growth of carrots (Mc Giffen *et al.*, 1997).

If temperatures fall below the optimum during the early vegetative stage, unwanted flower stalks may appear (bolt) (Mc Giffen *et al.*, 1997).

Alam *et al.* (2004) also indicated that the optimum day and night temperatures for plant growth are between 21 and 22 °C and 18 and 20 °C, respectively.

Temperature influences the composition of plant tissues during growth and development. The total available heat and the extent of low and high temperatures are the most important factors determining growth rate, chemical composition and consequently the yield of horticultural crops (Rubatzky *et al.*, 1999; Bonhomme, 2000; Lee and Kader, 2000).

Extremely high temperatures (>40°C) cause a bitter taste, reducing sweetness and increasing fibrous texture of the storage root (Rubatzky *et al.*, 1999).

Quality and yield however, are the best under cooler conditions (Alam *et al.*, 2004; Petzoldt, 2008).

Different carrot cultivars perform differently at different temperatures and locations. Hence, the development of cultivars adapted for cultivation in both summer and winter seasons on all continents has allowed all year round availability of carrots (Simon *et al.*, 2008). For example, in South Africa carrot cultivars such as Nectar, Star 3002, CS 1006, Cape Market, Chantenay Karoo and Kuroda are cultivated in summer while carrot cultivars such as Adelaide and Darling favour winter season cultivation (Manosa, 2011).

Manosa *et al.* (2010) evaluated the influence of temperature on yield and retinol content of two carrot cultivars. Both cultivars yielded higher at lower (10 °C) than higher temperature (18 °C), but retinol content was higher at 18 °C.

According to Nascimento *et al.* (2013) carrot seed germination can be erratic or reduced under temperatures above 35°C.

2.1.2 Effect of moisture

Tindall (1968) mentioned that carrots are tolerant to too little or too much irrigation. However, the availability of soil moisture throughout the growing season is one of the most vital production requirements for carrots (Rubatzky *et al.*, 1999; Suojala, 2000).

Yield and length of root were influenced by the soil moisture content during the vegetative stage (Henkel, 1970; Millette, 1983).

Long intervals between irrigation can cause the development of thinner roots (Nortje and Henrico, 1986). Frequent irrigations also discourage good root colour formation.

It is generally believed that, carrots are more tolerant to drought than other vegetable crops due to their extensive root system (Suojala, 2000; Lada and Stiles, 2004).

According to Fritz *et al.* (1998) moisture stress is reported to cause woody and poorly flavoured roots.

Inadequate soil moisture results in long and thin roots, while excessive soil moisture in short, thick and pale coloured roots (Joubert *et al.*, 1994; Fritz *et al.*,

1998; Rubatzky *et al.*, 1999; Manosa., 2011). Furthermore, low soil moisture will force the plants to invest in root extension growth rather than storage root development resulting in a reduction in root yield (Lada and Stiles, 2004).

Joubert *et al.* (1994) stated that soil that is well drained and regularly irrigated ensures uniform development and thus carrots of the best quality. Siddiqui (1995) indicated that proper scheduling of irrigation is one of the major agro techniques for maximizing the yield of carrot. Rainfall is the most essential climatic factor for plant growth and therefore irrigation is required throughout the season (Rubatzky *et al.*, 1999).

Suojala (2000) also reported that low precipitation at the end of the growing season may promote dying of the oldest leaves.

According to Lada and Stiles (2004) young carrot seedlings are very vulnerable to physiological damage if their moisture requirements are not met. They also indicated that the highest water demand of carrots is during the root enlargement phase.

Watering should gradually be reduced to prevent longitudinal splitting of the roots when the crop approaches maturity. Excessive or deficient soil moisture can affect the quality of the roots. Water stress during root development causes cracking of the roots. Carrots require a steady supply of moisture and available soil moisture needs to be maintained above 50% of plant available water throughout the growth season. Carrots require approximately 25 mm of water per week but under warm, dry conditions 50 mm will be required (Manosa, 2011).

2.2 Effect of sowing time and cultivar on growth and yield

Lipari (1980) studied the yields and growth pattern of the roots in carrot varieties in relation to time of sowing when sown between 15th October and 15th November and found significant differences between the two dates of sowing after 105th and 210th days from sowing in relation to plant weight, root yield per hectare, root weight, root length and diameter.

Warne (1961) concluded that sowing date is the crucial factor in the crop production with regard to marketable size and colour of carrot.

Forbes and Scudder (1963) obtained the best yields with all varieties of carrot from October or early November sown crop, when the seeds were sown at intervals from September to February. Cultivar Chantanay produced roots of larger diameter which consistently out yielded the slender fresh market types. Similar observation was recorded by Bakhchevanova (1974).

Bradley *et al.* (1967) studied the effects of planting date and variety on yield and colour of carrots. Danvers 126 and Royal Chantenay were the varieties used. Planting date was the most important factor affecting colour where as it had less effect on yield.

Arora *et al.* (1969) suggested early October sowing of carrot for maximum economic yield under North Indian conditions. They did not record any significant difference in yield between cultivars Desi and Pusa Kesar.

Gadzhonov (1972) studied the effect of sowing dates on the yield and quality of carrot cultivars Nantes and Chantenay when sown at monthly intervals from March

to August. According to him, sowing in June resulted in the highest total root yield of 23.5 t/ha for Nantes and 39 t/ha for Chantenay.

Vizzotto *et al.* (1986) compared the performances of nine cultivars of carrot in three different bi-monthly sowing from in September to November. With September sowing bolting was a problem. Nantes Superior and Nantes Demi-logue were found to be most resistant to bolting and also most productive, yielding 36 and 32 tonnes per hectare respectively. Both the varieties gave the lowest yields in later sowings because of susceptibility to *Alternaria dauci.* Cultivar Brasilia gave the highest yields in both the later sowings.

Cultivar Tropical was very prone to bolting and produced a satisfactory yield of high quality roots solely in the January sowing. Cultivars Nova Kuroda and Kuroda National also gave high yields when sown in January (Sadhu, 1986).

Carrot cultivars Pusa Meghali, Pusa Kesar and Half Long Nantes, were grown in Nadia at 4 dates. Nine quantitative traits, sugar content and total soluble solids were subjected to correlation analysis. Root length, root weight and top weight were significantly and positively correlated with yield. However, root length and root weight showed significant negative correlation with total sugar (Pariari *et al.*, 1992).

Pashine *et al.* (1993) studied the effect of sowing time and cultivars on the yield of carrot. Pusa Kesar, Nantes and local cultivars were sown on seven different dates from 5th November to 5th February at fortnightly intervals. Maximum yield was obtained by early sowing on 5th November, followed by sowing on 20th November Yield decreased with delayed sowing. The local cultivar produced the highest root yield, followed by Pusa Kesar.

Jaiswal *et al.* (2003) studied the effect of sowing date (20th July, 10th August, 30th August, 19th September and 9th October) on the quality of carrot (cv. Pusa Kesar). Early sowing (20th July) resulted in the high quality roots with highest plant height and number of leaves per plant.

Ahmadi *et al.* (2004) studied the performance of nine carrot cultivars and observed that cultivars Nantes Tip Top yielded 16.81 t/ha which was significantly higher compared to other cultivars.

Starkutė and Zalatorius (2006) investigated the optimum sowing and harvesting time of carrot Svalia F1. Seeds were sown in four intervals. It was seen that the sowing time significantly influenced the carrot yield but the time of harvesting doesn't influence much. It was also observed that carrots sown on April 20^{th} to 30^{th} and harvested on October 9^{th} had the best biochemical composition.

Gupta and Verma (2007) evaluated twenty seven European carrot genotypes along with two control cultivars, for their growth and yield. All the genotypes differed significantly for all the quantitative characters. The highest net marketable root weight per plot was recorded for New Kuroda (F), followed by Nandrin (95 × N) × 1061, Improved Kuroda and (28 × PY) × 1060. Likewise, Sutton's Early Nantes exhibited the highest contents for carotene, No. 44365 for moisture, CR-501 (Paras) for total soluble solids, New Kuroda (J) for reducing sugars and Sumrai Hindustan for total sugars.

Dahiya *et al.* (2007) reported that root qualitative and quantitative traits in carrot (*Daucus carota* L.) are affected by time of sowing. Sowing was done on 24^{th} August, 14^{th} September 4^{th} October and 23^{rd} October. Maximum root length was recorded in 4^{th} October sowing and minimum length of shoot was recorded in 23^{rd} October sowing. Root diameter was recorded maximum in 14^{th} September sowing.

Minimum root diameter was obtained in 24th August sowing and percentage of forked and splitting of carrot root was highest in early sown crop. It decreased in subsequent dates of sowing.

Gadomska and Wierzbicka (2010) observed that Florida F1 produced a much higher total yield and marketable yield compared to Deep Purple F1 and Purple Haze F1.

Richmond and Mendez (2010) evaluated twelve commercial hybrids of carrot. The highest yield was recorded in Bangor F1, Esperanza, Concerto F1, Nandrin F1 and Sirkana.

Karkleliene *et al.* (2012) compared the performance of cultivars and hybrids namely Svalia F1, Skalsa F1, Bolero F1, Noveno F1, Garduoles, Vaiguva, Vytėnų nanto, Satrija, Monanta, Tito, Samson, Magi and Crona. Seeds were sown on the 29th of April 2009 and 28th of April 2010. A two years' study showed that root yield of carrot hybrids was 10–20 per cent higher compared with the cultivars.

Different varieties of carrot and growing conditions showed highly significant influence on all most all the parameters studied. The highest yield and the quality was recorded in Brasilia Agroflora, while the lowest yield and germination were observed in New Kuroda (Malek *et al.*, 2012).

2.3 Effect of sowing time and cultivar on quality of carrot

Quality includes not only the structure or texture, but also the colour, flavour and constituents like carotene, reducing sugar, total sugar and total soluble solids. These vary greatly with change in different environmental conditions in different varieties.

Bradley *et al.* (1965) observed that total sugars and soluble solids were lowest in carrots sown on 2nd February compared to 21st March sown crop, but colour was not significantly affected by sowing dates. Delaying harvesting by 1 or 2 weeks increased yields by 1.8 and 2.9 ton per hectare respectively and also increased soluble solids. Royal Chantenay gave the highest yield, but colour, total soluble solids were lowest.

Eliseev and Nikolaeva (1964) reported that thirty one varieties belonging to eight types were sown in the spring (early April) and summer (early June). The spring sown crop of seven types produced higher total yields than the summer sown crops. Individual root weights were greater in the summer sown crops. Investigations were also conducted on nutritive values, and varieties suitable for spring and summer sowing.

Bradley *et al.* (1965) opined that planting date was the most important factor affecting root colour. The interaction of planting date and harvest sequences markedly affected soluble and total solid contents of roots. These effects seemed to be related to the temperature and day length changes which occurred in the several plantings.

Kabir *et al.* (2013) reported that winter sown carrots had high dry matter content and larger amount of carotene, sucrose, starch and cellulose and smaller quantities of invert sugar than in spring sown crops.

According to Krylov and Baranova (1966) winter sown carrot cultivar Chantenay had the highest carotene content than autumn or spring sown crop when sowing period extended between November and May.

Sistrunk *et al.* (1967) studied the influence of pre harvest factors on the content of different chemical constituents in three carrot cultivars and found that there were varietal differences in water soluble pectins, total sugars, starch and hemicelluloses contents of these cultivars. They also reported that most of the differences in chemical composition attributable to planting date were obtained between the spring and autumn crop.

Toul *et al.* (1986) estimated the content of ß carotene in 147 cultivars from 10 European countries, the USA and Japan, sown on two dates and noted that ß carotene content was generally higher in late September than in early August sown crop.

Fuhrmann *et al.* (1986) concluded that sugar content in carrot is a varietal characteristic and the same differed between the roots from the market and the freshly harvested ones, ranging from 3.03 to 5.69 per cent in the former and from 7.91 to 9.56 per cent in the later.

The effect of time of sowing on growth and chemical composition of carrot grown from May to November was studied by Nilsson (1987). He observed that delayed sowing for 1 to 2 months after the beginning of May resulted in a reduction in the growth of both roots and foliage and gave roots with lower dry matter content and glucose/fructose ratio. He also found that root yield, total sugars and carotene content of roots were closely correlated with the number of degree days over 6 °C from sowing to harvest. The growing condition considerably influenced the sucrose content in the roots. Dry matter, free amino acid and carotene increased over the harvest period.

Duczmal *et al.* (1987) observed that roots with the highest cold tolerance had the highest sucrose contents. They also noted that sucrose content which depended largely on growing conditions, reached a maximum at about 70 days after sowing.

Gupta *et al.* (2006) evaluated twenty seven European carrot genotypes, along with two control cultivars, for their root quality. All the genotypes varied in qualitative traits, Sutton's Early Nantes exhibited the highest contents carotene, CR-501 (Paras) for total soluble solids, New Kuroda (J) for reducing sugars and Sumrai Hindustan for total sugars.

Fikselova *et al.* (2010) examined the influence of area and variety on β carotene and dry matter content of four varieties of carrot. They cultivated carrot under different climatic and soil conditions in three areas of Slovakia, Nitra, Komarno and Prusy. Carrot varieties (Nevis F1, Idaho F1, Florida F1, Kathmandu F1) showed the greatest mean content of β carotene (23.25 mg 100 g^{-1}) in Nitra area and the highest content of β carotene was shown by variety Florida F1 (26.3 mg 100 g^{-1}).

On comparing different carrot varieties Matejkova and Petrikova (2010) observed that carotenoid content ranged from 60 mg kg^{-1} to 134 mg kg^{-1} and significantly higher levels of carotinoids were found in late and moderately late cultivars in comparison to early ones. Vitamin C content in these cultivars ranged from 54 mg kg^{-1} to 132 mg kg^{-1}. Significantly higher contents of vitamin C were also found in the late cultivars.

Vukasin *et al.* (2010) analyzed five varieties of carrot for the contents of carotene in the root. Highest carotene was recorded in the cultivar Scarla and lowest in the variety Danvers 126.

Gadomska and Wierzbicka (2010) conducted an experiment to determine chemical composition of carrot cultivars with orange and purple colour. The purple root cultivars recorded higher content of dry matter, ascorbic acid and total carbohydrates.

Karkleliene *et al.,* 2012, conducted studies on carrot cultivars and hybrids Svalia F1, Skalsa F1, Bolero F1, Noveno F1, Garduoles, Vaiguva, Vytenu nanto, Satrija, Monanta, Tito, Samson, Magi and Crona. Sowing was done on the 29th of April 2009 and 28th of April 2010. A two years' study showed that Noveno F1 had the highest content of carotene.

Marta *et al.* (2013) stated that the quantity of sugar in carrot roots has a great influence on the perception of sweetness and can even mask bitterness. In his experiment he used cultivar Nantes-5 and Flakker-3 and the sowing periods were March and May. Between the two carrot cultivars, the high content of sugar (10.73 % of fresh product) was recorded in the Nantes-5, sown early.

Aubert *et al.* (2013) reported that aroma compound levels in carrots were found to be highest in red, yellow and white carrots. The white, red and purple varieties had the highest levels of vitamin C. Only traces of carotenoids were detected in yellow carrots and no compounds were detected in white carrots. Those with an orange core showed levels of α and β carotene of up to 45 per cent higher than in yellow carrots. In this study, purple carrots, particular those with an orange core were found to be superior in nutritional quality.

2.4 Organoleptic evaluation

Sensory analysis is a technique that uses man as a measuring instrument. When applied to carrots, this tool makes it possible to describe the product's qualitative and quantitative organoleptic criteria (Cottet *et al.,* 2007).

Rosenfeld (1998) conducted experiment on carrot cv. Panther F1 grown in climate chambers at 9, 12, 15, 18 and 21°C, constant diurnal temperatures at three different periods of the year. The effect of varying solar radiation and temperatures

on growth, sensory attributes and chemical composition was evaluated. Higher levels of light significantly increased most chemical and physical variables of the carrot roots. Temperature was the most important factor determining the variation in sensory and chemical variables.

Borowska *et al.* (2005) evaluated fifteen varieties and six strains of carrot for sensory qualities like flavour, odour, colour and texture. It was found that in most cases, particular varieties and strains of carrot were significantly different ($p<0.05$) in terms of the indicators under study.

Navez *et al.* (2012) focused on the variability of sensory criteria in carrots. Thirty genotypes in three varieties namely Nantes, Imperator, Flakker were evaluated. Carrots genetic resources were characterized through descriptive and quantitative sensory analyses as well as physical-chemical measurements. Significant differences were observed for all criteria, allowing varieties to be grouped based on their sensory characteristics. Texture, flavour and aroma contribute to the identity of carrots. Overall aroma was correlated with perceptions of bitterness, sharpness and chemical aroma. The measured quantity of sugar was not an indicator of the taste perception of sweetness, due to the influence of the potential for bitterness.

MATERIALS AND METHODS

3. Materials and methods

Present experiment was carried out during the period between October and March of 2013-14 at the Department of Olericulture, College of Horticulture, Vellanikkara, to evaluate the performance of different varieties of carrot and to study their response to different sowing dates.

3.1 EXPERIMENT SITE, SOIL AND CLIMATE

The location of the site was at about 10° 31^{1} N latitude, 76° 13^{1} E longitude with an average altitude of 22.25 m above MSL. The area experienced typical warm humid tropical climate and received an average rainfall of 2663 mm per year. The soil of the experiment site is lateritic in origin grouped under the textural class of sandy clay loam and acidic in reaction. The climatic conditions during the period of the experimentation are shown in Appendix I.

The field was prepared thoroughly by repeated deep ploughing to get a fine tilth. The field was left for seven days for sun-drying to kill the harmful soil micro-organisms if any present in the soil. During the final land preparation the entire experiment field was leveled and divided into sub-plots (Plate 1).

The field was manured at 15 t ha^{-1} well decomposed farm yard manure about two weeks before sowing and thoroughly mixed with the soil. Nitrogen 50 kg ha^{-1} was applied in two splits, half at the time of sowing and the rest at one month after sowing. The full dose of Phosphorus (50 kg ha^{-1}) and Potassium (100 kg ha^{-1}) were applied as basal. Irrigation and other cultural operations were done in time as scheduled for carrot cultivation. The crop was harvested 80-110 days after sowing based on the varietal specifications.

Plate 1: Land Prepation

Plate 2: Field view

3.2 VARIETIES

Fifteen varieties were selected from both private and public sectors for evaluation and details are given in Table 1.

3.3 DATES OF SOWING

Seeds were sown at 15 days interval including five dates of sowing, *i.e.* 15th October, 1st November, 15th November, 1st December and 15th December. The experiment was laid out in split plot design. The crop was raised on beds (2 X 1.5 m). The seed rate was 8 kg ha^{-1}. The row to row distance was kept at 45cm while the plant to plant distance was maintained at 10 cm after thinning out of the plants when they were 21 days old. Two rows were maintained in each bed.

3.4 CHEMICALS AND GLASSWARE

The chemicals used for the present study were of good quality (AR grade) from NICE chemical agency and glass ware used was provided by Department of Olericulture.

3.5 EXPERIMENTAL DETAILS

3.5.1 Design of experiment

The experiment was laid out in two replications as split plot with sowing time in the main plot and varieties in the sub plot. The design adopted for field experiment was Randomized Block Design (RBD) and for organoleptic evaluation it was Complete Randomized Design (CRD).

Table-1: Details of carrot varieties used for the experiment

Treatments	Variety	Colour	Source	Duration(Days)	Type
T1	Pusa Rudhira	Red	IARI, New Delhi	90-110	Asiatic
T2	Pusa Meghali	Red	IARI, New Delhi	90-110	Asiatic
T3	Pusa Kesar	Red	IARI, New Delhi	90-110	Asiatic
T4	Nantes	Orange	IARI, New Delhi	110-120	European
T5	Kuroda (RKS)	Orange	R. K. Seeds	80-90	European
T6	Kuroda Improved	Orange	Tokita	80-90	European
T7	New Kuroda	Orange	Pradham Seeds Pvt. Ltd.	90	European
T8	Sarpan-601	Red	Sarpan Hybrid Seeds Co. Pvt. Ltd.	80	Asiatic
T9	Samson-196	Orange	Bejo-Sheetal Pvt . Ltd.	90	European
T10	Super Kuroda-1	Orange	Sakura Seed Corporation	90	European
T11	Century	Orange	Sakura Seed Corporation	90	European
T12	Flakker-2	Orange	Sakura Seed Corporation	90	European
T13	Desi Red (Lalit Kesar)	Red	Sakura Seed Corporation	90-110	Asiatic
T14	Super Kuroda-2	Orange	Ashoka Private seed company	80-90	European
T15	Indam Kuroda	Orange	Indo American Hybrid seeds	90	European

3.5.2 Morphological Characters

Ten normal plants were selected at random from each treatment and replication for recording following observations.

3.5.2.1 Days taken for germination

The number of days taken from sowing up to fifty per cent germination in each treatment and replication was recorded.

3.5.2.2 Plant height

Plant height was recorded using a meter rule, the measurement was taken from the base of the plant to the apex of the longest leaf and expressed in centimeters.

3.5.2.3 Plant spread

Plant spread was measured in two directions East-West and North-South and the mean is expressed as plant spread.

3.5.2.4 Number of leaves

The leaf number was recorded by counting all the leaves on the plant at the time of harvest and expressed in numbers.

3.5.2.5 Leaf length

Leaf length was measured from the base of leaf petiole to tip and expressed in centimeter. Third leaf from the top was used for taking observation

3.5.2.6 Leaf width

Same leaf used for measuring leaf length was used for recording leaf width and expressed in centimeters.

3.5.2.7 Length of petiole

Length of petiole was measured from the base of leaf petiole to starting of the leaf lamina and expressed in centimeters.

3.5.2.8 Foliage weight

Foliage weight was recorded at harvesting and expressed in grams.

3.5.2.9 Root/shoot ratio

Root/shoot ratio was calculated by using the following formula.

$$\text{Root/shoot ratio} = \frac{\text{Root weight}}{\text{Foliage weight}}$$

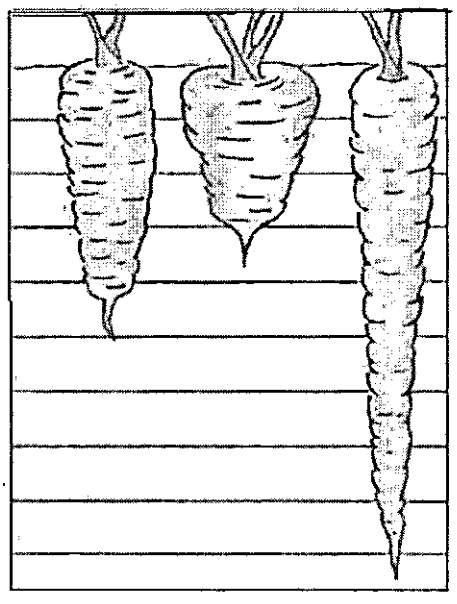
3.5.2.10 Root colour

The root colour of carrots was classified as white, yellow, orange, red or purple as per the colour indices of NBPGR descriptor.

3.5.2.11 Root shape

Root shape was recorded as cylindrical, conical or tapering based on following shapes.

Cylindrical Conical Tapering



3.5.2.12 Root tail

Root tail was recorded as acute or semi blunt or blunt based on the NBPGR descriptor.

3.5.2.13 Root length

Root length was measured from the crown to the end of the root and expressed in centimeters.

3.5.2.14 Root girth

Root girth (at center) was measured by using thread and scale and expressed in centimeters.

3.5.2.15 Root diameter

Root diameter (at centre) was measured by using scale and expressed in centimeters.

3.5.2.16 Root weight

Root weight was recorded by using an electric balance and expressed in grams.

3.5.2.17 Root pubescence

Root pubescence was observed during harvesting and expressed whether present or absent.

3.5.2.18 Coreness

Presence of central core was observed and recorded as present or absent.

3.5.2.19 Core size

Core size was recorded by measuring the diameter of core and expressed in centimeters.

3.5.2.20 Core colour

Core colour was recorded whether it is self coloured or white or cream or red colour based on NBPGR descriptor.

3.5.2.21 Days to harvest

Days to harvest was decided looking at the root maturity and based on the varietal characters.

3.5.2.22 Forking

All branched roots of each plot were collected at the harvest, their number was recorded and expressed in per cent.

3.5.2.23 Root splitting/cracking

Roots that cracked were collected from each plot and their total number was recorded and expressed in per cent.

3.5.2.24 Green shoulders

Number of roots with green shoulder was recorded during harvesting and expressed in per cent.

3.5.2.25 Bolting

Days taken for the bolting and the number of plants bolted were recorded and expressed as percentage.

3.5.2.26 Bitterness

Bitterness was decided by a ten member panel by sensory evaluation on the day of harvest.

3.5.2.27 Root yield per plot

All the carrots in a plot were harvested and root weight was recorded in kilograms.

3.5.2.28 Pest and disease incidence

Throughout the cropping period pest and disease incidence on crop was monitored and corrective measures were taken.

3.5.3 Sensory evaluation

Organoleptic evaluation of carrots was carried out using score card method (Swaminathan, 1974) by a panel of 10 judges. Test was carried out for fresh roots immediately after harvesting.

Ten quality attributes namely colour, odour, taste, flavour, hardness, sweetness, pungency (terpene flavour), crispness, after taste and general appearance were accessed on a nine point hedonic scale. Overall acceptability was calculated separately using the average of above mentioned quality attributes. The score used for the evaluation of carrot varieties is given in Appendix-II

3.5.4 Biochemical analysis

3.5.4.1 Root dry matter

After recording the fresh weight the root samples were oven dried for constant weight and the dry weight was recorded. Root dry matter was calculated by using following formula and expressed in percentage.

$$\text{Root dry matter} = \frac{\text{Dry weight}}{\text{Fresh weight}} \times 100$$

3.5.4.2 Total soluble solids

Total soluble solids in carrots was recorded by using a hand refractometer (Erma, Japan) (range 0-32 ^{0}B) at room temperature and the values were expressed in degree brix (Ranganna, 1986).

3.5.4.3 Total Sugars

Total sugar was determined by using the method, given by Lane and Eyon (Ranganna, 1986). From the clarified solution prepared by pulped carrot by filtering through Whatman no. 40 filter paper. 25 ml of filtrate was transferred to 250 ml conical flask and 100 ml water was added to it and neutralized by 1N sodium hydroxide (NaOH) using phenolphthalein as indicator (The end point is the appearance of brick red colour) and 2 ml lead acetate was added to clarify the solution and kept still for 10 min. Then 2 ml of potassium oxalate solution was added and allowed to settle as precipitate and waited for 5 min. and filtered the solution to a 250 ml standard flask and made up volume, from this 50 ml solution was taken and boiled gently after adding citric acid and Fehling's B solution. It was later neutralized with sodium hydroxide. An aliquot of this solution was titrated against Fehling's A solution. The total sugar content was expressed as percentage.

3.5.4.4 Acidity

Titratable acidity in carrot was estimated by the method suggested by Ranganna (1986). Extracts were prepared by boiling weighed quantity of fresh carrot in distilled water. An aliquot of the extract was titrated against 0.1 N sodium

hydroxide (NaOH) using phenolphthalein as indicator. Acidity was expressed in terms of percentage.

3.5.4.5 β carotene

β carotene content was estimated by Association of Official Agricultural Chemists (AOAC, 2005) method. Eight gram sample was taken in 150 ml glass stoppered Erlenmeyer flask and 40 ml water saturated butanol (WSB) was added. The content of flasks were mixed vigorously for 1 min. and kept overnight (16-18 hrs) at room temperature under dark for complete extraction of β carotene. On the next day, the contents were shaken again and then filtered completely through the Whatman no. 1 filter paper into a 100 ml volumetric flask. The optical density of the clear filtrate was measured at 440 nm using spectrophotometer. Pure WSB was used as blank. The β carotene was calculated from calibration curve from known amount of β carotene.

3.6 STATISTICAL ANALYSIS

The mean of the values observed on ten plants were recorded and tabulated and the data were analyzed statistically as Split plot design suggested by Fisher (1954). Analysis was carried out at the computer center, Department of Agricultural Statistics, Kerala Agricultural University.

RESULTS

04. RESULTS

The results of the experiment entitled "Performance evaluation and standardization planting time in carrot (*Daucus carota* L.)" are presented in this chapter.

4.1 MORPHOLOGICAL CHARACTERS

4.1.1 Days taken to germination

Carrot seed germination started from 7th day of sowing and was completed by the 10th day in all dates of sowing and the varieties.

4.1.2 Germination percentage

The germination of seed significantly differed among the different date of sowing and ranged from 45.80 to 66.03. The highest seed germination was recorded in D_4 (66.03 %) which was on par with D_2 (62.80 %) and D_3 (61.70 %). The lowest value of germination was recorded in D_5 (45.80 %) which was on par with D_1 (48.53 %) (Plate 3).

Significant variation in seed germination was also recorded among the cultivar studied. V_{15} recorded the highest per cent of seed germination with 63.10 per cent which was on par with V_3 (61.60 %) and were followed by V_2 (59.50 %), V_5 (58.60 %), V_{14} (58.40 %) and V_{10} (58.30 %). V_2, V_5, V_{14} and V_{10} were statistically on par. The lowest per cent of seed germination was recorded in V_6 (51.90 %).

There was differential germination noticed among the different varieties over the different dates of sowing. The highest per cent of seed germination was in D_2V_{15} (76.50 %) which was on par with D_3V_3 (76.00 %) and D_4V_{15} (76.00 %). They were in turn on par with D_3V_2, D_3V_1, D_4V_2, D_4V_{14}, D_3V_{15} and D_4V_{15}. The lowest value was recorded in D_5V_2 with 40.00 per cent of germination (Table.2).

15th October sowing

15th December sowing

Plate 3: Poor seed germination

4.1.3 Plant height

Plant height showed significant variation on all the dates of sowing. The highest plant height of 37.10 cm was recorded in D_1 followed by D_4, D_3 and D_2 with plant height of 33.57 cm, 33.37 cm and 33.12 cm respectively. Three sowing times namely D_2, D_3 and D_4 were statistically on par with respect to plant height. D_5 recorded lowest plant height among all the dates of sowing with 30.22 cm.

Plant height varied between 26.30 cm to 40.57 cm. significant differences were also noticed in plant height among cultivars. The highest plant height of 40.57 cm was recorded in V_8. It was followed by V_6, V_7 and V_3 with plant height of 37.63 cm, 37.12 and 36.40 cm respectively and V_3, V_6 and V_7 were spastically on par. The cultivar V_{11} recorded lowest height 26.30 cm and was on par withV_{12} with 26.50 cm.

Interaction between sowing time and cultivars also revealed highly significant variation with respect to plant height. The highest plant height of 50.34 cm was recorded in D_1V_3 which was on par with D_1V_8 (47.84 cm) followed by D_3V_8 (42.17 cm). D_3V_8 as on par with D_1V_1, D_1V_4, D_1V_6, D_1V_7, D_2V_6, D_2V_7, D_2V_8, D_3V_6, D_3V_7, D_4V_6, D_4V_7 and D_4V_8. The lowest plant height of 24 cm was recorded in D_2V_{11} (Table 3).

