

**STUDIES ON SEED PRODUCTION IN CARROT  
Cv. Pusa Kesar**

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# CONTENTS

SL. NO.	PARTICULARS
I.	INTRODUCTION
II.	REVIEW OF LITERATURE
III.	MATERIAL AND METHODS
IV.	EXPERIMENTAL RESULTS
V.	DISCUSSION
VI.	SUMMARY
VII.	REFERENCES
VIII.	APPENDICES
IX.	ABSTRACT

## LIST OF TABLES

Table No.	Title
1.	Effect of date of sowing and nutrition on plant height (cm) and number of leaves of carrot Cv. Pusa kesar
2.	Effect of date of sowing and nutrition on days to 50 % flowering and root length (cm) of carrot Cv. Pusa kesar
3.	Effect of date of sowing and nutrition on Root weight (g) and root diameter (cm) of carrot cv.Pusa kesar
4.	Effect of date of sowing and nutrition on number of umbels per plant and number of seeds per umbel of carrot Cv.Pusa kesar
5.	Effect of date of sowing and nutrition on Umbel diameter(cm) and 1000 seed weight(g) of carrot Cv.Pusa kesar
6.	Effect of date of sowing and nutrition on seed yield per plant and seed yield per plot (g) of carrot Cv.Pusa kesar
7.	Effect of date of sowing and nutrition on seed yield (Kg/ha) of carrot during seed production of Cv.Pusa kesar
8.	Effect of date of sowing and nutrition in germination (%) and speed of germination of carrot Cv.Pusa kesar
9.	Effect of date of sowing and nutrition on seedling root length (cm) and shoot length (cm) of carrot Cv.Pusa kesar
10.	Effect of date of sowing and nutrition on seedling vigour index and seedling dry weight dry weight of carrot Cv.Pusa kesar
11.	Effect of date of sowing and nutrition on field emergence percentage (%) of carrot Cv.Pusa kesar
12.	Effect of spacing and growth regulator on plant height and number of leaves of carrot Cv. Pusa kesar
13.	Effect of spacing and growth regulator on days to 50% flowering and root length (cm) of carrot cv. Pusa kesar
14.	Effect of spacing and growth regulator on root diameter (cm) and root weight (g) of carrot cv. Pusa kesar
15.	Effect of spacing and growth regulator on number of umbels per plant and number of seeds per umbel of carrot cv. Pusa kesar
16.	Effect of spacing and growth regulator on umbel diameter and 1000 seed weight (g) of carrot cv. Pusa kesar
17.	Effect of spacing and growth regulator on seed yield per plant and seed yield per plot of carrot cv.Pusa kesar
18.	Effect of spacing and growth regulator on seed yield (kg/ha) of carrot cv. Pusa kesar

<b>Table No.</b>	<b>Title</b>
19.	Effect of spacing and growth regulator on germination (%) and speed of germination of carrot cv. Pusa kesar
20.	Effect of spacing and growth regulator on root length (cm) and shoot length (cm) of carrot cv. Pusa kesar
21.	Effect of spacing and growth regulator on vigour index and seedling dry weight of carrot cv. Pusa kesar
22.	Effect of spacing and growth regulator on field emergence (%) of carrot cv. Pusa kesar

## LIST OF FIGURES

Figure No.	Title
1a.	Plan of layout of the experiment-I
1b.	Plan of layout of the experiment-II
2.	Effect of date of sowing and nutrition on number of umbles per plant of carrot Cv. Pusa kesar
3.	Effect of date of sowing and nutrition on seed yield (kg/ha) of carrot during seed production of Cv.Pusa kesar
4.	Effect of spacing and growth regulator on number of umbels per plant of carrot Cv. Pusa Kesa
5.	Effect of spacing and growth regulator on seed yield (kg/ha) of carrot cv. Pusa kesar

## LIST OF PLATES

<b>Plate No.</b>	<b>Title</b>
1.	General view of the experimental plot

## LIST OF APPENDICES

Appendix No.	Title
I.	Monthly meteorological data for the experimental year ( <i>kharif</i> , 2005) and the mean of past 55 years (1950-2004) as recorded at the Meteorological Observatory, Main Agricultural Research Station, University of Agricultural Sciences, Dharwad (Karnataka)
II.	Physical and chemical properties of the soil in the experimental site

# I. INTRODUCTION

Carrot (*Daucus carota* L.) is an important vegetable crop grown in spring, summer and autumn in temperate regions and during winter in tropical and sub-tropical regions. It belongs to family Umbelliferae. Carrot roots are used as a vegetable for soups, stews, curries and pies; grated roots are used as salad, tender roots as pickles. Carrot halwa and jam are also popular and the roots in the form of disc and slices can be also dehydrated. Carrot juice is a rich source of carotene and is sometimes used for colouring buffer and other food articles. Carrot tops are used for extraction of leaf protein, as fodder and also for the poultry feed.

Carrot is an excellent source of carotene (1890 µg/100 g fresh weight) a precursor of vitamin-A and fibre in the diet. Deficiency of vitamin A particularly in children causes xerophthalmia, an eye ailment. In India at present, there is an alarming situation because of the vitamin A deficiency. Hence there is an urgent need to direct various programmes for developing carotene rich crops. It has a strengthening effect on the heart and brain, prevention of constipation and possession of diuretic properties. Purple and black carrots are used for the preparations of a sort of beverages called 'kanjal', which is a very good appetizer.

The major carrot growing states in India are Punjab, Uttar Pradesh, Karnataka, Tamilnadu and Andhra Pradesh. The total area under carrot in India is over 22,538 ha with an annual production of 4.14 lakh tonnes and shares of Karnataka is 2968 ha with an estimated production of about 44,520 tonnes. Although, this root crop has been widely cultivated since long, yet its yield per acre remains very low and hence there is considerable scope to increase the production potential of carrot.

Success of any seed production programme depends on the quality of the seed, agronomic practices and plant protection measures taken to produce the healthy and vigorous crop. Among the agronomic practices, sowing at optimum time is considered as an important non-cash input that results in considerable increase in the yield and quality. Productivity of most of arable crops owing to change in the environmental conditions to which phenological stages of the crop are exposed. The modified environment resulting from different dates of sowing may thus influence the crop growth, flowering and seed development. If accidentally crop caught in unfavourable environment that will be detrimental to seed yield and quality.

The maintenance of adequate plant population per unit area is the most important factor that effects seed yield and quality. In vegetable crops, wider spacing is found advantages to obtain luxuriant crop growth since there will be less competition for nutrients and may result into increased seed size and ultimately higher yield and quality compared to narrow spacing. Hence, it becomes very important to find out the most suitable spacing in order to get higher seed productivity combined with quality.

Apart from spacing, nutrition also plays a key role in enhancing the seed yield and quality. Application of nitrogen is essential for vegetative growth of the plant and phosphorus effects the maturity of the crop whereas potassium is involved in developing resistance to lodging. The nutritional requirement varies with the genotypes, agro-climatic condition and fertility of the soil besides growing under rainfed or irrigated condition.

The application of organics such as FYM and vermicompost is becoming popular especially among the vegetable crop growers owing to high cost of chemical fertilizers. The role of organic manures in improving soil structure and fertility is well understood and organic manuring has positive influence on soil texture and structure, better water holding capacity and drainage, which in turn have positive influence on yield. FYM manure being a bulky organic material improves the aeration in addition to the supply of essential plant nutrients and organic matter, thereby increasing the soil microbial establishment along with accumulation of excess humus content.

Beneficial effect of earthworm and their casts were known even in Darwin's era. Vermicompost is rich in both macronutrients and micronutrients besides having plant growth substances and is considered as a bio-fertilizer because of its richness in humus forming and N fixing microorganisms (Kale and Bano, 1986).

According to Nickle (1978) the plant growth regulators are new generation agro chemicals and are expected to play an important role in overcoming the hurdles in manifestation of biological yield even in root crops. In recent years, plant growth regulators are used in overcoming the factors limiting the growth and yield to obtain maximum benefit from seed production. When added in small amounts modify the architect and growth of plant usually by stimulating or inhibiting a part of natural growth regulators. The plant growth regulators serve as highly influential agents by which growth is regulated, both in time during ontogeny and in space at any point of time. It is also observed that exogenous application of growth regulators increases the seed yield. These growth hormones regulate the physiological processes and balance the source and sink, there by increase the productivity and quality of many crop species.

GA<sub>3</sub> application brings about metabolic changes that affect both quality and quantity of the desired product. It stimulates synthesis of hydrolic enzymes which are secreted and act on starchy endosperm in turn affecting physiological of seed germination and establishment of seedlings. NAA improves the net photosynthesis rate by increasing CO<sub>2</sub> fixation and reducing the photorespiration. It also helps in mobilization of reserve food materials for seed filling, ultimately increase seed test weight.

The information on the role of time of sowing, nutrients, spacing and plant growth regulators in seed production of carrot is meager. Hence, there is an urgent need to study the influence of these factors on seed yield and quality components in carrot to boost the productivity potential. With this background, the present investigation was aimed with the following objectives;

1. To find out the suitable time of sowing to obtain higher seed yield and quality
2. To understand the effect of nutrients on seed yield and quality
3. To study the effect of spacing on seed yield and quality
4. To find out the influence of growth regulators on seed yield and quality
5. To study the interaction effect of time of sowing, nutrient, spacing and growth regulator spray on seed yield and quality.

## II. REVIEW OF LITERATURE

The literature pertaining to the effect of date of sowing, spacing, nutrition and growth regulators on growth, seed yield and quality of carrot and related crops are reviewed in this chapter.

### 2.1 INFLUENCE OF DATE OF SOWING ON GROWTH, SEED YIELD AND QUALITY PARAMETERS IN CARROT

Environmental conditions like rainfall, temperature, relative humidity and day length play an important role in modifying metabolic processes involved in plant growth as well as other plant processes.

#### 2.1.1 Influence of sowing date on growth parameters

Muller and Hartmann (1985) observed no effect of sowing date on crop yield but lettuce cv. reskia produced the smallest crop from the late sowing.

Basawana and Pandita (1989) reported that the crop sown on 15<sup>th</sup> September took maximum number of days to maturity. Delay in sowing reduced the period for maturity in fenugreek.

#### 2.1.2 Influence of sowing date on yield and yield parameters

Sing and Ravindranath (1971) based on their survey Conducted in Punjab on celery cultivation reported that celery seeds were sown in the first week of October and the seedlings were ready for transplanting in the second week of December.

Singh *et al.* (1979) evaluated three sowing dates at 15 days interval starting from 7<sup>th</sup> September, 22<sup>nd</sup> September and 7<sup>th</sup> October. Date of sowing influenced increased growth, yield and quality under 22<sup>nd</sup> September sowing in radish.

Singh and Singh (1983) obtained a maximum seed yield of 18.5 q/ha in *Ammi majus* by sowing the seeds on 30<sup>th</sup> October.

Keeley *et al.* (1987) reported that the growth of plants was slower in an early sown crop (March – July) and greater in autumn sown crop. Further, seed yield per unit area in the autumn sown crop was higher than that of Kharif.

Bhati *et al.* (1989) reported that sowing in November gave significantly higher seed yield and number of umbels per plant (3.85 g/ plant) whereas December sowing gave significantly less seed yield and number of umbels per plant in coriander.

Venkateswarlu *et al.* (1992) noticed the highest seed yield (965.5 kg/ ha) and essential oil yield when the crop was sown on 20<sup>th</sup> October in coriander.

Bhati and Shakatawat (1994) noticed that crops sown on 31<sup>st</sup> October produced 29.80 and 35.8 per cent higher yield of seed essential and fatty oils respectively than those sown on 20<sup>th</sup> November in coriander.

#### 2.1.3 Influence of sowing date on seed quality parameters

Song *et al.* (1990) studied the test weight of soybean genotypes and observed that the test weight ranged from 7.3 to 48.4 g per 100 seeds.

In soybean, Bhering *et al.* (1991) found that the seed quality was generally good with later sowing dates (November and December) as compared to early months (January-February) which gave low quality seeds.

Jehangir Khan *et al.* (1994) reported that seed production was greatest from sowing on 1<sup>st</sup> November and with harvesting leaves once during the season and seed quality (germination %) was also highest in spinach.

Chaudhari *et al.* (1995) noticed that sowing date had significant effects on seed yield and quality in coriander. The highest seed yield (9.83 q/ha), 1000- grain weight (11.25g) viability (66.35%) and dry weight of 10 seedlings (30.12 mg) were obtained with sowing on 1<sup>st</sup> November.

Ranganayaki and Krishnaswamy (2001) reported that September sown crop produced the highest test weight and seed germination percentage compared to late sown crop sunflower.

Vyakaranahal *et al.* (2001) reported that early sowing in *kharif* (July) recorded 38.4 per cent higher processed seed yield higher yield attributes and seed quality parameters compared to late planting (August) in.

## 2.2 INFLUENCE OF INORGANIC FERTILIZER ON GROWTH, SEED YIELD AND QUALITY IN CARROT

Major nutrients like Nitrogen (N), Phosphorus (P<sub>2</sub>O<sub>5</sub>) and Potassium (K<sub>2</sub>O) play an important role in vegetative and reproductive phase of crop growth. Nitrogen is the component of protoplasm, protein, nucleic acid, chlorophyll and plays a vital role in both vegetative and reproductive phase of crop growth. Phosphorus is also an important constituent of nucleo proteins, high energy transfer compounds such as ATP and plays a key role in energy transfer in the metabolic processes. Potassium is involved in carbohydrate metabolism protein synthesis, regulation of activities of various essential elements, activation of various enzymes.

### 2.2.1 Influence of inorganic fertilizer on growth parameters

Chougule and Mahajan (1979) reported significantly higher number of branches per plant with application of 200:120:120 kg NPK per ha, while less number of branches were noticed with 100:60:60 kg NPK per ha.

Shyam (1986) noticed the delayed flower initiation (42.37 days) in marigold with the application of higher doses of NPK (275:140:120 kg/ha) and early flower initiation (36 days) with 225:120:60 NPK kg/ha.

Mishra (1987) obtained more plant height (170.0 cm) and number of branches (12.94) per plant when radish crop cv. Pusa Rashmi was nourished with 80, 40 and 40 kg of nitrogen, phosphorus and potassium per hectare respectively.

Singh *et al.* (1990) observed that application of 120 kg nitrogen per hectare increased the plant height (143.28 cm) and delayed the 50 per cent flowering (42.4 days). Whereas, significantly more number of branches (40.57) were noticed with the application of 80 kg nitrogen per hectare in radish cv. Japanese White.

Sharma and Kanaujia (1992) recorded more plant height (106 cm), number of branches (12.2), diameter of shoot (2.45 cm), delayed bolting (82.9 days) and flowering (100.2 days) with the application of 200 kg nitrogen per hectare in radish.

Application of N @ 112.5 kg per ha gave highest plant height (149.5 cm) and number of branches per plant (46.04) over control (no nitrogen) and it recorded 133.4 cm plant height and 39.47 branches per plant. Similarly, application of phosphorus @ 20 kg per ha gave

highest plant height (146.7 cm) while, P@ 40 kg per ha gave highest number of branches per plant (43.73). While, control (no P) recorded only 141.1 cm plant height and 42.73 branches per plant in case of radish (Gill *et al.*, 1995).

Sharma (1995) noticed that application of increased levels of N (30 to 120 kg/ha) significantly increased the days to 50 per cent flowering (34.2 to 39.0 days) in tomato, with basal dose of 30 and 60 kg P and K per ha respectively.

Shrivastava (1996) reported that initiation of flowering and 50 per cent flowering were delayed by four to six days in sweet pepper plants receiving 100: 250 :250 kg NPK per ha.

Mantur (1998) also observed delay in days to 50 per cent flowering (77 days) in aster with higher dose of NPK (240:180:125 kg / ha) over the lower dose of NPK 120:60:75 kg per hectare (71 days).

The delay in 50 per cent flowering was related to enhanced vegetative growth of plants. Revanappa *et al.* (1998) also noticed that number of days required for flowering were increased (78.00 to 30.56 days) with increase in N (130 to 250 kg /ha) and with basal dose 75 kg per ha each of P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O in chilli.

Jadhao *et al.* (1999) noticed that the application of 100 kg nitrogen, 50 kg phosphorus and 25 kg potash increased the plant height (147.8 cm) and number of branches (17.8) per plant in radish cv. Pusa Chetki.

Sharma (2000) noticed increased plant height (134.1 cm) with 200 kg nitrogen and 30 kg phosphorus per hectare whereas more number of branches (8.57) were observed with 150 kg nitrogen and 90 kg phosphorus per hectare in radish cv. Japanese White.

Atam Prakash *et al.* (2002) recorded maximum number of flower buds (1069 / plant) and number of flowers (7.00 / plant) due to application of FYM (10 t/ha) compared to control (8.20 and 5.98, respectively) in marigold.

## 2.2.2 Influence of inorganic fertilizer on yield and yield parameters

Dhesi *et al.* (1964) observed that the application of 25 kg phosphate per hectare to radish in conjunction with 25, 50 and 75 kg of nitrogen and 25 or 50 kg potash per hectare caused significant increase in root length and root diameter. Application of 50 kg each of nitrogen and potassium per hectare gave the highest yield in carrot.

Das *et al.* (1991) recorded highest seed yield (23.24 q/ha) with the application of 40 kg N per ha whereas yield was less (15.05 q / ha) in control (no N). Further increase in N levels resulted in progressive and gradual decline in growth and yield of coriander. A increase of 44.26 per cent in yield over control was possible by applying 40 kg N per ha due to enhanced photosynthetic activity and accumulation of carbohydrate which in turn was Translocated in larger amount to the seed resulting in heavier and bolder seeds. Yield had positive and significant correlation with yield contributing parameters such as number of umbels per plant and number of seeds per plant.

Singh *et al.* (1991) reported, more plant height (165.8 cm) with the application of 112.5 kg nitrogen and 40 kg phosphorus per hectare, whereas 75 kg nitrogen 20 kg phosphorus increased the number of umbels per plant (30.96) in carrot cv. Sel 21.

Tomer *et al.* (1994) obtained highest number of seeds per umbellate, stover yield, seed yield (18.20 q / ha) and umbellates per umbel with the application of 80:40:30 kg NPK per ha to coriander. The cost benefit ratio was 0.81 in control (0:0:0 kg NPK / ha) whereas, it was 1.34 when 80:40:30 kg NPK per ha was supplemented.

Application of N @ 112.5 kg per ha to radish produced highest seed yield per ha (11.06 q) over control (No N) which recorded 6.81 q per ha. Similarly, application of

phosphorus @ 20 kg ha produced highest seed yield (9.75 q / ha) over control (No P) which recorded 8.65 per ha (Gill *et al.*, 1995).

Application of NPK @ 100:50:25 kg per ha to radish produced highest number of pods per plant (568.9) and seed yield per ha (13.79 q) (Jadhao *et al.*, 1999).

### 2.2.3 Influence of inorganic fertilizer on Seed quality parameters

Harrington (1960) reported that, germination of carrot seeds, lettuce and pepper plants was adversely affected when grown under several nutrient deficiencies. Seed yield and percentage of normal seeds were depressed in soils with low nitrogen, phosphorus, potassium or calcium. Under storage conditions of seeds low in potassium and calcium content deteriorated in germinability factor than those of normal seeds.

Malik (1973) recorded higher seed germination (87.3 %) and 1000 seed weight (2.84 g) with the application of 56 kg nitrogen per hectare in carrot cv. Pb. No. 29.

Mangal *et al.* (1988) recorded significantly higher 1000 seed weight (11.50 g) with the application of 75 and 25 kg of nitrogen and phosphorus respectively in radish cv. RH-1.

Mantur (1998) did not observe any significant effect of NPK on germination percentage, root length, shoot length and vigour index of seedlings in China aster.

Das *et al.* (1991) recorded highest 1000 seed weight (8.94 g) with the application of 40 kg N per ha whereas, it was (7.68 g) in control (no N) in coriander.

Singh *et al.* (1991) obtained that, the application of 112.5 kg nitrogen and 40 kg phosphorus increased 1000 seed weight (4.00 g) and seed vigour index (4211) in carrot cv. Sel -1.

Jadhao *et al.* (1999) noticed higher test weight (11.57 g) and germination (97.0 %) with the application of 100 kg nitrogen, 50 kg phosphorus and 25 kg potash in radish cv. Pusa Chetki.

Malav and Yadav (1997) reported that application of N @ 120 kg per ha to coriander recorded highest 1000 locule weight (9.36g).

## 2.3 INFLUENCE OF ORGANIC FERTILIZER ON GROWTH, SEED YIELD AND QUALITY IN CARROT

Farmyard manure occupies an important position among organic manures. The cattle excrete based FYM in India can potentially supply approximately 33 million of N, P and K per year (Gaur, 1984). The FYM seems to act directly by increasing crop yield either by acceleration of respiratory process or by cell permeability or by hormone growth action. It supplies N, P and K in available forms to the plants through biological decomposition on dry weight basis; it contains 0.50, 0.17 and 0.55 per cent of N, P and K, respectively.

Vermicomposting is a process of recycling of organic wasters in an environmentally safe method. Vermicompost is a mixture of worm casts which are rich source of micro and macro nutrients. The worm casts apart from increasing the density of microbes, also provide the required nutrients to plants. It contains plant growth promoting substances such as NAA, cytokinins, gibberellins, etc. It also increases the efficiency of added fertilizers in soil. At Dharwad, it was revealed that the per cent N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O content of vermicompost was 0.80, 1.10 and 0.50 (Giraddi, 1997). In composition of FYM, Vermicompost contains two times more N and five times more P<sub>2</sub>O<sub>5</sub> (Purakayastha and Bhatnagar, 1997).

### 2.3.1 Influence of organic fertilizer on growth parameter

Sutagaundi (2000) reported that application of vermicompost at 2.50 t per ha took less number of days to 50 per cent flowering (42.80 days) compared to other organic and inorganic fertilizer treatments in chilli.