Table 2 Interaction effect of dates of sowing and cultivars on germination per cent of carrot seeds

Cultivars	Dates of sowing					
	D_1	D_2	D_3	D_4	D_5	Mean (Cultivar)
V_1	44.00^{yz}	60.50^{ghij}	71.50^{ab}	63.50^{defg}	44.00^{yz}	56.70^{cde}
V_2	48.50^{rstu}	66.50^{cde}	72.00^{ab}	70.50^{ab}	40.00^{z}	59.50^{bc}
V_3	53.50^{nopq}	64.00^{defg}	76.00^{a}	67.50^{cde}	47.00^{uvwx}	61.60^{ab}
V_4	45.00^{wxyz}	66.00^{cde}	55.50^{lmno}	64.50^{defg}	51.00^{opqr}	56.40^{cde}
V_5	46.50^{vwxy}	66.50^{cde}	71.50^{ab}	65.50^{cde}	43.00^{yz}	58.60^{bc}
V_6	51.50^{opqr}	54.00^{mnop}	46.00^{vwxy}	64.50^{defg}	43.50^{yz}	51.90^{g}
V_7	53.00^{nopq}	57.00^{jklm}	49.50^{qrst}	64.50^{defg}	45.00^{wxyz}	53.80^{efg}
V_8	48.00^{stuv}	50.50^{pqrs}	51.50^{opq}	68.00^{bc}	49.00^{qrst}	53.40^{efg}
V_9	51.00^{opqr}	57.50^{ijkl}	56.50^{klmn}	56.00^{klmn}	45.00^{wxyz}	53.20^{fg}
V_{10}	57.50^{ijkl}	58.50^{hijk}	62.50^{efgh}	61.50^{fghi}	51.50^{opqr}	58.30^{bc}
V_{11}	45.50^{vwxy}	67.00^{cde}	59.50^{ghij}	68.00^{bc}	44.50^{xyz}	56.90^{cd}
V_{12}	45.50^{vwxy}	64.00^{cdef}	57.00^{jklm}	63.50^{defg}	46.00^{vwxy}	55.20^{de}
V_{13}	45.50^{vwxy}	68.00^{bc}	67.50^{cde}	63.50^{defg}	43.50^{yz}	57.60^{cd}
V_{14}	47.00^{uvwx}	65.50^{cde}	59.50^{ghij}	73.50^{ab}	46.50^{vwxy}	58.40^{bc}
V_{15}	46.00^{vwxy}	76.50^{a}	69.50^{ab}	76.00^{ab}	47.50^{tuv}	63.10^{a}
Mean (Dates of sowing)	48.53^{B}	62.80^{A}	61.70^{A}	66.03^{A}	45.80^{B}	

Mean values having similar alphabets in superscript, do not differ significantly

D1-15th October	**V1-Pusa Rudhira**	**V6-Kuroda Improved**	**V11-Century**
D2-1st November	**V2-Pusa Meghali**	**V7-New Kuroda**	**V12-Flakker-2**
D3-15th November	**V3-Pusa Kesar**	**V8-Sarpan 601**	**V13-Desi Red (Lalit Kesar)**
D4-1st December	**V4-Nantes**	**V9-Samson-196**	**V14-Super Kuroda-2**
D5-15th December	**V5-Kuroda (RKS)**	**V10-Super Kuroda-1**	**V15-Indam Kuroda**

Table 3 Interaction effect of dates of sowing and cultivars on plant height (cm) of carrot

Cultivars	Dates of sowing					
	D_1	D_2	D_3	D_4	D_5	Mean (Cultivar)
V_1	39.67^{bc}	31.67^{pqrs}	32.33^{nopq}	32.67^{lmno}	31.00^{qrst}	33.47^{ef}
V_2	37.83^{cde}	35.34^{fghi}	35.67^{efgh}	35.50^{fghi}	33.50^{ijkl}	35.57^{cd}
V_3	50.34^{a}	32.67^{lmno}	33.00^{jklm}	33.50^{ijkl}	32.50^{mnop}	36.40^{bc}
V_4	41.00^{bc}	31.00^{qrst}	32.50^{mnop}	31.84^{opqr}	30.50^{rstu}	33.37^{ef}
V_5	35.34^{fghi}	27.17^{xyz}	27.17^{xyz}	27.50^{wxyz}	23.80^{z}	28.19^{h}
V_6	38.67^{bc}	38.84^{bc}	38.83^{bc}	39.67^{bc}	32.17^{nopq}	37.63^{b}
V_7	38.67^{bc}	39.17^{bc}	38.50^{bc}	39.50^{bc}	29.78^{stuv}	37.12^{b}
V_8	47.84^{a}	40.84^{bc}	42.17^{b}	41.00^{bc}	31.00^{qrst}	40.57^{a}
V_9	31.17^{qrst}	29.34^{uvwx}	29.83^{stuv}	30.17^{rstu}	30.67^{rstu}	30.23^{g}
V_{10}	31.17^{qrst}	36.67^{efgh}	35.84^{efgh}	36.17^{efgh}	32.84^{klmn}	34.54^{de}
V_{11}	29.67^{tuvw}	24.00^{z}	24.84^{z}	25.67^{yz}	27.33^{wxyz}	26.30^{i}
V_{12}	32.00^{opqr}	24.34^{z}	25.17^{z}	25.67^{yz}	25.33^{z}	26.50^{i}
V_{13}	37.34^{cde}	38.00^{cde}	36.84^{efgh}	36.50^{efgh}	27.62^{wxyz}	35.26^{cd}
V_{14}	28.84^{vwxy}	33.83^{ijkl}	33.83^{ijkl}	33.33^{ijkl}	31.67^{pqrs}	32.30^{f}
V_{15}	37.00^{defg}	34.00^{hijk}	34.00^{hijk}	34.84^{ghij}	33.63^{ijkl}	34.69^{de}
Mean (Dates of sowing)	37.10^{A}	33.12^{B}	33.37^{B}	33.57^{B}	30.22^{C}	

Mean values having similar alphabets in superscript, do not differ significantly

D1-15th October **V1-Pusa Rudhira** **V6-Kuroda Improved** **V11-Century**

D2-1st November **V2-Pusa Meghali** **V7-New Kuroda** **V12-Flakker-2**

D3-15th November **V3-Pusa Kesar** **V8-Sarpan 601** **V13-Desi Red (Lalit Kesar)**

D4-1st December **V4-Nantes** **V9-Samson-196** **V14-Super Kuroda-2**

D5-15th December **V5-Kuroda (RKS)** **V10-Super Kuroda-1** **V15-Indam Kuroda**

4.1.4 Plant spread (E-W)

Significant variation was observed in plant spread (E-W) among dates of sowing, cultivar and interaction between dates of sowing and cultivar. Among dates of sowing highest plant spread (E-W) was observed in D_4 (34.66 cm) which was on par with D_3 (34.63 cm), D_2 (34.07 cm) and D_1 (34.02 cm). The lowest plant spread (E-W) was observed from D_5 with 29.86 cm.

Cultivar V_7 showed the highest plant spread of 47.09 cm followed by V_1 (42.03 cm), V_8 (40.79 cm) and V_{15} (37.63 cm). The lowest plant spread (E-W) was observed in V_4 (28 cm).

Among the interaction effects D_1V_7 showed highest plant spread (E-W) (52.67 cm) which was on par with D_2V_7 (51.67 cm), D_3V_7 (50.83 cm) and D_4V_7 (49.00 cm) followed by D_4V_1 (44.00 cm), D_1V_1 (43.83 cm) and D_3V_1 (43.67 cm). The lowest plant spread (E-W) was observed from D_1V_4 of 26.34 cm (Table 4).

4.1.5 Plant spread (N-S)

Significant difference in plant spread (N-S) was noticed among the dates of sowing, cultivars and the interactions between dates of sowing and cultivars. Among dates of sowing D_2 and D_4 recorded highest plant spread (N-S) of 36.37 cm which were on par with D_1 (36.27 cm) and D_3 (36.16 cm). The lowest plant spread was noticed in D_5 (29.89 cm).

Cultivar V_7 recorded highest plant spread (N-S) of 44.93 cm which was on par with V_1 (43.77 cm) followed by V_3 (41.38 cm), V_{13} (40.63 cm) and V_{10} (33.89 cm). The lowest plant spread (N-S) was recorded in V_4 (30.57 cm) which was on par with V_{12} (30.67 cm) and V_5 (30.7 cm).

Among interactions between dates of sowing and cultivars D_1V_7 recorded highest plant spread (N-S) of 51.00 cm which was on par with D_2V_7 (50.50 cm)

followed by D_2V_1 (47 cm), D_3V_7 (46.84 cm) and D_1V_1 (46.67 cm). The lowest plant spread (N-S) was recorded in D_5V_9 (25.17 cm) (Table 5).

Table 4 Interaction effect of dates of sowing and cultivars on plant spread (E-W) (cm) of carrot

Cultivars	Dates of sowing					
	D_1	D_2	D_3	D_4	D_5	Mean (Cultivar)
V_1	43.83^{b}	43.17^{bc}	43.67^{b}	44.00^{cde}	35.50^{efg}	42.03^{b}
V_2	28.33^{mnop}	29.67^{jklm}	30.84^{ghij}	31.34^{ghi}	30.10^{hijk}	30.05^{f}
V_3	30.50^{hijk}	30.00^{ijkl}	31.50^{ghij}	31.67^{ghij}	28.80^{lmno}	30.49^{f}
V_4	26.34^{s}	28.17^{nopq}	29.17^{klmn}	29.67^{jhij}	26.67^{rs}	28.00^{g}
V_5	29.00^{klmn}	29.50^{jklm}	30.67^{hijk}	30.17^{hijk}	27.67^{pqrs}	29.40^{fg}
V_6	31.50^{ghij}	31.00^{ghij}	31.83^{ghij}	31.50^{ghij}	28.00^{opqr}	30.77^{ef}
V_7	52.67^{a}	51.67^{a}	50.83^{a}	49.00^{a}	31.30^{ghij}	47.09^{a}
V_8	42.17^{bc}	42.00^{bc}	42.34^{bc}	42.67^{bc}	34.80^{fghi}	40.79^{b}
V_9	30.84^{ghij}	31.84^{ghij}	33.17^{ghij}	33.50^{ghij}	32.70^{ghij}	32.41^{de}
V_{10}	34.67^{fghi}	32.84^{ghij}	33.67^{ghij}	33.00^{ghij}	29.30^{jklm}	32.69^{d}
V_{11}	30.00^{ijkl}	30.67^{hijk}	31.00^{ghij}	31.50^{ghij}	30.34^{hijk}	30.70^{ef}
V_{12}	29.00^{klmn}	29.00^{klmn}	29.84^{jklm}	30.17^{hijk}	26.60^{rs}	28.92^{fg}
V_{13}	34.84^{fgh}	34.00^{jklm}	33.33^{ghij}	33.50^{ghij}	27.67^{pqrs}	32.67^{d}
V_{14}	27.17^{pqrs}	27.84^{pqrs}	28.84^{lmno}	29.50^{jklm}	27.00^{qrs}	28.07^{g}
V_{15}	39.50^{bc}	39.67^{bc}	38.83^{ghij}	38.67^{def}	31.50^{ghij}	37.63^{c}
Mean (Dates of sowing)	34.02^{A}	34.07^{A}	34.63^{A}	34.66^{A}	29.86^{B}	

Means values having similar alphabets in superscript, do not differ significantly

D1-15th October **V1-Pusa Rudhira** **V6-Kuroda Improved** **V11-Century**

D2-1st November **V2-Pusa Meghali** **V7-New Kuroda** **V12-Flakker-2**

D3-15th November **V3-Pusa Kesar** **V8-Sarpan 601** **V13-Desi Red (Lalit Kesar)**

D4-1st December **V4-Nantes** **V9-Samson-196** **V14-Super Kuroda-2**

D5-15th December **V5-Kuroda (RKS)** **V10-Super Kuroda-1** **V15-Indam Kuroda**

Table 5 Interaction effect of dates of sowing and cultivars on plant spread (N-S) (cm) of carrot

Cultivars	Dates of sowing					
	D_1	D_2	D_3	D_4	D_5	Mean (Cultivar)
V_1	46.67^{bc}	47.00^{bc}	45.33^{cde}	45.33^{cde}	34.50^{fghi}	43.77^{a}
V_2	33.50^{fghi}	33.67^{fghi}	33.84^{fghi}	34.34^{fghi}	28.25^{nop}	32.72^{cd}
V_3	44.17^{cde}	43.33^{cde}	41.84^{e}	41.84^{e}	35.75^{fg}	41.38^{b}
V_4	31.83^{ghij}	30.00^{jklm}	30.67^{hijk}	32.00^{fghi}	28.34^{nop}	30.57^{e}
V_5	31.00^{hijk}	31.50^{ghij}	31.84^{ghij}	31.67^{ghij}	27.50^{op}	30.70^{e}
V_6	33.33^{fghi}	34.33^{fghi}	34.84^{fghi}	35.17^{fgh}	28.50^{nop}	33.23^{cd}
V_7	51.00^{a}	50.50^{ab}	46.84^{bc}	46.34^{cd}	30.00^{jklm}	44.93^{a}
V_8	35.33^{fgh}	34.84^{fghi}	34.17^{fghi}	33.33^{fghi}	27.50^{op}	33.03^{cd}
V_9	34.17^{fghi}	34.50^{fghi}	33.67^{fghi}	34.50^{fghi}	25.17^{p}	32.40^{cde}
V_{10}	34.84^{fghi}	36.50^{f}	35.33^{fghi}	34.50^{fghi}	28.30^{nop}	33.89^{c}
V_{11}	30.67^{hijk}	31.34^{ghij}	32.50^{fghi}	33.50^{fghi}	31.34^{ghij}	31.87^{de}
V_{12}	30.50^{ijkl}	31.00^{hijk}	31.50^{ghij}	32.00^{fghi}	28.34^{nop}	30.67^{e}
V_{13}	42.33^{de}	42.84^{cde}	42.17^{de}	41.84^{e}	34.00^{fghi}	40.63^{b}
V_{14}	29.67^{klmn}	29.17^{lmno}	32.50^{fghi}	33.83^{fghi}	32.17^{fghi}	31.47^{de}
V_{15}	35.00^{fghi}	35.00^{fghi}	35.33^{fgh}	35.33^{fgh}	28.75^{mnop}	33.88^{c}
Mean (Dates of sowing)	36.27^{A}	36.37^{A}	36.16^{A}	36.37^{A}	29.89^{B}	

Mean values having similar alphabets in superscript, do not differ significantly

D1-15th October **V1-Pusa Rudhira** **V6-Kuroda Improved** **V11-Century**

D2-1st November **V2-Pusa Meghali** **V7-New Kuroda** **V12-Flakker-2**

D3-15th November **V3-Pusa Kesar** **V8-Sarpan 601** **V13-Desi Red (Lalit Kesar)**

D4-1st December **V4-Nantes** **V9-Samson-196** **V14-Super Kuroda-2**

D5-15th December **V5-Kuroda (RKS)** **V10-Super Kuroda-1** **V15-Indam Kuroda**

4.1.6 Number of leaves

Analysis of data on the number of leaves showed significant difference among dates of sowing. D_3 produced maximum number of leaves per plant (11.97) which was on par with D_4 (11.90) and D_2 (11.41). D_1 produced only 10.38 leaves which was the lowest among all dates of sowing and it was on par with D_5 (10.68).

Leaf number significantly varied among the cultivars and ranged from 7.23 to 16.83. V_3 produced maximum number of leaves (16.83) followed by V_2, V_1, V_7 and V_{13} with 14.08, 13.52, 13.17 and 12.73 leaves respectively. V_{11} produced only 7.23 leaves which was the lowest among the all cultivars.

Interaction effect was also highly significant in the case number of leaves. The number of leaves in different cultivars ranged between 6.17 and 20.00. In general V_5, V_9 and V_{11} had only 7-8 leaves in all the sowings while others produced more than 10.00 leaves. V_3 showed highly significant interaction effect in three dates of sowing namely D_2, D_3 and D_4. D_3V_3 produced maximum number of leaves (20.00) closely followed by D_2V_3, D_4V_3 and D_1V_7, with 19.34 leaves each, and all the four were statistically on par, while D_1V_{11} produced minimum number of leaves (6.17) (Table 6).

4.1.7 Leaf length

Leaf length differed significantly with dates of sowing, cultivars and interactions between dates of sowing and cultivars. Among the dates of sowing the leaf length of 41.18 cm was the highest from D_1 followed by 40.00 cm, 39.81 cm and 39.53 cm from D_3, D_2 and D_4 respectively. All the four dates of sowing were on par. The lowest leaf length was recorded from D_5 (34.86 cm).

Among the cultivars V8 recorded highest leaf length 48.82 cm followed by V_3 and V_7 with the leaf length of 44.00 cm and 43.25 cm respectively. V_3 and V_7 were statistically on par. Cultivar V_{12} recorded lowest leaf length of 33.35 cm.

Leaf length varied from 30.75 to 56.50, among the cultivars in different sowings. Interaction between dates of sowing and cultivars also differed significantly for leaf length. The highest leaf length was noticed in D_1V_3 of 56.50 cm which was on par with D_1V_8 (55.84) followed by D_2V_8 (50.84 cm), D_3V_8 (50.83 cm) and D_4V_8 (49.33 cm). The D_2V_8, D_3V_8 and D_4V_8 were statistically on par. D_5V_{13} showed lowest leaf length of 30.75 cm. In general all the cultivars provided long leaves in D_1, D_2 D_3 and D_4. Leaf length was poor only in D_5 (Table 7).

4.1.8 Leaf width

There was significant difference in leaf width among dates of sowing, cultivars and interactions between dates of sowing and cultivars. Among the dates of sowing highest value of leaf width (14.50 cm) was observed in D_1. The lowest leaf width was noticed from D_5 (13.38 cm) it was on par with D_2, D_3 and D_4.

Among the cultivars highest value of leaf width of 17.27 cm was observed in V_8 followed by V_7 (16.08 cm), V_{13} (16.50 cm) and V_3 (15.97 cm) and V_7, V_{13} and V_3 were statistically on par. The lowest leaf width (10.45 cm) was given by V_9.

Width of leaf ranged between 9.00 cm and 20.84 cm among the cultivars in the different sowings. Cultivar V_3, V_7, V_8 and V_{13} in general produced broad leaves in all sowings. The highest leaf width was observed in D_1V_1 (20.84 cm), which was on par with D_1V_8 (20.42 cm), followed by D_3V_8 (17.50 cm) D_2V_3, D_3V_3, D_4V_3, D_4V_7 and D_1V_{10}. The lowest value of leaf width was observed in D_1V_{14} (9.00 cm) (Table 8).

Table 6 Interaction effect of dates of sowing and cultivars on number of leaves of carrot

Cultivars	Dates of sowing					
	D_1	D_2	D_3	D_4	D_5	Mean (Cultivar)
V_1	17.84^{b}	11.50^{jklm}	12.84^{efgh}	13.00^{efgh}	12.44^{fghi}	13.52^{c}
V_2	8.17^{vwxy}	15.84^{c}	16.50^{c}	16.67^{c}	13.25^{efg}	14.08^{b}
V_3	11.00^{nopq}	19.34^{a}	20.00^{a}	19.34^{a}	14.50^{d}	16.83^{a}
V_4	10.50^{pqrs}	12.50^{fghi}	12.33^{fghi}	12.67^{fghi}	11.17^{lmno}	11.83^{e}
V_5	9.17^{tuv}	6.84^{z}	8.67^{uvw}	8.50^{vwxy}	8.00^{vwxy}	8.23^{i}
V_6	10.50^{pqrs}	11.00^{mnop}	11.67^{ijkl}	11.34^{klmn}	9.84^{stu}	10.87^{fg}
V_7	19.34^{a}	12.17^{ghij}	12.00^{ghij}	11.50^{jklm}	10.83^{nopq}	13.17^{cd}
V_8	8.84^{uvwx}	10.67^{opqr}	11.00^{nopq}	11.33^{klmn}	10.82^{opqr}	10.53^{fgh}
V_9	7.84^{wxyz}	7.00^{z}	7.67^{xyz}	7.84^{wxyz}	7.54^{yz}	7.58^{j}
V_{10}	7.84^{wxyz}	11.84^{hijk}	12.00^{ghij}	11.84^{hijk}	10.84^{nopq}	10.87^{fg}
V_{11}	6.17^{z}	6.67^{z}	7.50^{yz}	7.67^{xyz}	8.17^{vwxy}	7.23^{j}
V_{12}	6.84^{z}	11.00^{mnop}	11.00^{nopq}	11.34^{klmn}	10.50^{pqrs}	10.13^{h}
V_{13}	9.00^{tuv}	14.50^{d}	14.50^{d}	14.00^{de}	11.65^{ijkl}	12.73^{d}
V_{14}	9.17^{tuv}	10.17^{qrst}	10.84^{nopq}	11.00^{nopq}	10.62^{pqrs}	10.36^{gh}
V_{15}	13.50^{def}	10.17^{qrst}	11.00^{mnop}	10.50^{pqrs}	10.09^{rst}	11.05^{f}
Mean (Dates of sowing)	10.38^{B}	11.41^{AB}	11.97^{A}	11.90^{A}	10.68^{B}	

Mean values having similar alphabets in superscript, do not differ significantly

D1-15th October	**V1-Pusa Rudhira**	**.V6-Kuroda Improved**	**V11-Century**
D2-1st November	**V2-Pusa Meghali**	**V7-New Kuroda**	**V12-Flakker-2**
D3-15th November	**V3-Pusa Kesar**	**V8-Sarpan 601**	**V13-Desi Red (Lalit Kesar)**
D4-1st December	**V4-Nantes**	**V9-Samson-196**	**V14-Super Kuroda-2**
D5-15th December	**V5-Kuroda (RKS)**	**V10-Super Kuroda-1**	**V15-Indam Kuroda**

Table 7 Interaction effect of dates of sowing and cultivars on leaf length (cm) of carrot

Cultivars	Dates of sowing					
	D_1	D_2	D_3	D_4	D_5	Mean (Cultivar)
V_1	44.00^{def}	40.50^{efgh}	41.34^{def}	40.50^{efg}	35.50^{pqrs}	40.37^{c}
V_2	41.67^{def}	40.00^{fghi}	40.00^{fghi}	40.50^{efg}	37.00^{mnop}	39.83^{c}
V_3	56.50^{a}	43.84^{def}	42.67^{def}	42.33^{def}	34.67^{stuv}	44.00^{b}
V_4	43.67^{def}	39.50^{fghi}	39.34^{ghij}	39.00^{ijkl}	35.84^{opqr}	39.47^{cd}
V_5	38.00^{klmn}	35.34^{pqrs}	36.50^{nopq}	36.17^{nopq}	33.84^{tuv}	35.97^{e}
V_6	41.67^{def}	41.34^{def}	40.50^{efgh}	39.33^{ghij}	36.30^{nopq}	39.83^{c}
V_7	43.50^{def}	45.67^{cd}	45.67^{cd}	44.67^{de}	36.75^{mnop}	43.25^{b}
V_8	55.84^{a}	50.84^{b}	50.83^{b}	49.33^{bc}	37.25^{lmno}	48.82^{a}
V_9	33.17^{vwxy}	35.84^{opqr}	37.17^{lmno}	36.67^{nopq}	35.50^{opqr}	35.67^{ef}
V_{10}	37.00^{mnop}	39.83^{fghi}	39.00^{ijkl}	38.33^{jklm}	34.67^{stuv}	37.77^{d}
V_{11}	34.84^{rstu}	33.84^{tuv}	35.17^{qrst}	34.17^{tvwx}	32.50^{wxy}	34.10^{fg}
V_{12}	35.84^{opqr}	31.84^{yz}	33.17^{vwx}	33.67^{uvw}	32.27^{xyz}	33.35^{g}
V_{13}	39.17^{hijk}	42.67^{def}	41.34^{def}	40.67^{efgh}	30.75^{z}	38.92^{cd}
V_{14}	33.17^{opqr}	36.84^{mnop}	37.34^{lmno}	37.17^{lmno}	32.50^{wxy}	35.40^{ef}
V_{15}	39.67^{hijk}	39.34^{ghij}	40.00^{fghi}	40.50^{efgh}	37.60^{lmno}	39.42^{cd}
Mean (Dates of sowing)	41.18^{A}	39.81^{A}	40.00^{A}	39.53^{A}	34.86^{B}	

Mean values having similar alphabets in superscript, do not differ significantly

D1-15th October **V1-Pusa Rudhira** **V6-Kuroda Improved** **V11-Century**

D2-1st November **V2-Pusa Meghali** **V7-New Kuroda** **V12-Flakker-2**

D3-15th November **V3-Pusa Kesar** **V8-Sarpan 601** **V13-Desi Red (Lalit Kesar)**

D4-1st December **V4-Nantes** **V9-Samson-196** **V14-Super Kuroda-2**

D5-15th December **V5-Kuroda (RKS)** **V10-Super Kuroda-1** **V15-Indam Kuroda**

Table 8 Interaction effect of dates of sowing and cultivars on leaf width (cm) of carrot

Cultivars	Dates of sowing					
	D_1	D_2	D_3	D_4	D_5	Mean (Cultivar)
V_1	20.84^{a}	11.33^{tuvw}	12.00^{qrst}	12.17^{pqrs}	11.17^{tuvw}	13.50^{de}
V_2	12.84^{mnop}	14.17^{hijk}	14.67^{ghij}	14.00^{hijk}	13.00^{lmno}	13.73^{de}
V_3	14.84^{fgh}	16.00^{bc}	16.67^{bc}	16.67^{bc}	15.67^{cde}	15.97^{b}
V_4	15.67^{cde}	14.67^{ghij}	15.34^{efgh}	14.50^{ghij}	13.50^{klmn}	14.73^{c}
V_5	11.84^{rstu}	10.50^{xyz}	10.67^{wxy}	10.84^{vwx}	9.84^{xyz}	10.73^{g}
V_6	15.34^{efgh}	13.84^{ijkl}	14.17^{hijk}	13.34^{klm}	12.22^{pqrs}	13.78^{de}
V_7	15.50^{def}	15.67^{cde}	17.17^{bc}	16.67^{bc}	15.43^{efgh}	16.08^{b}
V_8	20.42^{a}	17.33^{bc}	17.50^{b}	16.17^{ghij}	14.93^{fghi}	17.27^{a}
V_9	12.00^{qrst}	9.17^{yz}	10.67^{wxy}	10.84^{vwx}	9.60^{yz}	10.45^{g}
V_{10}	16.50^{bc}	13.33^{klmn}	13.00^{lmno}	14.00^{hijk}	13.88^{ijkl}	14.14^{cd}
V_{11}	12.25^{pqrs}	11.00^{vwx}	11.17^{uvwx}	12.00^{qrst}	13.00^{lmno}	11.88^{f}
V_{12}	11.59^{stuv}	13.50^{klmn}	14.17^{hijk}	13.67^{jklm}	14.67^{ghij}	13.52^{de}
V_{13}	14.17^{hijk}	17.00^{bc}	17.34^{bc}	16.50^{bc}	17.50^{b}	16.50^{b}
V_{14}	9.00^{z}	11.84^{rstu}	12.50^{nopq}	11.84^{rstu}	12.84^{mnop}	11.60^{f}
V15	14.67^{ghij}	12.34^{opqr}	12.83^{mnop}	12.50^{nopq}	13.50^{klmn}	13.17^{e}
Mean (Date of sowing)	14.50^{A}	13.44^{B}	13.99^{AB}	13.71^{AB}	13.38^{B}	

Mean values having similar alphabets in superscript, do not differ significantly

D1-15th October	**V1-Pusa Rudhira**	**V6-Kuroda Improved**	**V11-Century**
D2-1st November	**V2-Pusa Meghali**	**V7-New Kuroda**	**V12-Flakker-2**
D3-15th November	**V3-Pusa Kesar**	**V8-Sarpan 601**	**V13-Desi Red (Lalit Kesar)**
D4-1st December	**V4-Nantes**	**V9-Samson-196**	**V14-Super Kuroda-2**
D5-15th December	**V5-Kuroda (RKS)**	**V10-Super Kuroda-1**	**V15-Indam Kuroda**

SARPAN-601

NEW KURODA

PUSA RUDHIRA

Plate 4: Varieties with high foliage weight

SAMSON-196

CENTURY

KURODA (RKS)

Plate 5: Varieties with low foliage weight

4.1.9 Length of petiole

The data on the mean length of petiole showed significant difference among dates of sowing. The longest petiole length of 14.01 cm recorded in D_4 was statistically on par with D_3 (14.00 cm) and D_1 (13.79 cm) followed by D_2 (13.51 cm). The lowest petiole length was observed in D_5 (11.91 cm).

Cultivars differed significantly for length of petiole. The longest petiole length with 15.06 cm produced by V_2 was on par with V_3 (14.91 cm), V_8 (14.42 cm), $V_1$and V_7 (14.27 cm) followed by V_6 (13.95 cm), V_{11} (13.67 cm) and V_4 (13.66 cm). The lowest petiole length was observed in V_9 (10.69 cm).

There was differential germination noticed among the different varieties over the different dates of sowing. The highest petiole length was seen in D_1V_3 (17 cm) followed by D_2V_2 (16.50 cm), D_2V_7 (16.17 cm) and D_3V_{10} (15.83 cm), while D_2V_9 (7.84 cm) showed the lowest petiole length (Table 9).

4.1.10 Foliage weight

Analysis of data on the foliage weight of carrot showed significant difference among the dates of sowing, cultivars and interactions between dates of sowing and cultivars. Among dates of sowing maximum foliage weight was observed in D_1 (72.99 g) which was on par with D_3 (67.26 g) and D_2 (66.87 g), followed by D_4 (64.88 g). The minimum foliage weight was recorded in D_5 of 41.87 g.

Foliage weight of cultivar V_8 (113.20 g) was the highest among all the cultivars which was followed by V_1 (95.00 g) and V_3 (93.88 g). V_1 and V_3 were statistically on par (Plate 4). The minimum foliage weight of carrot was observed in cultivar V_{11} (25.40 g) which was closely on par with V_5 (29.20 g) (Plate 5).

D_2V_8 and D_3V_8 showed maximum foliage weight of 131.00 g among interactions between dates of sowing and cultivars, it was on par with D_4V_8 (126.00

g) intimately on par with D_1V_7 (123.00 g). The minimum foliage weight was showed by D_5V_{11} (18.50 g) which was on par with D_2V_5, D_2V_9, D_2V_{11}, D_3V_5, D_3V_9, D_3V_{11}, D_4V_5, D_4V_9, D_4V_{11}, D_5V_6, D_5V_9, D_5V_{11}, D_5V_{13} and D_5V_{14}. (Table 10).

Table 9 Interaction effect of dates of sowing and cultivars on length of petiole (cm) of carrot

Cultivars	Dates of sowing					
	D_1	D_2	D_3	D_4	D_5	Mean (Cultivar)
V_1	13.50^{fghi}	15.50^{bc}	15.33^{bc}	15.00^{bc}	12.00^{opqr}	14.27^{ab}
V_2	15.50^{bc}	16.50^{b}	15.67^{bc}	15.17^{bc}	12.45^{mnop}	15.06^{a}
V_3	17.00^{a}	13.34^{ghij}	13.67^{efgh}	13.84^{defg}	11.71pqrs	14.91^{a}
V_4	13.67^{efgh}	14.84^{bc}	13.67^{efgh}	14.84^{bc}	11.30^{rstu}	13.66^{b}
V_5	13.17^{hijk}	11.17^{stuv}	12.84^{jklm}	12.67^{klmn}	12.17^{nopq}	12.40^{c}
V_6	12.00^{opqr}	15.17^{bc}	14.75^{bc}	15.58^{bc}	12.25^{nopq}	13.95^{b}
V_7	12.33^{nopq}	16.17^{bc}	15.67^{bc}	14.50^{bc}	12.70^{klmn}	14.27^{ab}
V_8	15.50^{bc}	14.84^{bc}	15.09^{bc}	15.09^{bc}	11.60^{pqrs}	14.42^{ab}
V_9	11.50^{qrst}	7.84^{x}	10.34^{w}	11.00^{tuvw}	12.80^{jklm}	10.69^{d}
V_{10}	12.42^{mnop}	15.84^{bc}	15.83^{bc}	15.00^{bc}	12.80^{jkln}	14.38^{ab}
V_{11}	12.25^{nopq}	13.50^{fghi}	14.67^{bc}	15.33^{bc}	12.60^{lmno}	13.67^{b}
V_{12}	12.59^{lmno}	12.50^{mnop}	13.17^{hijk}	13.67^{efgh}	11.25^{rstu}	12.63^{c}
V_{13}	15.00^{bc}	11.17^{stuv}	13.17^{hijk}	12.33^{nopq}	10.65^{vw}	12.46^{c}
V_{14}	11.34^{rstu}	11.67^{pqrs}	12.67^{klmn}	13.00^{ijkl}	11.60^{pqrs}	12.05^{c}
V_{15}	14.17^{cde}	12.67^{klmn}	13.50^{fghi}	13.17^{hijk}	10.80^{uvw}	12.86^{c}
Mean (Dates of sowing)	13.79^{A}	13.51^{B}	14.00^{A}	14.01^{A}	11.91^{C}	

Mean values having similar alphabets in superscript, do not differ significantly

D1-15th October **V1-Pusa Rudhira** **V6-Kuroda Improved** **V11-Century**

D2-1st November **V2-Pusa Meghali** **V7-New Kuroda** **V12-Flakker-2**

D3-15th November **V3-Pusa Kesar** **V8-Sarpan 601** **V13-Desi Red (Lalit Kesar)**

D4-1st December **V4-Nantes** **V9-Samson-196** **V14-Super Kuroda-2**

D5-15th December **V5-Kuroda (RKS)** **V10-Super Kuroda-1** **V15-Indam Kuroda**

Plate 6: Variation in root colour

DESI RED

PUSA RUDHIRA

Plate 7: Varieties with long roots

INDAM KURODA

SUPER KURODA-2

SUPER KURODA-1

Plate 8: Varieties with small roots

Table 10 Interaction effect of dates of sowing and cultivars on foliage weight of carrot

Cultivars	Dates of sowing					
	D_1	D_2	D_3	D_4	D_5	Mean (Cultivar)
V_1	116.00^{bc}	96.00^{efg}	102.50^{def}	97.50^{efg}	63.00^{mno}	95.00^{b}
V_2	58.50^{nop}	98.00^{ef}	104.40^{de}	100.40^{def}	66.00^{lmn}	85.46^{c}
V_3	70.20^{klm}	106.00^{de}	110.50^{cd}	108.70^{cd}	74.00^{jkl}	93.88^{b}
V_4	100.50^{def}	78.50^{ijk}	73.50^{jkl}	71.00^{klm}	38.00^{vwx}	72.30^{d}
V_5	36.50^{wxy}	28.50^{yz}	28.50^{yz}	29.00^{yz}	23.50^{z}	29.20^{gh}
V_6	56.00^{nop}	62.00^{mno}	60.00^{nop}	57.00^{nop}	27.50^{yz}	52.50^{e}
V_7	123.00^{ab}	85.00^{hi}	82.00^{ij}	74.00^{jkl}	49.50^{qrs}	82.70^{c}
V_8	85.00^{hi}	131.00^{a}	131.00^{a}	126.00^{a}	93.00^{fgh}	113.20^{a}
V_9	49.50^{qrst}	27.50^{yz}	27.50^{yz}	29.50^{yz}	25.50^{z}	31.90^{g}
V_{10}	52.00^{pqr}	44.00^{tuv}	43.00^{tuv}	35.50^{xy}	26.00^{z}	40.10^{f}
V_{11}	47.50^{rst}	21.00^{z}	20.50^{z}	19.50^{z}	18.50^{z}	25.40^{h}
V_{12}	59.00^{nopq}	56.00^{nop}	57.00^{nop}	55.00^{opq}	43.00^{tuv}	54.00^{e}
V_{13}	87.60^{ghi}	82.00^{ij}	82.00^{ij}	79.50^{ijk}	22.00^{z}	70.62^{d}
V_{14}	53.00^{opq}	41.00^{uvx}	40.00^{uvw}	46.10^{rst}	20.50^{z}	40.12^{f}
V_{15}	100.50^{def}	46.50^{rst}	46.50^{rstu}	44.50^{stu}	38.00^{vwx}	55.20^{e}
Mean (Dates of sowing)	72.99^{A}	66.87^{AB}	67.26^{AB}	64.88^{B}	41.87^{C}	

Mean values having similar alphabets in superscript, do not differ significantly

D1-15th October **V1-Pusa Rudhira** **V6-Kuroda Improved** **V11-Century**

D2-1st November **V2-Pusa Meghali** **V7-New Kuroda** **V12-Flakker-2**

D3-15th November **V3-Pusa Kesar** **V8-Sarpan 601** **V13-Desi Red (Lalit Kesar)**

D4-1st December **V4-Nantes** **V9-Samson-196** **V14-Super Kuroda-2**

D5-15th December **V5-Kuroda (RKS)** **V10-Super Kuroda-1** **V15-Indam Kuroda**

4.1.11 Root colour

In carrot the root colour is dependent on the type of carrot. Asiatic carrots are red in colour and European carrots are orange in colour. No significant variation was observed between the dates of sowing and interaction with respect to root colour of carrots cultivars. V_1, V_2, V_3, V_8 and V_{13} showed red colour in all five season of planting and remaining all varieties had orange colour (Table 11) (Plate 6).

4.1.12 Root shape

The root shape is also depending on varieties. No significant difference was found among the dates of sowing.V_1, V_2, V_7, V_8 and V_{13} exhibited tapering shape, V_5 had conical shape and V_3, V_4, V_9, V_{10}, V_{11}, V_{12}, V_{14} and V_{15} showed cylindrical shape during all five dates of planting (Table 12).

4.1.13 Root tail

There was no significant difference in the root tail among the dates of sowing but among the varieties the root tail differed. Cultivars V_1, V_3, V_5, V_{12} and V14 were having acute root tail, V_2, V_4, V_6, V_8, V_{11} and V_{15} were having semi blunt root hair and V_7, V_9 and V_{13} produced blunt root tail irrespective of dates of sowing (Table 13).

4.1.14 Root length

Analysis of data on the root length showed significant difference among dates of sowing, D_3 produced maximum root length of 14.94 cm which was on par with D_2 (14.88 cm) and D_4 (14.36 cm). D_5 produced root length of 12.17 cm which was lowest among all the dates of sowing followed by D_1 (13.76 cm).

Table 11 Interaction effect of dates of sowing and cultivars on root colour of carrot

Cultivars	Dates of sowing				
	D_1	D_2	D_3	D_4	D_5
V_1	Red	Red	Red	Red	Red
V_2	Red	Red	Red	Red	Red
V_3	Red	Red	Red	Red	Red
V_4	Orange	Orange	Orange	Orange	Orange
V_5	Orange	Orange	Orange	Orange	Orange
V_6	Orange	Orange	Orange	Orange	Orange
V_7	Orange	Orange	Orange	Orange	Orange
V_8	Red	Red	Red	Red	Red
V_9	Orange	Orange	Orange	Orange	Orange
V_{10}	Orange	Orange	Orange	Orange	Orange
V_{11}	Orange	Orange	Orange	Orange	Orange
V_{12}	Orange	Orange	Orange	Orange	Orange
V_{13}	Red	Red	Red	Red	Red
V_{14}	Orange	Orange	Orange	Orange	Orange
V_{15}	Orange	Orange	Orange	Orange	Orange

D1-15th October **V1-Pusa Rudhira** **V6-Kuroda Improved** **V11-Century**

D2-1st November **V2-Pusa Meghali** **V7-New Kuroda** **V12-Flakker-2**

D3-15th November **V3-Pusa Kesar** **V8-Sarpan 601** **V13-Desi Red (Lalit Kesar)**

D4-1st December **V4-Nantes** **V9-Samson-196** **V14-Super Kuroda-2**

D5-15th December **V5-Kuroda (RKS)** **V10-Super Kuroda-1** **V15-Indam Kuroda**

Table 12 Interaction effect of dates of sowing and cultivars on root shape of carrot

Cultivars	Dates of sowing				
	D_1	D_2	D_3	D_4	D_5
V_1	Tapering	Tapering	Tapering	Tapering	Tapering
V_2	Tapering	Tapering	Tapering	Tapering	Tapering
V_3	Cylindrical	Cylindrical	Cylindrical	Cylindrical	Cylindrical
V_4	Cylindrical	Cylindrical	Cylindrical	Cylindrical	Cylindrical
V_5	Conical	Conical	Conical	Conical	Conical
V_6	Cylindrical	Cylindrical	Cylindrical	Cylindrical	Cylindrical
V_7	Tapering	Tapering	Tapering	Tapering	Tapering
V_8	Tapering	Tapering	Tapering	Tapering	Tapering
V_9	Cylindrical	Cylindrical	Cylindrical	Cylindrical	Cylindrical
V_{10}	Cylindrical	Cylindrical	Cylindrical	Cylindrical	Cylindrical
V_{11}	Cylindrical	Cylindrical	Cylindrical	Cylindrical	Cylindrical
V_{12}	Cylindrical	Cylindrical	Cylindrical	Cylindrical	Cylindrical
V_{13}	Tapering	Tapering	Tapering	Tapering	Tapering
V_{14}	Cylindrical	Cylindrical	Cylindrical	Cylindrical	Cylindrical
V_{15}	Cylindrical	Cylindrical	Cylindrical	Cylindrical	Cylindrical

D1-15th October **V1-Pusa Rudhira** **V6-Kuroda Improved** **V11-Century**

D2-1st November **V2-Pusa Meghali** **V7-New Kuroda** **V12-Flakker-2**

D3-15th November **V3-Pusa Kesar** **V8-Sarpan 601** **V13-Desi Red (Lalit Kesar)**

D4-1st December **V4-Nantes** **V9-Samson-196** **V14-Super Kuroda-2**

D5-15th December **V5-Kuroda (RKS)** **V10-Super Kuroda-1** **V15-Indam Kuroda**

Table 13 Interaction effect of dates of sowing and cultivars on root tail of carrot

Cultivars	Dates of sowing				
	D_1	D_2	D_3	D_4	D_5
V_1	Acute	Acute	Acute	Acute	Acute
V_2	Semi blunt	Semi blunt	Semi blunt	Semi blunt	Semi blunt
V_3	Acute	Acute	Acute	Acute	Acute
V_4	Semi blunt	Semi blunt	Semi blunt	Semi blunt	Semi blunt
V_5	Acute	Acute	Acute	Acute	Acute
V_6	Semi blunt	Semi blunt	Semi blunt	Semi blunt	Semi blunt
V_7	Blunt	Blunt	Blunt	Blunt	Blunt
V_8	Semi blunt	Semi blunt	Semi blunt	Semi blunt	Semi blunt
V_9	Blunt	Blunt	Blunt	Blunt	Blunt
V_{10}	Acute	Acute	Acute	Acute	Acute
V_{11}	Semi blunt	Semi blunt	Semi blunt	Semi blunt	Semi blunt
V_{12}	Acute	Acute	Acute	Acute	Acute
V_{13}	Blunt	Blunt	Blunt	Blunt	Blunt
V_{14}	Acute	Acute	Acute	Acute	Acute
V_{15}	Semi blunt	Semi blunt	Semi blunt	Semi blunt	Semi blunt

D1-15th October **V1-Pusa Rudhira** **V6-Kuroda Improved** **V11-Century**

D2-1st November **V2-Pusa Meghali** **V7-New Kuroda** **V12-Flakker-2**

D3-15th November **V3-Pusa Kesar** **V8-Sarpan 601** **V13-Desi Red (Lalit Kesar)**

D4-1st December **V4-Nantes** **V9-Samson-196** **V14-Super Kuroda-2**

D5-15th December **V5-Kuroda (RKS)** **V10-Super Kuroda-1** **V15-Indam Kuroda**

Root length significantly varied among the cultivars, V_{13} produced the highest root length (18.08 cm) followed by V_1, V_2, V_7 and V_9 with 16.20 cm, 15.55 cm, 15.44 cm and 15.13cm respectively (Plate 7). V10 produced the lowest root length of 11.52 cm among the all cultivars (Plate 8).

Data on root length differed significantly among interactions between dates of sowing and cultivars. D_2V_{13} produced the highest root length of 21.50 cm which was on par with D_3V_{13} of 21 cm followed by D_4V_{13}, D_3V_1 and D_2V_9 with 19.17 cm, 17.84 cm and 17.50 cm respectively while D_5V_{12}, D_5V_{14} and D_5V_{15} produced the lowest root length of 10.50 cm (Table 14).

4.1.15 Root diameter

The data on the mean diameter of roots showed significant difference among dates of sowing. The highest root diameter with 4.23 cm produced by D_1 was statistically on par with D_2 and D_3 (4.14 cm) and D_4 (4.09 cm). The lowest root diameter was observed in D_5 (3.61 cm).

Cultivars differed significantly for root diameter. The highest root diameter of 5.45 cm was recorded by V_8 followed by V_5 (4.71 cm), V_4 (4.69 cm), V_6 (4.47 cm) and V_1 (4.46 cm). These V_5, V_4, V_6 and V_1 were statistically on par. The lowest root diameter was observed in V_{12} (2.86 cm).

Interaction between dates of sowing and cultivar also differed significantly in case of root diameter. The highest root diameter was produced by D_2V_8 and D_3V_8 (5.86 cm) which were on par with D_4V_8 (5.65 cm), D_1V_8 (5.52 cm), D_2V_5 (5.25 cm) and D_4V_5 (5.04 cm) followed by D_3V_5, D_2V_4 (4.96 cm), D_3V_2 (4.93 cm) and D_3V_4 (4.85 cm), while D_5V_2 (2.16 cm) showed the lowest root diameter (Table 15).

Table 14 Interaction effect of dates of sowing and cultivars on root length (cm) of carrot

Cultivars	Dates of sowing					
	D_1	D_2	D_3	D_4	D_5	Mean (Cultivar)
V_1	14.17^{ijkl}	17.34^{cd}	17.84^{bc}	17.17^{cd}	14.50^{hijk}	16.20^{b}
V_2	13.84^{klmn}	16.58^{cde}	16.84^{cde}	16.00^{cde}	14.50^{hijk}	15.55^{bc}
V_3	14.17^{ijkl}	14.84^{ghij}	15.00^{fghi}	14.00^{jklm}	11.50^{uvw}	13.90^{ef}
V_4	16.42^{cde}	13.92^{jklm}	14.25^{ijkl}	13.17^{mnop}	11.50^{uvw}	13.85^{fg}
V_5	14.50^{hijk}	13.67^{lmno}	12.84^{opqr}	13.17^{mnop}	11.50^{uvw}	13.13^{ghi}
V_6	14.33^{ijkl}	12.17^{qrst}	13.00^{nopq}	13.00^{nopq}	11.50^{uvw}	12.80^{hi}
V_7	13.97^{jklm}	16.92^{cde}	17.00^{cd}	15.84^{defg}	13.50^{mnop}	15.44^{c}
V_8	15.67^{defg}	15.84^{defg}	15.67^{defg}	14.33^{ijkl}	11.50^{uvw}	14.60^{de}
V_9	11.84^{stuv}	17.50^{cd}	17.00^{cd}	16.34^{cde}	13.00^{nopq}	15.13^{cd}
V_{10}	11.25^{uvw}	11.67^{tuvw}	11.67^{tuvw}	11.50^{uvw}	11.50^{uvw}	11.52^{k}
V_{11}	12.00^{rstu}	12.67^{opqr}	13.50^{mnop}	12.84^{opqr}	12.00^{rstu}	12.60^{hij}
V_{12}	11.33^{uvw}	15.50^{efgh}	14.50^{hijk}	14.50^{hijk}	10.50^{w}	13.27^{fgh}
V_{13}	14.25^{ijkl}	21.50^{a}	21.00^{a}	19.17^{b}	14.50^{hijk}	18.08^{a}
V_{14}	16.42^{cde}	11.17^{vw}	11.84^{stuv}	12.00^{rstu}	10.50^{w}	12.38^{ij}
V_{15}	12.34^{pqrs}	12.00^{rstu}	12.17^{qrst}	12.34^{pqrs}	10.50^{w}	11.87^{jk}
Mean (Dates of sowing)	13.76^{B}	14.88^{A}	14.94^{A}	14.36^{AB}	12.17^{C}	

Mean values having similar alphabets in superscript, do not differ significantly

D1-15th October **V1-Pusa Rudhira** **V6-Kuroda Improved** **V11-Century**

D2-1st November **V2-Pusa Meghali** **V7-New Kuroda** **V12-Flakker-2**

D3-15th November **V3-Pusa Kesar** **V8-Sarpan 601** **V13-Desi Red (Lalit Kesar)**

D4-1st December **V4-Nantes** **V9-Samson-196** **V14-Super Kuroda-2**

D5-15th December **V5-Kuroda (RKS)** **V10-Super Kuroda-1** **V15-Indam Kuroda**

Plate 9:Varieties with high root weight

Table 15 Interaction effect of dates of sowing and cultivars on root diameter (cm) of carrot

Cultivars	Dates of sowing					
	D_1	D_2	D_3	D_4	D_5	Mean (Cultivar)
V_1	4.46^{defg}	4.67^{cde}	4.72^{cde}	4.56^{defg}	3.87^{jklm}	4.46^{b}
V_2	3.83^{klmn}	4.77^{cde}	4.93^{bc}	4.72^{cde}	2.16^{z}	4.08^{cd}
V_3	3.24^{tuvw}	4.71^{cde}	4.47^{def}	4.21^{efgh}	3.76^{lmno}	4.08^{cd}
V_4	4.62^{defg}	4.96^{bc}	4.85^{bc}	4.75^{cde}	4.28^{efgh}	4.69^{b}
V_5	4.24^{dfgh}	5.25^{ab}	4.99^{bc}	5.04^{ab}	4.05^{fghi}	4.71^{b}
V_6	4.69^{cdef}	4.64^{cde}	4.59^{def}	4.54^{defg}	3.90^{ijkl}	4.47^{c}
V_7	4.72^{cdef}	3.71^{mnop}	3.77^{lmno}	3.71^{mnop}	3.97^{hijk}	3.98^{d}
V_8	5.52^{ab}	5.86^{a}	5.86^{a}	5.65^{ab}	4.37^{defg}	5.45^{a}
V_9	3.55^{opqr}	2.44^{z}	2.63^{yz}	2.68^{xyz}	2.71^{xyz}	2.80^{e}
V_{10}	4.29^{efgh}	3.93^{ijkl}	4.03^{ghij}	3.93^{ijkl}	3.41^{qrst}	3.92^{d}
V_{11}	3.47^{pqrs}	2.85^{wxyz}	3.04^{vwxy}	3.09^{uvwx}	3.25^{tuvw}	3.14^{e}
V_{12}	3.55^{opqr}	2.48^{z}	2.43^{z}	2.54^{z}	3.29^{stuv}	2.86^{e}
V_{13}	4.01^{hijk}	4.03^{ghij}	3.87^{jklm}	3.93^{ijkl}	3.27^{tuvw}	3.82^{d}
V_{14}	4.80^{bc}	3.45^{qrst}	3.34^{rstu}	3.55^{opqr}	3.61^{nopq}	3.75^{d}
V_{15}	4.46^{defg}	4.30^{efgh}	4.62^{defg}	4.40^{defg}	4.19^{efgh}	4.39^{bc}
Mean (Dates of sowing)	4.23^{A}	4.14^{A}	4.14^{A}	4.09^{A}	3.61^{B}	

Mean values having similar alphabets in superscript, do not differ significantly

D1-15th October **V1-Pusa Rudhira** **V6-Kuroda Improved** **V11-Century**

D2-1st November **V2-Pusa Meghali** **V7-New Kuroda** **V12-Flakker-2**

D3-15th November **V3-Pusa Kesar** **V8-Sarpan 601** **V13-Desi Red (Lalit Kesar)**

D4-1st December **V4-Nantes** **V9-Samson-196** **V14-Super Kuroda-2**

D5-15th December **V5-Kuroda (RKS)** **V10-Super Kuroda-1** **V15-Indam Kuroda**

4.1.16 Root girth

Analysis of data on the root girth of carrot showed significant difference among the dates of sowing, cultivars and interactions between dates of sowing and cultivars. Among dates of sowing maximum root girth was observed in D_1 (13.29 cm) which was statistically on par with D_3 (13.01 cm), D_2 (13.00 cm) and D_4 (12.84 cm). The minimum girth was seen in D_5 with of 11.33cm.

Girth of cultivar V_8 of 17.13 cm was the highest among all the cultivars followed by V_5 (14.81cm), V_4 (14.74 cm), V_6 (14.05 cm) and V_1 (14.00 cm). V_5, V_4, V_6 and V_1 were statistically on par. The minimum root girth of carrot was observed in cultivar V_9 (8.80 cm) followed by V_{12} and V_{11}.

D_2V_8 and D_3V_8 showed maximum root girth of 18.42 cm among interaction between dates of sowing and cultivars. They were on par with D_4V_8 (17.75 cm), D_2V_5 (16.50 cm) and D_4V_5 (15.83 cm) these three were statistically on par with each other. The minimum root girth was showed by D_2V_2 of 6.79 cm which was on par with D_3V_{12} of 7.63 cm, D_2V_2 of 7.80 cm and D_4V_{12} of 7.97 cm (Table 16)

4.1.17 Root weight

Significant variation was observed in root weight among dates of sowing, cultivar and interaction between dates of sowing and cultivar. Among dates of sowing the highest root weight was observed in D_3 (87.46 g) which was on par with D_2 (86.77g) and D_4 (85.06g) it was followed by D_1 (71.50g). The lowest root weight was observed in D_5 (49.60 g).

Cultivar V_4 (104.66 g) showed highest root weight, which was on par with V_8 of 102.22 g followed by V_1 (92.52 g), V_3 (91.70 g) and V_2 (90.16 g). V_1, V_2 and V_3 were statistically on par (Plate 9). The lowest root weight was observed in V_{11} (42.80 g).

Table 16 Interaction effect of dates of sowing and cultivars on root girth (cm) of carrot

Cultivars	Dates of sowing					
	D_1	D_2	D_3	D_4	D_5	Mean (Cultivar)
V_1	14.00^{defg}	14.67^{cdef}	14.83^{cdef}	14.33^{defg}	12.17^{jklm}	14.00^{b}
V_2	12.03^{klmn}	15.00^{cdef}	15.50^{bc}	14.83^{cdef}	6.79^{z}	12.83^{cd}
V_3	10.17^{tuvw}	14.80^{cdef}	14.05^{defg}	13.22^{efgh}	11.83^{lmno}	12.81^{cd}
V_4	14.50^{defg}	15.59^{bc}	15.25^{bcde}	14.92^{cdef}	13.46^{efgh}	14.74^{b}
V_5	13.34^{efgh}	16.50^{ab}	15.67^{bcde}	15.83^{abc}	12.73^{fghi}	14.81^{b}
V_6	14.75^{cdef}	14.59^{cde}	14.42^{defg}	14.25^{defg}	12.24^{ijkl}	14.05^{b}
V_7	14.84^{cdef}	11.67^{mnop}	11.84^{lmno}	11.67^{mnop}	12.48^{hijk}	12.50^{d}
V_8	17.33^{abc}	18.42^{a}	18.42^{a}	17.75^{ab}	13.73^{defg}	17.13^{a}
V_9	11.17^{opqrs}	7.67^{z}	8.25^{yz}	8.42^{xyz}	8.51^{xyz}	8.80^{e}
V_{10}	13.47^{efgh}	12.33^{ijkl}	12.67^{ghij}	12.34^{ijkl}	10.73^{qrst}	12.31^{d}
V_{11}	10.92^{pqrs}	8.95^{wxyz}	9.53^{vwxy}	9.70^{uvwx}	10.22^{tuvw}	9.86^{e}
V_{12}	11.17^{opqr}	7.80^{z}	7.63^{z}	7.97^{z}	10.33^{stuv}	8.98^{e}
V_{13}	12.59^{hijk}	12.67^{ghij}	12.17^{jklm}	12.33^{ijkl}	10.27^{tuvw}	12.00^{d}
V_{14}	15.08^{bc}	10.84^{qrst}	10.50^{rstu}	11.17^{opqr}	11.33^{nopq}	11.78^{d}
V_{15}	14.00^{defg}	13.50^{efgh}	14.50^{defg}	13.84^{defg}	13.17^{efgh}	13.80^{bc}
Mean (Dates of sowing)	13.29^{A}	13.00^{A}	13.01^{A}	12.84^{A}	11.33^{B}	

Mean values having similar alphabets in superscript, do not differ significantly

D1-15th October **V1-Pusa Rudhira** **V6-Kuroda Improved** **V11-Century**

D2-1st November **V2-Pusa Meghali** **V7-New Kuroda** **V12-Flakker-2**

D3-15th November **V3-Pusa Kesar** **V8-Sarpan 601** **V13-Desi Red (Lalit Kesar)**

D4-1st December **V4-Nantes** **V9-Samson-196** **V14-Super Kuroda-2**

D5-15th December **V5-Kuroda (RKS)** **V10-Super Kuroda-1** **V15-Indam Kuroda**

Table 17 Interaction effect of dates of sowing and cultivars on root weight of carrot

Cultivars	Dates of sowing					
	D_1	D_2	D_3	D_4	D_5	Mean (Cultivar)
V_1	75.00^{rst}	107.00^{efgh}	110.80^{cde}	102.80^{ghij}	67.00^{stuv}	92.52^{b}
V_2	61.50^{uvwx}	109.50^{def}	110.80^{cde}	108.00^{efg}	61.00^{vwx}	90.16^{b}
V_3	57.00^{wxy}	112.50^{bc}	115.00^{ab}	112.00^{bc}	62.00^{uvwx}	91.70^{b}
V_4	103.00^{fghi}	121.00^{ab}	119.00^{ab}	114.80^{ab}	65.50^{stuv}	104.66^{a}
V_5	72.00^{rstu}	67.00^{stuv}	69.00^{stuv}	67.00^{stuv}	38.50^{z}	62.70^{f}
V_6	93.00^{klmn}	87.50^{lmno}	76.50^{qrs}	73.50^{rstu}	38.50^{z}	73.80^{d}
V_7	59.50^{wxyz}	94.00^{klmn}	97.00^{ijk}	96.00^{jkl}	52.50^{z}	79.80^{c}
V_8	81.50^{opqr}	123.00^{ab}	124.30^{a}	121.80^{ab}	60.50^{vxy}	102.22^{a}
V_9	56.00^{yz}	50.00^{z}	55.00^{z}	62.00^{uvw}	44.00^{z}	53.40^{g}
V_{10}	63.00^{tuv}	82.00^{opqr}	81.00^{pqr}	76.50^{pqr}	40.50^{z}	68.60^{e}
V_{11}	45.00^{z}	39.00^{z}	44.50^{z}	47.00^{z}	38.50^{z}	42.80^{h}
V_{12}	56.00^{xyz}	84.00^{mnop}	81.00^{pqr}	76.30^{pqrs}	45.00^{z}	68.46^{e}
V_{13}	67.00^{stuv}	99.00^{hijk}	98.50^{hijk}	82.70^{nopq}	36.00^{z}	76.64^{cd}
V_{14}	94.50^{klm}	60.00^{vwx}	61.00^{vwx}	67.50^{stuv}	41.00^{z}	64.80^{ef}
V_{15}	88.50^{lmno}	66.00^{stuv}	68.50^{stuv}	68.00^{stuv}	53.50^{z}	68.90^{e}
Mean (Dates of sowing)	71.50^{B}	86.77^{A}	87.46^{A}	85.06^{A}	49.60^{C}	

Mean values having similar alphabets in superscript, do not differ significantly

D1-15th October **V1-Pusa Rudhira** **V6-Kuroda (Tokita)** **V11-Century**

D2-1st November **V2-Pusa Meghali** **V7-New Kuroda** **V12-Flakker-2**

D3-15th November **V3-Pusa Kesar** **V8-Sarpan 601** **V13-Desi Red (Lalit Kesar)**

D4-1st December **V4-Nantes** **V9-Samson-196** **V14-Super Kuroda-2**

D5-15th December **V5-Kuroda (RKS)** **V10-Super Kuroda-1** **V15-Indam Kuroda**

D_3V_8 showed highest root weight of 124.30 g which was closely on par with D_2V_8, D_4V_8, D_2V_4, D_3V_4, D_3V_3, D_4V_4 and D_4V_3. The lowest root weight was observed from D_5V_{13} of 36.00 g which on par with D_5V_6, D_5V_7, D_5V_9, D_5V_{10}, D_5V_{11}, D_5V_{12}, D_5V_{13}, D_5V_{14}, D_5V_{15}, D_1V_{11}, D_2V_{11}, D_3V_{11} and D_4V_{11} (Table 17).

4.1.18 Root shoot ratio

Analysis of data on the root shoot ratio of carrot showed significant difference among the dates of sowing, cultivars and interactions between dates of sowing and cultivars. Among dates of sowing maximum root shoot ratio was observed from D_4 (1.52) which was statistically on par with D_3 (1.49), D_2 (1.45) and D_5 (1.38) and the minimum root shoot ratio was shown from D_1 of 1.09.

Root shoot ratio of cultivar V_5 of 2.14 was the highest among all the cultivars which was followed by V_{11} (1.90), V_9 (1.76), V_{10} (1.74) and V_4 (1.51). V_9 and V_{10} were statistically on par. The minimum root shoot ratio of carrot was observed from cultivar V_8 (0.89) followed by V_3 (0.96) and V_1 (0.99).

D_3V_5 and D_4V_{11} showed maximum root shoot ratio of 2.42 among interactions between dates of sowing and cultivars, it was on par with D_2V_5 (2.35), D_4V_5 (2.32), D_3V_{11} (2.20), D_4V_{10} 2.16 and D_4V_9 (2.11). The minimum root shoot ratio was showed by D1V7 of 0.49 which was on par with D_1V_1 and D_5V_8 of 0.65 and D_1V_{13} of 0.77. (Table 18).

4.1.19 Root Pubescence

Root pubescence is a varietal character V_1, V_2 and V_3 has got root pubescence and remaining varieties did not produce any pubescence during all the five dates of sowing (Table 19) (Plate 12).

4.1.20 Core Size

Size of the core differed significantly among cultivars and interactions between dates of sowing and cultivars. Among dates of sowing much variation was not seen. The lowest core size was recorded in D_5 with 1.50 cm and highest core size was recorded in D_4 (1.86 cm) which was on par with D_1 and D_3 (1.76 cm) and D_2 (1.75 cm)

Cultivar V_9 (1.06 cm) recorded lowest core size which was on par with V_{12} (1.28 cm). V_1 recorded highest core size of 2.51 cm which was on par with V_2 (2.44 cm) and V_3 (2.41 cm) followed by V_4 (2.20 cm) and V_8 (2.15 cm).

Among the interactions between dates of sowing and cultivars, D_2V_9 recorded lowest core size of 0.89 cm. D_2V_1 and D_4V_1 recorded highest core size of 2.97 cm which were on par with D_4V_2 (2.93cm), D_2V_2 (2.84 cm) and D_3V_2 (2.83 cm) (Table 20).

Table 18 Interaction effect of dates of sowing and cultivars on root shoot ratio of carrot

Cultivars	Dates of sowing					
	D_1	D_2	D_3	D_4	D_5	Mean (Cultivar)
V_1	0.65^{z}	1.12^{stuv}	1.08^{uvwx}	1.06^{vwxy}	1.07^{uvwx}	0.99^{ij}
V_2	1.05^{wxyz}	1.12^{stuv}	1.06^{vwxy}	1.08^{uvwx}	0.93^{z}	1.05^{hi}
V_3	0.82^{z}	1.07^{uvwx}	1.04^{xyz}	1.03^{xyz}	0.84^{z}	0.96^{ij}
V_4	1.03^{yz}	1.55^{ghij}	1.62^{ghij}	1.62^{ghij}	1.73^{efgh}	1.51^{d}
V_5	1.97^{cde}	2.35^{a}	2.42^{a}	2.32^{ab}	1.64^{fghi}	2.14^{a}
V_6	1.67^{efgh}	1.41^{klmn}	1.28^{nopq}	1.30^{mnop}	1.41^{klmn}	1.41^{de}
V_7	0.49^{z}	1.11^{stuv}	1.19^{qrst}	1.32^{lmno}	1.09^{tuvw}	1.04^{hi}
V_8	0.96^{z}	0.94^{z}	0.95^{z}	0.97^{yz}	0.65^{z}	0.89^{j}
V_9	1.15^{rstu}	1.81^{defg}	2.01^{bc}	2.11^{ab}	1.73^{efgh}	1.76^{c}
V_{10}	1.22^{opqr}	1.87^{cde}	1.89^{cde}	2.16^{ab}	1.57^{ghij}	1.74^{c}
V_{11}	0.95^{z}	1.87^{cde}	2.20^{ab}	2.42^{a}	2.09^{ab}	1.90^{b}
V_{12}	0.95^{z}	1.50^{ijkl}	1.42^{klmn}	1.39^{klmn}	1.06^{vwxy}	1.26^{fg}
V_{13}	0.77^{z}	1.21^{pqrs}	1.20^{pqrs}	1.03^{xyz}	1.63^{ghij}	1.17^{gh}
V_{14}	1.79^{def}	1.46^{ijkl}	1.53^{hijk}	1.50^{ijkl}	2.00^{bc}	1.65^{c}
V_{15}	0.88^{z}	1.42^{klmn}	1.48^{ijkl}	1.53^{hijk}	1.44^{jklm}	1.35^{ef}
Mean (Dates of sowing)	1.09^{B}	1.45^{A}	1.49^{A}	1.52^{A}	1.38^{A}	

Mean values having similar alphabets in superscript, do not differ significantly

D1-15th October **V1-Pusa Rudhira** **V6-Kuroda Improved** **V11-Century**

D2-1st November **V2-Pusa Meghali** **V7-New Kuroda** **V12-Flakker-2**

D3-15th November **V3-Pusa Kesar** **V8-Sarpan 601** **V13-Desi Red (Lalit Kesar)**

D4-1st December **V4-Nantes** **V9-Samson-196** **V14-Super Kuroda-2**

D5-15th December **V5-Kuroda (RKS)** **V10-Super Kuroda-1** **V15-Indam Kuroda**

Table 19 Interaction effect of dates of sowing and cultivars on root pubescence of carrot

Cultivars	Dates of sowing				
	D_1	D_2	D_3	D_4	D_5
V_1	Present	Present	Present	Present	Present
V_2	Present	Present	Present	Present	Present
V_3	Present	Present	Present	Present	Present
V_4	Absent	Absent	Absent	Absent	Absent
V_5	Absent	Absent	Absent	Absent	Absent
V_6	Absent	Absent	Absent	Absent	Absent
V_7	Absent	Absent	Absent	Absent	Absent
V_8	Present	Present	Present	Present	Present
V_9	Absent	Absent	Absent	Absent	Absent
V_{10}	Absent	Absent	Absent	Absent	Absent
V_{11}	Absent	Absent	Absent	Absent	Absent
V_{12}	Absent	Absent	Absent	Absent	Absent
V_{13}	Present	Present	Present	Present	Present
V_{14}	Absent	Absent	Absent	Absent	Absent
V_{15}	Absent	Absent	Absent	Absent	Absent

D1-15th October	**V1-Pusa Rudhira**	**V6-Kuroda Improved**	**V11-Century**
D2-1st November	**V2-Pusa Meghali**	**V7-New Kuroda**	**V12-Flakker-2**
D3-15th November	**V3-Pusa Kesar**	**V8-Sarpan 601**	**V13-Desi Red (Lalit Kesar)**
D4-1st December	**V4-Nantes**	**V9-Samson-196**	**V14-Super Kuroda-2**
D5-15th December	**V5-Kuroda (RKS)**	**V10-Super Kuroda-1**	**V15-Indam Kuroda**

Table 20 Interaction effect of dates of sowing and cultivars on core size (cm) of carrot

Cultivars	Dates of sowing					
	D_1	D_2	D_3	D_4	D_5	Mean (Cultivar)
V_1	1.62^{ghij}	2.97^{a}	2.93^{ab}	2.97^{a}	2.05^{efgh}	2.51^{a}
V_2	1.43^{ijkl}	2.84^{ab}	2.83^{ab}	2.93^{ab}	2.15^{defg}	2.44^{ab}
V_3	1.49^{hijk}	2.75^{ab}	2.75^{ab}	2.82^{ab}	2.25^{cde}	2.41^{abc}
V_4	2.02^{efgh}	2.34^{ab}	2.33^{ab}	2.49^{ab}	1.85^{efgh}	2.20^{bc}
V_5	2.32^{ab}	1.32^{jklm}	1.35^{ijkl}	1.50^{hijk}	1.35^{ijkl}	1.57^{def}
V_6	1.70^{fghi}	1.29^{klmn}	1.25^{klmn}	1.34^{ijkl}	1.35^{ijkl}	1.38^{def}
V_7	2.95^{ab}	1.28^{klmn}	1.27^{klmn}	1.38^{ijkl}	1.40^{ijkl}	1.66^{d}
V_8	1.58^{ghij}	2.27^{bc}	2.34^{ab}	2.52^{ab}	2.05^{efgh}	2.15^{c}
V_9	1.35^{ijkl}	0.89^{o}	0.92^{no}	1.07^{mno}	1.10^{mno}	1.06^{g}
V_{10}	1.72^{fghi}	1.65^{fghi}	1.70^{fghi}	1.73^{fghi}	1.30^{jklm}	1.62^{de}
V_{11}	1.27^{klmn}	1.34^{ijkl}	1.45^{hijk}	1.53^{hijk}	1.20^{lmno}	1.36^{ef}
V_{12}	1.43^{ijkl}	1.24^{klmn}	1.25^{klmn}	1.37^{ijkl}	1.10^{mno}	1.28^{fg}
V_{13}	1.89^{efgh}	1.48^{hijk}	1.49^{hijk}	1.52^{hijk}	1.05^{mno}	1.48^{def}
V_{14}	1.94^{efgh}	1.35^{ijkl}	1.33^{ijkl}	1.44^{ijkl}	1.20^{lmno}	1.45^{def}
V_{15}	1.72^{fghi}	1.28^{klmn}	1.27^{klmn}	1.39^{ijkl}	1.10^{mno}	1.35^{ef}
Mean (Dates of sowing)	1.76^{A}	1.75^{A}	1.76^{A}	1.86^{A}	1.50^{B}	

Mean values having similar alphabets in superscript, do not differ significantly

D1-15th October **V1-Pusa Rudhira** **V6-Kuroda Improved** **V11-Century**

D2-1st November **V2-Pusa Meghali** **V7-New Kuroda** **V12-Flakker-2**

D3-15th November **V3-Pusa Kesar** **V8-Sarpan 601** **V13-Desi Red (Lalit Kesar)**

D4-1st December **V4-Nantes** **V9-Samson-196** **V14-Super Kuroda-2**

D5-15th December **V5-Kuroda (RKS)** **V10-Super Kuroda-1** **V15-Indam Kuroda**

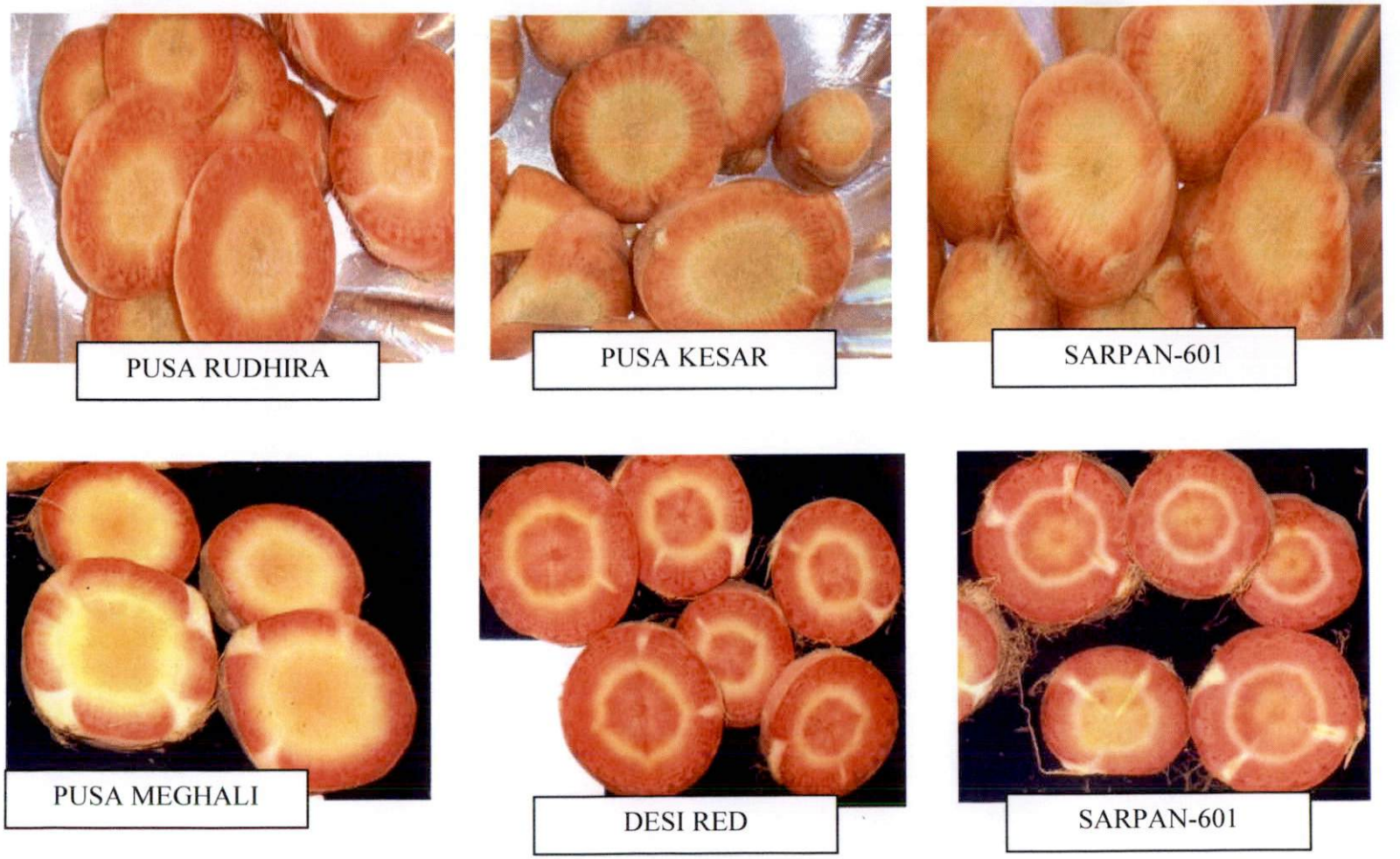
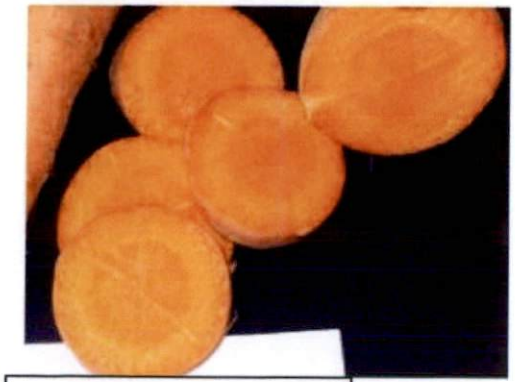


Plate 10: Varieties with distinct core

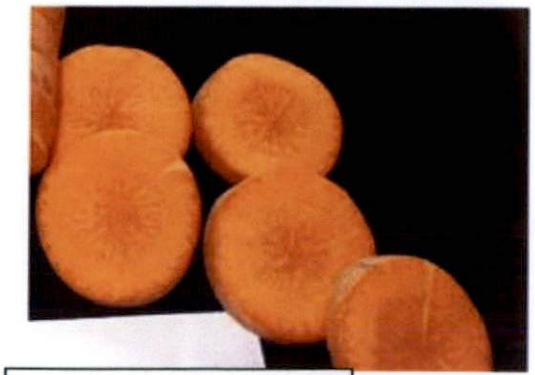
INDAM KURODA

KURODA

KURODA IMPROVED



SUPER KURODA 1



NANTES

SAMSON 196

Plate 11: Varieties with self coloured core

4.1.21 Core colour

The colour of core was not influenced by dates of sowing and varieties. V_1 V_3, V_7, V_8 and V_{13} shown distinct core and remaining all varieties were having self coloured core (Table 21) (Plate 10 and 11).