Reddy and Rao (2004) recorded higher vine length (225.80 cm), number of branches (11.00) per vine and fruit yield (7.99 t / ha) due to application of vermicompost at 30 t per ha compared to application of vermicompost at 10 t per ha (196.30 cm, 9.50 and 7.04t/ha, respectively) in bitter gourd.

### 2.3.2 Influence of organic fertilizer on yield and yield parameters

Mastiholi and Itanal (1997) revealed that application of vermicompost (2 t/ha) gave more grain yield (2132 kg) compared to control (1590 kg/ha) in rabi sorghum.

Ranwa and Singh (1999) in wheat noticed higher grain yield (3,835 kg/ha) with the application of vermicompost @ 10t/ha compared to 5 t/ha (3,578 kg/ha) in wheat.

Roy *et al.* (2004) reported in malt barley, increased plant height (92.8 cm) and grain yield (4.43 t/ha) with the application of vermicompost @ 10t /ha compared to control (88.20 cm and 4.02 t/ha, respectively).

Jitender and Singh (2005) observed that application of vermicompost at 15 tonnes per ha gave more yield (45.71 q/ha) compared to application of FYM at 15 t per ha (40.86 q/ha) in wheat.

### 2.3.3 Influence of organic fertilizer on seed quality parameter

Mahatwa Reddy *et al.* (1991) reported that in green gram application of FYM (8 t / ha) recorded higher 1000 seed weight (39.94 g) and seed yield (624 kg/ha) compared to control (38.22 and 526 kg/ha, respectively).

## 2.4 INFLUENCE OF ORGANIC AND INORGANIC FERTILIZERS ON GROWTH, SEED YIELD AND QUALITY IN CARROT

### 2.4.1 Influence of organic and inorganic fertilizers growth parameters

Damke *et al.* (1988) observed greater plant height of chilli with the application of FYM @ 9 t per ha along with 50 kg each of N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O compared to only NPK application

Surlekov and Rankov (1989) reported greater plant height (58.6 cm) and number of branches of capsicum (4.2) with the application of farmyard manure at 20 t per ha along with 1000:80:100 kg N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O per ha.

Natarajan (1990) reported higher plant height and number of branches per plant of chilli when FYM @ 25t per ha was applied as a basal dose along with 75:33:35 kg N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O per ha.

Balaji (1994) recorded increased plant height of china aster with the application of vermicompost (2.5t/ha) in combination with inorganic fertilizer.

Jasvir Singh *et al.* (1997) recorded greater plant height and number of branches per plant in chilli with the application of vermicompost at 10 tonnes per ha.

Shashidhara (2000) reported higher plant height (71.20 cm), number of branches (42.3 / hill) with application of vermicompost at 2.5 t per ha + 100 per cent RDF compared to application of 100 per cent RDF (65.20 cm and 40.20, respectively) in chilli.

Sutagundi (2000) observed early flowering (43.66 days) in plant receiving FYM at 10 t per ha compared to 100:50:50 kg NPK per ha (43.75 days) in chilli.

Sutagundi (2000) reported the higher plant height (99.79 cm) and number of branches (20.28) in chilli at 120 days after transplanting, when applied with vermicompost alone (84.06 cm, 15.17 branches / plant, respectively).

#### 2.4.2 Influence of organic and inorganic fertilizers on yield and yield parameters

Nair and Peter (1990) recorded the higher fruit number, fruit weight per plant and yield of chilli per ha with combined application of organic or inorganic sources and concluded that only organic or inorganic fertilizer sources did not increase yield of chilli but combined application was more effective in increasing yield of chilli. Application of FYM @ 5t per ha significantly increased yield over control (Anon., 1995).

Natarajan (1990) reported that higher fruit yield of chilli (1.83 t/ha) when FYM 25 tonnes per ha was applied as basal along with 75:35:35 kg NPK per ha.

Integrated application of recommended dose of NPK + FYM improved the growth parameters as well as yield and yield components in chilli (Mallanagouda *et al.*, 1995).

Jasvir Singh *et al.* (1997) recorded greater number of fruits per plant of chilli with the application of vermicompost @ 10.0 t per ha. Whereas, Patil (1995) observed that the inclusion of vermicompost along with 100 per cent RDF + FYM resulted in additional dry chilli yield of 1.68 q per ha.

Patil (1998) observed that the inclusion of vermicompost at 2.5 tonnes per ha along with 100 per cent RDF resulted in additional chilli yield of 1.68 q per ha.

Nirmala and Vaivel (1999) observed significant increase in number of fruits (9/vine), length of the fruits (11 cm), girth of the fruits (9 cm) and fruits yield (14.35 g/vine) with the application of 30 tonnes FYM along with 35 kg nitrogen per ha as compared to control in cucumber.

Shashidhara (2000) reported higher 1000 seed weight (5.84 g) by applying FYM at 5t per ha + 50 per cent RDF compared to 50 per cent RDF alone (5.02) g in chilli.

Subbarao and Ravisankar (2001) reported that the application of vermicompost along with NPK (100:60:60 kg / ha) recorded significantly higher fruit length (10.2 cm), number of fruits per plant (14.3) as compared to the NPK alone (8.8 cm, 14.0 and 9.64 t / ha, respectively) in brinjal.

#### 2.4.3 Influence of organic and inorganic fertilizers on seed quality parameters

Jeevansab (2000) reported significantly higher number of seeds (188.9) per fruit, seed weight per fruit (1.25 g) and seed weight (0.71 g) with the application of VC + RDF in capsicum.

Shashidhara (2000) reported higher 1000 seed weight (5.69 g) with the application of FYM (5 g / ha) + 50 per cent of RDF which is significantly superior over 50 per cent RDF (5.02 g) in chilli.

Sutagundi (2000) noticed significantly higher 100 seed weight (0.6 g) with application of FYM (10 t / ha) along with NPK (100:50:50 kg / ha) as compared to their individual

application in chilli. Shashidhara (2000) reported higher seed weight (5.84 g) by applying FYM (5 t / ha) + 50 per cent RDF compared to 50 per cent RDF alone (5.02 g) in chilli.

## 2.5 EFFECT OF SPACING (PLANT DENSITY) ON CROP GROWTH SEED YIELD AND QUALITY OF CARROT

### 2.5.1 Growth and growth parameters

Malik and Kanwar (1969) observed higher plant height (106.7 cm) at a row spacing of 45 cm, whereas higher numbers of branches (28.9/plant) were noticed with a wider row spacing of 75 cm in carrot.

Malik *et al.* (1983) reported a maximum plant height of 92.5 cm at 45 x 20 cm spacing when compared to two other spacings (45 x 30 x & 45 x 40 cm) in carrot Cv. Hissar Sel – 1.

As observed by Rastogi *et al.* (1987) the plants with closer spacing (60 x 30 cm and 60 x 45 cm) were significantly taller than those sown at wider spacing (60 x 60 cm). The maximum number of branches (14.5 / plant) were noticed at 60 x 45 cm and minimum (11.30) at the spacing of 60 x 30 cm in radish Cv. Japanese White.

Chatterjee and Som (1991) reported significantly superior gross weight of root (0.60 Kg) and number of branches per inflorescence stalk (6.85) at 40 x 20 cm spacing over its lower spacings (40 x 10 & 40 x 15 cm) in radish Cv. Improved Chinese Pink.

Ahmad and Tanki (1997) reported maximum plant height (113 cm) at 60 x 45 cm spacing over 60 x 30 (110 cm) and 60 x 60 cm (110 cm) spacing in carrot.

### 2.5.2 Influence of spacing on yield and Yield parameters

Malik and Kanwar (1969) obtained significantly higher seed yield (14.24 q/ha) at 60 x 30 cm spacing than wider spacing 75 x 30 cm (11.56 q/ha) in carrot.

Significantly higher seed yield (2.09 Kg/plot) at a spacing of 30 x 30 cm was observed when compared to wider spacing (60 x 30 cm and 90 x 30 cm) in carrot (Saini and Rastogi, 1976).

Gill *et al.* (1981) observed higher seed yield (553.17 g/plot) at a medium spacing of 50 x 30 cm compared to closer spacing of 40 x 30 cm (541.83 / plot) and wider spacing of 60 x 45 cm (424.16 g/plot) in carrot.

Maximum seed yield (11.34 q/ha) was recorded when the plants were spaced at 60 x 30 cm apart but increasing spacing reduced the seed yield, although the treatment differences were not significant in carrot (Sharma and Singh, 1981).

Malik *et al.* (1983) observed significantly higher seed yield (8.3 q/ha) at 45 x 20 cm spacing over 45 x 40 cm wider spacing in carrot. Seed yield at 45 x 30 cm spacing was on par with 45 x 20 cm spacing.

Lal and Pandey (1986) reported significantly higher seed yield (9.75 q/ha) at closer spacing of 30 x 30 cm over 45 x 35 (9.37 q/ha) and 75 x 75 cm (8.37 q/ha) in carrot.

Chatterjee and Som (1991) recorded significantly increased seed yield (18.55 q/ha) at 40 x 10 cm spacing over 40 x 15 cm (14.39 q/ha) and 40 x 20 cm (12.85 q/ha) in radish Cv. Improved Chinese Pink.

In carrot, Nazier Ahmad and Tanki (1997) observed the higher seed yield (12.44 q / ha), taller plants, more number of umbles with 60 x 30 cm spacing .

Malav and Yadav (1997) reported that 40 cm row spacing in coriander recorded highest number of umbels per plant (25.20) and seed yield per plant (3.58 g) while, 30 cm row spacing recorded highest seed yield per ha (12.44 q /ha).

### 2.5.3 Influence of spacing on seed quality parameters

Malik (1973) observed higher germination (90.0%) and thousand seed weight (2.74 g) when seed production was taken at a spacing of 75 × 30 cm when compared to other spacings (45 x 30 cm and 60 x 30 cm) in carrot Cv. Pb. No. 29.

According to Sharma and Singh (1982), maximum 1000 seed weight (2.0 g) and germination percentage (87.50%) were observed at 60 x 60 cm spacing over 60 x 15, 60 x 30 cm and 60 x 45 cm spacings in carrot Cv. Pusa Kesar.

Malik *et al.* (1983) noticed maximum 1000 seed weight (3.8 g) and germination (78.9%) at 45 x 40 cm spacing over other spacing (45 x 20 and 45 x 30 cm) in carrot Cv. Hissar SEI -1.

## 2.6 INFLUENCE OF GROWTH REGULATORS ON GROWTH, SEED YIELD AND QUALITY PARAMETERS IN CARROT

It is well established and documented that normal plant growth and development is controlled by chemicals synthesized by the plant itself. The production of these chemicals is under genetic control and these are called as growth regulators. In modern agriculture growth regulators are being used widely for increased agricultural production at an unprecedented rate by modifying its source to sink relationship (Nickell, 1982).

Plant growth regulators are involved in coordinating the development of specific plant organs and in controlling plant responses in relation to variable environment and crop management. The plant growth regulators are natural or synthetic compounds applied to the target plants to modify the developmental, morphological structure or both by manipulating the hormonal levels in different plant organs and at various stages in the plant life cycle so as to enhance its seed yield and quality (Setia *et al.*, 1991).

### 2.6.1 Influence of GA<sub>3</sub> on growth parameters

Increase in growth of carrot seed plant was observed by Joshi *et al.* (1975) on treatment with GA<sub>3</sub> at 100 and 200 ppm.

Dipping of root of five week old onion seedlings for 24 hours in GA<sub>3</sub> (40 ppm) solution produced highest number of leaves compared to control (Singh *et al.*, 1983). Whereas, Tomer *et al.*, (1988) also observed that the foliar application of GA<sub>3</sub> (200 ppm) at 120 DAS significantly increased the number of leaves per plant as compared to control in onion. Salah and Abd (1989) indicated that the application of GA<sub>3</sub> increased the number of leaves per plant significantly in onion.

Nandekar and Sawarkar (1992) reported that the roots of six week old onion seedlings dipped in (GA<sub>3</sub> 40 ppm) solution increased the number of leaves per plant significantly as compared to control. Similar results were also obtained by Nirmal *et al.* (1994) with GA<sub>3</sub> at 30 and 60 ppm in onion. Shashank Singh *et al.* (1995) noticed that the dipping of onion bulbs in GA<sub>3</sub> (300 ppm) increased number of leaves to a greater extent as compared to other treatments. Maximum number of leaves per plant produced when roots of six weeks old onion seedlings were dipped in GA<sub>3</sub> (50 ppm) solution (Shakhda and Gajipara, 1998).

Shashank Singh *et al.* (1995) recorded the maximum plant height with GA<sub>3</sub> (150 – 300 ppm) in onion. Similarly the maximum mean plant height was recorded with GA<sub>3</sub> (50 ppm) in onion by Shakhda and Gajipara (1998), Whereas, Gupta *et al.* (1997) observed that, an increase in the plant height (112 to 112 cm) of brinjal with increase in GA<sub>3</sub> concentration

from 100 to 300 ppm as compared to control.

Lone *et al.*, (2005) reported that more number of fruits (90.23) per plant and dry fruit yield (1680.31 kg) per ha was observed in GA<sub>3</sub> 250 ppm compared to GA<sub>3</sub> 100 ppm (83.72 and 1584.54 kg, respectively) in chilli.

### 2.6.2 Effect of GA<sub>3</sub> on yield and yield parameters

Seed yield was increased with application of GA<sub>3</sub> in many corps. Harrington (1960) reported that spraying of GA<sub>3</sub> (3 – 10 ppm) on lettuce plant at 4 and 8 leaf stage significantly increased the seed yield. With these treatments the seed crop matured two weeks earlier with extremely uniform maturity among plants. Similar results were reported by Shafi (1971) and Mukhanova and Trebukhina (1975) in lettuce.

There was an increase in onion seed yield by 30 – 40 per cent with application of GA<sub>3</sub> (Kruzilin and Svedskaja, 1963). Loper and Waller (1982) also reported that spraying of GA<sub>3</sub> (25, 50 or 500 ppm) on onion Cv. White Creole resulted in significant increase in seed yield. Comparison of seed yield obtained from control plots to treated plots showed that only GA<sub>3</sub> 50 ppm was significantly effective in increasing the seed yield of onion.

A combination of root soaking and foliar spray of GA<sub>3</sub> (100 ppm), to non bolting cultivars of carrot produced a higher percentage of flower than did spraying alone (Globerson, 1972).

Chandra and Shivaraj (1972) observed the greater reduction in flower drop (50.0%) with two times foliar spray of GA<sub>3</sub> (25 ppm) at 25 and 50 DAT compared to water spray (67.8%) in chilli.

Different method of application of GA<sub>3</sub> resulted in increased flowering of onion. Loper and Waller (1982) observed that spraying of onion Cv. While Creole with GA<sub>3</sub> at 25, 50 or 500 ppm induced bolting especially at the higher rate. Whereas, Vananagamudi *et al.*, (1988) found that soaking onion seeds with GA<sub>3</sub> (100 ppm) for three hours increased flowering in onion Cv. Rampur Local. While gibberellic acid injection prior to chilling increased the flowering percentage in some genotypes of onion under controlled conditions (Brewster and Butler, 1989).

Ruggeri and Branca (1993) opined that GA<sub>3</sub> (400 ppm) spraying improved flower induction and enhanced percentage of flowered plants in onion. Turnip took less number of days to 50 per cent bolting with GA<sub>3</sub> (400 ppm) (Mohammed Hussain *et al.*, 1988).

### 2.6.3 Effect of GA<sub>3</sub> on seed quality parameters

Harrington (1960) reported that, GA<sub>3</sub> spray on growing plants of lettuce had no effect on germination of the resulting seed. The carrot plants received a foliar spray of GA<sub>3</sub> (250 ppm) produced higher per cent (98.0) of filled seed and germination.

Banker (1980) noticed increased percentage of germination in seeds treated with GA<sub>3</sub> in winter annuals. Significantly higher seed germination percentage and shoot length were recorded with foliar spray of GA<sub>3</sub> (25 ppm) on tomato, over control (Balakumar and Balasubramanian, 1988).

Agwah *et al.* (1994) reported higher germination of harvested seeds treated with GA<sub>3</sub> (100 ppm) in onion Cv. Giza improved. The maximum seed germination percentage was observed with GA<sub>3</sub> at 200 ppm (90.83) as compared to control (88.5) (Shinde, 1994). Highest seed germination percentage and seedling vigour in onion were recorded with GA<sub>3</sub> (25 ppm) spray at 30 days after planting (Wagh and Deore, 1995). Improvement in germination percentage was observed with application of GA<sub>3</sub> (100 – 400 ppm) to turnip (Mohammed Hussain *et al.*, 1998).

## 2.7 INFLUENCE OF NAPHTHALENE ACETIC ACID ON GROWTH, SEED YIELD AND QUALITY PARAMETERS IN CARROT

NAA i.e. alpha - Naphthalene acetic acid, belongs to the auxin group of growth regulators. It is a synthetic auxin. Activity of the naphthalene acid was first observed by Zimmerman *et al.* (1936).

Auxin are essential for enlargement and development of ovary into a fruit (Salisbury and Ross, 1969). Actually auxins are synthesized in the stem and root apices and transported through the plant axis. They are characterized principally by their capacity to stimulate stem elongation in excised stem and coleoptile section, but also influence a host of other development responses, including root initiation, vascular differentiation, tropic responses and the development of auxilliary buds, flowers and fruits.

### 2.7.1 Influence of NAA on growth parameters

Goudappalavar (2000) reported significantly higher plant height (115.7 cm) with NAA 100 ppm sprayed at 50 per cent flowering stage as compared to control (70.6 cm) in tomato.

Chattopadhyay and Sen (1974) reported that, spraying of 70 ppm NAA at pre bloom stage not only increased short styled flowers of chilli but also increased the per cent fruit set (51.92%) compared to water spray (32.92%).

Pandita *et al.* (1980) reported that, spraying of 10 ppm NAA at flowering stage and three weeks later produced significantly more plant height (62.12 cm) over water spray (49.46 cm) in chilli.

Maurya and Lal (1987) reported that, chilli plants sprayed with NAA (150ppm) at flowering and 15 days interval for three times recorded the highest plant height (63.05 cm) while the lower plant height (49.16 cm) was observed in water spray.

Doddamani (1988) also recorded increased plant height of chilli crop with 20 ppm NAA spray at pre-bloom stage over unsprayed plants. Similarly, Hulamani (1989) recorded significantly more plant height in chilli with 10 ppm NAA. There was an increase in plant height, number of branches, stem diameter of capsicum plants after spraying with NAA at 50 or 100 ppm (Dod *et al.*, 1989).

Singh *et al.* (1990) stated that spraying of NAA at 10 ppm at 40 and 60 days after transplanting recorded higher number of branches per plant (10.0) against water spray (8.9) in chilli.

Nandekar and Sawarkar (1992) opined that application of NAA (40 ppm) gave highest number of leaves per plant as compared to control in onion.

Lata and Singh (1993) sprayed NAA (20, 40 and 60 ppm) at 30 and 60 days after transplanting and observed that the fruit set was higher (42.75%) with 40 ppm NAA and beyond this concentration; the fruit set percentage reduced greatly in chilli.

Shashank Singh *et al.*, (1995) recorded increased plant height, number and size of leaves in onion with NAA (300 ppm). Similar results were also reported in radish with NAA (150 ppm) spray at bolting (Sharma, 1995). Significantly increased dry weight was also reported with NAA (100 ppm) in onion (Padmavati, 1998).

### 2.7.2 Influence of NAA on yield and yield parameters

Chattopadhyay and Sen (1974) sprayed 50 and 75 ppm NAA at prebloom stage and observed the higher fruit length (4.00 cm) by application of 50 ppm NAA in chilli.

Application of planofix (NAA) either as seed treatment or spray at early stages of growth induced early flowering in chilli (Chandramony and George, 1976). Increased seed yield upto 41 per cent was noticed in chilli with 50 ppm NAA spray twice at full bloom and 20 days later (Mote *et al.*, 1975).

Hulmani (1988) obtained significantly increased mean fruit length (9.07 cm) of chilli by spraying of NAA 20 ppm at 40 and 60 days after transplanting as against water spray (8.21 cm). Increased fruit size due to NAA application was ascribed to its involvement in high rate of cell-division and cell-elongation or both and also due to translocation of metabolites from source to sink.

Lata and Singh (1993) reported that foliar spray of NAA (20 – 60 ppm) at 30 and 60 days after transplanting recorded higher number of fruit per plant (155) as compared to the water spray (120) in chilli.

Revanappa (1993) noticed that foliar spray of NAA at 10 and 40 ppm recorded fruit girth of 1.43 and 1.49 cm respectively as compared to the water spray (12.6 cm) in chilli.

Gedam *et al.* (1996) stated that the number of seeds per fruit (340) and seed yield per ha (789.3 kg) increased significantly due to spraying of NAA 50 ppm compared to control (184 and 459.4 kg) in onion and bitter gourd respectively.

Alagukannan and Vijayalakumar (1999) reported that NAA spray @ 20 ppm to fenugreek recorded highest seed yield per plot (390 g) and seed yield per ha (702 kg).

Gollagi (1999) observed increased number of seeds per fruit (85.2) with application of 100 ppm NAA at 45 and 65 DAT against unsprayed plants (63.3) in chilli.

### 2.7.3 Influence of NAA on seed quality parameters

Mantur (1998) reported that application of NAA to foliage of china aster Cv. Ostrich Plume mix improved the seed quality with respect to germination percentage, 1000 seed weight, shoot and root length of seedlings and vigour index. The germination percentage and vigour index were maximum with 2000 NAA during two seasons.

Singh and Gulshan Lal (1995) sprayed NAA (10 to 80 ppm) at 40 and 60 days after transplanting and reported that higher (66.1%) seed germination in chilli was recorded with 20 ppm NAA compared to water spray (56.1%).

Bhat and Singh (1996) reported that GA<sub>3</sub> application @ 200 ppm to Okra seed crop recorded highest germination (79.90%), seed vigour (6.41).