4.1.22 Days taken to harvest

Crop was harvested according to their maturity which was specified by the seed company (Table 1).

4.1.23 Forking

Highest forking observed during D_1 (26.31 %) followed by D_2 (6.02 %) and D_3 (5.70 %). Lowest forking percentage was recorded from D_4 (1.93 %) followed by D_5 (3.44 %) among dates of sowing.

Forking varied among the cultivars V_1 (28.43 %) forked more followed by V_2 (16.66 %), V_7 (11.70 %), V_3 (11.80 %) and V_9 (10.00 %). Forking was not seen in the variety V_{14} followed by V_5 (0.20 %) and V_{13} (1.60 %).

D1V7 shown highest forking percentage (57.25 %) followed by D1V1 (54.30 %), D1V12 (46.00 %) and D1V9 (49.00 %). Most of the interactions showed zero percent forking followed by D3V5 (1.00 %) and D4V6 (3.00 %) among interactions between dates of sowing and cultivars (Plate 12) (Table 22).

4.1.24 Root cracking

Root cracking was not observed in majority of varieties. In a few varieties it was seen only in three varieties in D_1, D_2 and D_3 and the values are meager. During D_4 and D_5 there was no cracking. Among these three season D_2 (1.53 percent) recorded lowest percent of cracking followed by D_3 (1.97 %) and highest cracking was recorded in D_1 (4.76 %).

The cracking was observed in V_5, V_6, V_{10}, V_{12} and V_{14}. Among these varieties lowest cracking was found in V_6 (2.00 %) followed by V_{12} (3.56 %). The highest cracking was found in V_{10} (9.30 %) followed by V_{14} (5.95 %).

Among interactions only D_1V_5, D_1V_{10}, D_3V_{10}, D_1V_{14}, D_2V_{10}, D_3V_6, D_3V_{10} and D_3V_{14} showed cracking. D_1V_{14} affected more (22.33 %) of cracking followed by D_2V_{10} (23.00 %), D_1V_5 (20.00 %), D_3V_{10} (17.30 %), D_3V_{10} (12.20 %), D_1V_{10} (11.33 %), D_3V_6 (10.00 %) and D_3V_{14} (7.40 %) (Table 23) (Plate 12).

Table 21 Interaction effect of dates of sowing and cultivars on core colour of carrot

Cultivars	Dates of sowing				
	D_1	D_2	D_3	D_4	D_5
V_1	Distinct	Distinct	Distinct	Distinct	Distinct
V_2	Self coloured	Self coloured	Self coloured	Self coloured	Self coloured
V_3	Distinct	Distinct	Distinct	Distinct	Distinct
V_4	Self coloured	Self coloured	Self coloured	Self coloured	Self coloured
V_5	Self coloured	Self coloured	Self coloured	Self coloured	Self coloured
V_6	Self coloured	Self coloured	Self coloured	Self coloured	Self coloured
V_7	Distinct	Distinct	Distinct	Distinct	Distinct
V_8	Distinct	Distinct	Distinct	Distinct	Distinct
V_9	Self coloured	Self coloured	Self coloured	Self coloured	Self coloured
V_{10}	Self coloured	Self coloured	Self coloured	Self coloured	Self coloured
V_{11}	Self coloured	Self coloured	Self coloured	Self coloured	Self coloured
V_{12}	Self coloured	Self coloured	Self coloured	Self coloured	Self coloured
V_{13}	Distinct	Distinct	Distinct	Distinct	Distinct
V_{14}	Self coloured	Self coloured	Self coloured	Self coloured	Self coloured
V_{15}	Self coloured	Self coloured	Self coloured	Self coloured	Self coloured

D1-15th October **V1-Pusa Rudhira** **V6-Kuroda Improved** **V11-Century**

D2-1st November **V2-Pusa Meghali** **V7-New Kuroda** **V12-Flakker-2**

D3-15th November **V3-Pusa Kesar** **V8-Sarpan 601** **V13-Desi Red (Lalit Kesar)**

D4-1st December **V4-Nantes** **V9-Samson-196** **V14-Super Kuroda-2**

D5-15th December **V5-Kuroda (RKS)** **V10-Super Kuroda-1** **V15-Indam Kuroda**

Table 22 Interaction effect of dates of sowing and cultivars on forking (%) of carrot

Cultivars	Dates of sowing					
	D_1	D_2	D_3	D_4	D_5	Mean
V_1	52.30	33.33	34.50	0	22.00	28.43
V_2	20.00	18.3	19.00	26.00	0	16.66
V_3	14.80	22.2	22.00	0	0	11.80
V_4	18.62	0	03.00	0	0	4.32
V_5	0	0	01.00	0	0	0.20
V_6	39.00	0	0	3.00	0	8.40
V_7	57.25	16.50	0	0	0	14.75
V_8	33.33	0	0	0	0	6.67
V_9	40.00	0	0	0	12.4	10.48
V_{10}	24.30	0	06.05	0	0	6.07
V_{11}	22.12	0	0	0	0	4.42
V_{12}	46.00	0	0	0	0	9.20
V_{13}	8.00	10.20	0	0	0	1.60
V_{14}	0	0	0	0	0	0.00
V_{15}	19.00	0	0	0	17.20	7.24
Mean	26.31	6.02	5.70	1.93	3.44	

D1-15th October	**V1-Pusa Rudhira**	**V6-Kuroda Improved**	**V11-Century**
D2-1st November	**V2-Pusa Meghali**	**V7-New Kuroda**	**V12-Flakker-2**
D3-15th November	**V3-Pusa Kesar**	**V8-Sarpan 601**	**V13-Desi Red (Lalit Kesar)**
D4-1st December	**V4-Nantes**	**V9-Samson-196**	**V14-Super Kuroda-2**
D5-15th December	**V5-Kuroda (RKS)**	**V10-Super Kuroda-1**	**V15-Indam Kuroda**

Table 23 Interaction effect of dates of sowing and cultivars on root cracking (percent) of carrot

Cultivars	Dates of sowing					
	D_1	D_2	D_3	D_4	D_5	Mean
V_1	0	0	0	0	0	0
V_2	0	0	0	0	0	0
V_3	0	0	0	0	0	0
V_4	0	0	0	0	0	0
V_5	20	0	0	0	0	4
V_6	0	0	10.00	0	0	2
V_7	0	0	0	0	0	0
V_8	0	0	0	0	0	0
V_9	0	0	0	0	0	0
V_{10}	11.33	23.00	12.20	0	0	9.30
V_{11}	0	0	0	0	0	0
V_{12}	17.82	0	0	0	0	3.56
V_{13}	0	0	0	0	0	0
V_{14}	22.33	0	07.40	0	0	5.95
V_{15}	0	0	0	0	0	0
	4.76	1.53	1.97	0	0	

D1-15th October	**V1-Pusa Rudhira**	**V6-Kuroda Improved**	**V11-Century**
D2-1st November	**V2-Pusa Meghali**	**V7-New Kuroda**	**V12-Flakker-2**
D3-15th November	**V3-Pusa Kesar**	**V8-Sarpan 601**	**V13-Desi Red (Lalit Kesar)**
D4-1st December	**V4-Nantes**	**V9-Samson-196**	**V14-Super Kuroda-2**
D5-15th December	**V5-Kuroda (RKS)**	**V10-Super Kuroda-1**	**V15-Indam Kuroda**

4.1.25 Green shoulder

Green shoulder was not observed in any of the dates of sowing, varieties and interactions.

4.1.26 Bolting

Bolting was observed in V_1, V_2 and V_8 during the D_1 and D_2 (83^{th} and 80^{th} days after sowing respectively) sowing time. Remaining sowing date bolting was not observed (Plate 12).

4.1.27 Bitterness

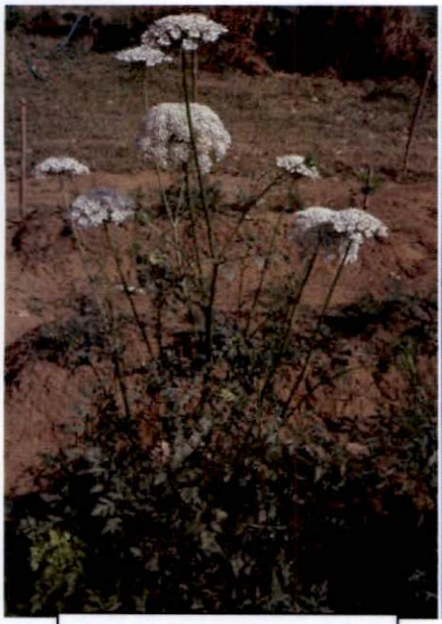
Bitterness was not seen in any cultivar in any of the sowing periods.

4.1.28 Yield per plot

Yield per plot differed significantly among dates of sowing. The highest yield per plot was recorded in D_3 (7.00 kg) which was on par with D_2 (6.94 kg) and D_4 (6.81 kg). The lowest yield was recorded in D_5 (3.97 kg) followed by D_1 (5.72 kg).

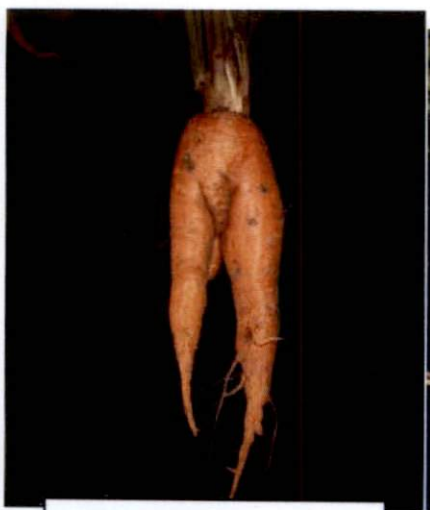
Cultivars significantly varied for root yield per plot. The highest yield was recorded from the cultivar V_4 (8.37 kg) which was on par with V_8 (8.18kg) followed by V_1 (7.40 kg), V_3 (7.34 kg) and V_2 (7.21 kg). Cultivars V_1, V_3 and V_2 were statistically on par. The lowest root yield of carrot was recorded from the cultivar V_{11} with 3.42 kg per plot followed by V_9 (4.27 kg per plot) and V_5 (5.02 kg per ha).

Interaction between dates of sowing and cultivars also differed significantly for root yield per plot. The highest yield was recorded from the D_3V_8 (9.95 kg) it was on par with D_2V_8, D_4V_8, D_2V_4, D_3V_4, D_3V_3 and D_4V_4. The lowest yield was recorded in D_5V_{13} (2.88 kg) which was on par with D_1V_3, D_1V_7, D_1V_9, D_1V_{11}, D_1V_{12}, D_2V_9, D_2V_{11}, D_3V_9, D_3V_{11}, D_4V_{11}, D_5V_5, D_5V_6, D_5V_7, D_5V_8, D_5V_9, D_5V_{10}, D_5V_{11}, D_5V_{12}, D_5V_{13}, D_5V_{14} and D_5V_{15}, (Table 24).



Bolting

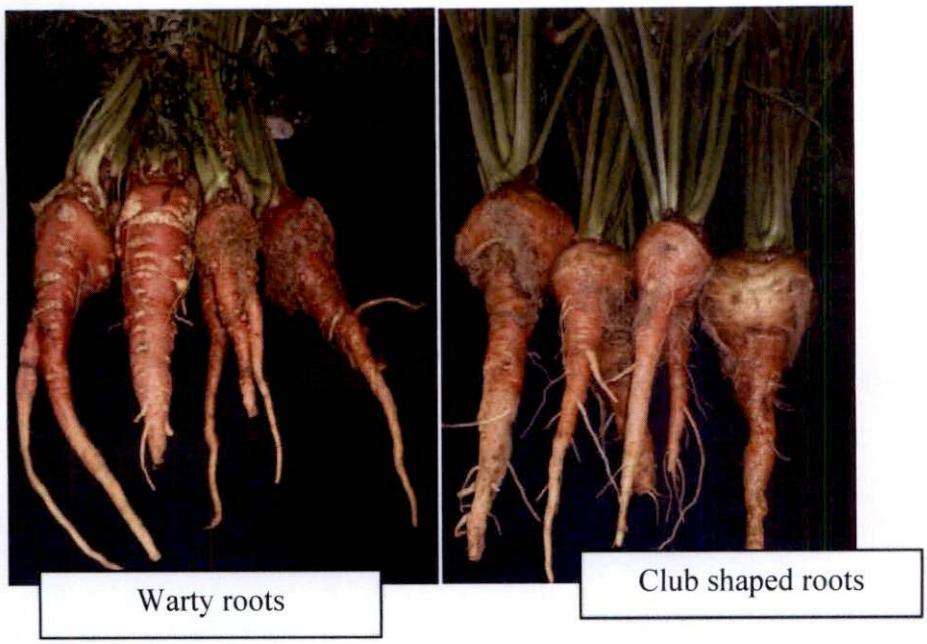
Termite Damage



Forking

Misshaped

Plate 12: Physiological disorders of carrot



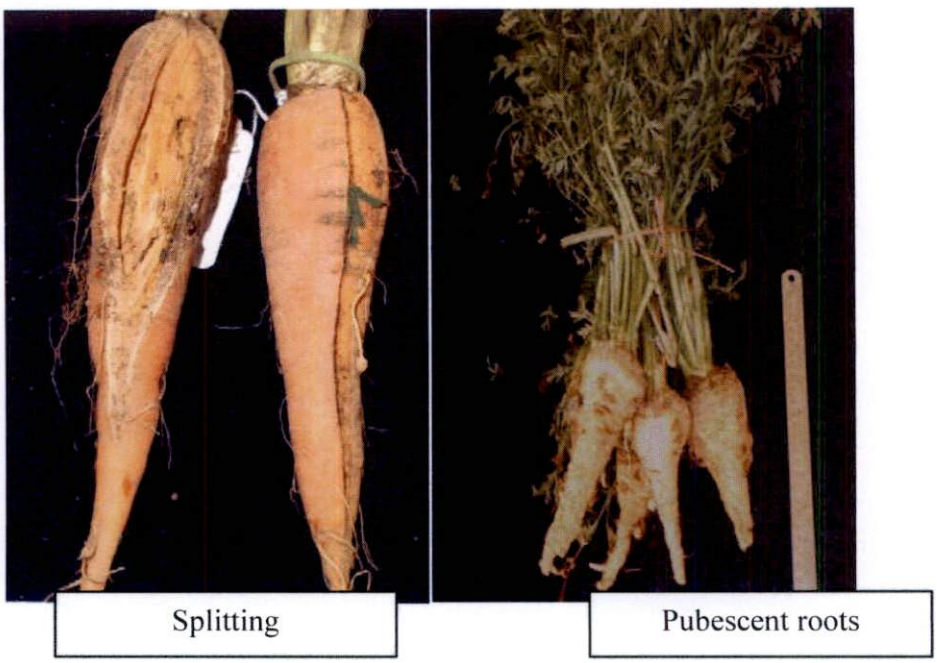


Plate 12: Continued: Physiological disorders of carrot

4.1.29 Yield per hectare

Yield per ha differed significantly among dates of sowing. The highest yield per ha was recorded in D_3 (23.32 tonnes) it was on par with D_2 (23.14 tonnes) and D_4 (22.68 tonnes) and the lowest yield was recorded in D_5 (13.23 tonnes).

Cultivars differed significantly for yield per ha the highest yield was recorded from the cultivar V_4 (27.91 tonnes) which was on par with V_8 followed by V_1 (24.67 tonnes), V_3 (24.45 tonnes) and V_2 (24.04 tonnes). These V_1, V_3 and V_2 were statistically on par. The lowest root yield of carrot was recorded in cultivar V_{11} (11.42 tonnes) followed by V_9 (14.24 tonnes) and V_5 (16.72 tonnes).

Interaction between dates of sowing and cultivars also differed significantly with respect to root yield per hector. The highest yield was recorded in D_3V_8 (33.15 tonnes) it was on par with D_2V_8 (32.80 tonnes), D_4V_8 (32.48 tonnes), D_2V_4 (32.27 tonnes), D_3V_4 (31.74 tonnes), D_3V_3 (30.67 tonnes) and D_4V_4 (30.62 tonnes). The lowest yield was recorded in D_5V_{13} (9.60 tonnes) which was on par with D_1V_3, D_1V_7, D_1V_9, D_1V_{11}, D_1V_{12}, D_2V_9, D_2V_{11}, D_3V_9, D_3V_{11}, D_4V_{11}, D_5V_2, D_5V_5, D_5V_6, D_5V_7, D_5V_9, D_5V_{10}, D_5V_{11}, D_5V_{12}, D_5V_{13}, D_5V_{14} and D_5V_{15}, (Table 25).

4.1.30 Pest and Diseases

No major diseases were observed. But there was severe attack of termite in all the varieties during D_1 (Plate 12).

4.1.31 Disorders

Apart from bolting, forking and splitting other disorders noticed were warty roots and misshaped roots (Plate 12).

Table 24 Interaction effect of dates of sowing and cultivars on yield/plot (kg) of carrot

Cultivars	Dates of sowing					
	D_1	D_2	D_3	D_4	D_5	Mean (Cultivar)
V_1	6.00^{rst}	8.56^{efgh}	8.87^{cde}	8.23^{ghij}	5.36^{stuv}	7.40^{b}
V_2	4.92^{uvwx}	8.76^{defg}	8.87^{cde}	8.64^{efgh}	4.88^{vwxy}	7.21^{b}
V_3	4.56^{wxyz}	9.00^{bc}	9.20^{ab}	8.96^{bc}	4.96^{uvwx}	7.34^{b}
V_4	8.24^{fghi}	9.68^{ab}	9.52^{ab}	9.19^{ab}	5.24^{stuv}	8.37^{a}
V_5	5.76^{rstu}	5.36^{stuv}	5.52^{stuv}	5.36^{stuv}	3.08^{z}	5.02^{f}
V_6	7.44^{klmn}	7.00^{lmno}	6.12^{qrs}	5.88^{rstu}	3.08^{z}	5.90^{d}
V_7	4.76^{wxyz}	7.52^{klmn}	7.76^{ijkl}	7.68^{jkl}	4.20^{z}	6.38^{c}
V_8	6.52^{opqr}	9.84^{ab}	9.95^{a}	9.75^{ab}	4.84^{wxyz}	8.18^{a}
V_9	4.48^{yz}	4.00^{z}	4.40^{z}	4.96^{uvwx}	3.52^{z}	4.27^{g}
V_{10}	5.04^{tuvw}	6.56^{opqr}	6.48^{pqr}	6.12^{pqrs}	3.24^{z}	5.49^{e}
V_{11}	3.60^{z}	3.12^{ab}	3.56^{z}	3.76^{z}	3.08^{z}	3.42^{h}
V_{12}	4.48^{xyz}	6.72^{mnop}	6.48^{pqr}	6.11^{qrs}	3.60^{z}	5.48^{e}
V_{13}	5.36^{stuv}	7.92^{hijk}	$7.88h^{ijk}$	6.62^{nopq}	2.88^{z}	6.13^{cd}
V_{14}	7.56^{klm}	4.80^{vwxy}	4.88^{vwxy}	5.40^{stuv}	3.28^{z}	5.18^{ef}
V_{15}	7.08^{lmno}	5.28^{stuv}	5.48^{stuv}	5.44^{stuv}	4.28^{z}	5.51^{e}
Mean (Dates of sowing)	5.72^{B}	6.94^{A}	7.00^{A}	6.81^{A}	3.97^{C}	

Mean values having similar alphabets in superscript, do not differ significantly

D1-15th October **V1-Pusa Rudhira** **V6-Kuroda Improved** **V11-Century**

D2-1st November **V2-Pusa Meghali** **V7-New Kuroda** **V12-Flakker-2**

D3-15th November **V3-Pusa Kesar** **V8-Sarpan 601** **V13-Desi Red (Lalit Kesar)**

D4-1st December **V4-Nantes** **V9-Samson-196** **V14-Super Kuroda-2**

D5-15th December **V5-Kuroda (RKS)** **V10-Super Kuroda-1** **V15-Indam Kuroda**

Table 25 Interaction effect of dates of sowing and cultivars on yield/ha (tonnes) of carrot

Cultivars	Dates of sowing					
	D_1	D_2	D_3	D_4	D_5	Mean (Cultivar)
V_1	20.00^{stu}	28.54^{fghi}	29.55^{cde}	27.42^{hijk}	17.87^{tuvw}	24.67^{b}
V_2	16.40^{vwxy}	29.20^{defg}	29.55^{cde}	28.80^{efgh}	16.27^{wxyz}	24.04^{b}
V_3	15.20^{xyz}	30.00^{bcde}	30.67^{ab}	29.87^{bc}	16.54^{vwxy}	24.45^{b}
V_4	27.47^{ghij}	32.27^{ab}	31.74^{ab}	30.62^{ab}	17.47^{tuvw}	27.91^{a}
V_5	19.20^{stuv}	17.87^{tuvw}	18.40^{tuvw}	17.87^{tuvw}	10.27^{z}	16.72^{f}
V_6	24.80^{lmno}	23.33^{mnop}	20.40^{rst}	19.60^{stuv}	10.27^{z}	19.68^{d}
V_7	15.87^{xyz}	25.07^{lmno}	25.87^{jklm}	25.60^{klm}	14.00^{z}	21.28^{c}
V_8	21.74^{pqrs}	32.80^{ab}	33.15^{a}	32.48^{ab}	16.14^{w}	27.26^{a}
V_9	14.94^{z}	13.33^{z}	14.67^{z}	16.54^{vwxy}	11.74^{z}	14.24^{g}
V_{10}	16.80^{uvwx}	21.87^{pqrs}	21.60^{qrs}	20.40^{rst}	10.80^{z}	18.29^{e}
V_{11}	12.00^{z}	10.40^{z}	11.87^{z}	12.54^{z}	10.27^{z}	11.42^{h}
V_{12}	14.94^{yz}	22.40^{nopq}	21.60^{qrs}	20.35^{rst}	12.00^{z}	18.26^{e}
V_{13}	17.87^{tuvw}	26.40^{ijkl}	26.27^{ijkl}	22.06^{opqr}	9.60^{z}	20.44^{cd}
V_{14}	25.20^{lmn}	16.00^{wxyz}	16.27^{wxyz}	18.00^{tuvw}	10.94^{z}	17.28^{ef}
V_{15}	23.60^{mnop}	17.60^{tuvw}	18.27^{tuvw}	18.13^{tuvw}	14.27^{z}	18.37^{e}
Mean (Dates of sowing)	19.07^{B}	23.14^{A}	23.32^{A}	22.68^{A}	13.23^{C}	

Mean values having similar alphabets in superscript, do not differ significantly

D1-15th October **V1-Pusa Rudhira** **V6-Kuroda Improved** **V11-Century**

D2-1st November **V2-Pusa Meghali** **V7-New Kuroda** **V12-Flakker-2**

D3-15th November **V3-Pusa Kesar** **V8-Sarpan 601** **V13-Desi Red (Lalit Kesar)**

D4-1st December **V4-Nantes** **V9-Samson-196** **V14-Super Kuroda-2**

D5-15th December **V5-Kuroda (RKS)** **V10-Super Kuroda-1** **V15-Indam Kuroda**

4.2 Biochemical analyses

4.2.1 Root dry matter

Significant variation was observed in root dry matter among dates of sowing, cultivar and interaction between dates of sowing and cultivar. Among dates of sowing highest root dry matter was observed in D_2 (19.52 %). The lowest root dry matter was observed from D_1 (16.18 %) which was on par with D_5 (16.50 %), D_4 (16.81 %) and D_3 (17.00 %).

Cultivar V_4 showed highest root dry matter of 18.92 per cent which was on par with V_8 of 18.12 per cent followed by V_6 and V_7 (17.17 %), V_1 (17.50 %) and V_{13} (17.15 %). The lowest root dry matter was observed in V_3 (15.94 %).

D_2V_{11} showed highest root dry matter of 26.25 per cent followed by D_2V_{15} (22.68 %), D_2V_6 (22.25 %), D_1V_9 (21.21 %) and D_1V_{14} (21.05 %). The lowest root dry matter was observed in D_1V_3 of 10.36 per cent which on par with D_1V_2 of 10.72 per cent (Table 26).

4.2.2 Total Soluble Solids

No significant difference was observed in case of TSS content among dates of sowing. In case of cultivars and interactions between dates of sowing and cultivars, significant variation was seen.

Among cultivars the highest TSS was recorded in V_{10} (12.66 ^{0}B) which was on par with V_8, V_{12}, V_1, V_2, V_4, V_7, V_9, V_{11} and V_{14}.The lowest TSS value was recorded from V_3 (10.42 ^{0}B) followed by V_{11} (10.87 ^{0}B).

Among interactions between dates of sowing and cultivars the highest TSS value of 13.80 ^{0}B was recorded in D_2V_{10} on par with D_1V_2, D_1V_7, D_1V_8, D_1V_9, D_1V_{12}, D_1V_{14}, D_1V_{15}, D_2V_1, D_2V_2, D_2V_4, D_2V_7, D_2V_8, D_2V_9, D_2V_{12}, D_2V_{14}, D_2V_{15}, D_3V_1, D_3V_2, D_3V_5, D_3V_6, D_3V_7, D_3V_8, D_3V_{12}, D_4V_1, D_4V_2, D_4V_6, D_4V_7, D_4V_8, D_4V_{10},

D_4V_{12}, D_4V_{15}, D_5V_1, D_5V_2, D_5V_4, D_5V_7, D_5V_8, D_5V_{13}, and D_5V_{14}.The lowest TSS recorded in D_4V_3 of 9.25 ^{0}B, was on par with D_1V_5, D_1V_6, D_3V_3, D_5V_3 and D_5V_{11} (Table 27).

4.2.3 Total sugar

Analysis of data on the total sugar showed significant variation among dates of sowing, D_1 (5.07 %) produced highest total sugar content which was on par with D_2 and D_4. Lowest total sugar content was recorded from D_5 (4.62 %) among dates of sowing and it was on par with D_3 (4.70 %).

Total sugar content significantly varied among the cultivars. V_6 (5.67 %) produced highest total sugar content which was on par with V_1, V_4, V_5 and V_7. V_3 recorded lowest total sugar content (4.39 %) among the all cultivars which was on par with V_2, V_8, V_{10}, V_{11}, V_{12} and V_{13}.

Data on total sugar content differed significantly among interactions between dates of sowing and cultivars. D_1V_1 recorded the highest total sugar content (6.62 %) which was on par with D_1V_{14}, D_2V_1, D_2V_7, D_3V_5, D_3V_6, D_4V_5, D_4V_6 and D_5V_6. While D_5V_{13} recorded lowest total sugar content of 4.01 % which was on par with D_1V_3, D_1V_{10}, D_1V_{11}, D_2V_3, D_2V_{10}, D_2V_{11}, D_3V_1, D_3V_2, D_3V_3, D_3V_7, D_3V_8, D_3V_{11}, D_3V_{12}, D_4V_1, D_4V_2, D_4V_4, D_4V_8, D_5V_1, D_5V_3, D_5V_4, D_5V_8, D_5V_{10}, D_5V_{12} and D_5V_{13} (Table 28).