Gedam *et al.* (1996) recorded significantly higher number of seeds (27.41 / fruit), 100 seed weight (21.42 g), germination (68.00%) and vigour index (2111) with foliar spray of NAA 100 ppm as compared to control (26.25, 30.12 g, 63.0 and 1975 respectively) in bitter gourd.

### III. MATERIAL AND METHODS

A field experiment was carried to study the effect of date of sowing, nutrition, plant geometry and application of growth regulator on growth, seed yield and quality in carrot (*Daucus carota*) cv. Pusa kesar. The studies were initiated at the Main Agricultural Research station, University of Agricultural Sciences, Dharwad. The details of the materials used and experimental techniques adopted during the course of investigation are presented in this chapter.

#### 3.1 EXPERIMENTAL SITE

The field experiment was carried out in Weed science block of Agricultural Sciences, Dharwad which is situated in the transitional tract of Karnataka state at 15°12' N latitude with an altitude of 678 m above mean sea level.

#### 3.2 CLIMATIC CONDITIONS

The meteorological data during the crop growth period (2005) and mean of the previous 50 years were collected from the meteorological observatory, agriculture college, University of agricultural sciences, Dharwad and are presented in Appendix I.

#### 3.3 SOIL

The experiment was laid out in medium black clay loam soil (Appendix II).

#### 3.4 EXPERIMENTAL DETAILS

**3.5 EXPERIMENT I** : Effect of date of sowing and nutrition, on growth, seed yield and quality of carrot Cv. Pusa kesar.

##### 3.5.1 Treatment details

The experiment was conducted under factorial randomized block design. There were 20 treatment combinations comprising four dates of sowing and five nutrition levels. The details are as follows.

Factor I: Date of sowing (S)

D<sub>1</sub> – August 15<sup>th</sup>

D<sub>2</sub> - September 1<sup>st</sup>

D<sub>3</sub> - September 15<sup>th</sup>

D<sub>4</sub> - October 1<sup>st</sup>

Factor II: Nutrition (N)

N<sub>1</sub> – 75: 62.5: 50 NPK kg per ha (RDF)

N<sub>2</sub> –RDF (50 %) + FYM (50 %)

N<sub>3</sub> – FYM 100 % (5t / ha)

N<sub>4</sub> – RDF (50 %) + vermicompost (50 %)

N<sub>5</sub> – Vermicompost 100 % (12.5 t / ha)



**Plate 1. General view of the experimental plot**

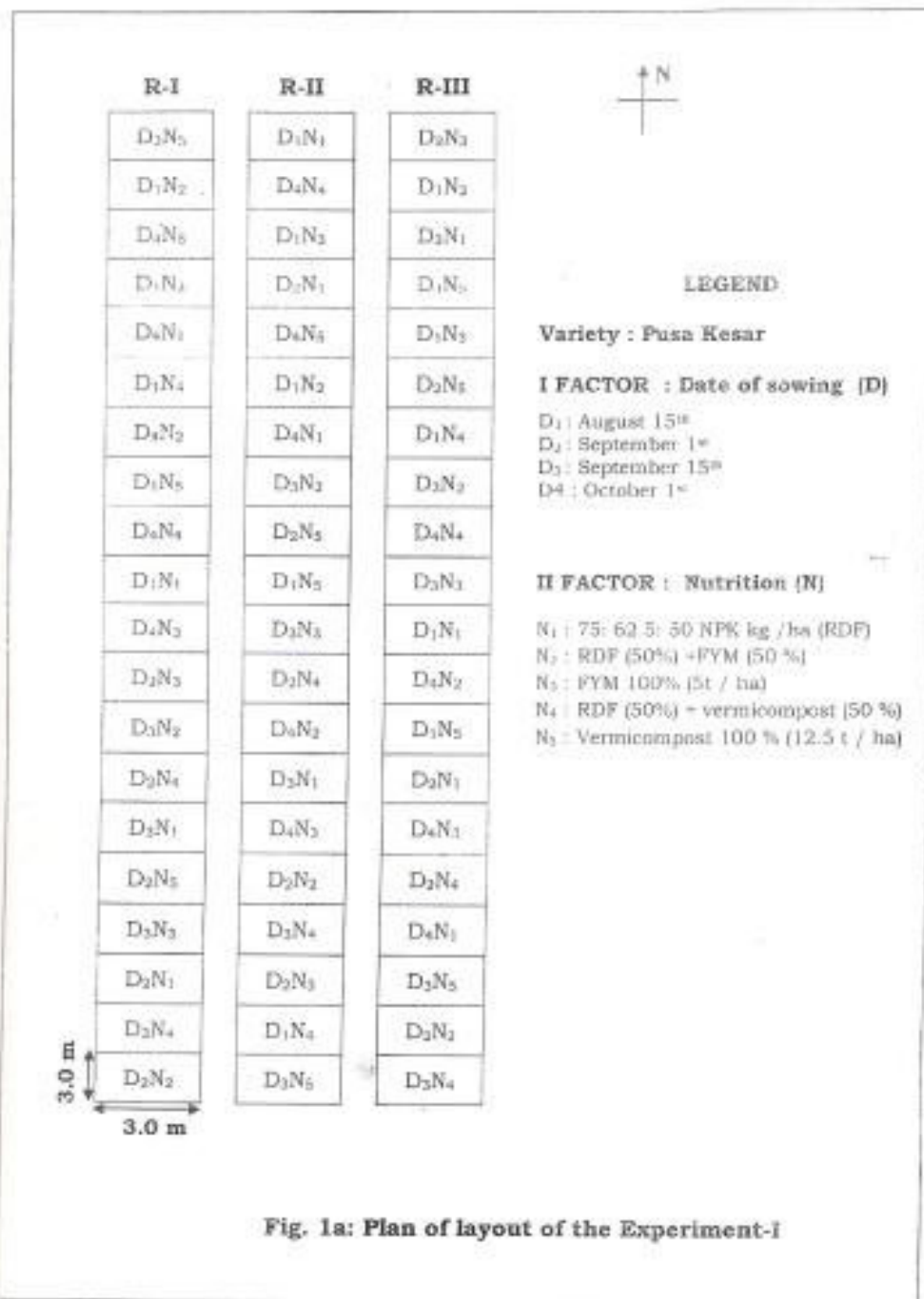


Fig. 1a: Plan of layout of the Experiment - I

Plot size

Gross plot size : 3.0 x 3.0 m

Net plot size : 2.0 x 2.0 m

### 3.6 CULTIVAR DESCRIPTION

Carrot Cv. Pusa kesar is a variety selected from a cross between local red and Nantes half long i.e., progeny of cross between desi and European types. Desi types are annuals and have early root development, while European types are biennials. The leaf top is markedly shorter than that of local red. The roots of Pusa kesar develop a narrow central core and the core is also sufficiently red coloured, unlike the yellow or white core in local Red. A notable feature of Pusa kesar is that, the roots stay about a month longer without showing any sign of bolting. The percentage of forked roots is also significantly lower than the local red. It has higher carotene content as compared to local and the roots become ready for harvesting in 80 to 85 days.

### 3.7 CULTURAL PRACTICES IN BRIEF

#### 3.7.1 Land preparation

The land was ploughed and harrowed twice after the harvest of previous crop followed by planking to bring the soil to a fine tilth.

#### 3.7.2 Application of fertilizers

The crop was fertilized with nitrogen, phosphorus and potassium at 75: 62.5: 50 kg / ha in the form of urea, single super phosphate and muriate of potash, respectively as basal dose.

#### 3.7.3 Spacing

Inter – row spacing : 22.5 cm

Intra – row spacing : 10.0 cm

#### 3.7.4 Sowing

Sowing was done at fifteen days interval on August 15<sup>th</sup>, September 1, September 15<sup>th</sup> and October 1<sup>st</sup>. Seeds were hand dibbled at a depth of about 2 cm in the soil. Thinning was done at 20 days after sowing by retaining one seedling per hill.

#### 3.7.5 Inter cultivation

In order to keep the soil porous and also free from weeds, regular intercultivation operations were carried out. Hand weeding was done as and when the weeds were seen to keep the plot clean and free from weeds competition.

#### 3.7.6 Irrigation

Two irrigations were given up to germination and there after the crop was irrigated at 8-10 days intervals depending upon the soil condition.

#### 3.7.7 Plant protection chemical

To control the pest and diseases, necessary plant protection measures were taken up as per the recommended package of practices for carrot.

### 3.7.8 Harvesting

The genotypes Pusa kesar cultivar harvested when umbels (heads) were fully ripped. All umbels were collected and were dried for 5-6 days under open sunlight. While drying, turning of the material from bottom to top was made for uniform drying. The seeds were separated by beating the dried umbels with sticks seeds were winnowed well blowing against wind. The seeds were cleaned and dried to 8.0 per cent moisture.

**3.8 EXPERIMENT II:** Effect of plant geometry and growth regulator on growth, seed yield and quality of carrot Cv.Pusa kesar.

#### 3.8.1 Treatment details

Factor I : Plant spacing(S)

S<sub>1</sub> – 30 x 20 cm

S<sub>2</sub> – 40 x 15 cm

S<sub>3</sub> – 60 x 10 cm

Factor II : Growth regulator (G)

G<sub>1</sub> – GA<sub>3</sub> (200 ppm)

G<sub>2</sub> – GA<sub>3</sub> (300 ppm )

G<sub>3</sub> – NAA (200 ppm)

G<sub>4</sub> – NAA (300 ppm )

G<sub>5</sub> – Water spray

#### 3.8.2 Collection for experimental data

Five plants were selected randomly from each plot and tagged for recording the observations on growth, seed yield and quality parameters as mentioned below.

#### 3.8.3 Growth parameters

##### 3.8.3.1 Plant height (cm)

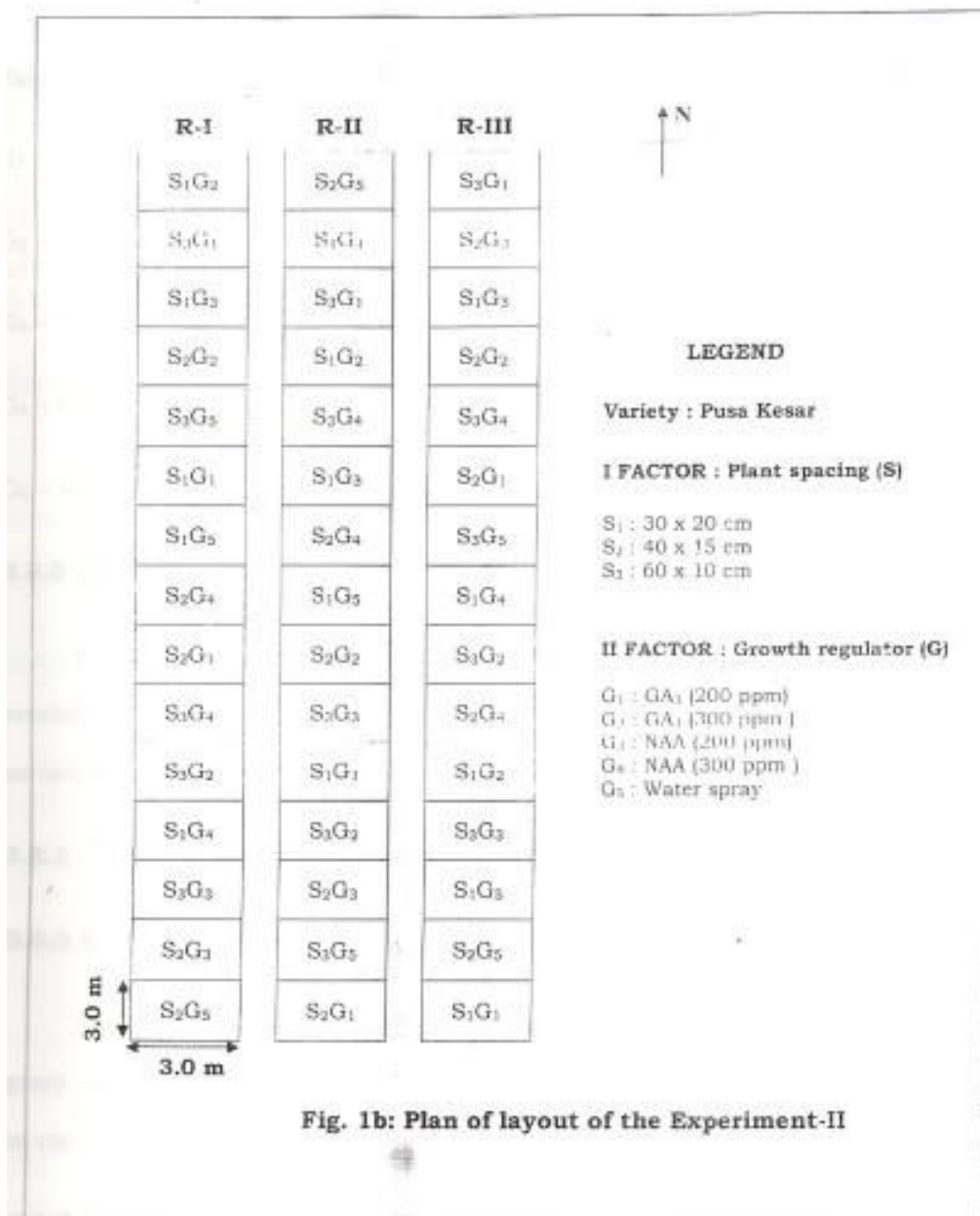
Plant height was recorded from base of the plant to the top of the plant at flower initiation and average plant height was then expressed in cm.

##### 3.8.3.2 Number of leaves per plant

The numbers of leaves in five tagged plants were counted at flower initiation and the average value was worked out.

##### 3.8.3.3 Days to 50 per cent flowering

The days required for attaining the 50 per cent flowering was judged, when 50 per cent flowering in selected plants initiated flowering.



**Fig. 1b: Plan of layout of the Experiment-II**

**Fig. 1b: Plan of layout of the Experiment -II**

### 3.8.4 Yield and yield parameters

#### 3.8.4.1 Root length (cm)

The length of the carrot root of five randomly selected plants at flower initiation was measured from the base of the root to top of the root and average root length was expressed in cm.

#### 3.8.4.2 Root diameter (cm)

The circumference of five roots selected randomly at five flower initiation at the basal portion of the root was measured with the help of thread and scale and the average root diameter was expressed in cm

#### 3.8.4.3 Root weight (g)

The fresh weights of randomly selected five roots at flower initiation were recorded and the average fresh weight of root was expressed in grams.

#### 3.8.4.4 Number of Umbels per plant

All the umbels on the five plants were counted after harvest and their average was taken as number of umbels per plant.

#### 3.8.4.5 Number of seeds per umbel

Five umbelletes selected from each of the five umbels for recording number of umbelletes per umbel were used for taking this observation. Total numbers of seeds were counted and their average was expressed as number of seeds per umbel.

#### 3.8.4.6 Umbel diameter (cm)

The circumference of five umbels selected randomly from five plants was measured with the help of thread and scale and the average umbel diameter was expressed in cm.

#### 3.8.4.7 Seed yield per plant (g)

The seed weight of five randomly selected plants was recorded and the mean was expressed as seed weight per plant in gram.

#### 3.8.4.8 Seed yield per plot (g) and hectare (kg)

The seed yield per net plot was recorded by pooling the seed yield of all the plants in each treatment of each replication separately and expressed in kilograms seed yield per hectare was computed based on net plot seed weight.

## 3.9 SEED QUALITY PARAMETERS

### 3.9.1 1000 seed weight

Thousand seed weight was recorded as per the procedure given by ISTA rules (Anon., 1996). The average weight was recorded and expressed in gram.

### 3.9.2 Seed germination (%)

The standard germination test was conducted by following paper towel method (Between paper) as prescribed by the International Seed Testing Association, (Anon., 1996). Germination was conducted by using 400 (100x4) seeds from each treatment. Germination

papers were sterilized by keeping in hot air oven. The rolled towels were placed in germination at  $25^{\circ}\text{C} \pm 1^{\circ}\text{C}$  seedlings were evaluated on 7<sup>th</sup> day and 12<sup>th</sup> day. Final germination was calculated on the basis of normal seedlings obtained in the final count.

### 3.9.3 Speed of germination

The daily germination count was made up to final count. The germination rate index or germination speed was calculated by using the following formula (Heydecker, 1969).

$$\text{GRI} = + \frac{G_1}{T_1} + \dots + \frac{G_n}{T_n}$$

Where,

$G_1, G_2, \dots, G_n$  = Number of seeds germinated

$T_1, T_2, \dots, T_n$  = Number of days taken for germination.

### 3.9.4 Root length and shoot length (cm)

From the standard germination test, ten normal seedlings from each replication as per treatment were randomly selected on the day of final count. The length of shoot and root was measured from collar region of the seedling and expressed in centimeters.

### 3.9.5 Vigour Index (VI)

The vigour index was determined by multiplying the percentage germination with the mean shoot and root length in centimeters (Abdul Baki and Anderson, 1973).

Vigour index = Mean[shoot length (cm) + root length (cm)]  $\times$  Mean germination (%)

### 3.9.6 Seedling dry weight (mg)

Ten seedlings selected for shoot and root length were dried in hot air oven maintained at  $110^{\circ}\text{C}$  for 17 hours, then cooled in a desiccators and mean seedling dry weight was recorded and expressed in milligrams .

### 3.9.7 Field emergence (%)

Seeds in four replications (100  $\times$  4) of each treatment were sown in the field. The field emergence was recorded on eleventh day after sowing. The total emergence was expressed in percentage.

### 3.9.8 Statistical analysis

The data was subjected analysis of variance following Panse and Sukhatme (1967). The level of significance used in P and T tests was  $P= 0.05$ . Critical differences were calculated wherever F test was found significant.

## IV. EXPERIMENTAL RESULTS

### 4.1 EXPERIMENT I: EFFECT OF DATE OF SOWING AND NUTRITION ON GROWTH SEED YIELD AND SEED QUALITY PARAMETERS

#### 4.1.1 Growth parameters

##### 4.1.2 Plant height (cm)

Data on mean plant height as influenced by date of sowing, nutrition at flower initiation stage of carrot are presented in Table 1.

Plant height measured at flower initiation was influenced by sowing dates. Significantly higher plant height (88.1 cm) was recorded in D<sub>2</sub> i.e., second sowing over D<sub>3</sub> i.e., third sowing (82.6 cm), D<sub>4</sub> fourth sowing (79.3 cm) and was on par with D<sub>1</sub> i.e., first sowing (86.9 cm). While D<sub>4</sub> recorded significantly lower plant height over D<sub>1</sub>, D<sub>2</sub> and D<sub>3</sub>.

Plant height differed between the different treatments at flower initiation stage. Significantly highest plant height (89.7 cm) was recorded in N<sub>4</sub> (50% RDF+ 50% VC) which was on par with N<sub>2</sub> (50% RDF+ 50% FYM) (89.2 cm) and significantly higher over N<sub>1</sub> (100% RDF) (84.5 cm), N<sub>5</sub> (100% VC) (79.7 cm), N<sub>3</sub> (100% FYM) (78.2 cm), respectively.

Interaction effect between the date of sowing, nutrition was non significant with respect to plant height at flower initiation stage.

##### 4.1.3 Number of leaves

The data on number of leaves at flower initiation as influenced by date of sowing, nutrition are presented in table 1.

Significantly higher number of leaves (14.40) were recorded at D<sub>2</sub> over D<sub>1</sub> (13.74), D<sub>3</sub> (12.58) and D<sub>4</sub> (11.50) at flower initiation. Significantly lower numbers of leaves were recorded in D<sub>4</sub> over D<sub>1</sub>, D<sub>2</sub> and D<sub>3</sub>.

Nutrition level influenced the number of leaves significantly, N<sub>4</sub> recorded significantly higher number of leaves (15.35), over N<sub>2</sub> (14.50), N<sub>1</sub> (12.98), N<sub>5</sub> (11.98) and N<sub>3</sub> (10.48) at flower initiation.

Interaction effect between the dates of sowing, nutrition was non-significant with respect to number of leaves.

##### 4.1.4 Days to 50 per cent flowering

The data on days to 50 per cent flowering was non-significantly influenced by date of sowing and nutrition level (Table 2).

Numerically lower number of days were taken for 50 per cent flowering by D<sub>4</sub> (115.6) as compared D<sub>2</sub> (121.5), D<sub>1</sub> (121.9) and D<sub>3</sub> (119.9) days.

Nutrition level did not influence the number of days to 50 % flowering However, numerically higher number of days took by N<sub>4</sub> (115.18) compared to N<sub>2</sub> (118.95), N<sub>1</sub> (120.78), N<sub>5</sub> (121.20), N<sub>3</sub> (122.63) respectively. Recorded more number of days to 50 % flowering in N<sub>5</sub>.

Interaction effect between the date of sowing and nutrition was non-significant with respect to days to fifty per cent flowering.

### 4.2 YIELD AND YIELD PARAMETERS

#### 4.2.1 Root length (cm)

The data on root length as influenced by date of sowing and nutrition are presented in table 2.

Root length of carrot was significantly influenced by date of sowing and nutrient level.

**Table 1. Effect of date of sowing and nutrition on plant height (cm) and number of leaves of carrot Cv. Pusa kesar**

Nutrition(N)	Plant height (cm)					Number of leaves				
	Date of sowing(D)				Mean	Date of sowing(D)				Mean
	D <sub>1</sub>	D <sub>2</sub>	D <sub>3</sub>	D <sub>4</sub>		D <sub>1</sub>	D <sub>2</sub>	D <sub>3</sub>	D <sub>4</sub>	
N <sub>1</sub> - Control (RDF)	87.2	88.1	82.9	79.7	<b>84.5</b>	13.70	14.30	12.70	11.20	<b>12.98</b>
N <sub>2</sub> - 50% RDF + 50% FYM	91.9	92.8	88.0	84.0	<b>89.2</b>	15.30	15.90	13.90	12.90	<b>14.50</b>
N <sub>3</sub> - 100% FYM	80.5	81.9	76.0	74.4	<b>78.2</b>	10.90	11.40	10.20	9.40	<b>10.48</b>
N <sub>4</sub> - 50% VC + 50% RDF	92.6	93.4	88.4	84.3	<b>89.7</b>	16.00	16.90	14.90	13.60	<b>15.35</b>
N <sub>5</sub> - 100% VC	82.4	84.4	77.9	74.1	<b>79.7</b>	12.80	13.50	11.20	10.40	<b>11.98</b>
<b>Mean</b>	<b>86.9</b>	<b>88.1</b>	<b>82.6</b>	<b>79.3</b>	<b>84.3</b>	<b>13.74</b>	<b>14.40</b>	<b>12.58</b>	<b>11.50</b>	<b>13.15</b>
For comparing means of	S.Em±				CD (0.05)	S.Em±				CD (0.05)
Date of sowing(D)	1.39				3.97	0.29				0.83
Nutrition (N)	1.55				4.44	0.32				0.92
Interaction (N x D)	3.10				NS	0.65				NS

D<sub>1</sub> - 15<sup>th</sup> August

D<sub>2</sub> - 1<sup>st</sup> September

D<sub>3</sub> - 15<sup>th</sup> September

D<sub>4</sub> - 1<sup>st</sup> October

RDF - Recommended dose of fertilizers

FYM - Farm yard manure

VC – Vermicompost

**Table 2. Effect of date of sowing and nutrition on days to 50 % flowering and root length (cm) of carrot Cv. Pusa kesar**

Nutrition(N)	Days to 50 % flowering					Root length (cm)				
	Date of sowing(D)				Mean	Date of sowing(D)				Mean
	D <sub>1</sub>	D <sub>2</sub>	D <sub>3</sub>	D <sub>4</sub>		D <sub>1</sub>	D <sub>2</sub>	D <sub>3</sub>	D <sub>4</sub>	
N <sub>1</sub> - Control (RDF)	123.3	122.2	120.4	117.2	<b>120.78</b>	22.80	23.90	21.10	19.60	<b>21.85</b>
N <sub>2</sub> - 50% RDF + 50% FYM	122.2	120.7	118.7	115.2	<b>118.95</b>	24.20	25.20	22.80	21.10	<b>23.33</b>
N <sub>3</sub> - 100% FYM	125.9	123.9	123.6	117.1	<b>122.63</b>	20.00	26.60	17.30	14.41	<b>18.08</b>
N <sub>4</sub> - 50% VC + 50% RDF	118.5	116.7	115.1	110.4	<b>115.18</b>	25.10	26.60	23.70	22.80	<b>24.55</b>
N <sub>5</sub> - 100% VC	120.6	124.0	121.8	118.4	<b>121.20</b>	19.80	20.90	20.40	19.70	<b>20.20</b>
<b>Mean</b>	<b>121.90</b>	<b>121.50</b>	<b>119.92</b>	<b>115.66</b>	<b>119.75</b>	<b>22.38</b>	<b>23.44</b>	<b>21.06</b>	<b>19.52</b>	<b>21.60</b>
For comparing means of	S.Em±				CD (0.05)	S.Em±			CD (0.05)	
Date (D)	1.73				NS	0.40			1.16	
Nutrition (N)	1.94				NS	0.45			1.29	
Interaction (N x D)	3.87				NS	0.90			NS	

D<sub>1</sub> - 15<sup>th</sup> August

D<sub>2</sub> - 1<sup>st</sup> September

D<sub>3</sub> - 15<sup>th</sup> September

D<sub>4</sub> - 1<sup>st</sup> October

RDF - Recommended dose of fertilizers    FYM - Farm yard manure

VC-Vermicompost

Among the four different dates of sowing significantly higher root length (23.44 cm) was recorded in D<sub>2</sub> over D<sub>3</sub> (21.06 cm) and D<sub>4</sub> (19.52 cm) but D<sub>2</sub> was on par with D<sub>1</sub> (22.38 cm), respectively.

Among the different nutrition level, significantly higher root length was recorded in N<sub>4</sub> (24.55 cm) over N<sub>3</sub> (18.08 cm), N<sub>1</sub> (21.85 cm), N<sub>5</sub> (20.20 cm) and was on par with N<sub>2</sub> (23.33 cm).

Interactions effect between the date of sowing and nutrition was non-significant with respect to root length.

#### 4.2.2 Root weight (g)

Root weight was significantly influenced by date of sowing and nutrition and but not with their interactions which is presented (table 3).

Significantly higher root weight (76.02 g) was recorded in D<sub>2</sub> over D<sub>3</sub> (69.14 g), D<sub>4</sub> (65.16 g) and was on par with D<sub>1</sub> (73.10 g).

Significantly higher root weight (78.08 g) was recorded in N<sub>4</sub> over N<sub>3</sub> (63.98 g), N<sub>5</sub> (66.68 g), N<sub>1</sub> (70.45 g) and was on par with N<sub>2</sub> (75.10 g).

Interaction effect was not significant between the date of sowing and nutrition with respect to root weight.

#### 4.2.3 Root diameter (cm)

Root diameter was significantly influenced by date of sowing and nutrition level (Table 3).

Significantly higher root diameter (12.38 cm) was recorded in D<sub>2</sub> over D<sub>3</sub> (10.67 cm), D<sub>4</sub> (9.59 cm) but was on par with D<sub>1</sub> (11.59 cm).

Significantly higher root diameter (13.25 cm) was recorded in N<sub>4</sub> (12.30 cm) over N<sub>3</sub> (8.67 cm), N<sub>5</sub> (9.96 cm), N<sub>1</sub> (11.13 cm) and was on par with N<sub>2</sub>.

Interaction effect was not significant between the date of sowing and nutrition with respect to root diameter.

#### 4.2.4 Number of umbels per plant

The data on number of umbels per plant as influenced by date of sowing, nutrition levels are presented in table 4.

The number of umbels per plant was significantly influenced by date of sowing. Significantly higher number of umbels per plant (38.39) was recorded in D<sub>2</sub> over D<sub>1</sub> (36.49), D<sub>3</sub> (34.91), D<sub>4</sub> (33.26) whereas, significantly lower number of umbels per plant was recorded in D<sub>4</sub>.

N<sub>4</sub> recorded significantly higher number of umbels per plant (38.64) was on par with N<sub>2</sub> (39.06) while lower number of umbels per plant was recorded in N<sub>3</sub> (31.79), N<sub>5</sub> (33.77) and N<sub>1</sub> (35.57).

Interaction effect was not significant between the date of sowing and nutrition with regards to number of umbels per plant.

#### 4.2.5 Number of seeds per umbel

The data on number of seeds per umbel as influenced by date of sowing, nutrition levels are presented in table 4.

Number of seeds per umbel was significantly influenced by date of sowing. Significantly higher number of seeds per umbel (25.56) was recorded in D<sub>2</sub> over D<sub>1</sub> (25.02), D<sub>3</sub> (24.62), D<sub>4</sub> (24.16) whereas, significantly lower number of seeds per umbel was recorded in D<sub>4</sub>.

N<sub>4</sub> recorded significantly higher number of seeds per umbel (26.13) was on par with N<sub>2</sub> (25.53) while lower number of seeds per umbel was recorded in N<sub>3</sub> (23.20), N<sub>5</sub> (24.48) and N<sub>1</sub> (24.88).

**Table 3. Effect of date of sowing and nutrition on Root weight (g) and root diameter (cm) of carrot cv.Pusa kesar**

Nutrition(N)	Root weight(g)					Root diameter (cm)				
	Date of sowing(D)				Mean	Date of sowing(D)				Mean
	D <sub>1</sub>	D <sub>2</sub>	D <sub>3</sub>	D <sub>4</sub>		D <sub>1</sub>	D <sub>2</sub>	D <sub>3</sub>	D <sub>4</sub>	
N <sub>1</sub> - Control (RDF)	72.30	75.40	68.90	65.20	<b>70.45</b>	11.68	12.47	10.82	9.54	<b>11.13</b>
N <sub>2</sub> - 50% RDF + 50% FYM	77.20	80.10	73.30	69.80	<b>75.10</b>	12.68	13.71	12.01	10.81	<b>12.30</b>
N <sub>3</sub> - 100% FYM	66.40	70.20	62.10	57.20	<b>63.98</b>	9.41	9.92	8.02	7.32	<b>8.67</b>
N <sub>4</sub> - 50% VC + 50% RDF	80.20	83.30	76.30	72.50	<b>78.08</b>	13.41	14.32	12.84	12.42	<b>13.25</b>
N <sub>5</sub> - 100% VC	69.40	71.10	65.10	61.10	<b>66.68</b>	10.80	11.48	9.64	7.90	<b>9.96</b>
<b>Mean</b>	<b>73.10</b>	<b>76.02</b>	<b>69.14</b>	<b>65.16</b>	<b>70.86</b>	<b>11.59</b>	<b>12.38</b>	<b>10.67</b>	<b>9.59</b>	<b>11.06</b>
For comparing means of	S.Em±				CD (0.05)	S.Em±				CD (0.05)
Date (D)	1.10				3.14	0.31				0.89
Nutrition (N)	1.23				3.51	0.35				1.00
Interaction (N x D)	2.45				NS	0.70				NS

D<sub>1</sub> - 15<sup>th</sup> August      D<sub>2</sub> - 1<sup>st</sup> September      D<sub>3</sub> - 15<sup>th</sup> September      D<sub>4</sub> -      -      1<sup>st</sup>      October  
RDF - Recommended dose of fertilizers      FYM - Farm yard manure      VC-Vermicompost

**Table 4 . Effect of date of sowing and nutrition on number of umbels per plant and number of seeds per umbel of carrot Cv.Pusa kesar**

Nutrition(N)	Number of umbels per plant					Number of seed per umbel				
	Date of sowing(D)				Mean	Date of sowing(D)				Mean
	D <sub>1</sub>	D <sub>2</sub>	D <sub>3</sub>	D <sub>4</sub>		D <sub>1</sub>	D <sub>2</sub>	D <sub>3</sub>	D <sub>4</sub>	
N <sub>1</sub> - Control (RDF)	36.09	38.14	34.10	33.94	<b>35.57</b>	25.1	25.5	24.7	24.2	<b>24.88</b>
N <sub>2</sub> - 50% RDF + 50% FYM	39.42	40.97	37.90	36.27	<b>38.64</b>	25.8	26.1	25.3	24.9	<b>25.53</b>
N <sub>3</sub> - 100% FYM	32.33	34.80	31.05	29.08	<b>31.79</b>	23.1	24.3	22.9	22.5	<b>23.20</b>
N <sub>4</sub> - 50% VC + 50% RDF	40.31	41.79	38.38	35.8	<b>39.06</b>	26.3	26.9	25.9	25.4	<b>26.13</b>
N <sub>5</sub> - 100% VC	34.41	36.26	32.77	31.63	<b>33.77</b>	24.8	25.0	24.3	23.8	<b>24.48</b>
<b>Mean</b>	<b>36.49</b>	<b>38.39</b>	<b>34.91</b>	<b>33.26</b>	<b>35.77</b>	<b>25.02</b>	<b>25.56</b>	<b>24.62</b>	<b>24.16</b>	<b>24.84</b>
For comparing means of	S.Em±				CD (0.05)	S.Em±				CD (0.05)
Date (D)	0.49				1.40	0.23				0.66
Nutrition (N)	0.55				1.57	0.26				0.74
Interaction (N x D)	1.10				NS	0.52				NS

D<sub>1</sub> - 15<sup>th</sup> August

D<sub>2</sub> - 1<sup>st</sup> September

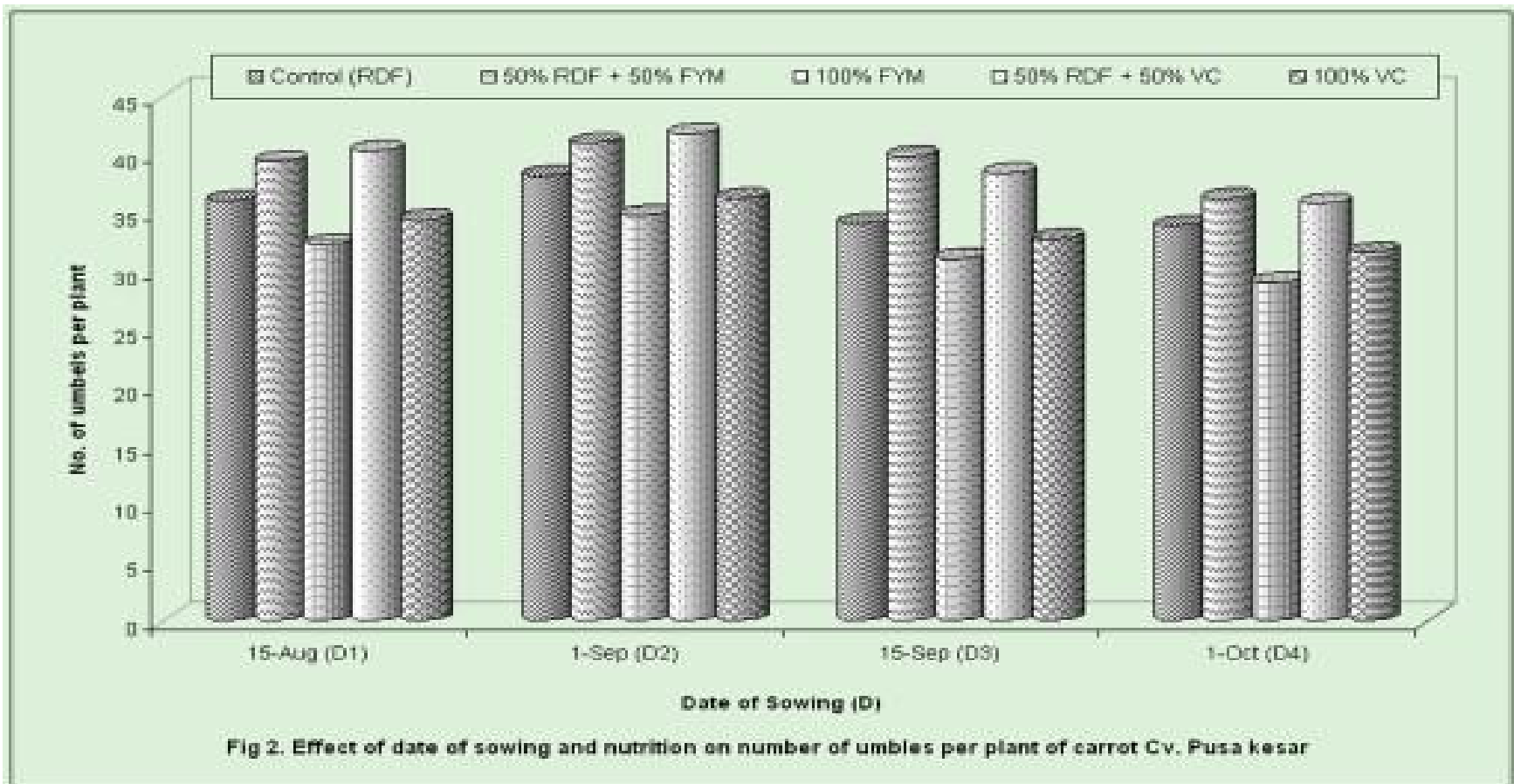
D<sub>3</sub> - 15<sup>th</sup> September

D<sub>4</sub> - 1<sup>st</sup> October

RDF - Recommended dose of fertilizers

FYM - Farm yard manure

VC-Vermicompost



**Fig2. Effect of date of sowing and nutrition on number of umbels per plant of carrot Cv. Pusa Kesar**

Interaction effect was not significant between the date of sowing and nutrition with regards to number of seeds per umbel.

#### 4.2.6 Umbel diameter

The data on umbel diameter was influenced by date of sowing and nutrition are presented in the Table 5.

Umbel diameter was significantly higher in D<sub>2</sub> (31.82 cm) over D<sub>3</sub> (22.11 cm), D<sub>4</sub> (26.58 cm) and was on par with D<sub>1</sub> (30.61 cm).

Nutrition level was significantly influenced the umbel diameter in N<sub>4</sub> (35.13 cm) over N<sub>3</sub> (22.95 cm), N<sub>1</sub> (29.32 cm), N<sub>3</sub> (22.95 cm) and was on par with N<sub>2</sub> (33.79 cm).

Interaction effect was found to be non significant between the dates of sowing and nutrition with respect to umbel diameter.

#### 4.2.7 1000 seed weight (g)

Data on thousand seed weight as influenced by date of sowing and nutrition are presented in table 5.

Thousand seed weight of carrot was significantly influenced by date of sowing. D<sub>2</sub> recorded significantly higher thousand seed weight (4.20 g) over D<sub>3</sub> (3.83 g) and D<sub>4</sub> (3.49 g) and was on par with D<sub>1</sub> (4.15 g).

Significantly higher thousand seed weight was recorded in N<sub>4</sub> (4.35 g) over N<sub>1</sub> (3.97 g), N<sub>5</sub> (3.75 g) and N<sub>3</sub> (3.26 g), while N<sub>4</sub> was on par with N<sub>2</sub> (4.25 g).

Interaction effect was not significant between the sowing date and nutrition levels for thousand seed weight.

#### 4.2.8 Seed yield per plant (g)

Data on seed yield per plant as influenced by sowing date and nutrition in carrot are presented in Table 6.

Seed yield per plant was significantly influenced by date of sowing. Significantly higher seed yield per plant was recorded in D<sub>2</sub> (38.86 g / plant) over D<sub>4</sub> (35 g / plant) and D<sub>3</sub> (37 g / plant) and was on par with D<sub>1</sub> (38.71 g / plant).

Seed yield per plant was significantly influenced by different nutrition. Significantly higher seed yield per plant (39.77 g / plant) was recorded in N<sub>4</sub> over N<sub>3</sub> (34 g / plant), N<sub>5</sub> (35.86 g / plant), N<sub>1</sub> (37.86 g / plant) and N<sub>4</sub> (39.77 g / plant) was on par with N<sub>2</sub> (40 g / plant). Significantly lower seed yield per plant was recorded in N<sub>3</sub> (34 g / plant).

Interaction effect for seed yield per plant was not significant due to date of sowing and nutrition.

#### 4.2.9 Seed yield per plot (g)

The data on seed yield per net plot is presented in Table 6.

Among the different dates of sowing, significantly higher seed yield per plot was recorded in D<sub>2</sub> (185.60 g / plant) over D<sub>3</sub> (176.03 g / plant) and D<sub>4</sub> (168.82 g / plant) while D<sub>2</sub> was on par with D<sub>1</sub> (183.46 g / plant). D<sub>4</sub> recorded the lowest seed yield per plot.

Significantly higher seed yield per plot was recorded in N<sub>4</sub> (192.18 g / plant) over N<sub>1</sub> (178.91 g / plant), N<sub>5</sub> (171.19 g / plant) and N<sub>3</sub> (162.77 g / plant) but N<sub>4</sub> was on par with N<sub>2</sub> (187.35), respectively.

Interaction effect between the date of sowing and nutrition with respect to seed yield per plot was non significant.

**Table 5. Effect of date of sowing and nutrition on Umbel diameter(cm) and 1000 seed weight(g) of carrot Cv.Pusa kesar**

Nutrition(N)	Umbel diameter (cm)					1000 seed weight (g)				
	Date of sowing(D)				Mean	Date of sowing(D)				Mean
	D <sub>1</sub>	D <sub>2</sub>	D <sub>3</sub>	D <sub>4</sub>		D <sub>1</sub>	D <sub>2</sub>	D <sub>3</sub>	D <sub>4</sub>	
N <sub>1</sub> - Control (RDF)	31.04	32.72	28.20	25.32	<b>29.32</b>	4.15	4.23	3.84	3.65	<b>3.97</b>
N <sub>2</sub> - 50% RDF + 50% FYM	35.04	36.34	32.90	30.90	<b>33.79</b>	4.46	4.52	4.13	3.89	<b>4.25</b>
N <sub>3</sub> - 100% FYM	23.49	25.40	21.28	21.64	<b>22.95</b>	3.60	3.64	3.29	2.53	<b>3.26</b>
N <sub>4</sub> - 50% VC + 50% RDF	36.79	37.45	34.05	32.24	<b>35.13</b>	4.55	4.60	4.23	4.00	<b>4.35</b>
N <sub>5</sub> - 100% VC	26.69	27.20	24.10	22.82	<b>25.20</b>	3.95	4.01	3.64	3.40	<b>3.50</b>
<b>Mean</b>	<b>30.61</b>	<b>31.82</b>	<b>28.11</b>	<b>26.58</b>	<b>29.28</b>	<b>4.15</b>	<b>4.20</b>	<b>3.83</b>	<b>3.49</b>	<b>3.92</b>
For comparing means of	S.Em±				CD (0.05)	S.Em±				CD (0.05)
Date (D)	0.46				1.32	0.07				0.19
Nutrition (N)	0.52				1.48	0.08				0.22
Interaction (N x D)	1.03				NS	0.15				NS

D<sub>1</sub> - 15<sup>th</sup> August

D<sub>2</sub> - 1<sup>st</sup> September

D<sub>3</sub> - 15<sup>th</sup> September

D<sub>4</sub> - 1<sup>st</sup> October

RDF - Recommended dose of fertilizers

FYM - Farm yard manure

VC-Vermicompost

**Table 6. Effect of date of sowing and nutrition on seed yield per plant and seed yield per plot (g) of carrot Cv.Pusa kesar**

Nutrition(N)	Seed yield per plant (g)					Seed yield per plot (g)				
	Date of sowing(D)				Mean	Date of sowing(D)				Mean
	D <sub>1</sub>	D <sub>2</sub>	D <sub>3</sub>	D <sub>4</sub>		D <sub>1</sub>	D <sub>2</sub>	D <sub>3</sub>	D <sub>4</sub>	
N <sub>1</sub> - Control (RDF)	39.1	39.11	37.47	35.77	<b>37.86</b>	181.44	183.16	179.94	171.08	<b>178.91</b>
N <sub>2</sub> - 50% RDF + 50% FYM	40.8	41.12	39.26	37.93	<b>39.77</b>	190.88	192.96	184.30	181.24	<b>187.35</b>
N <sub>3</sub> - 100% FYM	35.4	35.47	33.41	31.84	<b>34.04</b>	170.16	174.52	156.06	150.32	<b>162.77</b>
N <sub>4</sub> - 50% VC + 50% RDF	41.0	41.23	39.74	38.13	<b>40.03</b>	197.08	198.68	190.26	182.68	<b>192.18</b>
N <sub>5</sub> - 100% VC	37.3	37.35	35.41	33.42	<b>35.86</b>	177.72	178.68	169.58	158.76	<b>171.19</b>
<b>Mean</b>	<b>38.71</b>	<b>38.86</b>	<b>37.06</b>	<b>35.42</b>	<b>37.51</b>	<b>183.46</b>	<b>185.60</b>	<b>176.03</b>	<b>168.82</b>	<b>178.48</b>
For comparing means of	S.Em±				CD (0.05)	S.Em±			CD (0.05)	
Date (D)	0.53				1.52	2.89			8.27	
Nutrition (N)	0.59				1.70	3.23			9.24	
Interaction (N x D)	1.19				NS	6.45			NS	

D<sub>1</sub> - 15<sup>th</sup> August

D<sub>2</sub> - 1<sup>st</sup> September

D<sub>3</sub> - 15<sup>th</sup> September

D<sub>4</sub> - 1<sup>st</sup> October

RDF - Recommended dose of fertilizers

FYM - Farm yard manure

VC-Vermicompost

#### 4.2.10 Seed yield (kg/ha)

Seed yield was significantly influenced by the date of sowing and nutrition but not with their interactions (Table 7).