Table 26 Interaction effect of dates of sowing and cultivars on root dry matter (%) of carrot

Cultivars	Dates of sowing					
	D_1	D_2	D_3	D_4	D_5	Mean (Cultivar)
V_1	14.65^{tuvw}	17.75^{hijk}	18.87^{efgh}	18.23^{ghij}	18.00^{ghij}	17.50^{bc}
V_2	10.72^{y}	17.00^{klmn}	18.87^{efgh}	18.64^{fghi}	17.00^{klmn}	16.44^{ef}
V_3	10.36^{y}	15.20^{rstu}	19.20^{defg}	18.96^{efgh}	16.00^{nopq}	15.94^{f}
V_4	20.58^{cde}	19.32^{defg}	19.52^{defg}	19.19^{defg}	16.00^{nopq}	18.92^{a}
V_5	14.95^{stuv}	20.17^{def}	15.52^{pqrs}	15.36^{rstu}	17.25^{jklm}	16.65^{de}
V_6	16.55^{mnop}	22.25^{bc}	16.12^{nopq}	15.88^{opqr}	17.75^{hijk}	17.71^{bc}
V_7	16.60^{mnop}	18.50^{fghi}	17.76^{hijk}	17.68^{ijkl}	18.00^{ghij}	17.71^{bc}
V_8	14.40^{uvwx}	18.50^{fghi}	19.95^{defg}	19.75^{defg}	18.00^{ghij}	18.12^{ab}
V_9	21.21^{bc}	16.70^{lmno}	14.40^{uvwx}	14.96^{stuv}	15.75^{opqr}	16.60^{de}
V_{10}	18.94^{efgh}	20.22^{def}	16.48^{mnop}	16.12^{nopq}	15.00^{rstu}	17.35^{bc}
V_{11}	15.15^{rstu}	26.25^{a}	13.56^{x}	13.76^{wx}	16.00^{nopq}	16.94^{cd}
V_{12}	14.05^{vwx}	19.20^{defg}	16.48^{mnop}	16.11^{nopq}	16.50^{mnop}	16.47^{ef}
V_{13}	17.75^{hijk}	20.00^{def}	17.88^{hijk}	16.62^{mnop}	15.00^{rstu}	17.45^{bc}
V_{14}	21.05^{bc}	19.10^{defg}	14.88^{stuv}	15.40^{rstu}	14.75^{stuv}	17.04^{cd}
V_{15}	15.80^{opqr}	22.68^{b}	15.48^{qrst}	15.44^{qrst}	16.50^{mnop}	17.18^{cd}
Mean (Dates of sowing)	16.18^{B}	19.52^{A}	17.00^{B}	16.81^{B}	16.50^{B}	

Mean values having similar alphabets in superscript, do not differ significantly

D1-15th October **V1-Pusa Rudhira** **V6-Kuroda Improved** **V11-Century**

D2-1st November **V2-Pusa Meghali** **V7-New Kuroda** **V12-Flakker-2**

D3-15th November **V3-Pusa Kesar** **V8-Sarpan 601** **V13-Desi Red (Lalit Kesar)**

D4-1st December **V4-Nantes** **V9-Samson-196** **V14-Super Kuroda-2**

D5-15th December **V5-Kuroda (RKS)** **V10-Super Kuroda-1** **V15-Indam Kuroda**

Table 27 Interaction effect of dates of sowing and cultivars on TSS (^{0}B) of carrot

Cultivars	Dates of sowing					
	D_1	D_2	D_3	D_4	D_5	Mean
V_1	11.60^{cde}	12.50^{ab}	12.75^{ab}	12.25^{ab}	12.50^{ab}	12.32^{ab}
V_2	12.75^{ab}	12.45^{ab}	12.00^{ab}	12.00^{ab}	12.25^{ab}	12.27^{ab}
V_3	11.50^{cde}	11.60^{cde}	10.00^{ghij}	9.25^{j}	9.75^{hij}	10.42^{e}
V_4	11.75^{bc}	12.05^{ab}	11.75^{bc}	11.75^{bc}	13.50^{ab}	12.16^{abc}
V_5	9.50^{ij}	10.50^{fghi}	12.50^{ab}	12.00^{ab}	11.50^{cd}	11.20^{de}
V_6	9.50^{ij}	10.0^{ghi}	12.00^{ab}	12.25^{ab}	11.50^{cd}	11.05^{de}
V_7	12.00^{ab}	12.05^{ab}	12.50^{ab}	13.00^{ab}	12.75^{ab}	12.46^{ab}
V_8	12.25^{ab}	12.15^{ab}	13.50^{ab}	12.75^{ab}	12.00^{ab}	12.60^{a}
V_9	12.75^{ab}	12.75^{ab}	11.50^{cde}	10.50^{fghi}	11.25^{cde}	11.75^{bc}
V_{10}	13.75^{a}	13.80^{a}	11.50^{cde}	12.75^{ab}	11.50^{cde}	12.66^{a}
V_{11}	11.00^{defg}	11.50^{cd}	10.75^{efgh}	11.00^{defg}	10.10^{ghij}	10.87^{de}
V_{12}	12.50^{ab}	12.75^{ab}	12.00^{ab}	13.00^{ab}	11.50^{cde}	12.35^{ab}
V_{13}	10.95^{defg}	10.90^{defg}	11.40^{cde}	11.75^{bc}	12.00^{ab}	11.42^{cd}
V_{14}	12.00^{ab}	12.50^{ab}	12.00^{ab}	11.50^{cd}	12.00^{ab}	12.00^{abc}
V_{15}	12.10^{ab}	12.15^{ab}	11.50^{cde}	12.00^{ab}	11.80^{bc}	11.91^{abc}
Mean	11.73^{A}	11.97^{A}	11.84^{A}	11.85^{A}	11.73^{A}	

Mean values having similar alphabets in superscript, do not differ significantly

D1-15th October	**V1-Pusa Rudhira**	**V6-Kuroda Improved**	**V11-Century**
D2-1st November	**V2-Pusa Meghali**	**V7-New Kuroda**	**V12-Flakker-2**
D3-15th November	**V3-Pusa Kesar**	**V8-Sarpan 601**	**V13-Desi Red (Lalit Kesar)**
D4-1st December	**V4-Nantes**	**V9-Samson-196**	**V14-Super Kuroda-2**
D5-15th December	**V5-Kuroda (RKS)**	**V10-Super Kuroda-1**	**V15-Indam Kuroda**

4.2.4 Acidity

Dates of sowing did not affect the acidity of carrot but cultivars differed significantly with respect to acidity of carrot. The highest acidity was noticed in V_{13} (2.13 %) which was on par with V_5 and V_{10}. The lowest acidity was noticed in V_6 (1.15 %) which was on par with V_1, V_2, V_3, V_4, V_6, V_7, V_8, V_9, V_{11}, V_{12} and V_{13}.

Acidity differed significantly among interactions between dates of sowing and cultivars. The highest acidity was recorded in D_1V_{13} (2.68 %) which was on par with D_1V_2, D_1V_7, D_1V_8, D_1V_9, D_1V_{12}, D_1V_{14}, D_1V_{15}, D_2V_1, D_2V_2, D_2V_4, D_2V_7, D_2V_8, D_2V_9, D_2V_{12}, D_2V_{14}, D_2V_{15}, D_3V_1, D_3V_2, D_3V_5, D_3V_6, D_3V_7, D_3V_8, D_3V_{12}, D_3V_{15}, D_4V_1, D_4V_2, D_4V_6, D_4V_7, D_4V_8, D_4V_{10},D_4V_{12}, D_4V_{14}, D_5V_1, D_5V_2, D_5V_4, D_5V_7, D_5V_8, D_5V_{13} and D_5V_{14}. The lowest acidity recorded in D_1V_6 and D_4D_7 (0.89 % each) which was on par with D_1V_5, D_1V_6, D_3V_3, D_4V_3, D_5V_3 and D_1V_{12} (Table 29).

4.2.5 β carotene

Significant variation was observed in β carotene content among dates of sowing, cultivars and interactions between dates of sowing and cultivars. The highest value of β carotene was observed in D_3 (4.77 mg/100g) which was on par with D_1 (4.52 mg/100g) and D_2 (4.51 mg/100g). The lowest β carotene was observed in D_5 (4.12 mg/100g) which was on par with D_4 (4.37 mg/100g).

Among the cultivars the highest value of β carotene was observed in V_6 (5.44 mg/100g) which was on par with V_4, V_5, V_9, V_9, V_{11}, V_{12} V_9 and V_{15}. The lowest β carotene was observed in V_2 (2.97 mg/100g) which was on par with V_1 and V_{13}.

β carotene showed significant variation in interaction between dates of sowing and cultivars. The highest β carotene was observed in D_3V_4 (6.05 mg/100g) which was on par with D_1V_4, D_1V_5, D_1V_6, D_1V_9, D_1V_{11}, D_1V_{14}, D_2V_4, D_2V_5, D_2V_6, D_2V_9, D_2V_{11}, D_2V_{14}, D_3V_4, D_3V_5, D_3V_6, D_3V_9, D_3V_{10}, D_3V_{11}, D_3V_{12}, D_3V_{14}, D_4V_{12} and

D_4V_{14}. The lowest value of β carotene was observed in D_5V_1 (2.20 mg/100g) which was on par with V_1 and V_2. (Table 30)

Table 28 Interaction effect of dates of sowing and cultivars on total sugars (%) content of carrot

Cultivars	Dates of sowing					
	D_1	D_2	D_3	D_4	D_5	Mean (Cultivar)
V_1	6.62^{a}	6.50^{a}	4.26^{efg}	4.55^{def}	4.30^{efg}	5.25^{ab}
V_2	5.13^{bc}	5.20^{bc}	4.46^{def}	4.45^{def}	4.06^{gh}	4.66^{cd}
V_3	4.57^{def}	4.30^{efg}	4.36^{def}	4.55^{def}	4.16^{fgh}	4.39^{d}
V_4	4.80^{bc}	4.83^{bc}	4.67^{cd}	4.90^{bc}	4.55^{def}	4.75^{bc}
V_5	4.86^{bc}	4.90^{bc}	5.41^{ab}	5.62^{ab}	5.05^{bc}	5.17^{ab}
V_6	4.98^{bc}	4.94^{bc}	6.15^{ab}	6.56^{a}	5.70^{ab}	5.67^{a}
V_7	5.95^{ab}	5.99^{ab}	4.27^{efg}	4.90^{bc}	4.90^{bc}	5.20^{ab}
V_8	4.92^{bc}	4.80^{bc}	4.17^{fgh}	4.26^{efg}	4.40^{def}	4.51^{d}
V_9	4.94^{bc}	4.98^{bc}	4.88^{bc}	5.13^{bc}	4.65^{cd}	4.92^{bc}
V_{10}	4.50^{def}	4.20^{efgh}	4.88^{bc}	4.94^{bc}	4.35^{def}	4.57^{d}
V_{11}	4.49^{def}	4.54^{def}	4.45^{def}	4.67^{cd}	5.03^{bc}	4.64^{cd}
V_{12}	4.82^{bc}	4.70^{cd}	4.55^{def}	4.77^{cd}	4.53^{def}	4.67^{cd}
V_{13}	5.12^{bc}	5.00^{bc}	4.01^{h}	4.08^{gh}	4.32^{fgh}	4.51^{d}
V_{14}	5.48^{ab}	4.80^{bc}	5.13^{bc}	5.01^{bc}	4.56^{def}	5.00^{bc}
V_{15}	4.88^{bc}	4.90^{bc}	4.88^{bc}	4.65^{cd}	4.90^{bc}	4.84^{bc}
Mean (Dates of sowing)	5.07^{A}	4.97^{A}	4.70^{B}	4.82^{AB}	4.62^{B}	

Mean values having similar alphabets in superscript, do not differ significantly

D1-15th October **V1-Pusa Rudhira** **V6-Kuroda Improved** **V11-Century**

D2-1st November **V2-Pusa Meghali** **V7-New Kuroda** **V12-Flakker-2**

D3-15th November **V3-Pusa Kesar** **V8-Sarpan 601** **V13-Desi Red (Lalit Kesar)**

D4-1st December **V4-Nantes** **V9-Samson-196** **V14-Super Kuroda-2**

D5-15th December **V5-Kuroda (RKS)** **V10-Super Kuroda-1** **V15-Indam Kuroda**

Table 29 Interaction effect of dates of sowing and cultivars on acidity (%) of carrot

Cultivars	Dates of sowing					
	D_1	D_2	D_3	D_4	D_5	Mean
V_1	1.56^{ab}	1.78^{ab}	1.56^{ab}	1.78^{ab}	1.69^{ab}	1.67^{bc}
V_2	1.34^{bc}	1.11^{cd}	1.56^{ab}	1.56^{ab}	1.63^{ab}	1.53^{bc}
V_3	1.11^{cd}	1.11^{cd}	1.34^{bc}	1.56^{ab}	1.66^{ab}	1.36^{bc}
V_4	1.56^{ab}	1.78^{ab}	1.56^{ab}	1.11^{cd}	1.10^{cd}	1.42^{bc}
V_5	2.12^{ab}	2.23^{ab}	2.23^{ab}	1.34^{bc}	1.29^{bc}	1.84^{ab}
V_6	0.89^{d}	1.11^{cd}	1.56^{ab}	1.11^{cd}	1.08^{cd}	1.15^{c}
V_7	1.12^{cd}	1.56^{ab}	1.56^{ab}	0.89^{d}	0.90^{d}	1.20^{c}
V_8	1.56^{ab}	1.70^{ab}	1.34^{bc}	1.34^{bc}	1.33^{bc}	1.45^{bc}
V_9	1.56^{ab}	1.54^{ab}	1.78^{ab}	1.34^{bc}	1.26^{bc}	1.50^{bc}
V_{10}	2.23^{ab}	2.20^{ab}	1.78^{ab}	1.34^{bc}	1.18^{bc}	1.75^{ab}
V_{11}	1.56^{ab}	1.52^{ab}	1.34^{bc}	1.11^{cd}	1.16^{cd}	1.34^{bc}
V_{12}	1.56^{ab}	1.12^{cd}	1.78^{ab}	1.34^{bc}	1.27^{bc}	1.41^{bc}
V_{13}	2.68^{a}	2.23^{ab}	2.45^{ab}	1.78^{ab}	1.45^{ab}	2.12^{a}
V_{14}	1.79^{ab}	1.56^{ab}	1.56^{ab}	1.34^{bc}	1.22^{bc}	1.49^{bc}
V_{15}	1.56^{ab}	1.79^{ab}	2.23^{ab}	1.56^{ab}	1.45^{ab}	1.72^{b}
Mean	1.62^{A}	1.63^{A}	1.71^{A}	1.36^{A}	1.31^{A}	

Mean values having similar alphabets in superscript, do not differ significantly

D1-15th October **V1-Pusa Rudhira** **V6-Kuroda Improved** **V11-Century**

D2-1st November **V2-Pusa Meghali** **V7-New Kuroda** **V12-Flakker-2**

D3-15th November **V3-Pusa Kesar** **V8-Sarpan 601** **V13-Desi Red (Lalit Kesar)**

D4-1st December **V4-Nantes** **V9-Samson-196** **V14-Super Kuroda-2**

D5-15th December **V5-Kuroda (RKS)** **V10-Super Kuroda-1** **V15-Indam Kuroda**

Table 30 Interaction effect of dates of sowing and cultivars on β carotene (mg/100g) of carrot

Cultivars	Dates of sowing					
	D_1	D_2	D_3	D_4	D_5	Mean
V_1	3.001^{mno}	3.05^{klmno}	3.82^{jk}	3.05^{klmn}	2.20^{p}	3.02^{f}
V_2	2.95^{mno}	2.90^{mno}	3.30^{klmn}	3.05^{klmn}	2.55^{op}	2.97^{f}
V_3	3.45^{klmn}	3.30^{klmn}	3.40^{klmn}	3.35^{klmn}	3.35^{klmn}	3.37^{de}
V_4	5.60^{ab}	5.75^{ab}	6.05^{a}	5.25^{bc}	4.35^{ij}	5.40^{a}
V_5	5.50^{ab}	5.55^{ab}	5.85^{ab}	5.05^{defg}	5.20^{bc}	5.43^{a}
V_6	5.60^{ab}	5.55^{ab}	5.90^{ab}	5.20^{bc}	4.95^{defg}	5.44^{a}
V_7	3.70^{jklm}	3.68^{jklm}	3.35^{klmn}	3.40^{klmn}	2.85^{nop}	3.40^{de}
V_8	3.63^{jklm}	3.65^{klmn}	3.55^{klmn}	3.75^{jkl}	3.30^{klmn}	3.57^{d}
V_9	5.49^{ab}	5.51^{ab}	5.85^{ab}	5.00^{defg}	4.95^{defg}	5.36^{a}
V_{10}	5.08^{cd}	5.06^{cd}	5.35^{ab}	4.80^{fghi}	4.90^{efgh}	$5.04b^{c}$
V_{11}	5.27^{ab}	5.30^{ab}	5.30^{ab}	4.90^{efgh}	5.05^{defg}	5.16^{ab}
V_{12}	4.69^{ghi}	4.66^{ghi}	5.35^{ab}	4.85^{efgh}	4.60^{hi}	4.84^{c}
V_{13}	3.51^{klmn}	3.53^{klmn}	2.95^{mno}	3.15^{klmn}	3.15^{klmn}	3.25^{ef}
V_{14}	5.35^{ab}	5.32^{ab}	5.90^{ab}	5.30^{ab}	5.25^{bc}	5.43^{a}
V_{15}	5.00^{de}	4.80^{defg}	5.70^{ab}	5.45^{ab}	5.10^{cde}	5.30^{ab}
Mean	4.52^{AB}	4.51^{AB}	4.77^{A}	4.37^{BC}	4.12^{C}	

Mean values having similar alphabets in superscript, do not differ significantly

D1-15th October **V1-Pusa Rudhira** **V6-Kuroda Improved** **V11-Century**

D2-1st November **V2-Pusa Meghali** **V7-New Kuroda** **V12-Flakker-2**

D3-15th November **V3-Pusa Kesar** **V8-Sarpan 601** **V13-Desi Red (Lalit Kesar)**

D4-1st December **V4-Nantes** **V9-Samson-196** **V14-Super Kuroda-2**

D5-15th December **V5-Kuroda (RKS)** **V10-Super Kuroda-1** **V15-Indam Kuroda**

4.3 Correlation

Correlation provides the information about the nature and relationship of yield with its component characters and used as tool towards further exploitation of the component character towards improvement of yield. The genotypic correlation provides a reliable measure of genetic association between the characters and helps to differentiate the vital association useful in breeding from non-vital ones (Falconer, 1981). Selection for yield alone need not be effective or rather not possible since there may not be any gene or genes for yield alone and it is a consequence of multiplicative interaction of several component characters (Singh, 1983).

The genotypic correlations between different pairs of characters were estimated and presented in Table 31.

In the present study it was observed that yield had highly significant and positive genotypic correlation with root weight (0.959), foliage weight (0.886), leaf width (0.809), number of leaves per plant (0.739), core size (0.711), leaf length (0.630) and root diameter (0.591). On the other hand yield showed significant and negative correlation with root shoot ratio (-0.380).

Number of leaves expressed positive genotypic correlation with foliage weight (0.750), root weight (0.706), core size (0.658), leaf width (0.656) and leaf length (0.457). Root shoot ratio was significant and has got negative genotypic correlation with number of leaves per plant (-0.471).

The characters having significant and positive genotypic correlation with leaf width of carrot were foliage weight (0.817), leaf length (0.768), root weight (0.745), root diameter (0.457), root length (0.429) and core size (0.403) while significant and negative genotypic correlation expressed with root shoot ratio (-0.564)

Leaf length had significant and positive genotypic correlation with foliage weight (0.771), root weight (0.646), root diameter (0.638), root length (0.387) and

core size (0.370). But the root shoot ratio showed significant and negative genotypic correlation with leaf length (-0.157).

Foliage weight showed significant positive genotypic correlation with root weight (0.887), core size (0.709), root diameter (0.542) and root length (0.443). On other hand foliage weight showed significant and negative correlation with root shoot ratio (-0.580).

Core size expressed positive genotypic correlation with root weight (0.744) and root diameter (0.444) while significant and negative genotypic correlation was expressed with root shoot ratio (-0.313). Root length had significant and negative correlation with root shoot ratio (-0.502)

Root diameter had significant and positive genotypic correlation with root weight of carrot (0.674).

Table 31 Correlation matrix for root yield and other biometric characters of carrot (r values)

	X2	X3	X4	X5	X6	X7	X8	X9	X10
X1	0.739*	0.809*	0.630*	0.886*	0.711*	0.336	0.591*	0.959*	-0.380*
X2		0.656*	0.457*	0.750*	0.658*	0.349	0.290	0.706*	-0.471*
X3			0.768*	0.817*	0.403*	0.429*	0.457*	0.745*	-0.564*
X4				0.771*	0.370*	0.387*	0.638*	0.646*	-0.384*
X5					0.709*	0.443*	0.542*	0.887*	-0.580*
X6						0.118	0.444*	0.744*	-0.313
X7							0.004	0.289	-0.502*
X8								0.674*	0.114
X9									-0.336

* Significant at 5 per cent level

X1- Yield kg/plot, X2- Number of leaves, X3- Leaf width, X4- leaf length, X5- foliage weight, X6-Core size, X7- Root length, X8-Root diameter, X9-Root weight, X10- Root shoot ratio

4.4 PATH COEFFICIENT ANALYSIS

The direct and indirect contribution of component characters and yield can be found out by partitioning the correlation between yield and component characters into direct and indirect effects. The result of path coefficient analysis is furnished in Table 32.

The highest positive direct genotypic effect on yield was exhibited by foliage weight (4.91), followed by root weight (0.699), leaf width (0.303), core size (0.061) and number of leaves (0.012).

Direct effect of number of leaves on yield was positive (0.121) and its correlation with yield was also positive (0.734).

Leaf width also showed direct positive effect on yield (0.303) and its genotypic correlation with yield was also positive (0.809).

Leaf length showed negative direct effect on root yield (-0.129). But its genotypic correlation with yield was found positive (0.631).

Foliage weight showed highly direct positive effect on yield (4.91). Its correlation with yield was also found to be positive (0.885).

Direct effect of core size on yield was negligible (0.061). Its correlation with yield was also found to be positive (0.711).

Direct effect of root weight on yield was positive (0.699) and its correlation with yield was also positive (0.959).

Correlation of root length with yield was found to be positive and significant (0.355). Root diameter showed positive correlation with yield (0.591) and characters like root length and root diameter was having negligible direct effect on yield.

Table 32 Genotypic path coefficient analysis of the various characters on the yield of carrot

	X1	X2	X3	X4	X5	X6	X7	X8	X9	rg
X1	**0.0121**	0.1 993	-0.0592	3.6814	0.0402	-0.0004	-0.0004	0.4935	-3.6273	0.734
X2	0.0079	**0.3038**	-0.0996	4.0095	0.0247	-0.0005	-0.0006	0.5208	-3.9566	0.809
X3	0.0055	0.2334	**-0.1296**	3.7874	0.0226	-0.0004	-0.0008	0.4518	-3.7395	0.631
X4	0.0091	0.2481	-0.1000	**4.9100**	0.0433	-0.0005	-0.0007	0.6204	-4.8436	0.885
X5	0.0079	0.1225	-0.0479	3.4791	**0.0611**	-0.0001	-0.0006	0.5202	-3.4312	0.711
X6	0.0042	0.1305	-0.0501	2.1735	0.0072	**-0.0011**	0.000	0.2018	-2.1303	0.335
X7	0.0035	0.1388	-0.0827	2.6637	0.0271	0.000	**-0.0013**	0.4717	-2.6299	0.591
X8	0.0085	0.2262	-0.0838	4.3559	0.0455	-0.0003	-0.0009	**0.6993**	-4.291	0.959
X9	0.009	0.2482	-0.1001	4.9098	0.0433	-0.0005	-0.0007	0.6195	**-4.8438**	0.885

r (Residual value) = 0.0485

X1- Number of leaves, X2- Leaf width, X3- leaf length, X4- foliage weight, X5-Core size, X6- Root length, X7-Root diameter, X8-Root weight, X9- Root shoot ratio

Root shoot ratio showed highly negative direct effect on root yield (-4.843). But its genotypic correlation with yield was found positive (0.885).

The characters like number of leaves per plant, leaf width, foliage weight, core size and root weight exhibited direct and positive phenotypic effect on yield. In path coefficient analysis the highest positive direct phenotypic effect on yield was exhibited by foliage weight (4.91) and its phenotypic correlation was also positive (0.885).

4.5 Organoleptic evaluation

Ten quality characters *viz.* depth of colour, strength of smell, taste, flavor, hardness, sweetness, pungency, crispness, after taste and general appearance of fresh roots were assessed in organoleptic evaluation for fifteen carrot varieties during all the five dates of sowing and average scores are presented in Table 33. Significant variation was seen in all the varieties with respect to all the characters studied.

4.5.1 Colour

The score for depth of colour varied between 3.00 and 8.40. The highest score of 8.40 was recorded for two varieties, V_4 and V_6 which were significantly superior to all others. These were followed by V_9 (8.20) and V_5 and V_{10} (7.80 each). The lowest score of 3.00 was recorded for the cultivar V_8.

4.5.2 Odour

For strength of smell the highest score recorded was 8.20 for the cultivars V_4 and V_6 followed by V_9 (8.00), V_{14} (7.80) and V_5 (7.60). The lowest score recoded was 5.20 for the cultivar V_{13}.

4.5.3 Taste

The cultivar V_6 significantly superior to all others, recorded the highest value of 8.40 for taste followed by V_{12} (7.80), V_4 and V_9 (7.60 each) while the lowest value of 2.60 was recorded for the cultivar V_2.

4.5.4 Flavour

For flavour the highest score of 8.20 was recorded for cultivar V_6 which was significantly superior which was followed by V_{11} (7.60). The lowest score of 3.20 was recorded for the cultivar V_8.

4.5.5 Hardness

The score for hardness varied between 3.40 and 8.00. The highest score of 8 was recorded for cultivar V_9 followed by V_6 and V_{15} (7.60 each). The lowest score of 3.40 was recorded for the two cultivars V_3 and V_8.

4.5.6 Sweetness

For sweetness the highest significantly superior score recorded was 8.20 for the cultivar V_6 followed by V_{15} (7.60). The lowest score recoded was 2.4 for the cultivar V_2.

4.5.7 Pungency

The cultivar V_5 recorded the highest value of 7.80 for pungency followed by V_6 and V_{14} (7.60 each) while the lowest value of 4.40 was recorded for the accession V_8.

Table 33 Organoleptic evaluation of carrot varieties

Cultivars	Characters										
	Depth of colour	Strength of smell	Taste	Flavour	Hardness	Sweetness	Pungency	Crispness	After taste	General appearance	Total score
V_1	7.4^{e}	6.8^{g}	3.4^{l}	7.2^{d}	5.0^{j}	3.6^{j}	6.6^{e}	4.8^{k}	3.9^{j}	7.0^{e}	55.7^{i}
V_2	7.2^{f}	6.6^{h}	2.6^{n}	6.6^{f}	3.6^{k}	2.4^{k}	6.4^{f}	3.8^{l}	6.2^{e}	5.3^{g}	50.7^{j}
V_3	5.8^{h}	4.2^{k}	3.2^{m}	6.8^{e}	3.4^{l}	3.6^{j}	4.6^{i}	3.6^{m}	4.4^{i}	3.8^{i}	43.4^{k}
V_4	8.4^{a}	8.2^{a}	7.6^{c}	5.6^{i}	6.8^{e}	7.2^{c}	7.6^{b}	6.6^{e}	7.8^{a}	7.8^{b}	73.6^{d}
V_5	7.8^{c}	7.6^{d}	7.2^{e}	7.6^{c}	7.2^{d}	6.8^{d}	7.8^{a}	7.0^{c}	7.4^{c}	7.6^{c}	74.0^{cd}
V_6	8.4^{a}	8.2^{a}	8.4^{a}	8.2^{a}	7.6^{b}	8.2^{a}	7.6^{b}	7.4^{b}	7.8^{a}	8.0^{a}	79.8^{a}
V_7	6.4^{g}	6.0^{i}	6.8^{f}	5.6^{i}	5.4^{h}	6.6^{e}	6.2^{g}	5.2^{i}	5.8^{g}	6.2^{f}	60.2^{h}
V_8	3.0^{j}	4.2^{k}	3.6^{k}	3.2^{k}	3.4^{l}	4.4^{i}	4.4^{j}	3.0^{n}	2.6^{k}	2.4^{j}	34.2^{l}
V_9	8.2^{b}	8.0^{b}	7.6^{c}	7.6^{c}	8.0^{a}	7.6^{b}	7.4^{c}	7.8^{a}	7.8^{a}	8.0^{a}	78.0^{b}
V_{10}	7.8^{c}	7.0^{f}	6.2^{h}	6.4^{g}	6.4^{f}	5.8^{f}	6.8^{d}	6.2^{g}	6.8^{d}	7.2^{d}	66.6^{f}
V_{11}	7.4^{e}	7.4^{e}	6.0^{i}	7.8^{b}	5.6^{g}	5.6^{g}	6.8^{d}	5.4^{h}	6.8^{d}	7.0^{e}	65.8^{fg}
V_{12}	5.2^{f}	6.8^{g}	7.8^{b}	6.2^{h}	7.4^{c}	7.2^{c}	6.8^{d}	6.4^{f}	6.0^{f}	4.8^{h}	64.6^{g}
V_{13}	7.6^{d}	5.2^{j}	5.6^{j}	3.8^{j}	5.2^{i}	5.4^{h}	5.2^{h}	5.0^{j}	5.2^{h}	7.2^{d}	55.4^{i}
V_{14}	7.2^{f}	7.8^{c}	6.6^{g}	6.6^{f}	6.8^{e}	6.8^{d}	7.6^{b}	6.8^{d}	7.6^{b}	7.0^{e}	70.8^{e}
V_{15}	7.6^{d}	7.4^{e}	7.4^{d}	7.6^{c}	7.6^{b}	7.6^{b}	7.4^{c}	7.4^{b}	7.6^{b}	7.8^{b}	75.4^{c}

Mean values having similar alphabets in superscript, do not differ significantly

Maximum score: 9

V1-Pusa Rudhira **V4-Nantes** **V7-New Kuroda** **V10-Super Kuroda-1** **V13-Desi Red (Lalit Kesar)**

V2-Pusa Meghali **V5-Kuroda (RKS)** **V8-Sarpan 601** **V11-Century** **V14-Super Kuroda-2**

V3-Pusa Kesar **V6-Kuroda Improved** **V9-Samson-196** **V12-Flakker-2** **V15-Indam Kuroda**

4.5.8 Crispness

For crispness the highest score of 7.80 was recorded for accessions, V_9 followed by V_6 (7.40). The lowest score of 3 was recorded for the cultivar V_8.

4.5.9 After taste

The score for after taste varied between 2.60 and 7.80. The highest score of 7.80 was recorded for three cultivars V_4, V_6 and V_9 followed by V_{14} and V_{15} (7.60). The lowest score of 3.40 was recorded for the two cultivars V_3 and V_8.

4.5.10 General appearance

The cultivar V_6 and V_9 were more appealing in appearance with a score of 8.00 out of 9.00. The lowest score of 2.40 was recorded for the cultivar V_8.

4.5.11 Total

From the total scores obtained for different cultivars it could be concluded that V_6 with the overall score of 79.80 out of 90.00 was the most accepted cultivar followed by V_9 (78.00), V_{15} (75.40) and V_5 (74.00). It could also be observed that the least accepted cultivar was V_8 with the total score of 34.2 out of 90 followed by V_3 (43.4) and V_2 (50.70).

DISCUSSION

5. DISCUSSION

Carrot (*Daucus carota* L.) belongs to the family Umbelliferea (Apiaceae) (Joubert *et al.*, 1994; Rubatzky *et a.l*, 1999). It is a widely grown vegetable cultivated for the storage roots which have high nutritional value. Carrots are cool season crop but can be sown throughout the year. Climate has the greatest overall influence on crop production, and temperature is one of its most important components (Rubatzky *et al.*, 1999). Productivity and quality parameters of carrot root yield depend on cultivar-specific, climatic, soil, and agronomic factors [Kaack *et al.* 2001, Gajewski *et al.* 2007].

There are many reasons for its low productivity in India. Raising quality roots is very difficult. There is excessive forking and splitting of roots, if crop is grown in unfavourable season. Also the time and method of sowing have no significant effect on the quality of root and yield. Extension of carrot cultivation in a diverse variety of soils and environmental conditions is needed to increase carrot production in the country. (Dahiya *et al.*, 2007).

In Kerala generally cool season vegetables are mainly grown in high altitude regions of Idukki, Wayanad and Palakkad districts where mild subtropical climate prevails. With the development of tropical varieties in cool season vegetables, their cultivation is spreading towards non-traditional areas as well. Popularization of carrot cultivation in the plains will help to minimize truckloads of pesticide loaded carrot coming from the neighbouring states. This will also help to increase the overall vegetable production of the state.

The present investigation was envisaged to identify ideal carrot varieties for cultivation in the plains of Kerala, to find suitable planting time for successful cultivation of carrot and to study the influence of sowing time on various qualitative and quantitative characters. The results of the study are discussed in the ensuing pages.

5.1 Influence of sowing time on vegetative characters of carrot

The germination percentage was greatly influenced by dates of sowing. Maximum percentage of germination (66.03 %) was noticed in the crop sown during 1st December which was on par with 1st November and 15th November. From 1st November to 15th December the weather conditions were very congenial for the germination of the carrot seeds. Optimum temperature of 32 ^{0}C, relative humidity between 80 and 90 and low rain fall prevalent during that period might have helped in the maximum germination of seeds. During 15th October the temperature was low RH was above 95 and rain fall was very high. These may be the reasons for the low germination during 15th October. Drastic reduction in the relative humidity might be the reason for low germination during 2nd week of December. These results are in close proximity with findings of Nascimento *et al.* (2013) where germination of seeds has been reduced with increase in temperature, low humidity and high rainfall.

Plant height, plant spread, number of leaves, leaf length, leaf width, length of petiole and foliage weight differed significantly with dates of sowing. Maximum plant height (37.1 cm) was recorded in 15th October sowing followed by 1st December, 15th November and 1st November. Plant height on three dates of sowing *viz.*, 1st November, 15th November and 1st December were statistically on par. Heavy rains during 2nd week October might have contributed to vigorous plant growth in first sowing. 15th December recorded lowest plant height (30.22 cm) among all the dates of sowing. The reason for reduced plant height may be due to the high temperature and low humidity prevailed from 15th December onwards. Very high temperature during the growth and development of carrot during February and March had adversely affected the crop growth in 15th December sowing (Appendix-I).

There was only a small effect of sowing date on plant spread. However sowing on 1st December recorded the highest spread (E-W 34.66 cm and N-S 36.37 cm) in both directions and which was on par with 15th October, 1st November and 15th

November, but 15th December sowing put forth the lowest spread (E-W 29.86 cm and N-S 29.89 cm). After the 5th sowing (15th December) the temperature increased more than 35 ^{0}C which may be the reason behind this decrease in plant spread (Appendix-I).

Plants sown on 15th November produced maximum number of leaves (11.97) per plant which was on par with 1st December and 1st November. Crop sown during 15th October produced less leaves (10.38) among all dates of sowing and it was on par with the crop sown during 15th December. Leaf length was highest (41.18 cm) in the crop sown during 15th October and was on par with 1st November, 15th November and 1st December. The lowest leaf length (34.86 cm) was recorded in the crop sown during 15th December. Highest value of leaf width (14.50 cm) was also observed in the crop sown during 15th October. It was on par with 15th November and 1st December. The lowest leaf width (13.38 cm) was noticed in the crop sown during 15th December and it was on par with the crop sown during 1st November. The longest petiole length (14.01 cm) was recorded in the crop sown during 1st December which was statistically on par with the crop sown during 15th November and 15th October followed by 1st November sowing. The lowest petiole length (11.91 cm) was observed in the crop sown during 15th December. Among dates of sowing maximum foliage weight (72.99 g) was observed from the crop sown during 15th October which was on par with the crop sown during 15th November and 1st November. The minimum foliage weight (41.87 g) was recorded in the crop sown during 15th December.

In most of the cases crop sown during 15th December performed very poor. The high temperature above 32 ^{0}C and low relative humidity below 75 per cent prevailed after December up to March might have adversely affected the crop growth and hence the overall plant growth was very poor in 15th December sowing. 15th October sowing showed huge vegetative growth without adequate root growth. It may be because of the heavy rains, high RH and low temperature prevailed during October

period. Moderate plant growth and good root development were observed in 1st November, 15th November and 1st December sowings. Low temperature, moderate humidity, and low rainfall have contributed to the satisfactory growth of the crop during that period. These findings go in line with the reports of Hussain *et al.* (2008).

5.2 Influence of sowing time on root characters of carrot.

Root length, root girth, root diameter, and root weight directly contribute to yield. All these root characters differed significantly with respect to five dates of sowing. Root length was maximum (14.94 cm) on 15th November and was on par with 1st November and 1st December. The shortest roots (12.17 cm) were found during 15th December followed by 15th October. Root diameter and girth were highest (4.23 cm and 13.29 cm respectively) in 15th October and it was on par with 1st November, 15th November and 1st December. Lowest diameter and girth were seen in 15th December sowing (3.61 cm and 11.33cm respectively).

The most obvious visual characteristics of carrots associated with quality are root length, diameter and girth (Benjamin and Sutherland, 1989). Early sown crops produced longer carrots compared to their diameters. Root length, diameter and girth increased in late sown crops. This was also reported by Banga *et al.* (1955) and Rosenfeld *et al.* (1998). Weather parameters had a strong influence on the root characters.

Highest forking was observed in 15th October sowing. It may be due to the hard pan created in the growing beds after the heavy rains occurred during its root growth. In rest of the sowing forking was not a problem at all.

The maximum root weight (87.46 g) was recorded in 15th November sowing which was on par with 1st November and 1st December sowings. The lowest root weight (49.60 g) was observed in 15th December sowing. It may be due to the high temperature (35 ^{0}C) recorded after the last date of sowing (15th December)

Appendix-I. Results of the present investigation revealed that these findings go in line with the reports of Dahiya *et al.* (2007). The overall growth of the roots of all carrot varieties were remarkably good in crop sown during 1st November, 15th November and 1st December. It shows that the weather parameters especially temperature around 32 ^{0}C, relative humidity around 70-90 per cent and low rain fall prevailed from early November to mid-January were highly favourable for proper root growth and development of carrot. It has resulted in very good root yield with moderate vegetative growth.

Relative partitioning to roots generally increased with later sown carrots, whereas early sowing favoured vegetative growth. At lower solar radiation the relatively low amount of assimilates produced may be used preferentially by the relatively stronger sinks developing leaves (Brouwer, 1962). The result obtained in the present investigation is also in accordance with the above findings. The crop sown during 1st December produced highest root shoot ratio (1.52) which was statistically on par with 15th November, 1st November and 15th December. The minimum root shoot ratio (1.09) was seen in 15th October sowing where the weather parameters were highly unfavourable. It is also supported by the findings of Hussain *et al.*, (2008) where they found that the root shoot ratio increased with late sown crop whereas early sown carrots more inclined towards leaf growth.

Variation in yield of carrot was statistically significant with respect to different dates of sowing (Fig. 5). The maximum yield was recorded from early sown crop of 1st November (7 kg/plot) followed by 1st December (6.94 kg/plot) and 15th November (5.72 kg/plot) and yield was low in case of late sown crop of 15th December (3.97 kg/plot). This was also supported by the findings of Dahia *et al.*, 2007 and Manosa *et al.*, 2010. Kabir *et al.* (2013) reported that among four dates of sowing (28th November, 8th December, 18th December and 28th December) 28th November sowing gave the maximum yield and it was gradually decreased from 28th November to 28th December.

Among varieties, Pusa Rudhira, Pusa Kesar, Pusa Meghali, new Kuroda and Sarpan-601 showed forking of roots. In all these varieties forking was highest in 15th October sowing. The heavy rains followed by a dry period had created a hard pan in the growing beds which has led to forking of roots.

Root cracking was very minimum in all varieties in all dates of sowing only 4.70 per cent was noticed during 15th October sowing. Among varieties super Kuroda-1 and Super Kuroda-2 showed root cracking in first date of sowings.

Root pubescence was seen in Pusa Rudhira, Pusa Meghali and Pusa Kesar and rests of the varieties were free from pubescence. Green shoulders and bitterness were not seen in any of the varieties.

Bolting was observed in Pusa Rudhira, Pusa Meghali and Sarpan-601in 15th October and 1st November sowings on 80-83 days after sowing.

Termite attack was very severe in 15th October sowing in all the varieties due to the hard pan created in the soil after the heavy rains, the irrigation water could not reach the bottom of the bed in the following dry span which has helped termite infestation.

Taking into consideration all the root characters and yield recorded in the present investigation it may be concluded that the best planting time for carrot is from 1st November to 1st December for satisfactory growth and yield. If the seeds are sown during October the plants will grow up generally with huge vegetative growth with minimum root yield, and if sowing is done late in December both the vegetative and root growth are affected. Therefore to get a reasonably good crop carrot seeds should be sown from 1st week of November to 2nd week of December.

5.3 Influence of sowing time on qualitative characters of carrot

The root quality of carrots is determined by core size, root colour, root shape root tail and root pubescence. It is also determined by biochemical characters like root dry matter, β carotene, TSS, acidity and total sugars.

Significant difference was not seen in root colour, root shape, root tail, pubescence, TSS and acidity among dates of where as it was slightly significant in case of core size. The lowest core size was recorded in 15th December with 1.5 cm and highest core size was recorded in 1st December (1.86 cm) which was on par with 15th October, 1st November (1.75 cm) and 15th November (1.76 cm). Root dry matter, β carotene and total sugars content varied with sowing date. Analysis of data on the total sugars showed significant variation among dates of sowing. 15th October sowing produced the highest total sugar content (5.07 %) which was on par with the crop sown during 1st November and 1st December. Lowest total sugar content (4.62 %) was recorded from the crop sown during. In general early sown crop had highest sugar content compared to late sowing.

Among dates of sowing highest root dry matter (19.52 %) was observed in 1st November. The lowest root dry matter (16.18 %) was observed from the crop sown on 15th October which was on par with the crops sown on 15th December, 1st December and 15th November. High average temperature and regular irrigation results in less root dry matter (Dysko and Kanisewski, 2007). β carotene is a highly pigmented fat soluble compound and it is a precursor of Vitamin A. According to our study early sowing of carrots increased the β carotene content. Significant variation was observed in β carotene content among dates of sowing, cultivar and interactions between dates of sowing and cultivars. The highest value of β carotene (4.77 mg/100g) was observed in the crop sown on 15th November which was on par with 15th October and 1st November. The lowest β carotene (4.12 mg/100g) was observed in crop sown on 15th December it was on par with 1st December.

It may be noticed that characters such as root colour, root shape, root tail, root pubescence *etc.*, were not affected much by sowing time, but dry matter, β carotene and total sugars varied with the time of sowing. To obtain high β carotene and sugars sowing of carrot should be taken up in the month of November. Sowing before and after November adversely affected these characters due to unfavourable weather conditions.

5.4 Influence of varieties on morphological characters

Seed germination significantly varied among varieties and ranged 51.90 per cent to 63.10 per cent. Variety Indam Kuroda recorded the highest (63.10 %) seed germination which was on par with Pusa Kesar. These were followed by Pusa Meghali, Kuroda, Super Kuroda-2 and Super Kuroda-1 and they were statistically on par. Kuroda Improved showed the lowest (51.90 %) germination. A tentative explanation for the difference in germination percentage may be due to the climatic factor and suitability of variety to climate. (Appendix-1). Alam *et al.* (2004) reported that the optimum day night temperature for germination of carrot seed is between 21 ^{0}C and 22 ^{0}C and 18 ^{0}C and 20 ^{0}C respectively.

Sarpan-601 showed the highest (40.57 cm) plant height; it was followed by Kuroda Improved, New Kuroda and Pusa Kesar which were statistically on par. Century recorded the lowest (26.30 cm) plant height which was on par with Flakker-2. It may be due to the varietal characters as Asiatic types of carrots show more plant height compare to European types (Rajan and Markos, 2007). New Kuroda exhibited highest spread in both directions whereas least spread in both directions was noticed in Nantes.

Pusa Kesar produced maximum number of leaves (16.83). Century recorded the least number (7.23) among the all cultivars. Sarpan-601 recorded highest leaf length (48.82 cm) followed by Pusa Kesar and New Kuroda. Cultivar Flakker-2 recorded lowest leaf length (33.35 cm). Highest value of leaf width (17.27 cm) was

observed in Sarpan-601 followed by New Kuroda, Desi Red (Lalit Kesar) and Pusa Kesar. New Kuroda, Desi Red (Lalit Kesar) and Pusa Kesar were statistically on par. The lowest leaf width (10.45 cm) was given by Samson-196. The longest petiole length (15.06 cm) was seen in Pusa Meghali which was on par with Pusa Kesar, Sarpan-601, Pusa Rudhira and New Kuroda followed by Kuroda Improved, Century and Nantes. The lowest petiole length (10.69 cm) was observed in Samson-196. In the case of foliage weight cultivar Sarpan-601 had the highest value (113.20 g) among all the cultivars which was followed by Pusa Rudhira and Pusa Kesar. Pusa Rudhira and Pusa Kesar were statistically on par. The lowest foliage weight (25.40 g) was observed in cultivar Century which was closely on par with Kuroda. These are all varietal characters. Generally Asiatic/tropical carrots produce more number of leaves, leaf length, leaf width, length of petiole and foliage weight. European/temperate carrots produce less number of leaves, small leaves, less leaf width, small petiole and less foliage weight (Rajan and Markose, 2007). Our findings tally with the findings of Rajan and Markose, 2007.

5.5 Influence of varieties on root characters

Root length, root girth, root diameter, root weight and root shoot ratio differed significantly with varieties. Root length ranged between 11.52 cm to18.08 cm. Variety Desi Red produced the highest root length (18.08 cm) followed by Pusa Rudhira, Pusa Meghali, New Kuroda and Samson-196. Super kuroda-1 produced the lowest root length (11.52 cm) among the all cultivars. The highest root diameter and girth (5.45 cm and 17.13 cm respectively) were recorded by Sarpan-601 followed by Kuroda (RKS), Nantes, Kuroda Improved and Pusa Rudhira. Kuroda (RKS), Nantes, Kuroda Improved and Pusa Rudhira were statistically on par. The lowest root diameter and girth were observed (2.86 cm and 8.80 cm respectively) in Flakker-2. Similar observations were recorded by Forbes and Scudder (1963) and Bakhchevanova (1974)

Root shoot ratio was the highest (2.14) in cultivar Kuroda which was followed by Century, Samson-196, Super Kuroda-1 and Nantes. Samson-196 and Super Kuroda-1 were statistically on par. The minimum root shoot ratio of carrot (0.89) was observed from cultivar Sarpan-601 followed by Pusa Kesar and Pusa Rudhira. All the European carrot types produced higher root shoot ratio compared to Asiatic carrots. This may be because Asiatic carrots produced more vegetative growth than the root growth. Hussain *et al.* (2008) reported that the certain genotypes consistently have high partitioning ratios.

Nantes showed highest root weight (104.66 g), which was on par with Sarpan-601 followed by Pusa Rudhira, Pusa Kesar and Pusa Meghali. Pusa Rudhira, Pusa Meghali and Pusa Kesar were statistically on par. The lowest root weight (68.40 g) was observed in Flakker-2 which was on par with Super Kuroda-1, Indam Kuroda and Super Kuroda-2. Most of the tropical varieties produced bigger roots compared to European types but quality wise tropical types were very poor.

Among cultivars the highest yield was recorded in Nantes (8.37 kg/plot and 27.91 tonnes/ha) which was on par with Sarpan-601(8.18 kg/plot and 27.26 tonnes/ha) followed by Pusa Rudhira (7.40 kg/ha and 24.67 tonnes/ha), Pusa Kesar (7.34 kg/plot and 24.45 tonnes/ha) and Pusa Meghali (7.21 kg/plot and 24.04 tonnes/ha). Pusa Rudhira, Pusa Kesar and Pusa Meghali were statistically on par. The lowest root yield of carrot was recorded in cultivar Century (3.42 kg/plot and 11.42 tonnes/ha) followed by Samson-196 (4.27 kg/plot and 14.24 tonnes/ha) and Kuroda (RKS) (5.02 kg/plot and 16.72 tonnes/ha). Varieties with higher root weight and longer length produced higher yield. Gadzhonov (1972) reported the effect of sowing dates on the yield and quality of carrot cultivars Nantes and Chantenay. Nantes recorded the highest total root yield of 23.5 t/ha and 39 t/ha for Chantenay. This yield was comparable with the yield that we got.

5.6 Influence of varieties on qualitative characters

The root quality of carrots is determined by core size, core colour, root colour, root shape root tail, root cracking, forking and root pubescence. It is also determined by biochemical characters like root dry matter, β carotene, TSS, acidity and total sugars.

The pubescence was seen only in tropical varieties but it was absent in European types. European types exhibited orange coloured root with self coloured core while Asiatic types exhibited red coloured root with distinct core. Pusa Rudhira, Pusa Meghali, New Kuroda and Sarpan-601 exhibited tapering shape, Kuroda (RKS) had conical shape and Pusa Kesar, Nantes, Samson-196, Super Kuroda-1, Century, Flakker-2, Super Kuroda-2 and Indam Kuroda showed cylindrical shape during all five dates of sowing. Cultivars Pusa Rudhira, Pusa Kesar, Kuroda (RKS), Flakker-2 and Super Kuroda-2 were having acute root tail, in Pusa Meghali, Nantes, Kuroda Improved, Sarpan-601, Century and Indam Kuroda were having semi blunt root tail and New Kuroda, Samson-196 and Desi Red produced blunt root tail irrespective of dates of sowing.

Root cracking was observed only five varieties *viz.*, in Kuroda (RKS), Kuroda Improved, Super Kuroda-1, Flakker-2 and Super Kuroda-2. Among these varieties the lowest cracking was found in Kuroda Improved (2.00 %) followed by Flakker-2 (3.56 %). The highest cracking was found in Super Kuroda-1 (9.30 per %) followed by Super Kuroda-2 (5.95 %) rest of the varieties were free from cracking.

Forking varied among the cultivars Pusa Rudhira (28.43 %) forked more followed by Pusa Meghali (16.66 %), New Kuroda (11.70 %), Pusa Kesar (11.80 %) and Samson-196 (10.00 %). Forking was not seen in the variety Super Kuroda-2.

Samson-196 (1.06 cm) recorded lowest core size which was on par with Flakker-2 (1.28 cm). Pusa Rudhira recorded highest core size of 2.51 cm which was

on par with Pusa Meghali (2.44 cm) and Pusa Kesar (2.41 cm). Nantes showed highest root dry matter (18.92 %) which was on par with Sarpan-601 followed by Kuroda Improved, New Kuroda, Pusa Rudhira and Desi Red. The lowest root dry matter (15.94 %) was observed in Pusa Kesar.

TSS content in fifteen carrot varieties ranged between 10.42 ^{0}B to 12.66 ^{0}B. The highest TSS was recorded in Super Kuroda-1 which was on par with Sarpan-601, Flakker-2, Pusa Rudhira, Pusa Meghali, Nantes, New Kuroda, Samson-196, Century and Super Kuroda-2.The lowest TSS content was recorded in Pusa Kesar followed by Century. Total sugar content significantly varied among the cultivars. Kuroda Improved (5.67 %) produced highest total sugar content which was on par with Pusa Rudhira, Nantes, Kuroda and New Kuroda. Pusa Kesar (4.39 %) recorded lowest total sugar content which was on par with Pusa Meghali, Sarpan-601, Super Kuroda-1, Century, Flakker-2 and Desi Red and it ranged between 4.39 to 5.67 per cent. These quality characters in carrot may be the varietal characters. Gupta and Verma (2007) found that among ten carrot varieties the TSS content ranged between 11.5 ^{0}B to 12.10 ^{0}B and total sugars content ranged between 6.00 to 6.3 per cent. According to Fuhrmann *et al.* (1986) the total sugar content in carrot is a varietal characteristic and the same differed between the roots from the market and the freshly harvested ones, ranging from 3.03 to 5.69 per cent in the former and from 7.91 to 9.56 per cent in the later. Fikselova *et al.* (2010) examined the influence of area and variety on β-carotene and dry matter content of four varieties of carrot. They cultivated carrot under different climatic and soil conditions in three areas of Slovakia, Nitra, Komarno and Prusy. Carrot varieties (Nevis F1, Idaho F1, Florida F1, Kathmandu F1) showed the greatest mean content of β carotene (23.25 mg 100/g) in Nitra area and the highest content of β-carotene was shown by variety Florida F1 (26.3 mg 100/g).

In the case of acidity significant variation was noticed. The highest acidity was noticed in Desi Red (2.13 %) which was on par with Kuroda and Super Kuroda-

1. The lowest acidity (1.15 %) was noticed in Kuroda Improved and it was in the range of 1.15 % to 2.12 %.

The highest β carotene was observed in Kuroda Improved (5.44 mg/100g) which was on par with Nantes, Kuroda, Samson-196, Samson-196, Century, Flakker-2 Samson-196 and Indam Kuroda. The lowest β carotene was observed in Pusa Meghali (2.97 mg/100g) which was on par with Pusa Rudhira and Desi Red. All the European types produced high β carotene compared to Asiatic types. Gupta *et al.* (2006) evaluated twenty seven European carrot genotypes, along with two control cultivars, for their root quality. All the genotypes varied in qualitative traits, Sutton's Early Nantes exhibited the highest content of carotene, CR-501 (Paras) for total soluble solids, New Karoda (J) for reducing sugars and Sumrai Hindustan for total sugars.

5.7 Interaction effect of dates of sowing and varieties on morphological characters

Interaction effect of dates of sowing and varieties was found significant for all the qualitative and quantitative characters. The highest per cent of seed germination was seen in Indam Kuroda (76.50 %) sown during 1st November which was on par with Pusa Kesar of 15th November sowing and Indam Kuroda of 1st December sowing. The lowest per cent of seeds were germinated in Pusa Meghali (40.00 %) sown during 15th December. The results were in agreement with the findings of Nascimento, 2013 where he found that Carrot seed germination can be erratic or reduced under temperatures above 35°C. In our study in RH and increase in temperature might have led to poor germination in 15th December sowing.

Interactions between sowing time and cultivars also revealed highly significant variation with respect to plant height. The highest plant height (50.34 cm) was recorded in Pusa Kesar sown during 15th October which was on par with Sarpan-601 sown during 15th October followed by Sarpan-601 sown during 15th November.

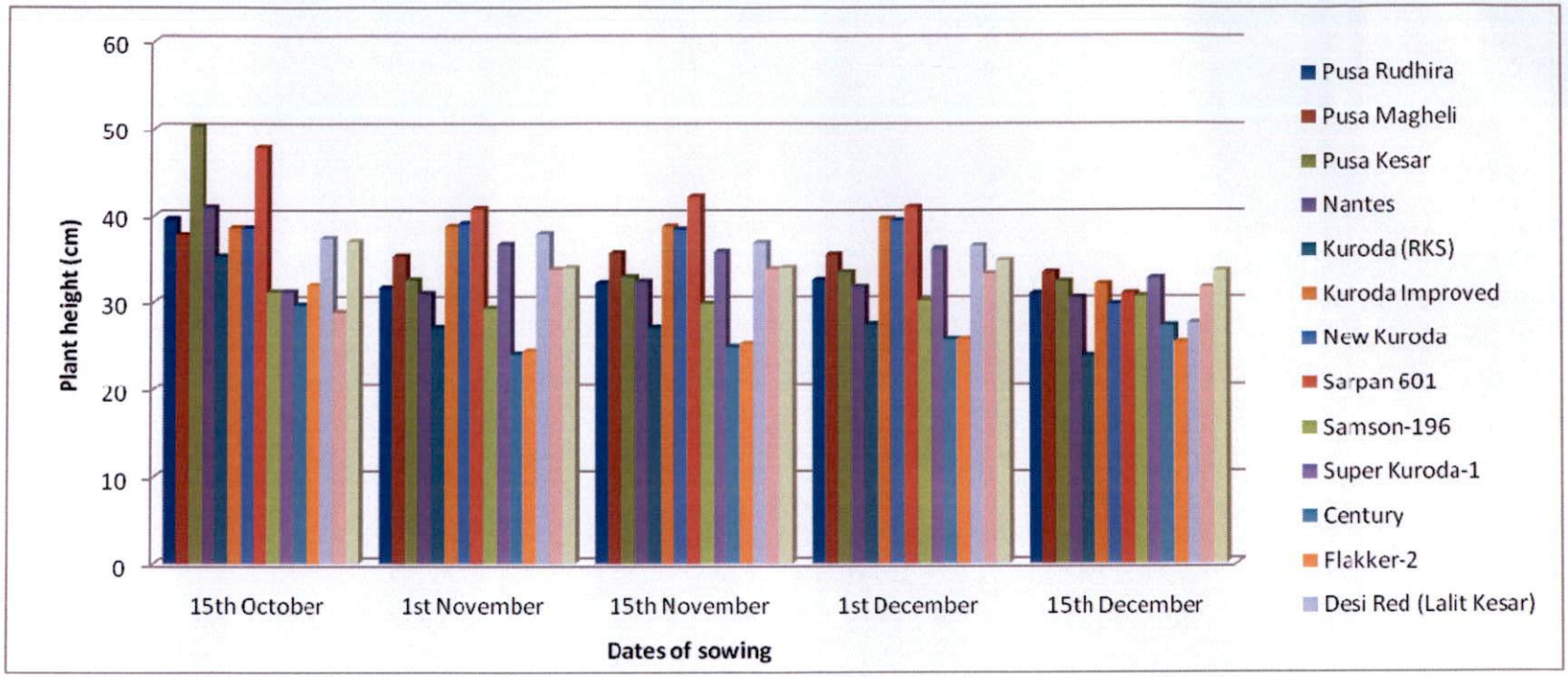


Figure 1: Effect of sowing time on plant height (cm) of carrot varieties

The lowest plant height was recorded in Century (24.00 cm) sown during 1st November (Fig. 1). The plant height is a varietal character. Asiatic/tropical carrots produce taller plants and European/temperate carrots produce short statured plants (Rajan and Markose, 2007). The varieties New Kuroda sown during 15th October exhibited highest spread in both directions (52.67 cm and 51 cm respectively) which was on par with New Kuroda sown during 1st November and least spread was observed in Samson-196 (26.34 cm) sown during 15th December

The number of leaves in different cultivars ranged between 6.17 and 20. In general Kuroda (RKS), Samson-196 and Century had only 7-8 leaves in all the sowings while others produced more than 10 leaves. Pusa Kesar produced maximum number of leaves (20) in all three dates of sowing *viz.*, 1st November, 15th November and 1st December. The highest leaf length (56.50 cm) was also noticed in Pusa Kesar sown during 15th October which was on par with Sarpan-601 planted during 15th October, all the cultivars produced long leaves in 15th October, 1st November, 15th November and 1st December. Leaf length was poor (30.75 cm) only in 15th December. It may be because of the high temperature and low RH after the last sowing period during the growth and development stage which might have resulted in reduced leaf growth (Appendix-I). Width of Leaf ranged between 9.00 cm and 20.84 cm among the varieties in the different sowings. The highest leaf width was observed in Pusa Rudhira (20.84 cm) in 15th October sowing. The lowest leaf width was observed in Desi Red in 15th October. The highest petiole length (17 cm) was seen in Pusa Kesar planted in 15th October, while Samson-196 in 1st November showed the lowest petiole length (7.84 cm). Sarpan-601 planted during 1st November and during 15th November showed maximum foliage weight (131 g). The minimum foliage weight was seen in Century (18.50 g) planted in 15th December. These are varietal characters and generally Asiatic/tropical carrots produced more number of leaves, leaf length, leaf width, length of petiole and foliage weight, while European/temperate carrots produced less number of leaves, small leaves, less leaf

width, small petiole and less foliage weight. Similar results have been reported by Rajan and Markose (2007).

5.8 Interaction effect of dates of sowing and varieties on root characters

Desi Red sown on 1st November produced the highest root length (21.50 cm) which was on par with Desi Red sown on 15th November. Indam Kuroda sown on 15th December produced the lowest root length (10.50 cm) (Fig. 2). The highest root diameter and girth (5.86 cm and 18.42 cm respectively) were produced by Sarpan-601 sown during all five dates of sowing. Kuroda sown on 1st November and 1st December, while Pusa Meghali sown on 15th December showed the lowest root diameter and girth (2.16 cm and 7.97 cm respectively) (Fig. 3). The root length, root diameter and root girth are clearly under very strong genetic control rather than environment control. The results of present study are in agreement with previous findings of Hussain *et al.*, (2008) where they had sown 40 selected temperate and tropical varieties in three different dates of sowing (March, April and May). Yield and quality increased with late sowing (May).

Sarpan-601 sown on 15th November exhibited highest root weight (124.30 g). Very low root weight was observed in all the varieties sown on 15th December. It may be due to the unfavourable climatic condition from sowing to harvesting. During this season the temperature was too high (35 ^{0}C) Appendix-I.

Certain varieties had consistently high root shoot ratio. Such as Kuroda sown during 15th November and Century sown during 1st December exhibited maximum root shoot ratio (2.42), it was on par with Kuroda sown on 1st November and 1st December, Century sown on 15th November, Super Kuroda-1 sown on 1st December and Samson-196 sown on 1st December. The least root shoot ratio (0.77) was shown by New Kuroda sown during 15th October which was on par with Sarpan-601 sown on 15th December and Desi Red sown on 15th October. The present study is in agreement with the previous findings of Hussain *et al.* (2008) whereas root shoot

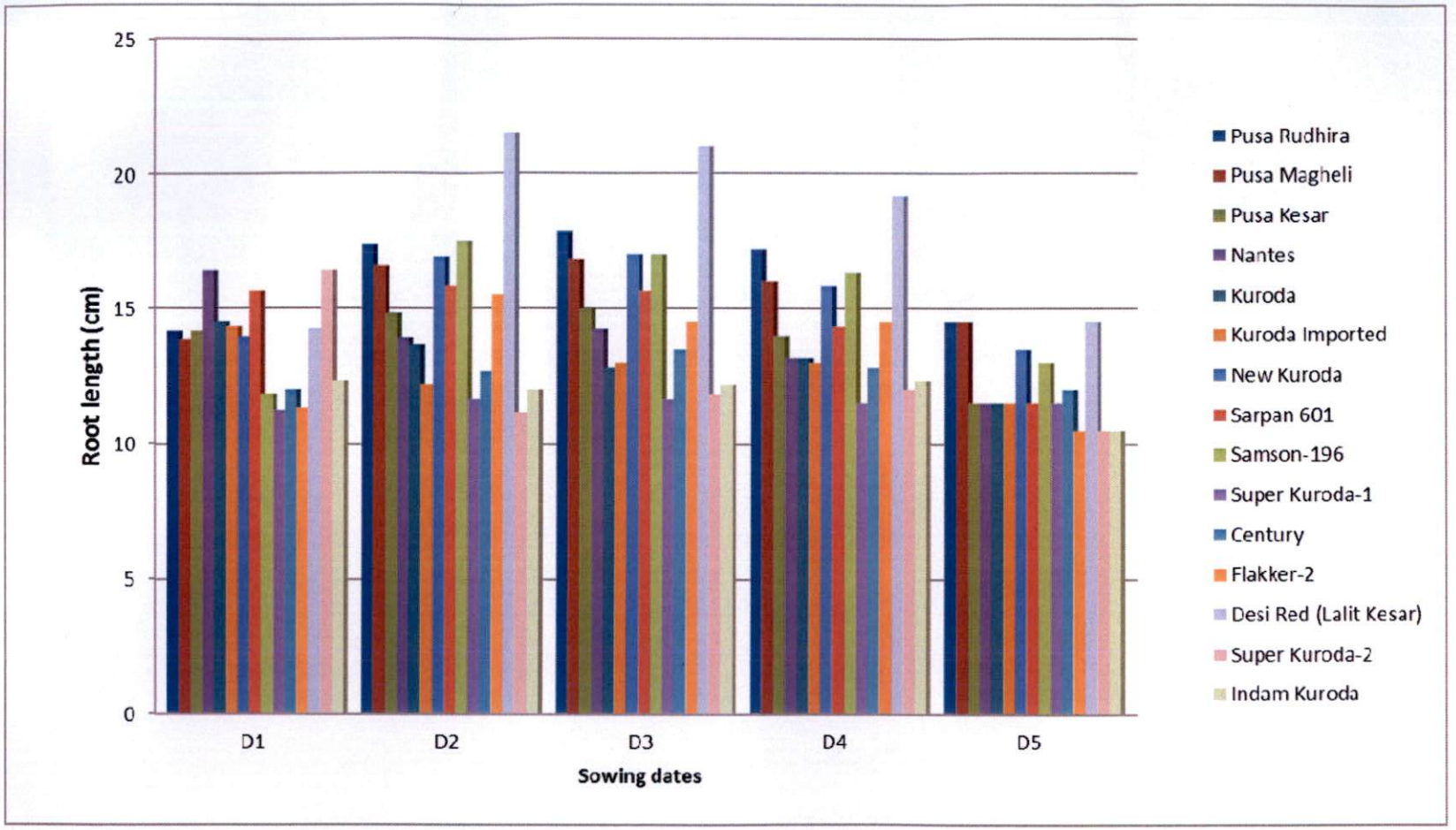


Figure 2: Effect of sowing time on root length (cm) of carrot varieties

ratio increased with late sown crops and early sown crops were more inclined towards leaf growth.

Samson-196 planted during 1st November recorded lowest core size (0.89 cm) while Pusa Rudhira sown on 1st November and 1st December recorded highest core sizes (2.83 cm) which were on par with Pusa Meghali sown on 1st December, 1st November and 15th November) (Fig. 4).

Yield was very high in all varieties sown during November to December. The highest yield was recorded in Sarpan-601 (9.95 kg/plot) sown during 15th November which was on par with 1st November and 1st December, Nantes sown on 1st November, 15th November and 1st December and Pusa Kesar sown on 15th November. The lowest yield was recorded in Desi Red planted on 15th December (2.88 kg) (Fig. 5). This was also supported by the reports of Dahia *et al.*, 2007 reported that among four dates of sowing (28th Novemer, 8th December, 18th December and 28th December) 28th November sowing gave the maximum yield (25 tones/ha), it was gradually decreased from 28th November to 28th December sowing.

5.9 Interaction effect of dates of sowing and varieties on biochemical characters

The root dry matter, TSS, total sugars, acidity and β carotene were found significant in interaction between sowing times and cultivars. The highest TSS was recorded in Super Kuroda-1 (13.80^{0}B) planted during 1st November which was on par with Pusa Meghali, New Kuroda, Sarpan-601, Samson-196, Flakker-2, Super Kuroda-2 and Indam Kuroda sown during 15th October, 1st November and 15th November. The lowest TSS was recorded from Pusa Kesar (9.25^{0}B) which was sown during 1st December. It was on par with Kuroda (RKS), Kuroda Improved sown during 15th October, Pusa Kesar sown on 15th November and Pusa Kesar and Century sown on 15th December. Most of the varieties had almost same TSS content throughout five sowing periods. Therefore we may say that TSS content is variety specific character and it is less influenced by sowing time (Appendix-I) (Fig. 6).

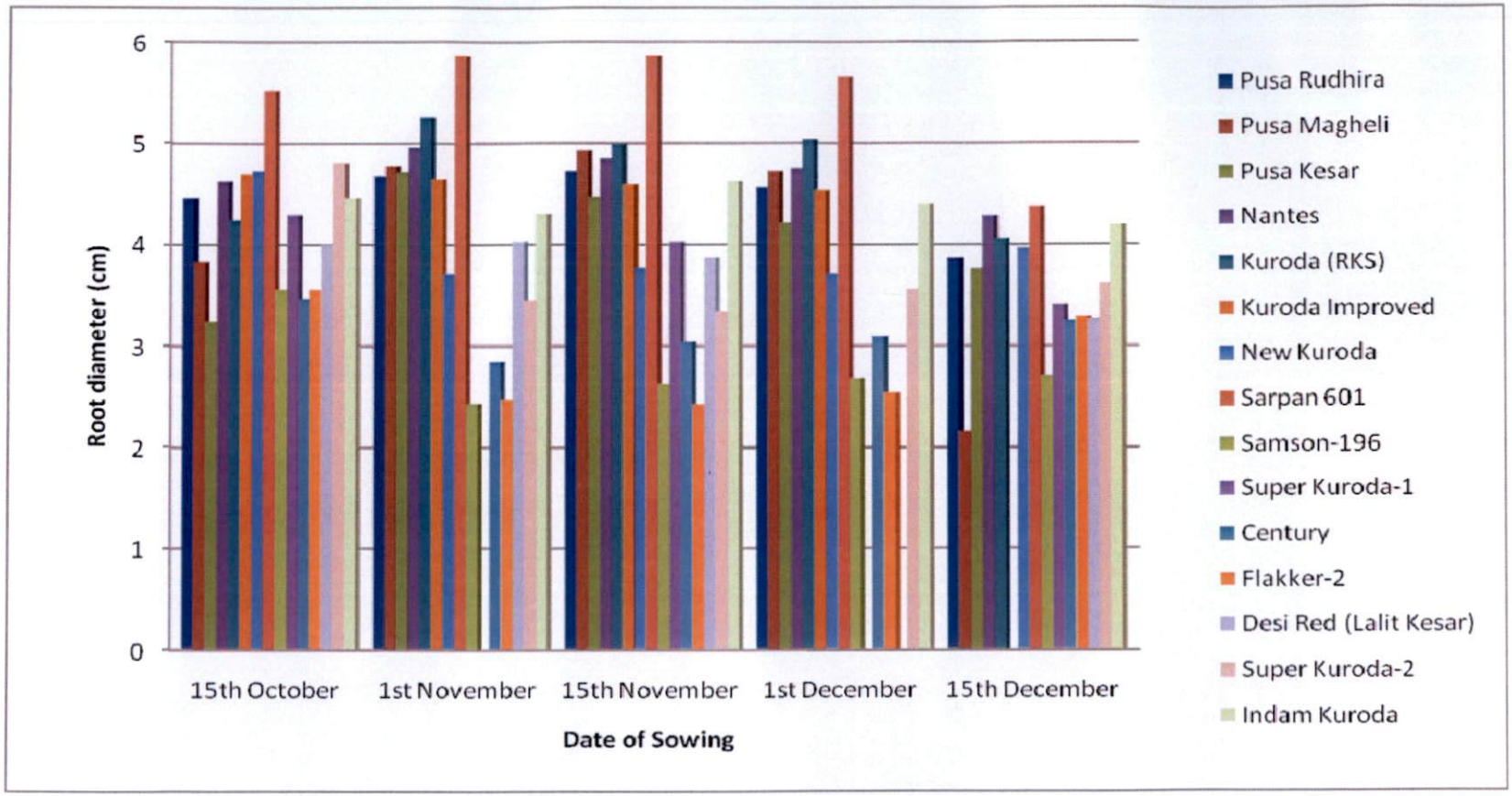


Figure 3: Effect of sowing time on root diameter (cm) of carrot varieties

ratio increased with late sown crops and early sown crops were more inclined towards leaf growth.