Among the different date of sowings, significantly higher seed yield was recorded in D<sub>2</sub> (464 kg / ha) over D<sub>3</sub> (440.07 kg / ha) and D<sub>4</sub> (422.04 kg / ha), while D<sub>2</sub> was on par with D<sub>1</sub> (458.64 kg / ha).

Seed yield was significantly influenced by nutrition. Significantly higher seed yield was recorded in N<sub>4</sub> (480.44 kg/ ha) over N<sub>1</sub> (447.26 kg / ha), N<sub>5</sub> (427.96 kg / ha) and N<sub>3</sub> (406.91 kg / ha) whereas, N<sub>4</sub> was on par with N<sub>2</sub> (468.36 kg/ha) respectively.

Interaction effect between the date of sowing and nutrition with respect to seed yield per hectare was non significant.

### 4.3 SEED QUALITY PARAMETERS

#### 4.3.1 Seed germination (%)

Data on per cent seed germination as influenced by sowing date nutrition and their interactions during carrot seed production are presented in Table 8.

Higher per cent of seed germination was recorded in D<sub>2</sub> (86.72) over D<sub>1</sub> (85.76), D<sub>3</sub> (84.39), D<sub>4</sub> (83.80).

Higher seed germination per cent was recorded in N<sub>4</sub> (86.67) over N<sub>2</sub> (86.04), N<sub>1</sub> (85.93), N<sub>5</sub> (84.08) and N<sub>3</sub> (83.13).

Seed germination did not differ significantly by date of sowing and nutrition and their interactions.

#### 4.3.2 Speed of germination

Data on speed of germination as significantly influenced by date of sowing and nutrition and their interaction are presented in Table 8.

Speed of germination was significantly higher in D<sub>2</sub> (20.40) over D<sub>3</sub> (19.48), D<sub>4</sub> (18.68) and was on par with D<sub>1</sub> (20.76).

Nutrition level was significantly influenced the speed of germination in N<sub>4</sub> (20.90) over N<sub>3</sub> (17.98), N<sub>1</sub> (19.98), N<sub>3</sub> (17.98) and was on par with N<sub>2</sub> (21.63).

Interaction effect was found to be significant between the dates of sowing and nutrition with respect to speed of germination.

#### 4.3.3 Root length and shoot length (cm)

The data on seedling root length and shoot length as influenced by date of sowing and nutrition are presented in Table 9.

Root length and shoot length were significantly influenced by date of sowing. Higher root length (10.0 cm) and shoot length (9.3 cm) was recorded in D<sub>2</sub> over D<sub>3</sub> (9.64 cm and 8.84 cm), D<sub>4</sub> (9.38 cm and 8.50 cm) and was on par with D<sub>1</sub> (10.00 cm and 9.16 cm) respectively.

Nutrient levels also influenced significantly the root length and shoot length. Higher root length and shoot length was recorded in N<sub>4</sub> (10.30 cm and 9.50 cm) over N<sub>3</sub> (9.03 cm and 8.33 cm), N<sub>1</sub> (9.70 cm and 8.95 cm) and was on par with N<sub>2</sub> (10.18 cm and 9.35 cm) respectively.

Interaction effect between the date of sowing and nutrition with respect to root length and shoot length was non significant.

#### 4.3.4 Seedling vigour index

Data on seedling vigour index was significantly influenced by date of sowing and nutrition (Table 10).

**Table 7. Effect of date of sowing and nutrition on seed yield (Kg/ha) of carrot during seed production of Cv.Pusa kesar**

Nutrition(N)	Seed yield (Kg / ha)				
	Date of sowing(D)				Mean
	D <sub>1</sub>	D <sub>2</sub>	D <sub>3</sub>	D <sub>4</sub>	
N <sub>1</sub> - Control (RDF)	453.6	457.90	449.85	427.70	<b>447.26</b>
N <sub>2</sub> - 50% RDF + 50% FYM	477.2	482.40	460.75	453.10	<b>468.36</b>
N <sub>3</sub> - 100% FYM	425.4	436.30	390.15	375.80	<b>406.91</b>
N <sub>4</sub> - 50% VC + 50% RDF	492.7	496.70	475.65	456.70	<b>480.44</b>
N <sub>5</sub> - 100% VC	444.3	446.70	423.95	396.90	<b>427.96</b>
<b>Mean</b>	<b>458.64</b>	<b>464.00</b>	<b>440.07</b>	<b>422.04</b>	<b>446.19</b>
For comparing means of	S.Em±			CD (0.05)	
Date (D)	7.22			20.67	
Nutrition (N)	8.07			23.10	
Interaction (N x D)	16.14			NS	

D<sub>1</sub> - 15<sup>th</sup> August

D<sub>2</sub> - 1<sup>st</sup> September

D<sub>3</sub> - 15<sup>th</sup> September

D<sub>4</sub> - 1<sup>st</sup> October

RDF - Recommended dose of fertilizers

FYM - Farm yard manure

VC-Vermicompost

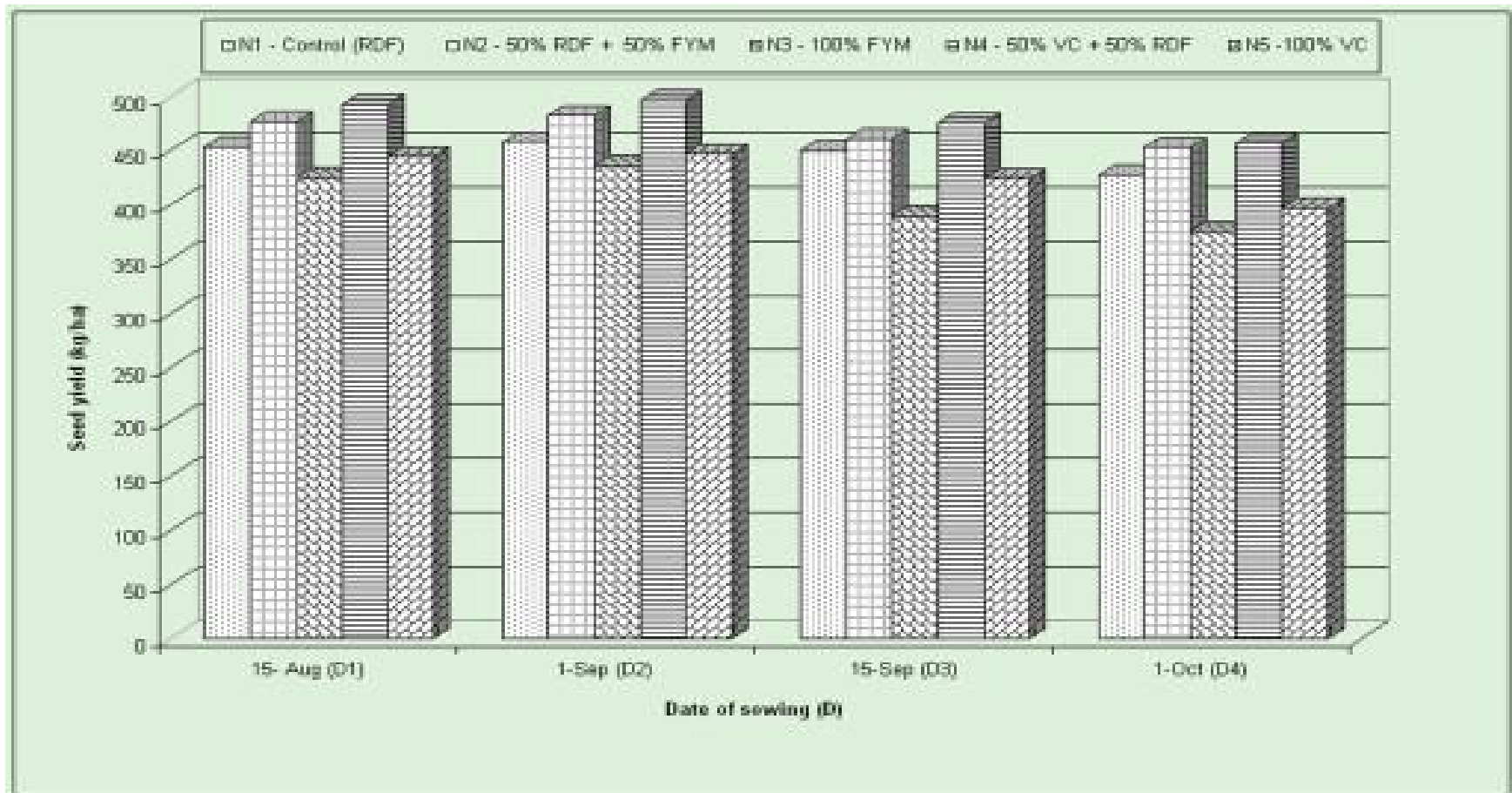


Fig. 3. Effect of date of sowing and nutrition on seed yield (Kg/ha) of carrot during seed production of Cv. Pusa kesar

**Table 8. Effect of date of sowing and nutrition in germination (%) and speed of germination of carrot Cv.Pusa kesar**

Nutrition(N)	Germination (%)					Speed of germination				
	Date of sowing(D)				Mean	Date of sowing(D)				Mean
	D <sub>1</sub>	D <sub>2</sub>	D <sub>3</sub>	D <sub>4</sub>		D <sub>1</sub>	D <sub>2</sub>	D <sub>3</sub>	D <sub>4</sub>	
N <sub>1</sub> - Control (RDF)	86.21 (68.17)	87.23 (69.03)	85.45 (67.55)	84.82 (67.04)	<b>85.93</b> <b>(67.94)</b>	19.40	21.10	19.90	19.50	<b>19.98</b>
N <sub>2</sub> - 50% RDF + 50% FYM	86.35 (68.29)	87.29 (69.08)	85.31 (67.43)	85.21 (67.35)	<b>86.04</b> <b>(68.03)</b>	24.00	20.90	19.50	19.20	<b>20.90</b>
N <sub>3</sub> - 100% FYM	84.52 (66.80)	85.44 (67.54)	81.92 (64.81)	80.64 (63.87)	<b>83.13</b> <b>(65.72)</b>	18.60	19.50	17.50	16.00	<b>17.90</b>
N <sub>4</sub> - 50% VC + 50% RDF	86.41 (68.34)	87.62 (69.37)	86.12 (68.09)	86.52 (68.43)	<b>86.67</b> <b>(68.55)</b>	21.30	22.50	21.50	21.20	<b>21.63</b>
N <sub>5</sub> - 100% VC	85.33 (67.45)	86.01 (68.00)	83.17 (65.75)	81.82 (64.73)	<b>84.08</b> <b>(66.46)</b>	18.70	19.80	19.00	17.50	<b>18.75</b>
<b>Mean</b>	<b>85.76</b> <b>(67.80)</b>	<b>86.72</b> <b>(68.60)</b>	<b>84.39</b> <b>(66.70)</b>	<b>83.80</b> <b>(66.24)</b>	<b>85.17</b> <b>(67.32)</b>	<b>20.40</b>	<b>20.76</b>	<b>19.48</b>	<b>18.68</b>	<b>19.83</b>
For comparing means of	S.Em±			CD (0.05)		S.Em±			CD (0.05)	
Date (D)	0.87			NS		0.34			0.98	
Nutrition (N)	0.97			NS		0.38			1.09	
Interaction (N x D)	1.94			NS		0.76			NS	

D<sub>1</sub> - 15<sup>th</sup> August      D<sub>2</sub> - 1<sup>st</sup> September      D<sub>3</sub> - 15<sup>th</sup> September      D<sub>4</sub> - 1<sup>st</sup> October  
RDF - Recommended dose of fertilizers      FYM - Farm yard manure      VC-Vermicompost

\*Figures in parenthesis are arcsine values

**Table 9. Effect of date of sowing and nutrition on seedling root length (cm) and shoot length (cm) of carrot Cv. Pusa kesar**

Nutrition(N)	Seedling root length (cm)					Seedling Shoot length (cm)				
	Date of sowing(D)				Mean	Date of sowing(D)				Mean
	D <sub>1</sub>	D <sub>2</sub>	D <sub>3</sub>	D <sub>4</sub>		D <sub>1</sub>	D <sub>2</sub>	D <sub>3</sub>	D <sub>4</sub>	
N <sub>1</sub> - Control (RDF)	9.80	9.90	9.60	9.50	<b>9.70</b>	9.10	9.20	8.90	8.60	<b>8.95</b>
N <sub>2</sub> - 50% RDF + 50% FYM	10.30	10.40	10.10	9.90	<b>10.18</b>	9.60	9.70	9.20	8.90	<b>9.35</b>
N <sub>3</sub> - 100% FYM	9.20	9.40	9.00	8.50	<b>9.03</b>	8.50	8.70	8.20	7.90	<b>8.33</b>
N <sub>4</sub> - 50% VC + 50% RDF	10.40	10.60	10.20	10.0	<b>10.30</b>	9.70	9.90	9.40	9.00	<b>9.50</b>
N <sub>5</sub> - 100% VC	9.50	9.70	9.30	9.00	<b>9.38</b>	8.90	9.00	8.50	8.10	<b>8.63</b>
<b>Mean</b>	<b>9.84</b>	<b>10.0</b>	<b>9.64</b>	<b>9.38</b>	<b>9.72</b>	<b>9.16</b>	<b>9.30</b>	<b>8.84</b>	<b>8.50</b>	<b>8.95</b>
For comparing means of	S.Em±			CD (0.05)		S.Em±			CD (0.05)	
Date (D)	0.06			0.18		0.06			0.18	
Nutrition (N)	0.07			0.20		0.07			0.20	
Interaction (N x D)	0.14			NS		0.14			NS	

D<sub>1</sub> - 15<sup>th</sup> August

D<sub>2</sub> - 1<sup>st</sup> September

D<sub>3</sub> - 15<sup>th</sup> September

D<sub>4</sub> - 1<sup>st</sup> October

RDF - Recommended dose of fertilizers    FYM - Farm yard manure

VC-Vermicompost

**Table 10. Effect of date of sowing and nutrition on seedling vigour index and seedling dry weight dry weight of carrot Cv.Pusa kesar**

Nutrition(N)	Seedling vigour index					Seedling dry weight (mg)				
	Date of sowing(D)				Mean	Date of sowing(D)				Mean
	D <sub>1</sub>	D <sub>2</sub>	D <sub>3</sub>	D <sub>4</sub>		D <sub>1</sub>	D <sub>2</sub>	D <sub>3</sub>	D <sub>4</sub>	
N <sub>1</sub> - Control (RDF)	1629	1666	1580	1535	<b>1602</b>	11.38	11.48	11.12	11.10	<b>11.27</b>
N <sub>2</sub> - 50% RDF + 50% FYM	1718	1754	1646	1601	<b>1679</b>	12.27	13.06	11.93	11.81	<b>12.27</b>
N <sub>3</sub> - 100% FYM	1496	1546	1409	1322	<b>1443</b>	09.97	10.12	9.52	8.22	<b>9.46</b>
N <sub>4</sub> - 50% VC + 50% RDF	1736	1796	1687	1643	<b>1715</b>	12.98	13.00	12.31	12.01	<b>12.58</b>
N <sub>5</sub> - 100% VC	1570	1608	1480	1399	<b>1514</b>	10.41	10.92	10.22	10.12	<b>10.42</b>
<b>Mean</b>	<b>1629</b>	<b>1674</b>	<b>1560</b>	<b>1500</b>	<b>1591</b>	<b>11.40</b>	<b>11.72</b>	<b>11.02</b>	<b>10.65</b>	<b>11.19</b>
For comparing means of	S.Em±			CD (0.05)		S.Em±			CD (0.05)	
Date (D)	8.66			24.79		0.12			0.33	
Nutrition (N)	9.68			27.71		0.13			0.37	
Interaction (N x D)	19.35			NS		0.26			NS	

D<sub>1</sub> - 15<sup>th</sup> August

D<sub>2</sub> - 1<sup>st</sup> September

D<sub>3</sub> - 15<sup>th</sup> September

D<sub>4</sub> - 1<sup>st</sup> October

RDF - Recommended dose of fertilizers

FYM - Farm yard manure

VC-Vermicompost

Significantly higher seedling vigour index (1674) was recorded in D<sub>2</sub> over D<sub>1</sub> (1629), D<sub>3</sub> (1560), D<sub>4</sub> (1500) whereas, significantly lower seedling vigour index was recorded in D<sub>4</sub>.

N<sub>4</sub> recorded significantly higher seedling vigour index (1715) was on par with N<sub>2</sub> (1679) while lower seedling vigour index was recorded in N<sub>3</sub> (1443), N<sub>5</sub> (1514) and N<sub>1</sub> (1602).

Interaction effect was non-significant between the dates of sowing and nutrition with respect to the seedling vigour index.

#### 4.3.5 Seedling dry weight (mg)

Data on Seedling dry weight significantly influenced by date of sowing and nutrition are presented in Table 10.

Seedling dry weight was significantly higher in D<sub>2</sub> (11.72 mg) over D<sub>3</sub> (11.02 mg), D<sub>4</sub> (10.65 mg) and was on par with D<sub>1</sub> (11.40 mg).

Nutrition level was significantly influenced the Seedling dry weight in N<sub>4</sub> (12.58 mg) over N<sub>3</sub> (9.46 mg), N<sub>1</sub>(11.27 mg) , N<sub>5</sub> (10.42 mg) and was on par with N<sub>2</sub> (12.27 mg).

Interaction effect was found to be significant between the dates of sowing and nutrition with respect to Seedling dry weight.

#### 4.3.6 Field emergence (%)

Field emergence was significantly influenced by dates of sowing and nutrition (Table 11).

Field emergence of carrot was significantly influenced by date of sowing. D<sub>2</sub> recorded significantly higher field emergence (80.88) over D<sub>3</sub> (79.46) and D<sub>4</sub> (79.02) and was on par with D<sub>1</sub> (79.74).

Significantly higher Field emergence was recorded in N<sub>4</sub> (80.43) over N<sub>1</sub> (80.00), N<sub>5</sub> (79.45) and N<sub>3</sub> (78.73), while N<sub>4</sub> was on par with N<sub>2</sub> (80.28).

Interaction effect was not significant between the sowing date and nutrition levels for Field emergence.

### 4.4 EXPERIMENT II : EFFECT OF SPACING AND GROWTH REGULATORS ON GROWTH SEED YIELD AND SEED QUALITY PARAMETERS

#### 4.4.1 Growth parameters

#### 4.4.2 Plant Height (cm)

Data on mean plant height as influenced by spacing and growth regulators at flower initiation stage of carrot are presented in Table 12.

Plant height was higher in S<sub>3</sub> (60 × 10 cm) i.e., (91.30 cm) compared to S<sub>2</sub> (40x15 cm) i.e., (87.56 cm) but it was significantly from spacing S<sub>1</sub> (30x20 cm) i.e., (86.10 cm).

Growth regulator showed significant effect on plant height. Among the different concentration of growth regulator G<sub>1</sub>-GA<sub>3</sub>(200 ppm), recorded significantly higher plant height (98.67 cm) when compared to all other growth regulators G<sub>2</sub>-GA<sub>3</sub>(300 ppm) i.e., (87.83 cm), G<sub>3</sub>-NAA(200 ppm) (93.23 cm), G<sub>4</sub>-NAA(300 ppm) (82.73 cm), G<sub>5</sub>-water(as control) (79.13 cm), respectively.

The interaction effect of spacing and growth regulators on plant height was non significant with respect to plant height.

#### 4.4.3 Number of leaves

The data on number of leaves at flower initiation as influenced by spacing and growth regulators are presented in the table 12.