Samson-196 planted during 1st November recorded lowest core size (0.89 cm) while Pusa Rudhira sown on 1st November and 1st December recorded highest core sizes (2.83 cm) which were on par with Pusa Meghali sown on 1st December, 1st November and 15th November) (Fig. 4).

Yield was very high in all varieties sown during November to December. The highest yield was recorded in Sarpan-601 (9.95 kg/plot) sown during 15th November which was on par with 1st November and 1st December, Nantes sown on 1st November, 15th November and 1st December and Pusa Kesar sown on 15th November. The lowest yield was recorded in Desi Red planted on 15th December (2.88 kg) (Fig. 5). This was also supported by the reports of Dahia *et al.*, 2007 reported that among four dates of sowing (28th Novemer, 8th December, 18th December and 28th December) 28th November sowing gave the maximum yield (25 tones/ha), it was gradually decreased from 28th November to 28th December sowing.

5.9 Interaction effect of dates of sowing and varieties on biochemical characters

The root dry matter, TSS, total sugars, acidity and β carotene were found significant in interaction between sowing times and cultivars. The highest TSS was recorded in Super Kuroda-1 (13.80^{0}B) planted during 1st November which was on par with Pusa Meghali, New Kuroda, Sarpan-601, Samson-196, Flakker-2, Super Kuroda-2 and Indam Kuroda sown during 15th October, 1st November and 15th November. The lowest TSS was recorded from Pusa Kesar (9.25^{0}B) which was sown during 1st December. It was on par with Kuroda (RKS), Kuroda Improved sown during 15th October, Pusa Kesar sown on 15th November and Pusa Kesar and Century sown on 15th December. Most of the varieties had almost same TSS content throughout five sowing periods. Therefore we may say that TSS content is variety specific character and it is less influenced by sowing time (Appendix-I) (Fig. 6).

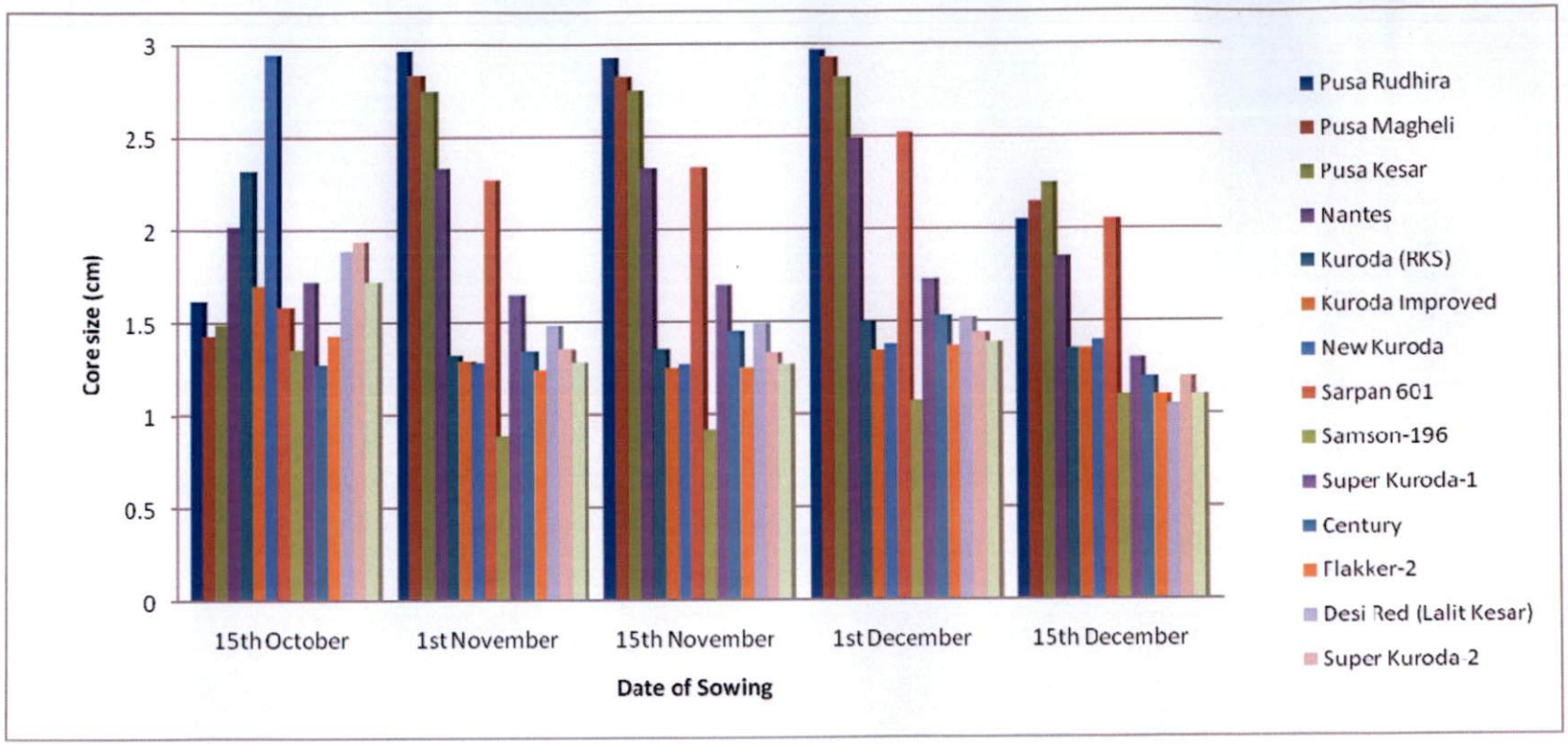


Figure 4: Effect of sowing time on core size (cm) of carrot varieties

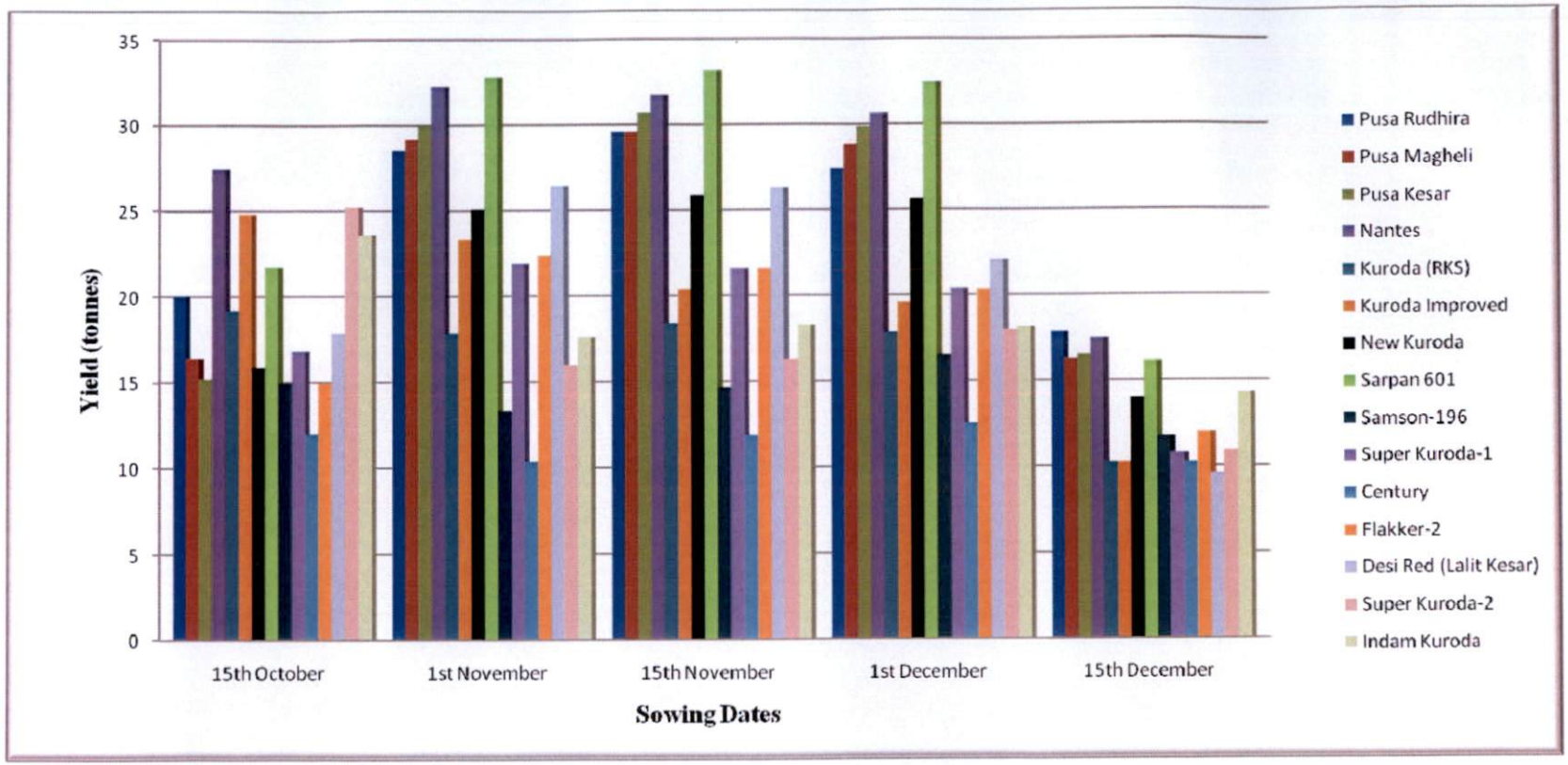


Figure 5: Effect of sowing time on yield (tons/ha) of carrot varieties

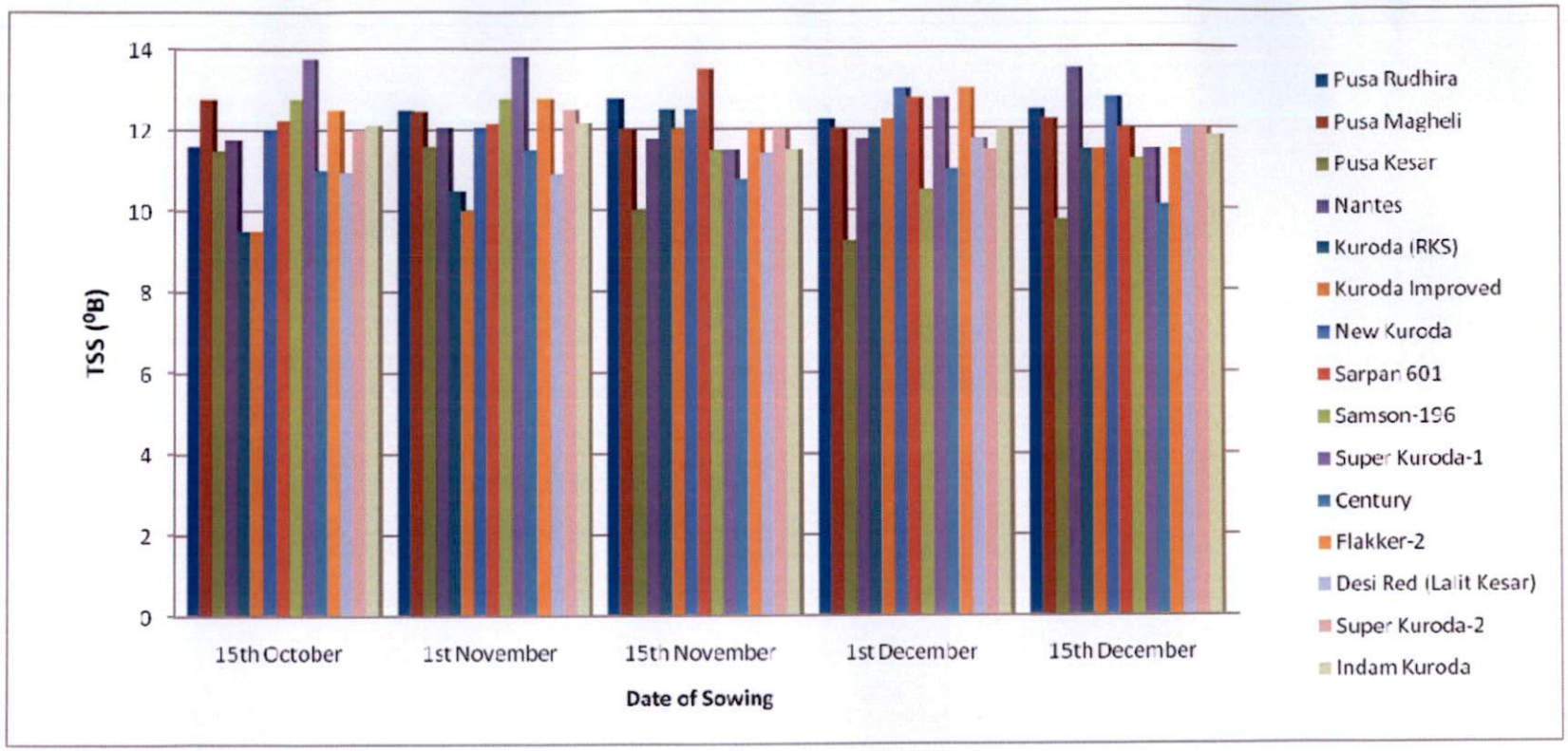


Figure 6: Effect of sowing time on TSS (^{0}B) of carrot varieties

Pusa Rudhira sown during 15th October recorded the highest total sugar content (6.62 %) which was on par with Super Kuroda-2 sown on 15th October, Pusa Rudhira and New Kuroda sown on 1st November, Kuroda and Kuroda Improved sown on 15th November, Kuroda and Kuroda Improved sown on 1st December and Kuroda Improved sown on 15th December (Fig. 7). Desi Red sown during 15th December recorded lowest total sugar content (4.01 %). This was in accordance with the previous findings of Gocan *et al.*, 2013 and Baranski *et al.*, 2011.

The highest acidity (2.68 %) was recorded from Desi Red which was planted during 15th October. The lowest acidity recorded in Kuroda Improved sown on 15th October and New Kuroda sown on 1st December (0.89 % each) (Fig. 8). In general acidity was high in early sowings compared to late sowing. In the case of β carotene for interaction between dates of sowing and cultivars significantly differed. The highest β carotene (6.05 mg/100g) was observed in Nantes sown on 15th November which was on par with Nantes sown on 15th October, Kuroda, Kuroda Improved, Samson-196, Century, Super Kuroda-2 sown on 15th October, Nantes, Kuroda, Kuroda Improved, Samson-196, Century, Super Kuroda-2 sown on 1st November, Nantes, Kuroda, Kuroda Improved, Samson-196, Super Kuroda-1, Century, Flakker-2 and Super Kuroda-2 sown on 15th November and Flakker-2 and Super Kuroda-2 sown on 15th November. The lowest value of β carotene (2.20 mg/100g) was observed in Pusa Rudhira sown on 15th December which was on par with Pusa Meghali and New Kuroda sown on 15th December (Fig. 9). In general β carotene was high in early sowing compared to late. Baranski *et al.* (2011) reported that the total carotenoid content is related to root colour and range from 0 to 40 mg/100g in fresh weight. Orange rooted European accessions were more carotenoid rich than Asian accessions. Findings of Baranski *et al.*, 2011 go in line with the findings of present investigation where European types exhibited more carotene content compared to Asiatic types.

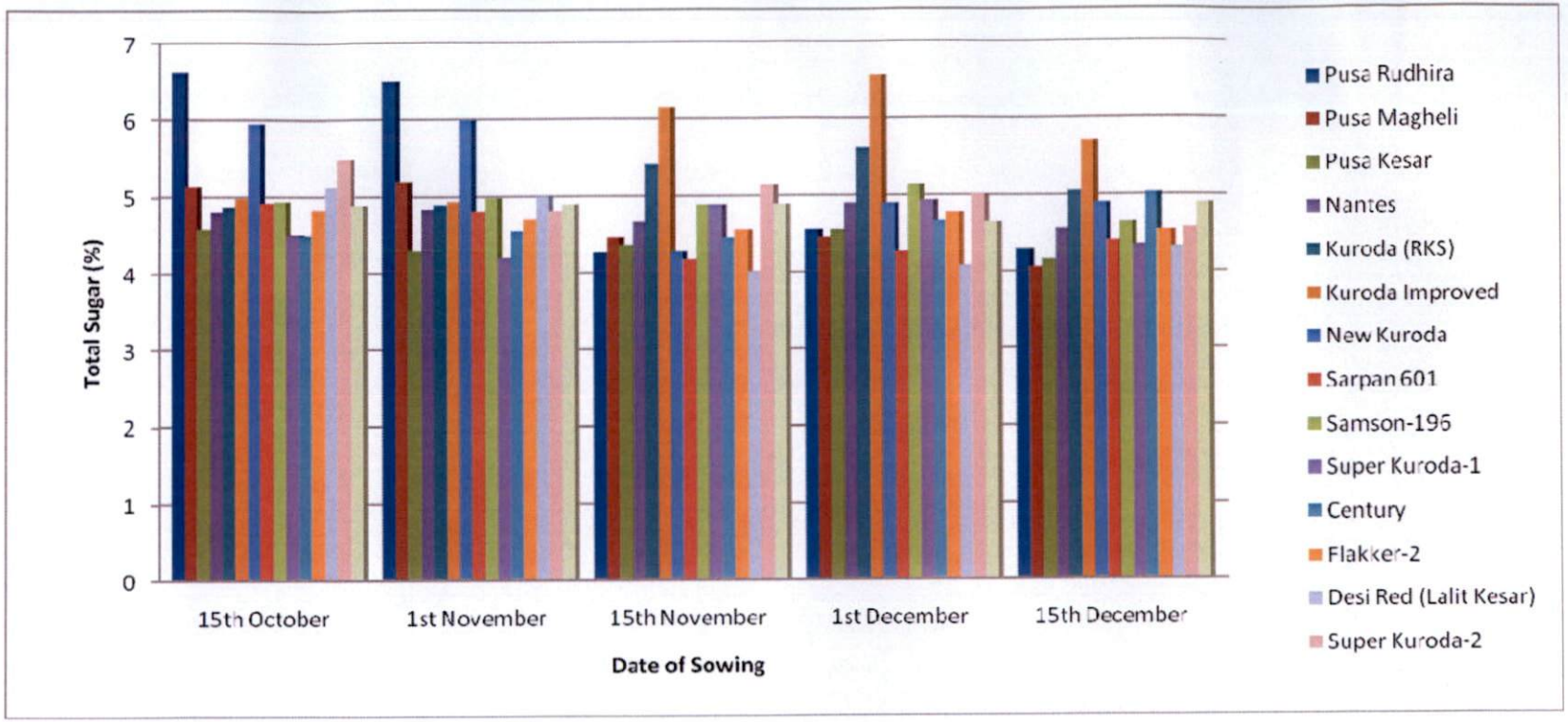


Figure 7: Effect of sowing time on total sugar (%) of carrot varieties

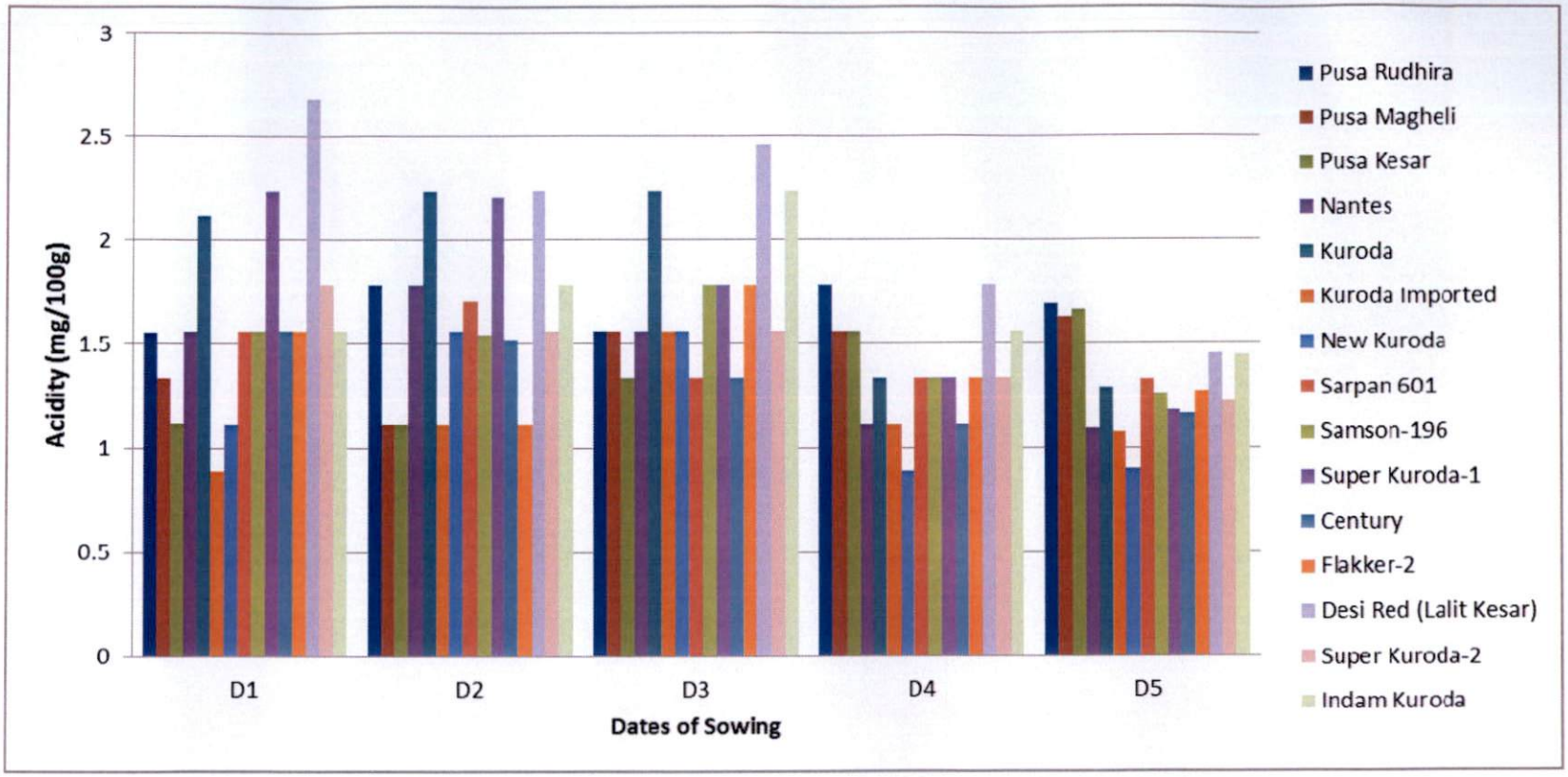


Figure 8: Effect of sowing time on acidity (%) of carrot varieties

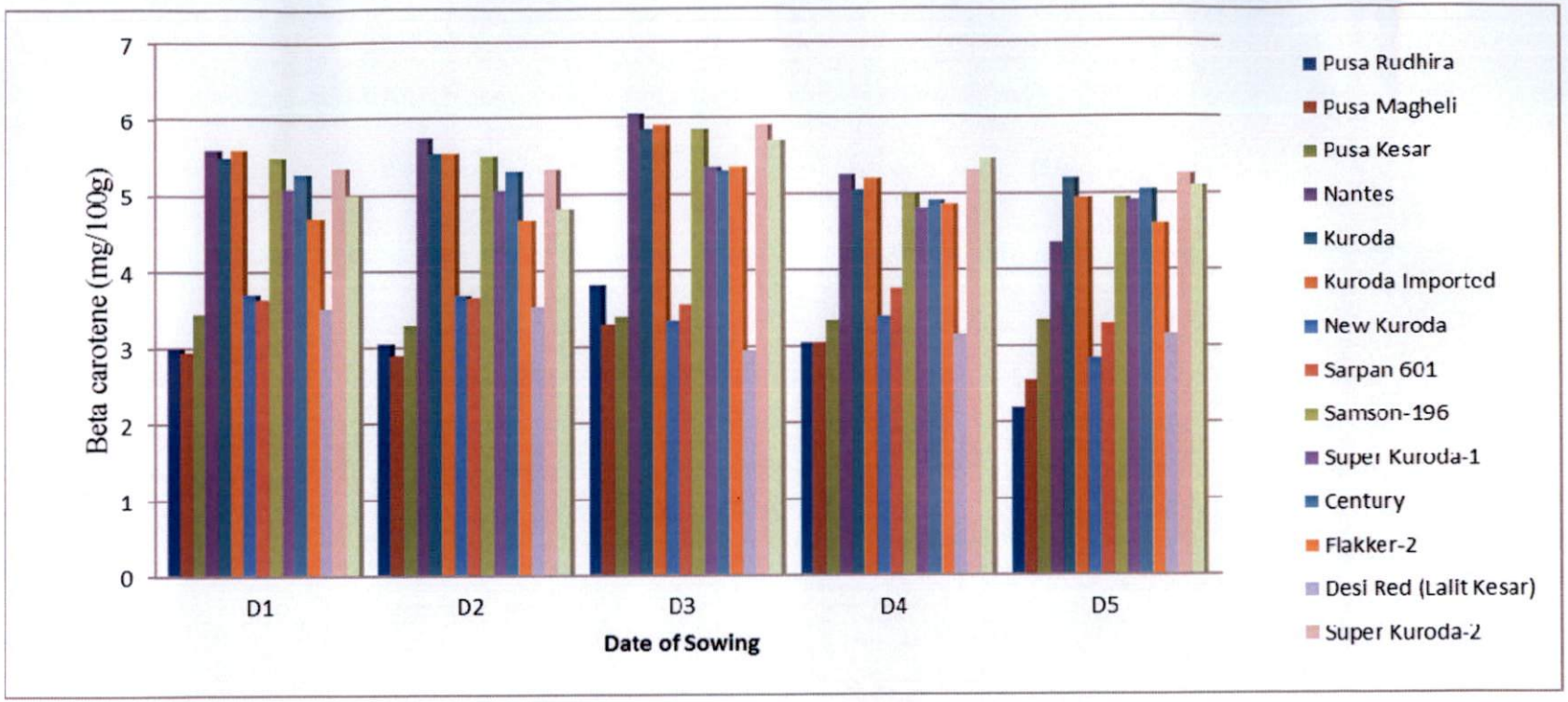


Figure 9: Effect of sowing time on beta carotene (mg/100g) of carrot varieties

5.10 Correlation

Yield is a complex character contributed by many mutually related components. Hence information on the magnitude of relationship of individual yield components to the final yield and relationship among themselves would play a vital role for the identification of characters which would influence the economic traits (Nadarajan and Gunasekaran, 2005). Simultaneous increase of yield and its component characters is possible only with a thorough knowledge of the direction of the interaction of these component traits with yield.

In the present investigation, yield was significant and has got positive correlation with root weight (rg=1.00, rp- 0.959). This indicates the importance of this trait in determining the yield since it has a direct inherent effect on yield.

The genotypic correlation coefficient of foliage weight, leaf width, number of leaves per plant, core size, leaf length and root diameter were higher than the phenotypic correlation coefficient. This indicates the direct influence of these characters with yield. The low phenotypic correlation coefficient indicates the less effect of environment on yield. This was also supported by the reports Gupta and Verma, 2007 and Gupta *et al.*, 2006.

5.11 Path coefficient analysis

Path coefficient analysis is simply a standardized partial regression coefficient which splits the correlation coefficients into the measure of direct and indirect effects. It measures the direct and indirect contribution of various independent characters on a dependent character (Singh and Narayanan, 2009).

In the present study on partitioning of the coefficients into direct and indirect effects, it was observed that maximum positive direct effect on yield was exhibited by total foliage weight (4.91) followed by root weight (0.699), leaf width (0.303), core size (0.061) and number of leaves (0.012). This reveals the direct relationship

between these characters and yield. Hence these characters can be considered for selection in yield improvement programmes.

Even though root length and root diameter showed direct positive effect on yield, their correlation with yield was found to be negative. In such situation, direct selection for the trait should be practiced to reduce the undesirable indirect effects.

5.12 Organoleptic evaluation

Organoleptic evaluation of the variety was done by an expert panel of 10 and the varieties were scored using 0-9 hedonic scale (Appendix-II). The highest score for colour was recorded for two varieties, Nantes and Kuroda Improved followed by Samson-196, Kuroda and Super Kuroda-1. The lowest score was recorded for the cultivar Sarpan-601. For odour the highest score was recorded for the cultivars Nantes and Kuroda Improved followed by Samson-196, Super Kuroda-2 and Kuroda. The lowest score was recorded for the cultivar Desi Red. The cultivar Kuroda Improved recorded the highest value of 8.4 for taste followed by Flakker-2, Nantes and Samson-196 while the lowest value was recorded for the cultivar Pusa Meghali. For flavour the highest score was recorded for cultivar Kuroda Improved followed by Century. The lowest score was recorded for the cultivar Sarpan-601. The highest score for hardness was recorded for cultivar Samson-196 followed by Kuroda Improved and Indam Kuroda. The lowest score was recorded for the two cultivars Pusa Kesar and Sarpan-601. For sweetness the highest score was recorded for the cultivar Kuroda Improved followed by Indam Kuroda. The lowest score was recorded for the cultivar Pusa Meghali. The cultivar Kuroda recorded the highest value of 7.8 for pungency followed by Kuroda Improved and Super Kuroda-2 while the lowest value was recorded for the accession Sarpan-601. Taste wise Sarpan-601 was very poor. For crispness the highest score was recorded for accessions, Samson-196 followed by Kuroda Improved. The lowest score was recorded for the cultivar Sarpan-601.

The highest score for after taste was recorded for three cultivars Nantes, Kuroda Improved and Samson-196 followed by Super Kuroda-2 and Indam Kuroda. The lowest score was recorded for the two cultivars Pusa Kesar and Sarpan-601. The cultivar Kuroda Improved and Samson-196 was more appealing in appearance. The lowest score recorded for the cultivar Sarpan-601.

In the organoleptic evaluation Kuroda Improved with total score of 79.8 followed by Samson-196, Indam Kuroda, Kuroda (RKS) and Nantes were found to be the most accepted one. With respect to the qualitative and quantitative characters these cultivars found to be average performers. It could also be observed that the least accepted cultivar was Sarpan-601 with the total score of 34.2 out of 90 followed by Pusa Kesar (43.4) and Pusa Meghali (50.7).

5.13 Conclusion

On evaluating the performance of fifteen carrot varieties on five sowing dates, it was observed that the congenial temperature, relative humidity, sunshine hours and rainfall play a great role in seed germination, vegetative growth, root development and quality parameters of carrot. Good germination, optimum vegetative growth, high root weight and total yield along with good quality of roots were observed in most of the varieties when seeds were sown from 1st November to 1st December. It is because of the favourable weather conditions prevailed in November, December and up to mid-February when the plants put forth vegetative growth along with root enlargement. 31 to 33 ^{0}C, 70 to 80 per cent RH, 7 to 9 hours/day sunshine and minimum rainfall prevalent during that period might have contributed to the good growth and development of roots in carrot sown from 1st November to 1st December. Heavy rains occurred during October adversely affected germination but helped the crop to produce very vigorous vegetative growth at the expense of root development and it adversely affected the yield of the crop sown during October. Late sown crop

Table 34 Comparison between yield and quality

Sl. No	Cultivars	Yield/plot (kg)	Organoleptic score(Total)	TSS	Total sugar	β carotene	Remarks
1	Pusa Rudhira	7.40	55.7	12.32	5.25	3.02	Medium quality, High yield
2	Pusa Meghali	7.21	50.7	12.27	4.66	2.97	Medium quality, High yield
3	Pusa Kesar	7.34	43.4	10.42	4.39	3.37	Poor quality, high yield
4	Nantes	8.37	73.6	12.16	4.75	5.40	Good quality, high yield
5	Kuroda (RKS)	5.02	74.0	11.20	5.17	5.43	Good quality, Medium yield
6	Kuroda Improved	5.90	79.8	11.05	5.67	5.44	Good quality, Medium yield
7	New Kuroda	6.38	60.2	12.46	5.20	3.40	Medium quality, Medium yield
8	Sarpan- 601	8.18	34.2	12.60	4.51	3.57	Poor quality, High yield
9	Samson-196	4.27	78.0	11.75	4.92	5.36	Good quality, Low yield
10	Super Kuroda-1	5.49	66.6	12.66	4.57	5.04b	Medium quality, Medium yield
11	Century	3.42	65.8	10.87	4.64	5.16	Medium quality, Low yield
12	Flakker -2	5.48	64.6	12.35	4.67	4.84	Medium quality, Medium yield
13	Desi Red	6.13	55.4	11.42	4.51	3.25	Medium quality, Medium yield
14	Super Kuroda-2	5.18	70.8	12.00	5.00	5.4	Good quality, Medium yield
15	Indam Kuroda	5.51	75.4	11.91	4.84	5.30	Good quality, Medium yield

Organoleptic score if <50 Poor quality, 50 to 70 Medium quality and >70 Good quality
Yield if < 5 kg Low yield, 5 to 7 kg Medium Yield and > 7 kg High Yield

Plate 13:Best performed carrot varieties

Plate 13: Continued:Best performed carrot varieties

during December did not germinate properly. Due to high temperature and very low RH prevalent during growth and development of that crop adversely affected root and shoot growth resulting in poor yield. Therefore taking into consideration all the plant and root characters, yield and quality of the roots, it may be stated that the best time of sowing of carrots in the plains of Kerala is from 1st November to 1st December. Early October sowing and late December sowing may be avoided for successful cultivation of carrot in the plains.

The varieties studied could be grouped into high yielders (>7 kg/plot), medium yielders (5 to 7 kg/plot) and low yielders (<5 kg/plot). On the basis of organoleptic score, varieties were grouped as good quality (score >70), medium quality (score 50 to 70) and poor quality (score <50). Varieties like Kuroda Improved, Samson-196, Indam Kuroda, Kuroda (RKS), Nantes and Super Kuroda-2 produced high quality roots. Varieties like Nantes, Sarpan-601, Pusa Rudhira, Pusa Meghali and Pusa Kesar produced higher yield and Kuroda Improved, Super Kuroda-2 and Indam Kuroda got medium yield (Table-34).

Considering organoleptic acceptance, root characters and economic yield of carrot the following recommendations can be made. Nantes is the best cultivar for growing in Kerala with high yield, good quality, good appearance, minimum disorders, high TSS and high β carotene with medium total sugar and good organoleptic acceptance followed by Kuroda Improved, Super Kuroda-2 Indam Kuroda and Kuroda (RKS) (Plate 13) All these varieties were having self coloured core (Plate 11) with high quality roots, high TSS, high total sugars and higher β carotene with medium yield. They can also be recommended for cultivation in plains.