**Table 11. Effect of date of sowing and nutrition on field emergence percentage (%) of carrot Cv.Pusa kesar**

Nutrition(N)	Field emergence percentage (%)				
	Date of sowing(D)				Mean
	D <sub>1</sub>	D <sub>2</sub>	D <sub>3</sub>	D <sub>4</sub>	
N <sub>1</sub> - Control (RDF)	80.10 (63.54)	81.10 (64.26)	79.60 (63.18)	79.20 (62.90)	<b>80.00</b> <b>(63.47)</b>
N <sub>2</sub> - 50% RDF + 50% FYM	80.30 (63.68)	81.40 (64.48)	79.90 (63.40)	79.50 (63.11)	<b>80.28</b> <b>(63.67)</b>
N <sub>3</sub> - 100% FYM	78.30 (62.27)	79.80 (63.32)	78.70 (62.55)	78.10 (62.13)	<b>78.73</b> <b>(62.57)</b>
N <sub>4</sub> - 50% VC + 50% RDF	80.40 (63.75)	81.60 (64.63)	80.10 (63.54)	79.60 (63.18)	<b>80.43</b> <b>(63.78)</b>
N <sub>5</sub> - 100% VC	79.60 (63.18)	80.50 (63.83)	79.00 (62.76)	78.70 (62.55)	<b>79.45</b> <b>(63.08)</b>
<b>Mean</b>	<b>79.74</b> <b>(63.28)</b>	<b>80.88</b> <b>(64.10)</b>	<b>79.46</b> <b>(63.08)</b>	<b>79.02</b> <b>(62.77)</b>	<b>79.78</b> <b>(63.31)</b>
For comparing means of	S.Em±			CD (0.05)	
Date (D)	1.10			NS	
Nutrition (N)	1.23			NS	
Interaction (N x D)	2.45			NS	

D<sub>1</sub> - 15<sup>th</sup> August

D<sub>2</sub> - 1<sup>st</sup> September

D<sub>3</sub> - 15<sup>th</sup> September

D<sub>4</sub> - 1<sup>st</sup> October

RDF - Recommended dose of fertilizers

FYM - Farm yard manure

VC-Vermicompost

\*Figures in parenthesis are arcsine values

**Table 12. Effect of spacing and growth regulator on plant height and number of leaves of carrot Cv. Pusa kesar**

Growth regulators(G)	Plant height (cm)				Number of leaves			
	Spacing(S)				Spacing(S)			
	S1	S2	S3	Mean	S1	S2	S3	Mean
G <sub>1</sub> -GA <sub>3</sub> (200 ppm)	96.30	97.90	101.80	<b>98.67</b>	15.20	17.10	13.90	<b>15.40</b>
G <sub>2</sub> -GA <sub>3</sub> (300 ppm)	85.40	86.90	91.20	<b>87.83</b>	11.40	15.50	10.80	<b>12.57</b>
G <sub>3</sub> -NAA (200 ppm)	91.30	92.00	96.40	<b>93.23</b>	14.10	16.40	12.00	<b>14.17</b>
G <sub>4</sub> -NAA (300 ppm)	80.70	82.60	84.90	<b>82.73</b>	10.20	12.80	09.10	<b>10.70</b>
G <sub>0</sub> -water (control)	76.80	78.40	82.20	<b>79.13</b>	09.70	10.20	07.30	<b>09.07</b>
<b>Mean</b>	<b>86.10</b>	<b>87.56</b>	<b>91.30</b>	<b>88.32</b>	<b>12.12</b>	<b>14.40</b>	<b>10.62</b>	<b>12.38</b>
For comparing means of	S. Em.±		CD (0.05)		S. Em.±		CD (0.05)	
Spacing(S)	1.33		3.86		0.27		0.77	
Growth regulator(G)	1.72		4.99		0.34		0.99	
Interaction (S x G)	2.98		NS		0.60		NS	

S<sub>1</sub> = 30 x 20 cm S<sub>2</sub> = 40 x 15 cm S<sub>3</sub> = 60x 10cm      NS- Non significia  
 G<sub>1</sub> - GA<sub>3</sub> (200 ppm)    G<sub>2</sub>- GA<sub>3</sub> (300 ppm)    GA<sub>3</sub> - NAA (200 ppm)    G<sub>4</sub>- NAA (300 ppm)    G<sub>5</sub> - Control

The number of leaves differed significantly among the different spacing at flower initiation stage. Significantly higher number of leaves (14.40) were recorded at  $S_2$  over  $S_1$ (12.12) and  $S_3$  (10.62) at flower initiation. Significantly lower number of leaves was recorded in  $S_3$  over  $S_2$  and  $S_1$ .

Number of leaves differed significantly at different concentration of growth regulator at flower initiation stage. At flowering, significantly higher number of leaves (15.40) was recorded at  $G_1$  over  $G_3$  (14.17),  $G_2$  (12.57),  $G_4$  (10.70) and  $G_5$  (9.7).

Interaction effect between the spacing and growth regulator was non significant with respect to number of leaves.

#### 4.4.4 Days to 50% flowering

The results obtained due to effect of spacing growth regulators and their interaction on days taken for 50 per cent flowering are presented in table 13.

The spacing effect on 50 % flowering was non significant but  $S_3$  took lesser number of days (118.0),  $S_2$  (119.5),  $S_1$  (118.9).

The days to 50 per cent flowering differed significantly due to different concentration of growth regulators. Significantly early flowering was noticed in  $G_1$  (114.33) over  $G_5$  (123.43),  $G_4$  (121.67),  $G_2$  (119.00) and  $G_3$  (115.67).

Interaction effects of spacing and growth regulators on 50 per cent flowering were non-significant with respect to fifty percent flowering.

## 4.5 YIELD AND YIELD PARAMETERS

### 4.5.1 Root length

The data on root length was influenced by spacing, growth regulators and their interaction are presented in Table 13.

The root length differed among the different spacing at flower initiation stage. Higher root length (26.41 cm) was recorded in  $S_2$  over  $S_1$  (25.68 cm) and  $S_3$  (25.14 cm) at flower initiation. Lower root length was recorded in  $S_3$  respectively.

Significantly higher root length was recorded in  $G_1$  (30.91 cm) at flower initiation stage over  $G_3$  (28.60 cm),  $G_2$  (26.77 cm),  $G_4$  (22.40 cm) and  $G_5$  (20.03 cm).

Interaction effect between the spacing and growth regulator was non significant with respect to root length.

### 4.5.2 Root diameter

The data on root diameter was significantly influenced by growth regulators but non significantly influenced by spacing (Table 14).

Numerically higher root diameter (11.78 cm) was recorded in  $S_2$  over  $S_1$ (11.22 cm) and  $S_3$  (11.00 cm). Lower root diameter was recorded in  $S_3$ .

Significantly higher root diameter was recorded in  $G_1$ (14.53 cm) over  $G_3$  (13.10 cm),  $G_2$  (11.33 cm),  $G_4$  (9.57 cm) and  $G_5$  (8.13 cm).

Interaction effect between the spacing and growth regulator was non significant with respect to root diameter.

### 4.5.3 Root weight

The data on root weight was significantly influenced by growth regulators but non significantly influenced by spacing at flower initiation. The data presented in Table 14.

Higher root weight (74.40 g) was recorded in  $S_2$  over  $S_1$ (73.66 g) and  $S_3$  (72.52 g).

Significantly higher root weight was recorded in  $G_1$  (81.90 g) over  $G_3$  (77.80 g),  $G_2$  (73.53 g),  $G_4$  (69.37 g) and  $G_5$  (65.03 g).

Interaction effect between the spacing and growth regulator was non significant with respect to root weight.

**Table 13. Effect of spacing and growth regulator on days to 50% flowering and root length (cm) of carrot**

**cv. Pusa kesar**

Growth regulators(G)	Days to 50% flowering				Root length (cm)			
	Spacing(S)				Spacing(S)			
	S1	S2	S3	Mean	S1	S2	S3	Mean
G <sub>1</sub> -GA <sub>3</sub> (200 ppm)	116.6	114.2	112.2	<b>114.33</b>	31.13	31.40	30.20	<b>30.91</b>
G <sub>2</sub> -GA <sub>3</sub> (300 ppm)	117.4	120.3	119.3	<b>119.00</b>	26.40	26.30	27.60	<b>26.77</b>
G <sub>3</sub> -NAA (200 ppm)	115.2	116.7	115.1	<b>115.67</b>	28.70	29.10	28.00	<b>28.60</b>
G <sub>4</sub> -NAA (300 ppm)	121.9	122.8	120.3	<b>121.67</b>	24.30	22.40	20.50	<b>22.40</b>
G <sub>0</sub> -water (control)	123.4	123.6	123.3	<b>123.43</b>	21.50	19.20	19.40	<b>20.03</b>
<b>Mean</b>	<b>118.9</b>	<b>119.5</b>	<b>118.0</b>	<b>118.82</b>	<b>25.68</b>	<b>26.41</b>	<b>25.14</b>	<b>25.74</b>
For comparing means of	S. Em.±		CD (0.05)		S. Em.±		CD (0.05)	
Spacing(S)	1.93		NS		0.47		NS	
Growth regulator(G)	2.50		NS		0.60		1.75	
Interaction (S x G)	4.32		NS		1.04		NS	

S<sub>1</sub> = 30 x 20 cm S<sub>2</sub> = 40 x 15 cm S<sub>3</sub> = 60x 10cm NS- Non significant

G<sub>1</sub> - GA<sub>3</sub> (200 ppm) G<sub>2</sub> - GA<sub>3</sub> (300 ppm) GA<sub>3</sub> - NAA (200 ppm) G<sub>4</sub> - NAA (300 ppm) G<sub>5</sub> - Control

**Table 14. Effect of spacing and growth regulator on root diameter (cm) and root weight (g) of carrot cv. Pusa kesar**

Growth regulators(G)	Root diameter(cm)				Root weight (g)			
	Spacing(S)				Spacing(S)			
	S1	S2	S3	Mean	S1	S2	S3	Mean
G <sub>1</sub> -GA <sub>3</sub> (200 ppm)	14.40	15.10	14.10	<b>14.53</b>	82.40	83.10	80.20	<b>81.90</b>
G <sub>2</sub> -GA <sub>3</sub> (300 ppm)	11.90	11.20	10.90	<b>11.33</b>	72.70	75.30	72.60	<b>73.53</b>
G <sub>3</sub> -NAA (200 ppm)	13.40	13.30	12.60	<b>13.10</b>	78.20	78.90	76.30	<b>77.80</b>
G <sub>4</sub> -NAA (300 ppm)	09.90	09.90	08.90	<b>09.57</b>	70.70	68.90	68.50	<b>69.37</b>
G <sub>0</sub> -water (control)	09.30	06.60	08.50	<b>08.13</b>	64.30	65.80	65.00	<b>65.03</b>
<b>Mean</b>	<b>11.22</b>	<b>11.78</b>	<b>11.00</b>	<b>11.33</b>	<b>73.66</b>	<b>74.40</b>	<b>72.52</b>	<b>73.53</b>
For comparing means of	S. Em.±		CD (0.05)		S. Em.±		CD (0.05)	
Spacing(S)	0.33		NS		1.07		NS	
Growth regulator(G)	0.43		1.25		1.38		3.99	
Interaction (S x G)	0.75		NS		2.39		NS	

S<sub>1</sub> = 30 x 20 cm    S<sub>2</sub> = 40 x 15 cm    S<sub>3</sub> = 60x 10cm    NS- Non significant

G<sub>1</sub> - GA<sub>3</sub> (200 ppm)    G<sub>2</sub> - GA<sub>3</sub> (300 ppm)    G<sub>3</sub> - NAA (200 ppm)    G<sub>4</sub> - NAA (300 ppm)    G<sub>5</sub> - Control

#### 4.5.4 Number of umbels / plant

Data on number of umbels per plant as influenced by spacing, growth regulators and their interactions are presented in Table 15.

Number of umbels per plant of carrot was significantly influenced by spacing.  $S_2$  recorded significantly higher number of umbels (38.51) over  $S_3$  (35.33) and was on par with  $S_1$  (37.12).

Significantly more number of umbels per plant was recorded in  $G_1$  (43.96) over  $G_3$  (41.37),  $G_2$  (37.35),  $G_4$  (33.01) and  $G_5$  (29.24).

Interaction effect was non significant between spacing and growth regulators with respect to number of umbels per plant.

#### 4.5.5 Number of seeds / umbel

Data on number of seeds per umbel as influenced by spacing and growth regulators are presented in Table 15.

Number of seeds per umbel of carrot was significantly influenced by spacing  $S_2$  recorded significantly higher number of seeds per umbel (25.27) over  $S_3$  (28.28) and was on par with  $S_1$  (23.33).

Significantly more number of seeds per umbel was recorded in  $G_1$  (25.72) over  $G_3$  (23.21),  $G_2$  (22.47),  $G_4$  (22.28) and  $G_5$  (22.11).

Interaction effect was non significant between spacing and growth regulators with respect to number of seeds per umbel.

#### 4.5.6 Umbel diameter

Data on umbel diameter as influenced by spacing, growth regulators and their interactions are presented in Table 16.

Umbel diameter was numerically influenced by spacing. Higher umbel diameter was recorded in  $S_2$  (31.50 cm) over  $S_1$  (30.26) and  $S_3$  (28.66).

Significantly higher umbel diameter was recorded in  $G_1$  (38.33 cm) over  $G_3$  (34.23 cm),  $G_2$  (30.00 cm),  $G_4$  (26.10 cm) and  $G_5$  (22.03), respectively.

#### 4.5.7 1000 seed weight (g)

The data on 1000 seed weight as influenced by spacing and growth regulators are presented in table16.

1000 seed weight was significantly influenced by spacing  $S_1$  recorded significantly higher 1000 seed weight (4.13 g) over  $S_3$  (3.56 g) and was on par with  $S_2$  (4.01 g).

Significantly higher 1000 seed weight was recorded in  $G_1$  (4.75 g) over  $G_3$  (4.23 g),  $G_2$  (3.88 g),  $G_4$  (3.52 g) and  $G_5$  (3.13 g).

Interaction effect was non significantly between the spacing and growth regulators with respect to 1000 seed weight.

#### 4.5.8 Seed yield per plant (g/plant)

Data on seed yield as influenced by spacing and growth regulators in carrot are presented in Table17.

Seed yield was significantly influenced by spacing. Significantly higher seed yield per plant was recorded in  $S_2$  (41.26 g / plant) over  $S_3$  (36.58 g / plant) and was on par with  $S_1$  (39.90 g / plant). Significantly lower seed yield per plant was recorded in  $S_3$ .

Seed yield per plant was significantly influenced by growth regulators. Significantly higher seed yield per plant was recorded in  $G_1$  (46.30 g / plant) over  $G_3$  (43.40 g / plant),  $G_2$  (39.87 g / plant),  $G_4$  (35.57 g / plant) and  $G_5$  (31.10 g / plant) respectively.

Interaction effect for seed yield per plant was not significant due to spacing and growth regulators.

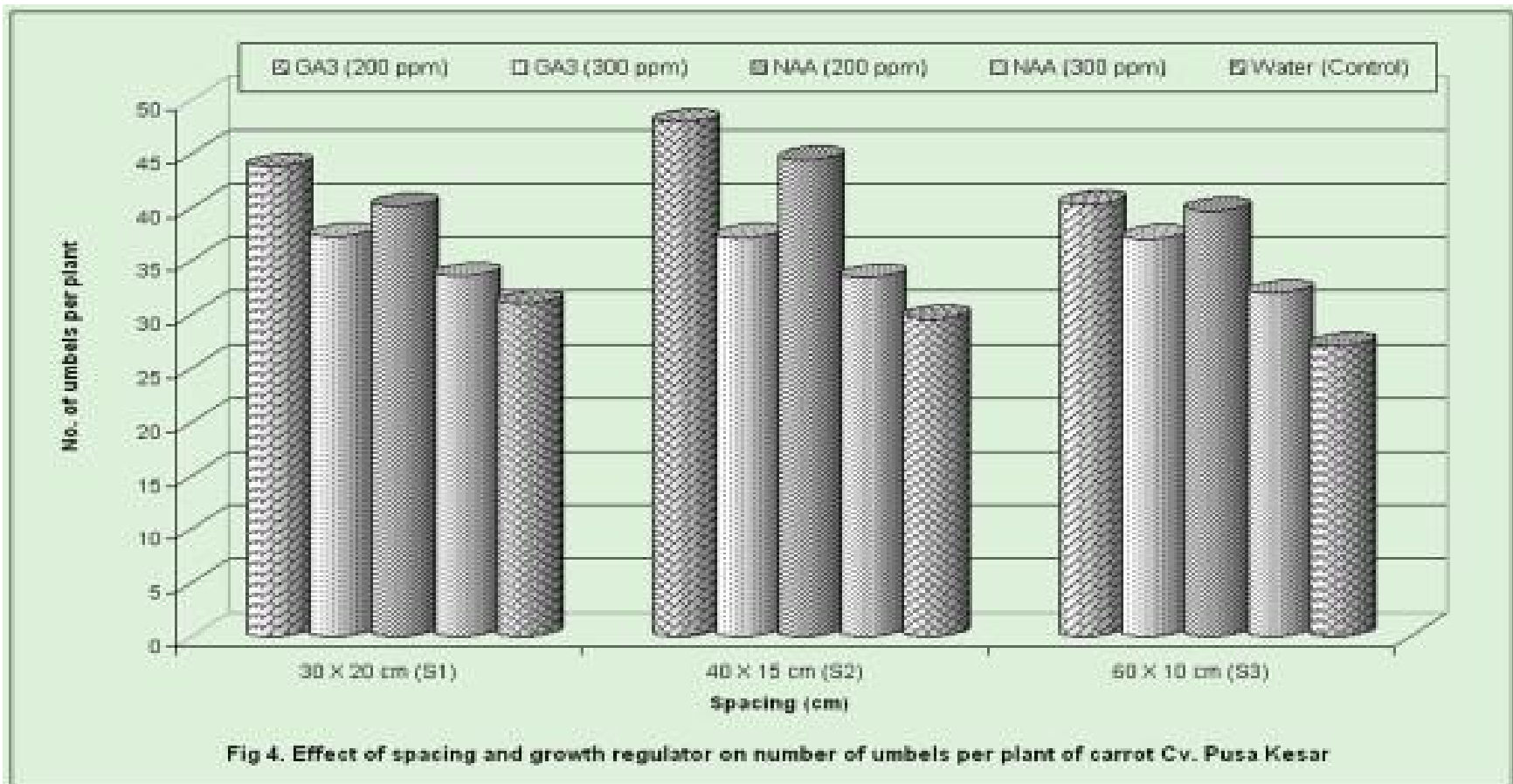
**Table 15. Effect of spacing and growth regulator on number of umbels per plant and number of seeds per umbel of carrot cv. Pusa kesar**

Growth regulators(G)	Number of umbels per plant				Number of seeds per umbel			
	Spacing(S)				Spacing(S)			
	S1	S2	S3	Mean	S1	S2	S3	Mean
G <sub>1</sub> -GA <sub>3</sub> (200 ppm)	43.72	47.89	40.27	<b>43.96</b>	22.90	26.10	28.20	<b>25.72</b>
G <sub>2</sub> -GA <sub>3</sub> (300 ppm)	37.27	37.17	37.60	<b>37.35</b>	23.80	23.50	20.10	<b>22.47</b>
G <sub>3</sub> -NAA (200 ppm)	40.05	44.42	39.66	<b>41.37</b>	24.40	26.10	19.10	<b>23.21</b>
G <sub>4</sub> -NAA (300 ppm)	33.56	33.46	32.02	<b>33.01</b>	23.80	25.50	17.50	<b>22.28</b>
G <sub>0</sub> -water (control)	31.02	29.61	27.10	<b>29.24</b>	21.70	25.10	16.50	<b>22.11</b>
<b>Mean</b>	<b>37.12</b>	<b>38.51</b>	<b>35.33</b>	<b>36.99</b>	<b>23.33</b>	<b>25.27</b>	<b>28.28</b>	<b>22.96</b>
For comparing means of	S. Em.±		CD (0.05)		S. Em.±		CD (0.05)	
Spacing(S)	0.56		1.63		0.99		2.87	
Growth regulator(G)	0.72		2.09		1.28		NS	
Interaction (S x G)	1.25		NS		2.21		NS	

S<sub>1</sub> = 30 x 20 cm  
G<sub>1</sub> - GA<sub>3</sub> (200 ppm)

S<sub>2</sub> = 40 x 15 cm S<sub>3</sub> = 60x 10cm  
G<sub>2</sub> - GA<sub>3</sub> (300 ppm) GA<sub>3</sub> - NAA (200 ppm)

NS- Non significant  
G<sub>4</sub> - NAA (300 ppm) G<sub>5</sub> - Control



**Fig 4. Effect of spacing and growth regulator on number of umbels of umbels per plant of carrot Cv. Pusa kesar**

**Table 16. Effect of spacing and growth regulator on umbel diameter and 1000 seed weight (g) of carrot cv. Pusa kesar**

Growth regulators(G)	Umbel diameter (cm)				1000 seed weight (g)			
	Spacing(S)				Spacing(S)			
	S1	S2	S3	Mean	S1	S2	S3	Mean
G <sub>1</sub> -GA <sub>3</sub> (200 ppm)	38.50	39.20	37.30	<b>38.33</b>	5.11	4.80	4.33	<b>4.75</b>
G <sub>2</sub> -GA <sub>3</sub> (300 ppm)	29.30	31.30	29.40	<b>30.00</b>	4.10	3.97	3.57	<b>3.88</b>
G <sub>3</sub> -NAA (200 ppm)	34.90	35.10	32.70	<b>34.23</b>	4.42	4.30	3.96	<b>4.23</b>
G <sub>4</sub> -NAA (300 ppm)	26.10	27.50	24.70	<b>26.10</b>	3.64	3.72	3.21	<b>3.52</b>
G <sub>0</sub> -water (control)	22.50	24.40	19.20	<b>22.03</b>	3.39	3.25	2.74	<b>3.13</b>
<b>Mean</b>	<b>30.26</b>	<b>31.50</b>	<b>28.66</b>	<b>30.14</b>	<b>4.13</b>	<b>4.01</b>	<b>3.56</b>	<b>3.90</b>
For comparing means of	S. Em.±		CD (0.05)		S. Em.±		CD (0.05)	
Spacing(S)	0.93		NS		0.06		0.17	
Growth regulator(G)	1.21		3.49		0.08		0.22	
Interaction (S x G)	2.09		NS		0.13		NS	

S<sub>1</sub> = 30 x 20 cm S<sub>2</sub> = 40 x 15 cm S<sub>3</sub> = 60x 10cm NS- Non significant

G<sub>1</sub> - GA<sub>3</sub>(200 ppm) G<sub>2</sub> - GA<sub>3</sub>(300 ppm) GA<sub>3</sub> - NAA (200 ppm) G<sub>4</sub> – NAA (300 ppm) G<sub>5</sub> - Control

#### 4.5.9 Seed yield per plot

Data on seed yield per plot as influenced by spacing and growth regulators in carrot are presented in Table 17.

Among the three spacing, significantly higher seed yield per plot was recorded in S<sub>2</sub> (173.38 g / plot) over S<sub>3</sub> (157.75 g / plot) and was on par with S<sub>1</sub> (166.99 g / plot).

Significantly higher seed yield per plot was recorded in G<sub>1</sub> (189.36 g / plot) over G<sub>3</sub> (178.13 g / plot), G<sub>2</sub> (165.92 g / plot), G<sub>4</sub> (154.59 g / plot) and G<sub>5</sub> (142.18 g / plot).

Interaction effect between the spacing and growth regulators with respect to seed yield per plot was non significant.

#### 4.5.10 Seed yield (kg/ha)

Seed yield was significantly influenced by the spacing and growth regulators (Table18).

Seed yield per hectare was significantly influenced by spacing. Significantly higher seed yield was recorded in S<sub>2</sub> (433 kg / ha) over S<sub>3</sub> (394 kg / ha) and was on par with S<sub>1</sub> (417 kg / ha).

Seed yield per hectare was significantly influenced by growth regulators. Significantly higher seed yield was recorded in G<sub>1</sub> (473 kg / ha) over G<sub>3</sub> (445 kg / ha), G<sub>2</sub> (414 kg / ha), G<sub>4</sub> (386 kg / ha) and G<sub>5</sub> (355 kg / ha).

### 4.6 SEED QUALITY PARAMETERS

#### 4.6.1 Seed germination (%)

Data on germination per cent as influenced by spacing and growth regulators in carrot are presented in table19.

Higher seed germination was recorded in S<sub>1</sub> (85.69 %) compared to S<sub>2</sub> (85.16 %) and S<sub>3</sub> (83.87 %).

Higher seed germination was recorded in G<sub>1</sub> (86.94 %) compared to G<sub>2</sub> (84.99 %) , G<sub>3</sub> (85.65 %) , G<sub>4</sub>(83.83 %) and G<sub>5</sub> (83.12 %). Lowest seed germination was recorded in G<sub>5</sub>.

Interaction effect was non significant between spacing and growth regulators with respect to seed of germination.

#### 4.6.2 Speed of germination

Data on speed of germination as affected by spacing, growth regulators are non significant (Table 19).

The spacing effect on speed of germination was non significant but S<sub>3</sub> recorded higher speed of emergence (21.54), compared to S<sub>2</sub> (22.08), S<sub>1</sub> (21.76).

The speed of germination differed numerically due to different concentration of growth regulators. Higher speed of germination was notice in G<sub>1</sub> (22.37) over G<sub>5</sub> (21.33), G<sub>4</sub> (21.47), G<sub>2</sub> (21.83) and G<sub>3</sub> (21.97).

Interaction effects of spacing and growth regulators on were non-significant with respect to speed of germination.

#### 4.6.3 Root length and shoot length

The data on root length and shoot length as influenced by spacing and growth regulators are presented in Table 20.

Significantly higher root length (8.60 cm) and shoot length (8.58 cm) was observed in S<sub>2</sub> compared to S<sub>3</sub> (8.17 cm and 7.91 cm) and was on par with S<sub>1</sub>(8.34 cm and 8.41 cm) respectively.

Significantly higher root length and shoot length was observed in G<sub>1</sub>(8.80 cm and 8.80 cm) compared to G<sub>3</sub>(8.69 cm and 8.53 cm), G<sub>2</sub> (8.35 cm and 8.30 cm), G<sub>4</sub> (8.17 cm and 8.07 cm) and G<sub>5</sub> (7.88 cm and 8.30 cm) respectively.

**Table 17. Effect of spacing and growth regulator on seed yield per plant and seed yield per plot of carrot cv.Pusa kesar**

Growth regulators(G)	Seed yield per plant(g)				Seed yield per plot(g)			
	Spacing(S)				Spacing(S)			
	S1	S2	S3	Mean	S1	S2	S3	Mean
G <sub>1</sub> -GA <sub>3</sub> (200 ppm)	47.20	47.20	44.50	<b>46.30</b>	187.91	201.26	178.92	<b>189.36</b>
G <sub>2</sub> -GA <sub>3</sub> (300 ppm)	39.60	41.30	38.70	<b>39.87</b>	168.92	171.23	157.62	<b>165.92</b>
G <sub>3</sub> -NAA (200 ppm)	44.60	44.40	41.20	<b>43.40</b>	179.14	187.13	168.13	<b>178.13</b>
G <sub>4</sub> -NAA (300 ppm)	35.70	38.70	32.30	<b>35.57</b>	157.26	159.9	146.62	<b>154.59</b>
G <sub>0</sub> -water (control)	32.40	34.70	26.20	<b>31.10</b>	141.73	147.37	137.45	<b>142.18</b>
<b>Mean</b>	<b>39.90</b>	<b>41.26</b>	<b>36.58</b>	<b>39.25</b>	<b>166.99</b>	<b>173.38</b>	<b>157.75</b>	<b>166.04</b>
For comparing means of	S. Em.±		CD (0.05)		S. Em.±		CD (0.05)	
Spacing(S)	0.53		1.55		2.67		7.73	
Growth regulator(G)	0.69		1.99		3.44		9.98	
Interaction (S x G)	1.19		NS		5.96		NS	

S<sub>1</sub> = 30 x 20 cm S<sub>2</sub> = 40 x 15 cm S<sub>3</sub> = 60x 10cm NS- Non significant  
G<sub>1</sub> - GA<sub>3</sub> (200 ppm) G<sub>2</sub> - GA<sub>3</sub> (300 ppm) GA<sub>3</sub> - NAA (200 ppm) G<sub>4</sub> - NAA (300 ppm) G<sub>5</sub> - Control

**Table 18. Effect of spacing and growth regulator on seed yield (kg/ha) of carrot cv. Pusa kesar**

Growth regulators(G)	Seed yield (kg/ha)			
	Spacing(S)			
	S1	S2	S3	Mean
G <sub>1</sub> -GA <sub>3</sub> (200 ppm)	469.78	503.15	447.30	<b>473.41</b>
G <sub>2</sub> -GA <sub>3</sub> (300 ppm)	422.30	428.08	394.05	<b>414.81</b>
G <sub>3</sub> -NAA (200 ppm)	447.85	467.83	420.33	<b>445.34</b>
G <sub>4</sub> -NAA (300 ppm)	393.15	399.75	366.55	<b>386.48</b>
G <sub>0</sub> -water (control)	354.33	368.43	343.63	<b>355.46</b>
<b>Mean</b>	<b>417.48</b>	<b>433.45</b>	<b>394.37</b>	<b>415.10</b>
For comparing means of	S. Em.±		CD (0.05)	
Spacing(S)	6.67		19.32	
Growth regulator(G)	8.61		24.95	
Interaction (S x G)	14.91		NS	

S<sub>1</sub> = 30 x 20 cm  
G<sub>1</sub> - GA<sub>3</sub> (200 ppm)

S<sub>2</sub> = 40 x 15 cm  
G<sub>2</sub> - GA<sub>3</sub> (300 ppm)

S<sub>3</sub> = 60x 10cm  
GA<sub>3</sub> - NAA (200 ppm)

NS- Non significant

G<sub>4</sub> - NAA (300 ppm)

G<sub>5</sub> - Control

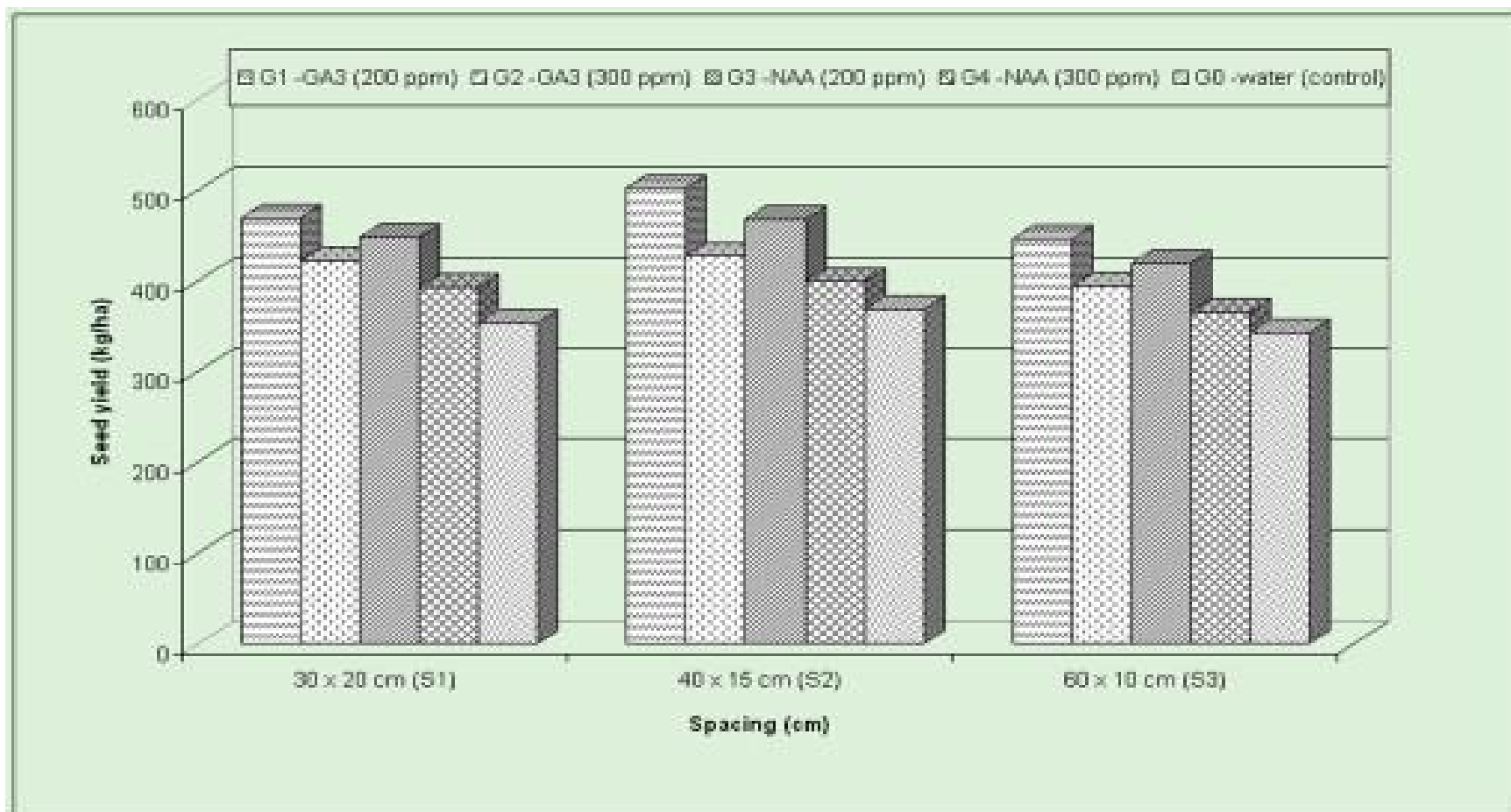


Fig. 5: Effect of spacing and growth regulator on seed yield (kg/ha) of carrot cv. Pusa kesar

**Table 19. Effect of spacing and growth regulator on germination (%) and speed of germination of carrot cv. Pusa kesar**

Growth regulators(G)	Germination (%)				Speed of germination			
	Spacing(S)				Spacing(S)			
	S1	S2	S3	Mean	S1	S2	S3	Mean
G <sub>1</sub> -GA <sub>3</sub> (200 ppm)	87.01 (68.85)	85.30 (67.93)	88.51 (70.16)	<b>86.94</b> <b>(68.79)</b>	22.1	23.0	22.0	<b>22.37</b>
G <sub>2</sub> -GA <sub>3</sub> (300 ppm)	85.22 (67.36)	85.34 (67.46)	84.43 (66.73)	<b>84.99</b> <b>(67.18)</b>	22.2	21.8	21.5	<b>21.83</b>
G <sub>3</sub> -NAA (200 ppm)	86.62 (68.52)	85.12 (67.28)	85.21 (87.36)	<b>85.65</b> <b>(67.71)</b>	22.0	22.7	21.2	<b>21.97</b>
G <sub>4</sub> -NAA (300 ppm)	84.11 (66.43)	85.22 (67.36)	82.16 (64.99)	<b>83.83</b> <b>(66.26)</b>	21.3	21.5	21.6	<b>21.47</b>
G <sub>0</sub> -water (control)	85.53 (67.61)	84.82 (67.04)	79.02 (62.71)	<b>83.12</b> <b>(65.72)</b>	21.2	21.4	21.4	<b>21.33</b>
<b>Mean</b>	<b>85.69</b> <b>(67.74)</b>	<b>85.16</b> <b>(67.32)</b>	<b>83.87</b> <b>(66.29)</b>	<b>84.91</b> <b>(67.11)</b>	<b>21.76</b>	<b>22.08</b>	<b>21.54</b>	<b>21.79</b>
For comparing means of	S. Em.±		CD (0.05)		S. Em.±		CD (0.05)	
Spacing(S)	0.80		NS		0.20		NS	
Growth regulator(G)	1.03		NS		0.26		NS	
Interaction (S x G)	1.79		NS		0.45		NS	

S<sub>1</sub> = 30 x 20 cm S<sub>2</sub> = 40 x 15 cm S<sub>3</sub> = 60x 10cm NS- Non significant

G<sub>1</sub> - GA<sub>3</sub> (200 ppm) G<sub>2</sub> - GA<sub>3</sub> (300 ppm) GA<sub>3</sub> - NAA (200 ppm) G<sub>4</sub> - NAA (300 ppm) G<sub>5</sub> - Control

\*Figures in parenthesis are arcsine values

**Table 20. Effect of spacing and growth regulator on root length (cm) and shoot length (cm) of carrot cv. Pusa kesar**

Growth regulators(G)	Root length (cm)				Shoot length (cm)			
	Spacing(S)				Spacing(S)			
	S1	S2	S3	Mean	S1	S2	S3	Mean
G <sub>1</sub> -GA <sub>3</sub> (200 ppm)	8.80	9.1	8.50	<b>8.80</b>	8.95	9.0	8.45	<b>8.80</b>
G <sub>2</sub> -GA <sub>3</sub> (300 ppm)	8.30	8.6	8.15	<b>8.35</b>	8.40	8.6	7.9	<b>8.30</b>
G <sub>3</sub> -NAA (200 ppm)	8.65	9.0	8.40	<b>8.68</b>	8.70	8.85	8.05	<b>8.53</b>
G <sub>4</sub> -NAA (300 ppm)	8.11	8.3	8.00	<b>8.14</b>	8.1	8.35	7.75	<b>8.07</b>
G <sub>0</sub> -water (control)	7.85	8.0	7.80	<b>7.88</b>	7.90	8.1	7.40	<b>7.80</b>
<b>Mean</b>	<b>8.34</b>	<b>8.60</b>	<b>8.17</b>	<b>8.37</b>	<b>8.41</b>	<b>8.58</b>	<b>7.91</b>	<b>8.30</b>
For comparing means of	S. Em.±		CD (0.05)		S. Em.±		CD (0.05)	
Spacing(S)	0.07		0.19		0.07		0.19	
Growth regulator(G)	0.09		0.25		0.09		0.25	
Interaction (S x G)	0.15		NS		0.15		NS	

S<sub>1</sub> = 30 x 20 cm S<sub>2</sub> = 40 x 15 cm S<sub>3</sub> = 60x 10cm NS- Non significant

G<sub>1</sub> - GA<sub>3</sub> (200 ppm) G<sub>2</sub> - GA<sub>3</sub> (300 ppm) GA<sub>3</sub> - NAA (200 ppm) G<sub>4</sub> - NAA (300 ppm) G<sub>5</sub> - Control

Interaction effect was non-significantly between the spacing and growth regulators with respect to root length and shoot length.

#### 4.6.4 Seedling vigour index

Data on seedling vigour index was significantly influenced by spacing and growth regulators (Table 21).

Vigour index was significantly influenced by spacing.  $S_1$  recorded significantly higher vigour index (1446) over  $S_3$  (1340) and was on par with  $S_2$  (1445).

Significantly higher vigour index was recorded in  $G_1$  (1512) over  $G_3$  (1503),  $G_2$  (1415),  $G_4$  (1365) and  $G_5$  (1258).

Interaction effect was non-significantly between the spacing and growth regulators with respect to vigour index.

#### 4.6.5 Seedling dry weight (mg/g 5 seedlings)

Data on seedling dry weight as influenced by spacing and growth regulators (Table 21).

The spacing effect on seedling dry weight was non-significant. Higher seedling dry weight was recorded in  $S_2$  (11.65) compared to  $S_1$  (11.45) and  $S_3$  (11.30).

Seedling dry weight differed numerically due to the different concentration of growth regulators. Higher seedling dry weight was noticed in  $G_1$  (11.83) over  $G_3$  (11.64),  $G_2$  (11.40),  $G_4$  (11.33) and  $G_5$  (11.19).

Interaction effect of spacing and growth regulators on was non-significant with respect to seedling dry weight.

#### 4.6.6 Field emergence (%)

Data on field emergence as influenced by spacing, growth regulators in carrot are presented in table 22.

Higher field emergence was recorded in  $S_1$  (80.15 %) compared to  $S_2$  (79.40 %) and  $S_3$  (78.62 %).

Higher field emergence was recorded in  $G_1$  (81.10 %) compared to  $G_2$  (79.42 %),  $G_3$  (79.96 %),  $G_4$  (78.70 %) and  $G_5$  (77.75 %).

Interaction effect was non-significant between the spacing and growth regulators with respect to field emergence.

**Table 21. Effect of spacing and growth regulator on vigour index and seedling dry weight of carrot cv. Pusa kesar**

Growth regulators(G)	Vigour index				Seedling dry weight(mg)			
	Spacing(S)				Spacing(S)			
	S1	S2	S3	Mean	S1	S2	S3	Mean
G <sub>1</sub> -GA <sub>3</sub> (200 ppm)	1578	1458	1500	<b>1512</b>	11.84	11.95	11.69	<b>11.83</b>
G <sub>2</sub> -GA <sub>3</sub> (300 ppm)	1423	1468	1355	<b>1415</b>	11.37	11.57	11.26	<b>11.40</b>
G <sub>3</sub> -NAA (200 ppm)	1503	1519	1487	<b>1503</b>	11.68	11.82	11.41	<b>11.64</b>
G <sub>4</sub> -NAA (300 ppm)	1383	1419	1294	<b>1365</b>	11.32	11.51	11.15	<b>11.33</b>
G <sub>0</sub> -water (control)	1347	1365	1064	<b>1259</b>	11.16	11.40	11.00	<b>11.19</b>
<b>Mean</b>	<b>1447</b>	<b>1446</b>	<b>1340</b>	<b>1411</b>	<b>11.45</b>	<b>11.65</b>	<b>11.30</b>	<b>11.48</b>
For comparing means of	S. Em.±		CD (0.05)		S. Em.±		CD (0.05)	
Spacing(S)	22.35		64.78		0.13		NS	
Growth regulator(G)	28.85		83.63		0.18		NS	
Interaction (S x G)	49.98		NS		0.30		NS	

S<sub>1</sub> = 30 x 20 cm S<sub>2</sub> = 40 x 15 cm S<sub>3</sub> = 60x 10cm      NS- Non significant  
 G<sub>1</sub> - GA<sub>3</sub> (200 ppm)    G<sub>2</sub> - GA<sub>3</sub> (300 ppm)    GA<sub>3</sub> - NAA (200 ppm)    G<sub>4</sub> – NAA (300 ppm)    G<sub>5</sub> - Control

**Table 22. Effect of spacing and growth regulator on field emergence (%) of carrot cv. Pusa kesar**

Growth regulators(G)	Field emergence (%)			
	Spacing(S)			
	S1	S2	S3	Mean
G <sub>1</sub> -GA <sub>3</sub> (200 ppm)	81.38 (64.47)	79.61 (63.19)	82.32 (65.17)	<b>81.10</b> <b>(64.26)</b>
G <sub>2</sub> -GA <sub>3</sub> (300 ppm)	79.39 (63.03)	79.81 (63.33)	79.07 (62.81)	<b>79.42</b> <b>(63.05)</b>
G <sub>3</sub> -NAA (200 ppm)	81.42 (64.49)	79.20 (62.89)	79.26 (62.94)	<b>79.96</b> <b>(63.44)</b>
G <sub>4</sub> -NAA (300 ppm)	78.71 (62.55)	79.27 (62.95)	78.12 (62.14)	<b>78.70</b> <b>(62.55)</b>
G <sub>0</sub> -water (control)	79.83 (63.35)	79.11 (62.83)	74.32 (59.58)	<b>77.75</b> <b>(61.89)</b>
<b>Mean</b>	<b>80.15</b> <b>(63.57)</b>	<b>79.40</b> <b>(63.04)</b>	<b>78.62</b> <b>(62.49)</b>	<b>79.39</b> <b>(63.03)</b>
For comparing means of	S. Em.±		CD (0.05)	
Spacing(S)	1.23		NS	
Growth regulator(G)	1.59		NS	
Interaction (S x G)	2.76		NS	

S<sub>1</sub> = 30 x 20 cm S<sub>2</sub> = 40 x 15 cm S<sub>3</sub> = 60x 10cm

NS- Non significant

G<sub>1</sub>-GA<sub>3</sub> (200 ppm) G<sub>2</sub>-GA<sub>3</sub> (300 ppm)

GA<sub>3</sub>-NAA (200 ppm) G<sub>4</sub>-NAA (300 ppm) G<sub>5</sub> - Control

\*Figures in parenthesis are arcsine values

## V. DISCUSSION

Many of the physiological processes are directly or indirectly controlled by environment under which crops are grown. In addition, genotype, soil and cultural practices have a profound influence on the productivity of crop plants. In order to suit the requirement for a crop, the environment can be manipulated to certain extent by cultural practices. Hence, an attempt was made to increase the yield as well as quality by way of manipulating cultural practices like date of sowing, nutrition, spacing and growth regulators to see their impact on the productivity potential as well as quality of carrot seeds Cv. Pusa Kesar. Results obtained in the present investigation have been discussed in this chapter under the following headings.