The varieties like Samson-196 produced very good quality roots with self coloured core, high TSS medium total sugar and β carotene but the yield was very low.

Pusa Rudhira, Pusa Meghali and Pusa Kesar produced high yield but the root quality was not up to the mark. The organoleptic acceptance was very poor and they were having distinct coloured core (Plate 10). Hence these varieties may not be accepted by the farmers.

Among fifteen varieties only two varieties had pungent, very poor quality roots. They were Pusa Kesar and Sarpan-601. Though both these varieties were high yielders they cannot be recommended for cultivation due to pungency.

All other varieties namely New Kuroda, Super Kuroda-1, Century, Flakker-2 and Desi Red gave medium quality roots with medium yield.

As future line of work more varieties are to be tested at more locations to arrive at a conclusive result for successful cultivation of carrot in Kerala.

SUMMARY

6. SUMMARY

The present study on "Performance evaluation and standardization of planting time in carrot (*Daucus Carota L.*)" was carried out in the Department of Olericulture, College of Horticulture, Vellanikkara during October 2013 – March 20134

The experiment was carried out with the objective to identify ideal carrot varieties for cultivation in the plains, to select suitable planting time for successful cultivation of carrot in the plains and to study the influence of planting time on the qualitative and quantitative traits of carrot. The experiment was laid out in split plot with two replications and fifteen carrot varieties (European and Asiatic) were evaluated on five different sowing dates at an interval of fifteen days commencing from 15th October 2013 to 15th December 2013.

The salient findings of the study are summarized below:

1. Seeds of all the varieties during all the dates of sowing germinated within 7-10 days. The germination percentage was greatly influenced by dates of sowing. Maximum percentage of germination (66.03 %) was noticed in the crop sown during 1st December. Maximum plant height (37.1 cm) was recorded in 15th October sowing. There was only a small effect of sowing date on plant spread. Sowing during 1st December recorded the highest spread (E-W 34.66 cm and N-S 36.37 cm) in both directions. The crop sown during 15th November produced maximum number of leaves per plant (11.97), leaf length (41.18 cm), and leaf width (14.50 cm). Foliage weight was highest in the crop sown during 15th October. The longest petiole length (14.01 cm) was recorded in the crop sown during 1st December.
2. Among varieties Indam Kuroda recorded the highest per cent of seed germination (63.10 %). Sarpan-601 showed the highest plant height (40.57

cm), leaf length (33.35 cm), leaf width (17.27 cm) and foliage weight. Pusa Kesar produced maximum number of leaves (16.83), and the longest petiole (15.06 cm) was produced by Pusa Meghali

3. In case of interaction between cultivars and sowing date the highest 76.50 per cent seeds were germinated in Indam Kuroda sown during 1st November. The highest plant height (50.34 cm) was recorded in Pusa Kesar sown during 15th October. The varieties New Kuroda sown during 15th October exhibited highest spread in both directions (52.67 cm and 51 cm respectively). Pusa Kesar produced maximum number (20) of leaves in three dates of sowing *viz.*, 1st November, 15th November and 1st December. The highest leaf length (56.50 cm) was also noticed in Pusa Kesar sown during 15th October. All the cultivars produced long leaves in 15th October, 1st November, 15th November and 1st December. The highest leaf width (20.84 cm) was observed in Pusa Rudhira in 15th October. The highest petiole length (17 cm) was seen in Pusa Kesar planted in 15th October. Sarpan-601 planted during 1st November and 15th November showed maximum foliage weight (131 g).
4. Root length, root girth, root diameter, and root weight directly contribute to yield. Root length (14.94 cm) was maximum on 15th November. Root diameter and girth (4.23 cm and 13.29 cm respectively) were highest in 15th October sowing. The maximum root weight (87.46 g) was recorded in 15th November sowing. Sowing on 1st December produced highest root shoot ratio (1.52). The maximum yield was recorded from early sown crop of 1st November (7 kg/plot).
5. Variety Desi Red produced the highest root length (18.08 cm). The highest root diameter and girth (5.45 cm and 17.13 cm respectively) were recorded by Sarpan-601. Root shoot ratio (2.14) was highest in cultivar Kuroda (RKS). Nantes and Sarpan-601 showed highest root weight and

yield per plot was maximum in the cultivar Nantes (8.37 kg) followed by Sarpan-601 (8.18kg).

6. Among interaction Desi Red sown on 1st November recorded the highest root length (21.50 cm). The highest root diameter and girth (5.86 cm and 18.42 cm respectively) were observed in Sarpan-601sown during all five dates of sowing. Sarpan-601 sown on 15th November exhibited highest root weight of 124.30 g.
7. Century sown during 1st December exhibited maximum root shoot ratio (2.42). Samson-196 planted during 1st November recorded lowest core size. The highest yield was recorded in Sarpan-601 (9.95 kg/plot) sown during 15th November.
8. Interaction between varieties and sowing time revealed that the performance of all the varieties were very poor in the 1st sowing (15th October) and last sowing (15th December). In both sowings germination was very poor. In the 15th October sowing all the varieties had very vigorous vegetative growth with poor root yield whereas in 15th December sowing both vegetative and root formation were very poor resulting in very poor yield.
9. The highest root dry matter (19.52 %) was observed in 1st November sowing TSS and acidity did not vary with sowing time. The highest value of beta carotene (4.77 mg/100g) was observed in the crop sown on 15th November. Early sown crop exhibited highest sugar content compared to late sown. 15th October sowing produced highest total sugar content (5.07 %). Characters such as root colour, root shape, root tail, root pubescence *etc.*, were not affected by sowing time but dry matter, beta carotene and total sugars varied with the time of sowing.
10. The pubescence was seen only in tropical varieties but it was absent in European types. European types exhibited orange coloured root with self-

coloured core while Asiatic types exhibited red coloured root with distinct core. Samson-196 recorded lowest core size. Nantes showed highest root dry matter (18.92 %). TSS ranged between 10.42 to 12.66 ^{0}B. The highest TSS (12.66 ^{0}B) was recorded in Super Kuroda-1. Total sugar content significantly varied among the cultivars. Lowest acidity was recorded in Kuroda Improved (1.15 %). Desi Red (2.13 %) was most acidic in nature. The highest beta carotene content (5.44 mg/100g) was recorded in Kuroda Improved and among varieties the values ranged between 2.9 mg/100g to 5.44 mg/100g.

11. Among interactions the highest TSS (13.80^{0}B) was recorded in Super Kuroda-1 planted during 1st November. Pusa Rudhira sown during 15th October recorded the highest total sugar content (6.62 %). The highest acidity was recorded in Desi Red which was planted during 15th October. In general early sown crops more acidic. The highest beta carotene was observed in Nantes sown on 15th November (6.05 mg/100g).
12. The génotypic correlation coefficient of foliage weight, leaf width, number of leaves per plant, core size, leaf length and root diameter were higher than the phenotypic correlation coefficient. This indicates the direct influence of these characters on yield.
13. On partitioning of the coefficients into direct and indirect effects, it was observed that maximum positive direct effect on yield was exhibited by total foliage weight (4.91) followed by root weight (0.699), leaf width (0.303), core size (0.061) and number of leaves (0.012). This reveals the direct relationship between these characters and yield.
14. In organoleptic evaluation Nantes and Kuroda Improved showed high colour and odour. The highest score was recorded for the cultivars Nantes and Kuroda Improved. The cultivar Kuroda Improved showed the highest values for taste, flavour and sweetness. For crispness the highest score

was recorded in Samson-196. The cultivar Kuroda Improved and Samson-196 was more appealing in appearance. Taking into consideration all the characters in organoleptic evaluation Kuroda Improved with a total score of 79.80 was the best followed by Samson-196, Indam Kuroda, Kuroda (RKS) and Nantes.

15. Carrot is mainly a cool season crop. It requires cool temperature for its growth and developments. From present study we conclude that the best time for sowing of carrot in plains of Kerala may be from 1st November to 1st December. If the seeds are sown during October the plants will have huge vegetative growth with minimum root yield. When the sowing is done late in December, both the vegetative and root growth are affected. Therefore to get a reasonably good crop of carrot, seeds should be sown from 1st week of November to 1st week of December.
16. Varieties like Kuroda Improved, Samson-196, Indam Kuroda, Kuroda (RKS), Nantes and Super Kuroda-2 produced good quality roots. Varieties like Nantes, Sarpan-601, Pusa Rudhira, Pusa Meghali and Pusa Kesar produced higher yield. Kuroda Improved, Super Kuroda-2 and Indam Kuroda recorded medium yield.
17. The varieties studied could be grouped into high yielders (>7 kg/plot), medium yielder (5 to 7 kg/plot) and low yielder (<5 kg/plot). On the basis of organoleptic score varieties were grouped as good quality (score >70), medium quality (score 50 to 70) and low poor quality (score <50). Varieties like Kuroda Improved, Samson-196, Indam Kuroda, Kuroda (RKS), Nantes and Super Kuroda-2 produced high quality roots. Varieties like Nantes, Sarpan-601, Pusa Rudhira, Pusa Meghali and Pusa Kesar produced higher yield and Kuroda Improved, Super Kuroda-2 and Indam Kuroda got medium yield.

18. Considering both organoleptic acceptance and economic yield of carrot the following recommendations can be made. Nantes is the best cultivar for growing in Kerala with high yield, minimum forking, cracking and bolting, high TSS and high β carotene with medium total sugars and very good organoleptic acceptance followed by Kuroda Improved, Super Kuroda-2 Indam Kuroda and Kuroda (RKS) (Plate 13) All these varieties were having self-coloured core (Plate 6) with high quality roots, high TSS, high total sugars and higher β carotene with medium yield. These varieties were equally good and they can also be recommended for cultivation in plains.
19. The varieties like Samson-196 produced very good quality roots with self-coloured core, high TSS medium total sugar and β carotene but the yield was very low.
20. Sarpan-601, Pusa Rudhira, Pusa Meghali and Pusa Kesar produced high yield but the root quality was very low in organoleptic acceptance. They were having distinct coloured core and high level of forking. Hence these varieties may not be accepted by the farmers.
21. Among fifteen varieties only two varieties had pungent, poor quality roots they were Pusa Kesar and Sarpan-601. Though both these varieties were high yielders they cannot be recommended for cultivation.
22. All other varieties namely New Kuroda, Super Kuroda 1, Century, Flakker 2, and Desi Red gave medium quality roots with medium yield.

As future line of work more varieties are to be tested at more locations to arrive at a conclusive result for successful cultivation of carrot in Kerala.

REFERENCES

7. References

[Anonymous]. 2009. Ageless Documentation [on line]. Properties and therapeutic uses of carrots. Available: www.ageless.co.za/herbcarrot.htm[18/05/2016].

Ahmadi, H. A., Moghaddam, H. A., and Kohkan, S. A. 2004. Study of yield of some carrot cultivars in Sistan. *Seed. Plant.* 20(1): 133-135.

Alam, S., Coares, K., Lee, S., Lovegrove, M., Robalino, M., Sakata, T., Santella, D., Surendran, S., and Urry, K., 2004. Influence of temperature on yield of carrots. *Proc. Am. Soc. Hort. Sci.* 90: 182-189.

AOAC (Association of Official Agricultural Chemists). 2005. [online] available: http://www.nutraingredients-usa.com/Suppliers2/AOAC-validates-beta-carotene-method.

Arora, P. N., Pandey, S. L. and Basantani, H. T. 1969. Effect of time and method of sowing of carrot on yield. *Indian J. Agron.* 12(1): 14-16.

Arthey, V. D. 1975. *Quality of horticulture products.* Butterworth and co. London 64-72.

Aubert, C., Chalot, G. and Jost, M. 2013. Aroma and nutritional quality of carrots: characteristics of varietal types. *Infos-Ctifl.* 291: 60-65.

Bakhchevanova, S. 1974. Results of testing new carrot variety. *Gardening.* 16(2): 19-22..

Banga, O., De Bruyn, J. N., and Smeets, L. 1955. Selection of carrots for carotene content. *Euphytica.* 4: 183-189.

Baranski, R., Allender, C., and Klimek-Chodacka, M. 2011. Towards better tasting and more nutritious carrots: carotenoid and sugar content variation in carrot genetic resources. *Food Res. Int.* 47(2): 182-187.

Barnes, W. C. 1936. *Effects of some environmental factors on growth and color of carrots.* Horticulture Bulletin No.70. Agriculture Experiment Station, Cornell University. Available: http://krishikosh.egranth.ac.in/bitstream/1/2032384/1/259.pdf.

Benjamin, L. R. and Sutherland, R. A. 1989. Storage-root weight, diameter and length relationships in carrot (*Daucus carota*) and red beet (*Beta vulgaris*). *J. Agric. Sci.* 113(1): 73-90.

Bonhomme, R. 2000. Bases and limits of using "degree day" units. *Euro. J. Agron.* 13: 1-10.

Borowska, E. J., Zadernowski, R., Szajdek, A., and Majewska, K. 2005. Organoleptic, physical and chemical properties of some varieties of carrots suitable in juice production. *Polish J. Nat. Sci.* 21(2): 173-186.

Bradley, G. A. and Smittle, D. 1965. Carrot quality as affected by variety, planting and harvest dates. *Proc. Am. Soc. Hort. Sci.* 86: 397-405.

Bradley, G. A. 1963. Carrots-potential crop for Arkansas. *Arkansas Farm Res.*12(5): 10.

Bradley, G. A. 1967. Carrot yields and color in Arkansas. *Arkansas Farm Res.* 14(3): 8.

Brouwer, R. 1962. Distribution of dry matter in plant. *Neth. J. Agric. Sci.* 10: 361-376.

Cottet, V., Navez, B., Villeneuve, F., Jost, M., Latour, F., Geoffriau, E., and Huet, S. 2005. Organoleptic quality of carrot: approach for choosing batches evaluated using hedonic tests. *Infos-Ctifl.* 299: 53-56.

Dahiya, M. S., Yadav, A. C., Singh, V. P., and Malik, Y. S. 2007. Effect of time and method of sowing on root quality of carrot cv. Hisar Gairic. *Haryana J. Hort. Sci.* 36(3/4): 377-378.

De Lannoy, G., 2000. *Root and Bulb Vegetables, Crop Production in Tropical Africa.* Edited by Roman H. Raemaekers. CIP Royal Library Albert 1, Brussels. 480-484.

Duczmal, K. W., Ratajczak, K., and Ratajczak, K. 1987. The resistance of carrot roots to low temperature and their sucrose content. *The Forestry Letters* 61: 37-38.

Dyśko, J. and Kaniszewski, S. 2007. Effect of drip irrigation, N-fertigation and cultivation methods on the yield and quality of carrot. *Veg. Crops Res. Bull.* 67: 25-33.

Eliseev and Nikolaeva, 1964. The quantity and quality of carrot yields in relation to sowing dates. *Ann. Plant Physiol.* 12(2): 119p.

Falconer, D. S. 1981. *Introduction to quantitative Genetics.* Longman, New York. 340p.

Fikselova, M., Marecek, J., and Mellen, M. 2010. Carotenes content in carrot roots (*Daucus carota* L.) as affected by cultivation and storage. *Veg. Crops Res. Bull.*74: 47-54.

Fisher, R. A. 1954. A fuller theory of junctions in breeding. *Heridity.* 8: 187-197

Forbes, A. and Scudder, B. 1963. Carrot planting date trials in Central Florida. *Proc. Florida State Hortic. Soc.* 76: 195.

Fritz, V., Tong, C., Rosen, C., and Wright, J. 1998. Carrots (Vegetable Crop Management). University of Minnesota Extension Service Bulletin. [On-line]. Available: WW-7196GO.http://www3extension.umn.edu/distribution/horticulture/DG7196.htm[24/012/15].

Fuhrmann, H., Schon, M., and Dapper, H. 1986. Quality studies in radish and carrot. *Veg.* 22(8): 328-331.

Gadomska, J. M. and Wierzbicka, B. 2010. The yield and nutritive value of selected carrot cultivars with orange and purple colored storage roots. *Acta Hortic.* 9 (4): 75-84.

Gadzhonov, I. 1972. The effect of sowing date on the yield and quality of carrots intended for seed production. *Hortic. Vitic. Sci.* 9(3): 47-54.

Gajewski, M., Szymczak, P., Elkner, K., Dąbrowska, A., Kret, A., and Danilcenko, H. 2007. Some aspects of nutritive and biological value of carrot cultivars with orange, yellow and purple colored roots. *Veg. Crops Res. Bull.* 67: 149-161.

Gocan, T. M., Maniuţiu, D. N., Andreica, I., Balcau, S., Lazar, V., and Bogdan, I. 2013. Sugar content of carrot roots influenced by the sowing period. *J. Hort. Forest. Biotechnol.*17(1): 66-69.

Gopalan, C., Sastri, B. V. R., and Balasubramanian, S. C. 1989. *Nutritional value of Indian Foods.* National Institute of Nutrition., Hyderabad. 58-64.

Gupta, A. J. and Verma, T. S. 2007. Studies on genetic variability and selection parameters in European carrot. *Haryana J. Horict. Sci.* 36(1/2): 166-168.

Gupta, A., Verma, T., Shruti, S., and Gyanendra, S. 2006. Evaluation of European carrot genotypes including F_1 hybrids for their root quality, yield and nutritive characters. *Indian J. Hortic.* 63(1): 48-52.

Henkel, A. 1970. Investigations on the use of irrigation for late carrots. *Deutsche Gartenbau.* 17: 67-68.

Hussain, S. I., Hadley, P., Pearson, S., and Hidayatullah, A. 2008. Genetic variability of carrots. I. Effect of sowing dates on quality and growth characteristics in carrot (*Daucus carota* L.) cultivars. *Pakist. J. Agri. Res.* 21(1/4): 54-64.

Jaiswal, M. D., Adpawar, R. M., Parlawar, N. D., and Yadgirwar, B. M. 2003. Effect of planting dates and spacing on growth, seed yield and quality of carrot. *Ann. Plant Physiol.* 17 (2): 117-119.

Joubert, T., Boelema, B. H., and Daiber, K. C. 1994. *The production of carrots Vegetable and Ornamental Plant.* Agricultural Research Council, Roodeplaat. 122p.

Kaack, K., Nielsen, M., Christensen, L. P., and Thorup Kristensen K. 2001. Nutritionally important chemical constituents and yield of carrot (*Daucus carota* L.) roots grown organically using ten levels of green manure. *Acta Agric. Scand. Sect. B. Soil Plant Sci.* 51: 125-136.

Kabir, A., Ali, A., Waliullah, M. H., Rahman, M., and Rashid, A. 2013. Effect of spacing and sowing time on growth and yield of carrot. *Int. J. Sustain. Agric.* 5(1): 29-36.

Karkleliene, R., Audrius, R., Edita, D., Elena, U., Ceslovas, B., Laisvune, D., Danguole, K., and Ona, B. 2012. Root yield, quality and disease resistance of organically grown carrot (*Daucus sativus* L.) hybrids and cultivars. *Agric.* 99: (4) 393-398.

Kluepfel, M. and Smith, P. 2002. Carrot, Beet and Radish. Lexington Country Extension Agent. Clemson University, Clemson. 68p.

Krickl, M. 1963. Carrots. Primary aims of improving form, the inner structure of the root and in consequence, the biological value. *Mit. Klosterneuburg*, 13B: 230-268.

Krylov, S. V. and Baranova, N. D. 1966. The dynamics of carotene accumulation in carrot roots in relation to the date of sowing. *Int. J. Hort.* 22(1): 85p.

Lada, R. and Stiles, A. 2004. Processing carrot research program water requirement and irrigation management for optimizing carrot yield and quality. *Agric.* 82(2): 324p

Lee, S. K. and Kader, A. A. 2000. Pre harvest and pre harvest factors influencing vitamin C content of horticultural crops. *Post harvest. Biol. Tech.* 20: 200-220.

Lipari, V. 1980. The yield and growth pattern of the roots in carrot varieties in relation to time of sowing. *Tech. Agric.* 32(3): 157-177.

Malek, M. A., Mohammed, D., Sikdar, M., and Rahman, M. S. 2012. Effects of variety and growing condition on yield and quality of carrot seed. *J. Environ. Sci. Nat. Resour.* 5: 301-306.

Manosa, N. A. 2011. Influence of temperature on yield and quality of carrots (*Daucus carota* var. *sativa*). M. Sc. (Agri.) thesis, University of the Free State Bloemfontein. 84p.

Manosa, N. A., Engelbrecht, G. M. and Allemann, J. 2010. Influence of temperature on yield of carrots. *African J. Plant Sci.* 20(2): 205-208.

Marta, G., Danut N., Ileana, B., and Vasile, L. 2013. Sugar content of carrot as influenced by the cultural technology. *Nat. Sci. Biol.* 69(1). 122-129.

Matejkova, J. and Petrikova, K. 2010. Variation in content of carotenoids and vitamin C in carrots. *Nat. Sci. Biol.* 2(4): 88-91.

McGiffen, M., Nunez, J., Suslow, T., and Mayberry, K. 1997. Carrot production in California. *J. Environ. Sci. Nat. Resour.* 6(3): 130-136.

Millette, J. A. 1983. Effect of water table depths on the growth of carrots and onions on an organic soil in vitro. *Can. J. Plant Sci.* 63: 739-746.

Nadarajan, N. and Gunasekaran, M. 2005. *Quantitative genetics and Biometrical techniques in plant breeding.* Kalyani Publisher, New Delhi. 258p.

Nascimento, W. M., Pereira, R. S., Vieira, J. V., and Cantliffe, D. J. 2012. Carrot seed germination at high temperature conditions. *Acta Hortic.* 936: 133-137.

Nascimento, W. M., Vieira, J. V., Silva, G. O., Reistma, K. R., and Cantliffe, D. J. 2013. Carrot seed germination at high temperature: effect of genotype and association with ethylene production. *Hortic. Sci.* 43: 1538-1543

Navez, B., Cottet, V., Villeneuve, F., Jost, M., Geoffriau, E., and Huet, S. 2012. Organoleptic quality of carrot: differences in sensory criteria according to variety. *Infos-Ctifl.* 284: 52-60.

Nilsson, T. 1987. Growth and chemical composition of carrots as influenced by the time of sowing and harvest. *J. Agric. Sci.* 108: 459-468.

Nortje, F. and Henrico, S. 1986. The influence of irrigation interval on crop performance of carrots (*Daucus carota* L.) during winter production. *Acta Hortic.* 194: 153-158.

Pariari, A., Maity, T. K., and Gayen, P. 1992. Association of physical characters with yield and quality in carrot. *Ann. Agric. Res.* 13(1): 96-98.

Pashine, Y. P. Deshmukh, P. P. Diware, D. V. Deshmukh, S. V., and Uke, P. C. 1993. Effect of sowing time on the yield of carrot (*Daucus carota* Linn.). *Annals Plant Physiol.* 7(1): 134-135.

Petzoldt, C. 2008. Carrots. IPM program. New York State. [on-line]. Available: www.nysaes. cornell.edu/recommends/16carrots.html[16/02/2014].

Quagliotti, L. 1967. Effects of different temperatures on stalk development, flowering habit, and sex expression in the carrot (*Daucus carota* L.). *Euphytica.* 16: 83-103.

Rajan, S. and Markos, B. 2008. *Propagation of horticultural crops.* New India Publishing Agency. New Delhi. 255p.

Ranganna, S. 1986. *Handbook of Analysis and Quality Control for Fruit and Vegetable Products.* Tata McGraw-Hill Education, 1112p.

Richmond, S. and Mendez, G. 2010. Yield of twelve commercial hybrid carrot (*Daucus carota* L.) in the field and the packing facilities. *Agron. Mesoamericana.* 21(1):167-176.

Rosenfeld, H. J. 1998. The influence of climate on sensory quality and chemical composition of carrots for fresh consumer and industrial use. *Acta Hortic.* 476: 69-76.

Rubatzky, V. E., Quiros, C. F., and Simon, P. W. 1999. *Carrots and related vegetable of Umbelliferae.* Cabi Publishing. 304p.

Sadhu, A. N. 1986. *Agricultural Problems in India (Development Policies and Prospects).* Himalaya Publishing House. New Delhi. 386p.

Siddiqui, A. B. 1995. Local adaptability and suitability of vegetable and spice crops. *Pakist. J. Agri. Res.* 12(8). 125-131.

Simon, P. W., Freeman, R. E., Vieira, J. V., Boiteux, L. S., Briard, M., Nothnagel, T., Michalik, B., and Kwon, Y. 2008. *Handbook of Plant Breeding. Volume 2.* Springer. New York. 725p.

Singh, B. D. 1983. *Plant breeding.* Kalyani publishers, Ludhina. 869p.

Singh, P. and Narayanan, S. S. 2009. *Biometrical techniques in plant breeding.* Kalyani Publisher, New Delhi. 343p.

Sistrunk, W. A., Bradely, G. A., and Smittle, D. 1967. Influence of preharvest factors on carbohydrates in carrots. *Proc. Am. Soc. Hortic. Sci.* 90: 239-251.

Starkute, R. and Zalatorius, F. 2006. Effects of harvesting time on the yields of onion cultivars and hybrids grown from seedlings. *Gardening Hortic.* 25(1): 144-151.

Suojala, T. 2000. Variation in sugar content and composition of carrot storage roots at harvest and during storage. *Agron. Mesoamericana.* 16: 47-55.

Swaminathan, M. 1974. *Essentials of Food and Nutrition, Volume I and II.* The Bangalore Printing and Publishing Co. Ltd., Bangalore. 1091p.

Tindall, H. D. Rice, R.P., and Rice, J.W. 1986. *Fruits and vegetables in the tropics.* Macmillan publishers Ltd. 578p.

Tindall, H. D. 1968. *Commercial vegetable growing.* Oxford University Press, Oxford. 430p.

Toul, V., Indrak, P., and Kvasnicka, P. 1986. β-Carotene content in a carrot cultivar collection. *Proc. ÚVTIZ, Hortic.* 13(2): 120-127.

Tweneboah, C. K. 1997. *Vegetables and spices in West Africa.* Co-Wood publishers, North Dworwulu, Accra, Ghana. 180p.

Vizzotto, V. J., Silva, Junior, A. A., and Müller, J. 1986. Evaluation of carrot cultivars in the coastlands of Santa Catarina. *Pesquisa em Andamento.* 5p.

Vukasin, B., Moravcevic, D., Jelacie, S., and Damir, B. 2010. Effect of cultivar on carotene and vitamin C content in carrot root. *Proc. Am. Soc. Hortic. Sci.* 120(1): 135-142.

Warne, S. 1961. Sowing date is the crucial factor for carrots. *Commercial Grow.* 3441: 1205-1207.

APPENDICES

APPENDIX I

Weather data of the experimental site

Hours of observation I-0700 hrs LMT (07.25 IST); II- 1400 hrs LMT (14.25 IST)

October 2013 to March 2014 weekly weather data

Standard week		Temperature		Relative humidity		Sun shine (hrs/day)	Rainfall (mm)
		Maximum	Minimum	I	II		
Oct. 2013	41	30.70	22.60	96.00	69.00	6.27	60.10
	42	30.80	23.10	96.00	72.00	4.96	150.60
	43	24.60	23.00	97.00	77.00	2.74	117.10
	44	32.80	24.00	89.00	62.00	7.07	29.80
Nov. 2013	45	32.40	24.10	76.00	54.00	7.89	0.00
	46	31.80	23.20	87.00	63.00	4.79	61.30
	47	32.90	23.90	94.00	63.00	5.69	13.20
	48	33.10	22.40	92.00	60.00	6.09	6.30
Dec. 2013	49	32.30	22.40	81.00	44.00	7.17	0.50
	50	32.40	22.50	87.00	51.00	6.56	0.00
	51	31.40	21.80	77.00	43.00	9.59	0.00
	52	31.30	22.10	66.00	39.00	10.37	0.00
Jan. 2014	1	32.60	22.40	74.00	34.00	9.27	0.00
	2	32.80	23.10	68.00	37.00	8.10	0.00
	3	33.20	23.70	63.00	38.00	8.77	0.00
	4	33.70	22.30	60.00	33.00	9.89	0.00
Feb. 2014	5	35.10	21.00	74.00	28.00	9.84	0.00
	6	33.60	22.60	89.00	51.00	7.41	0.00
	7	35.00	23.40	70.00	38.00	7.54	0.00
	8	35.20	24.60	78.00	42.00	8.71	0.00
Mar. 2014	9	35.10	25.10	71.00	38.00	7.20	0.00
	10	37.40	22.70	66.00	18.00	9.69	0.00
	11	37.30	24.70	84.00	44.00	8.51	0.00
	12	38.10	24.30	81.00	31.00	8.87	0.00

APPENDIX – II
Score card for organoleptic evaluation of carrot

	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}	T_{11}	T_{12}	T_{13}	T_{14}	T_{15}
Colour															
Odour															
Taste															
Flavour															
Hardness															
Sweetness															
Pungency															
Crispness															
After taste															
General appearance															

Name of the judge:
Date:

Like extremely	9
Like very much	8
Like moderately	7
Like slightly	6
Neither like nor dislike	5
Dislike slightly	4
Dislike moderately	3
Dislike very much	2
Dislike extremely	1

Signature of the judge

PERFORMANCE EVALUATION AND STANDARDIZATION OF PLANTING TIME IN CARROT (*Daucus carota* L.)

By

BASAVARAJ VITTHAL SIMPI

(2012-12-118)

ABSTRACT OF THE THESIS

Submitted in partial fulfillment of the

requirement for the degree of

Master of Science in Horticulture

Faculty of Agriculture

Kerala Agriculture University

DEPARTMENT OF OLERICULTURE

COLLEGE OF HORTICULTURE

VELLANIKKARA, THRISSUR-680 656

KERALA, INDIA

2016

ABSTRACT

The experiment entitled "Performance evaluation and standardization of planting time in carrot (*Daucus carota L.*)" was carried out in the Department of Olericulture, College of Horticulture, Vellanikkara during October 2013 – March 2014. The major objectives of the study were to identify ideal varieties for the plains of Kerala to select suitable planting time and to study the influence of planting time on the quantitative and qualitative traits of carrot. Fifteen carrot varieties were evaluated in five different sowing dates with an interval of fifteen days which was commenced from 15th October 2013 to 15th December 2013, in randomized block design.

All the varieties of carrot and dates of sowing differed significantly and had marked influence on all the quantitative and qualitative characters studied. Root length, root girth, root diameter, and root weight directly contribute to yield. On comparing different sowing dates maximum root length (14.94 cm) was seen in 15th November sowing. Root diameter and girth (4.23 cm and 13.29 cm respectively) were highest in 15th October sowing. The maximum root weight (87.46 g) was recorded in 15th November sowing. Sowing on 1st December produced highest root shoot ratio (1.52). The maximum yield was recorded from early sown crop of 1st November (7 kg/plot).

Among different varieties Desi Red produced the highest root length (18.08 cm). The highest root diameter and girth (5.45 cm and 17.13 cm respectively) were recorded in Sarpan-601. Root shoot ratio (2.14) was highest in cultivar Kuroda (RKS). Nantes and Sarpan-601 showed highest root weight and yield per plot was maximum in Nantes (8.37 kg) followed by Sarpan-601 (8.18kg).

Among interaction Desi Red sown on 1st November recorded the highest root length (21.50 cm). The highest root diameter and girth (5.86 cm and 18.42 cm respectively) were observed in Sarpan-601sown during all five dates of sowing.

Sarpan-601 sown on 15th November exhibited highest root weight of 124.30 g. Century sown during 1st December exhibited maximum root shoot ratio (2.42). Samson-196 planted during 1st November recorded lowest core size. The highest yield was recorded in Sarpan-601 (9.95 kg/plot) sown during 15th November. The yield per hectare ranged between 11.42 t/ha to 27.91 t/ha and the highest value was recorded in Nantes and lowest was recorded in Century.

Interaction between varieties and sowing time revealed that the performance of all the varieties were very poor in the 1st sowing (15th October) and last sowing (15th December). In both sowings germination was very poor. In the 15th October sowing all the varieties had very vigorous vegetative growth with poor root yield whereas in 15th December sowing both vegetative and root formation were very poor resulting in very poor yield.

The highest root dry matter (19.52 g/100g) was observed in 1st November. The highest value of beta carotene (4.77 mg/100g) was observed in the crop sown on 15th November. No variation was seen in acidity and TSS with respect to dates of sowing. Characters such as root colour, root shape, root tail and root pubescence were not affected by sowing time. The pubescence was seen only in tropical varieties but it was absent in European types. European types exhibited orange coloured root with self coloured core while Asiatic types exhibited red coloured root with distinct core. Asiatic carrots were more inclined towards vegetative growth compared to European type carrots.

From present study it may be concluded that the best time for sowing of carrot in plains of Kerala may be from 1st November to 1st December. If the seeds are sown during October the plants will have huge vegetative growth with minimum root yield. When the sowing is done late in December, both the vegetative and root growth are affected. Therefore to get a reasonably good crop of carrot, seeds should be sown from 1st week of November to 1st week of December.

Varieties like Kuroda Improved, Samson-196, Indam Kuroda, Kuroda (RKS), Nantes and Super Kuroda-2 produced high quality roots. Varieties like Nantes, Sarpan-601, Pusa Rudhira, Pusa Meghali and Pusa Kesar produced higher yield and Kuroda Improved, Super Kuroda-2 and Indam Kuroda recorded medium yield.

Considering both organoleptic acceptance, root quality and economic yield of carrot the following recommendations can be made. Nantes is the best cultivar for growing in Kerala with high yield, high TSS and high β carotene with medium total sugar and good organoleptic acceptance followed by Kuroda Improved, Super Kuroda-2 Indam Kuroda and Kuroda (RKS). All these varieties were having self coloured core with high quality roots, high TSS, high total sugars and higher β carotene with medium yield. They can also be recommended for cultivation in plains.

The varieties like Samson-196 produced very good quality roots with self coloured core, high TSS medium total sugar and β carotene but the yield was very low.

Sarpan-601 and Pusa Rudhira, Pusa Meghali and Pusa Kesar produced high yield but the root quality was very low in organoleptic acceptance and they were having distinct coloured core. Hence these varieties may not be accepted by the farmers.

Among fifteen varieties only two varieties had pungent, very poor quality roots. They were Pusa Kesar and Sarpan-601. Though both these varieties were high yielders they cannot be recommended for cultivation due to high pungency.

All other varieties namely New Kuroda, Super Kuroda-1, Century, Flakker-2 and Desi Red gave medium quality roots with medium yield.