### 5.1 INFLUENCE OF DATE OF SOWING ON GROWTH, SEED YIELD AND QUALITY

In the present investigation, the carrot Cv. Pusa kesar was sown on four times viz., 15<sup>th</sup> August, 1<sup>st</sup> September, 15<sup>th</sup> September and 1<sup>st</sup> October to find out optimum date of sowing to obtain maximum seed yield and quality.

The significantly highest seed yield (464.00 kg/ha) was obtained when sowing was made on 1st September which was on par with earlier sowing 15<sup>th</sup> August (458.64 kg/ha). As the sowing was delayed after September first week, a significant decrease in seed yield was noticed. The higher seed yield noticed with 1<sup>st</sup> September sowing and at August 15<sup>th</sup> sowing were due to better field performance of seed crop to the congenial environment experienced by the mother plants during that period. Similar benefits influence of early sowing were also made by Shantha Nagarajan *et al.* (1998) in their study with the effect of sowing time on emergence characteristics of Asiatic carrot. Their study also clearly demonstrated the significant role played by environmental conditions prevailing at the time of sowing (first environment) i.e. September sowing had a favourable mean monthly maximum temperature of 32°C and mean minimum temperature of 22.6°C. In the present study also higher reproductive output noticed was due to higher vegetative input and effective seed stalks.

September 1<sup>st</sup> sowing. Grewal and Kumar (1989) also confirmed the benefits of early sowing in okra seed production. He opined that early sown plants got more time for growth, development and fruiting. Moreover, early sown crop escaped to a greater extent, the ill effects of rains associated with high insect attack and virus infection. Lower temperature during that period resulted in better seed stalk formation (Singh *et al.*, 1990) significantly higher plant growth attributed to higher plant height and more number of leaves were recorded during 1<sup>st</sup> September sowing followed by August mid sowing.

As the sowing was delayed, environmental conditions went on becoming adverse and affected the plant growth, yield and seed quality (Grewal *et al.*, 1971). Uniform and effective flowering and bolting was exhibited by early sowings taking numerically higher number of days for fifty per cent flowering which adequately provided sufficient source like root length, root weight and root girth etc for further effective reproductive phase. Difference in the sowing date resulted in variation of root weight, girth and length as the crop needs particular temperature for ensuring high yield and good quality roots of radish (Singh *et al.*, 1979). Similar positive relationship of some agro-climatic conditions on the yield okra. Whereas later sowings (i.e. 15<sup>th</sup> September and October 1<sup>st</sup>) took less number of days and comparatively built up poor vegetative source. Seed yield and ability of a crop is the reflection of yield attributing character.

Higher seed yield was also attributed to higher number of umbels per plant and higher thousand seed weight during 15<sup>th</sup> September sowing and decline in seed yield contributing traits was observed in delayed sowings due to unfavourable ecological conditions. Similar observations were also made by Yadav and Khurana (1999) who obtained higher primary, secondary and tertiary umbels with early sowing. Shanta Nagarajan *et al.* (1998) also confirmed the same in their experiment with carrot. The maximum seed yield was also recorded in "September end" sowing in fennel which might be due to more umbels and higher seed weight per umbel as compared to other sowing dates (Batra *et al.*, 2002).

Decrease in thousand seed weight was also observed by Grewal *et al.* (1971) as the sowing was delayed in okra. Present results are also in agreement with Shyam Singh (1968) who reported that the delayed planting and onion bulbs by an interval of fortnight from

October 1st to October end brought out about a corresponding reduction in seed yield.

Seed yield of wheat was significantly reduced after when sown late during November. The poor yield of late sown wheat may be attributed to reduction in the number of effective tillers and test weight. Adverse climatic condition might have caused forced maturity of late sown cultivars (Samre *et al.*, 1989)

Mid September sowing produced the seeds of test weight which was on par with 15th August. Present experimental results were also similar to the results obtained by Batra *et al.* (2002).

The test weight and seed yield reduced significantly later which might be attributed to forced maturity of seed without proper development.

The previous study, Time of sowing influenced differentially the seed quality. Seed germination in the laboratory did not differ significantly due to date of sowing. But seedling vigour was maximum at September 15th sowing and reduced afterwards. Decreased seedling vigour at delayed sowings might be due to poor development of seed and higher temperature prevailed in later sowings. The present results are in line with the research work of Batra *et al.* (2002) in fennel.

### Influence of nutrition on growth and seed yield and seed quality

Combined application of inorganic and organic manures significantly influenced the growth parameters in carrot. This has been the consequence as a result of higher nutrient availability and increased nitrogen from organic manure (VC i.e vermicompost) along with inorganic fertilizers (RDF i.e Recommended dose of fertilizers) which had profound influence in mobilizing the nutrients from the non available form of nutrients mainly due to improved physical, chemical and biological properties of the soil.

In the present study, the combined application of VC + RDF followed by FYM + RDF significantly influenced the plant height and higher number of leaves. The application of 50 per cent RDF along with 50 per cent VC per ha favourably influenced the plant height and number of leaves followed by 50% RDF + 50% FYM which was on par with (118.95). This clearly indicated the importance of adding organic manures to the soil in conjunction with inorganic fertilizers, which increases the availability of nutrients considerably resulting in positive effect of growth parameters. Increase in growth parameters might have facilitated quick and greater availability of plant nutrients and thus provide a better environment for root growth and proliferation. It also creates more adsorptive surface for uptake of nutrients. These results are in accordance with the findings of Demke *et al.* (1988) who reported increased plant height and branches per plant in chili due to combined application of organic and inorganic fertilizers and also significant improvement in soil properties. Similar results are also reported by Natarajan (1990) and Sutagatti in chilli.

In the present study, days to 50 per cent flowering was significantly influenced by combined application of inorganic and organic manures. The application of RDF (50%) + VC (50%) recorded numerically lower number of days to 50 per cent flowering (115.18 days) followed by 50% RDF + 50% FYM per ha (118.95 days) and also not significant effect on other nutrients.

The control took numerically more number of days (117.20 days) for 50 per cent flowering. The induction of early flowering due to the application of VC was mainly due to the process of bio-regulators which have an influence on early flower initiation. These results are in line with the findings of Nirmala and Vadivel (1999) in bittergourd and Kodalli (2006) in chilli.

Another probable reason may be due to better nutritional status of the plants which was favoured by the treatments. Increased production of leaves might have helped to elaborate more photosynthates and induce flowering stimulates, thus effecting early initiation of flower bud. These are in close conformity with the findings of Darley Jose (1984) in brinjal.

Yield is the manifestation of morphological, physiological, biochemical and growth parameters and is considered to result from the trapping and conversion of solar energy efficiency. Yield is the polygenic in nature and is influenced by several internal and external factors throughout the crop growth period.

In the present study, the treatment with organics especially vermicompost along with RDF recorded significantly higher root yield weight (78.08 g) , root diameter (13.25 cm) , root length(24.55 cm) followed by FYM + RDF and it was on par with 75.10 over. The increased yield was attributed to increased solubilization effect and availability of nutrients by addition of vermicompost and increased physiological activity leading to the build up of sufficient food reserves for developing sinks and better partitioning towards the developing sink.

Seed yield and quality is more important than total biological yield which results from different combination of many physiological processes based on environment under which the crop is grown. Seed yield and quality depends upon production of photosynthates and their distribution among various plant parts. The synthesis accumulation and translocation of photosynthates depend upon efficient photosynthetic structure as well as source to sink relationship. The seed yield of carrot was significantly influenced by the application of organics in combination with inorganics i.e. RDF + VC (480.44 kg / ha) followed by RDF + FYM (468.36 kg / ha). Both of these treatments are significantly superior over control (447.26 kg / ha). The higher seed yield of carrot may be attributed to improved growth parameters and seed yield components which ultimately resulted in higher seed yield. It can be also due to the supply of major nutrients and indirectly improved the physical properties of soil like aggregation, aeration, permeability, water holding capacity and biological condition of soil, which resulted in higher seed yield. These results are in accordance with the findings of Damke *et al.* (1988), Kodalli (2006) in chilli and Renuka and Ravishankar (2001) in tomato.

The use of organic manures alone suffers from draw back of low contents of nutrients and its slow release. Therefore, to get maximum economic yield, an integrated approach was followed. Application of RDF + VC at 50 per cent of recommended dose recorded maximum number of umbel (39.06), umbel diameter (35.13), 1000 seed weight and seed yield per plant (40.03). The treatments were followed by RDF + FYM (39.77, respectively) over the control (37.86, respectively).

The increase in growth and yield components noticed in the present study may be due to the fact that organics are known to enhance microbial activity which might have helped and improved availability of nutrients through mineralization and eventually leading to better canopy coverage, higher photosynthesis and translocation of photosynthates from source to sink (Jeevansab, 2000). The beneficial effect of organics may be due to accumulation of substances and availability of nutrients for longer period and reduced losses of nutrients through leaching. The increased microbial activity improves the availability of soil phosphorus and nitrogen (Hiremani, Yadav and Vijay Kumari, 2003) may be also due to better development of umbels, increased uptake of N in plants leading to enhanced chlorophyll content and carbohydrate synthesis, higher accumulation of photosynthates and their distribution to developing ovules. These results are in accordance with findings of Chavan *et al.* (1997), Sutagundi (2000) and Kodalli (2006) in chilli.

Mother plant nutrition influences significantly on seed quality and seedling vigour. In the present study, the significant difference in seed quality parameters were observed in carrot due to application of organics in combination with inorganic RDF + VC application recorded numerically higher germination percentage (86.67%), significantly higher root (10.30 Cm) - shoot (9.50 Cm) length which increased the seedling vigour index (1716) and seedling dry weight (12.58 mg). RDF + VC were on par with RDF + FYM.

Increase in germination may be because of higher 1000 seed weight and bolder seeds that contain greater metabolites for resumption of embryonic growth during germination. In addition to these metabolites, release of certain enzymes responsible for degradation of macro-molecules into micro-molecules within the seed. The increase in seed quality parameters due to certain changes in metabolisms during pollination , fertilization and seed development due to which there would be greater accumulation of food reserves resulting in higher seed quality. These results are in accordance with findings of Balaraj (1999) and Kodalli (2006) in chilli.

### Influence of spacing on growth, seed yield and quality

Plant spacing (geometry) had significant effect on plant height number of leaves per plant, test weight and seed yield. The data revealed that tallest plants (91.30 Cm) were observed under plant spacing of 60 x 10 cm whereas shortest plants (86.10 Cm) were

observed in 30 x 20 cm spacing. Plant height under plant geometry of 60 x 10 cm and 40 x 15 cm were statistically at par but significantly superior over 30 x 20 cm. Increase in plant height at closer intra row spacing was due to mutual shading by the plants and competition for light. This confirms the findings of earlier workers Verma *et al.* (1994) in onion, Singh *et al.* (1998) and Singh *et al.* (1999) in onion.

Higher numbers of umbels (38.51) per plant were recorded with plant spacing (geometry) of 40 x 15 cm which was followed by 30 x 20 cm lowest numbers of umbels (35.33) per plant were observed under plant geometry of 60 x 10 cm which was significantly lower than 40 x 15 cm and 30 x 20 cm plant spacing. Similar results were also made by Singh *et al.* (1999) in onion Cv. Hisar-2.

Plant spacing (geometry) of 30 x 20 cm recorded highest test weight (4.13) whereas lowest was recorded with 60 x 10 cm and the differences were significant. More number of umbels per plant and highest test weight at wider intra row spacing in plant geometry of 40 x 15 cm and 30 x 20 cm may be due to conducive micro climate, less competition for light, nutrient, moisture and space as compared close intra row spacing. These results confirm the findings of Narendra Singh *et al.* (1999), Singh and Sachan (1998) in onion.

Different plant spacing did not influence the 50% flowering root weight, root length, root diameter.

Higher seed yield (433.45 Kg/ha) was obtained under plant spacing of 40 x 15 cm which was statistically at par with 30 x 20 cm spacing (417.48 Kg/ha) and both were significantly superior than 60 x 10 cm plant spacing (394.37 Kg/ha). The highest seed yield at 40 x 15 cm plant spacing have been contributed by more number of umbels per plant and higher test weight, umbels diameter, seed yield / plot, seed yield per plot.

The present results confirm the findings of Narendra Singh *et al.* (1999), Bhatia and Pandey (1989) in onion.

Different plant spacing did not influence seed germination, speed of germination, seedling dry weight, field emergence. But numerically higher percent of germination and field emergence were obtained.

### Influence of growth regulators on growth, seed yield and quality

Plant growth regulators are involved in co-ordinating the development of specific plant organs and in controlling plant responses in relation to variable environment and crop management. The plant growth regulators are natural or synthetic compounds applied to the target plants to modify the developmental, morphological structures or both by manipulating the hormonal levels in different plant organs and at various stages in the plant life cycle so as to enhance its seed quality and quality (Setia *et al.*, 1991).

Among the growth regulators, GA<sub>3</sub> (200 ppm) recorded significantly higher (98.67) plant height and number of leaves etc. It also recorded less number of days to (114.33) 50 per cent flowering and days to maturity also. The increase in plant height was mainly due to the hormonal action of enhancing cell elongation. Further, GA<sub>3</sub> acts at the gene level influencing the translocation and transcription mechanisms of protein biosynthesis (Key, 1969) thus resulting in increased number of branches and early maturity (Lone *et al.*, 2005 in Chilli). Early flowering in GA<sub>3</sub> spray may be due to increase in the endogenous gibberellins levels in the plants, as gibberellins are well known for inducing early flowering in several crops.

Spraying of NAA (200 ppm) was the next best treatment, which was significantly superior over NAA (300 ppm) and control in recording the growth components. Significant performance of GA<sub>3</sub> (200 ppm) and NAA (200 ppm) as compared to control was attributed to stimulating action of auxins, which soften the cell wall and plasticity. The growth regulators are involved in increasing the photosynthetic activity, metabolic products causing the rapid cell elongation of the plant (in meristematic region of shoot) or stimulation of growth besides increasing the uptake of nutrients. These results are in conformity with findings of Balaraj (1999) in Chilli.

In general, GA<sub>3</sub> (200 ppm) recorded significantly higher values for all the yield parameters and produced (43.96) umbels per plant and (473) kg seed yield per ha while, water spray (control) recorded least number of umbels per plant (123.43) and seed yield

(355.46 kg/ha). The increase in yield and yield parameters with GA<sub>3</sub> spraying was due to better crops growth, more leaves which increased the number of umbels per plant and ultimately increased the seed yield. The sprayed plants remained physiologically more active and built up sufficient food reserves for developing flowers and seeds. The results are in conformity with the findings of Balaraj (1999) in chilli, Goudappalavar (2000) in tomato (Bhat and Singh, 1997) in okra.

GA<sub>3</sub> spray also recorded significantly higher values for most of the quality parameters. It recorded (4.75g) thousand seed weight, (86.94 %) germination and (1512) vigour index. This is mainly due to GA<sub>3</sub> application which brings about metabolic changes that affect the both quality and quantity of the desired product. It also stimulates synthesis of hydrolytic enzymes which are secreted and act as starch endosperm in turn affecting physiology of seed germination and seedling vigour. Similar effects and GA<sub>3</sub> on seed germination and vigour was also reported by Bhat and Singh (1996) in okra. Increase in germination percentage may be because of bolder seeds that contain greater metabolites for resumption of embryonic growth during germination. In addition to these metabolites, release of certain enzymes responsible for degradation of macromolecules into micro molecules within the seed. The increase in seed quality parameters due to certain changes in metabolism during seed development due to which there would be greater accumulation of food reserves resulting in higher seed quality. These results are in line with the findings of Balakumar and Balasubramanian (1988) in tomato, Soumya Ayyan Gowda (2003) in coriander and Kodalli (2006) in chilli.

## VI. SUMMARY

A field experiment was conducted at Main Agricultural Research station, College of Agriculture, Dharwad during 2005, to the effect of date of sowing, nutrition, spacing and growth regulator on crop growth, seed yield and quality of carrot Cv. Pusa Kesar. The inference drawn from the results obtained are summarized below.

### EXPERIMENT - I: INFLUENCE OF DATE OF SOWING AND NUTRITION ON PLANT GROWTH, SEED YIELD AND QUALITY OF CARROT Cv. PUSA KESAR

The experiment consisted of four dates of sowing viz., 15<sup>th</sup> August, 1<sup>st</sup> September, 15<sup>th</sup> September and 1<sup>st</sup> October as a main factor and five nutrition levels viz., N<sub>1</sub> (RDF), N<sub>2</sub> (50% RDF + 50% FYM), N<sub>3</sub> (100% FYM), N<sub>4</sub> (50% RDF + 50% VC), N<sub>5</sub> (100% VC) as sub factors.

The second date of sowing D<sub>2</sub> recorded significantly higher plant height and more number of leaves per plant and also took less number of days to 50 per cent flowering.

Second date of sowing recorded significantly higher values for all the yield parameters. The superiority of 2<sup>nd</sup> date of sowing was also seen in seed quality parameters recording significantly higher 1000 seed weight, shoot length, root length, seedling vigour index and numerically higher values for germination and field emergence percentage.

Among the nutrition treatments, N<sub>4</sub> (50% RDF + 50% VC) nutrition level recorded significantly higher plant height, number of leaves, days to 50 per cent flowering. It was seen that N<sub>4</sub> was on par with N<sub>2</sub> in growth parameters. For all the parameters N<sub>4</sub> was on par with N<sub>2</sub> except for number of leaves.

The N<sub>4</sub> nutrition level was superior over other nutrition levels and recorded significantly higher values for all the yield attributes like root weight, root length, root diameter, number of umbels per plant, number of seeds per umbel, umbel diameter, 1000 seed weight, seed yield per plant, seed yield per plot, seed yield per ha. While, N<sub>3</sub> (100% FYM) recorded significantly lower values for all the yield parameters. For all the yield parameters, N<sub>4</sub> was on par with N<sub>2</sub>.

The superiority of N<sub>4</sub> nutrition level was also seen in seed quality parameters which recorded significantly higher values of test weight, root length, shoot length, vigour index and also numerically higher values in germination percentage and field emergence. It was also seen that N<sub>4</sub> nutrition level was on par with N<sub>2</sub> nutrition level for seed quality parameters.

The interaction effects between date of sowing and nutrition did not show any significant effect on any plant growth, seed yield and seed quality parameters.

### EXPERIMENT II: INFLUENCE OF SPACING AND GROWTH REGULATORS ON PLANT GROWTH, SEED YIELD AND QUALITY OF CARROT Cv. PUSA KESAR

The experiment consisted of 3 spacing viz., S<sub>1</sub> (30x20 cm), S<sub>2</sub> (40x15 cm), S<sub>3</sub> (60x10 cm) as main factor and five growth regulators viz., G<sub>1</sub> (GA<sub>3</sub> 200 ppm), G<sub>2</sub> (GA<sub>3</sub> 300 ppm), G<sub>3</sub> (NAA 200 ppm), G<sub>4</sub> (NAA 300 ppm), G<sub>5</sub> (water spray as control) as sub factors.

The plant height was increased in S<sub>3</sub> (60 x 10 cm). The plant height was increased with application of growth regulator i.e. G<sub>1</sub> (GA<sub>3</sub> 200 ppm) when compared to G<sub>2</sub>, G<sub>3</sub>, G<sub>4</sub> and G<sub>5</sub>. While, the interaction (SxG) did not influence the plant height.

Number of leaves was increased in S<sub>2</sub> (40x15 cm). Application of growth regulator increased significantly higher number of leaves in G<sub>1</sub> compared to G<sub>2</sub>, G<sub>3</sub>, G<sub>4</sub> and G<sub>5</sub>. But the interaction (S x G) did not influence the number of leaves.

S<sub>3</sub> spacing took lesser number of days to 50 per cent flowering. Between the different concentrations of growth regulators significantly early flowering was noticed in G<sub>1</sub> over G<sub>2</sub>, G<sub>3</sub> over G<sub>4</sub>.

Yield parameters like root weight, root diameter, root length, number of umbels per plant, number of seeds per umbel, umbel diameter, seed yield per plant, seed yield per plot and seed yield per ha recorded significantly higher in S<sub>2</sub> spacing compared to other two spacing, but thousand seed weight was significantly higher in S<sub>1</sub>.

At different concentration of growth regulator G<sub>1</sub> recorded significantly higher yield parameters as mentioned above parameters,

While, the interaction effect of S x G was found non-significant.

Seed quality parameters like speed of emergence, seedling root length, shoot length, seedling dry weight recorded higher result at S<sub>2</sub> spacing but germination, seedling vigour index and field emergence recorded higher results in S<sub>1</sub> spacing.

Growth regulator G<sub>1</sub> gave higher results with respect to above seed quality parameters compared to G<sub>2</sub>, G<sub>3</sub>, G<sub>4</sub>, and G<sub>5</sub>. But seed quality parameters were not affected by the interaction of spacing and growth regulators.

From the results of the present investigation, following results have to be brought for practical application of seed production in carrot.

## PRACTICAL APPLICATION OF THE RESULTS

- 1) Sowing of carrot seeds on 15<sup>th</sup> August or 1<sup>st</sup> September was found ideal for higher seed yield and seed quality for seed production.
- 2) The applications of 50 per cent vermicompost along with 50 per cent RDF were found effective to obtain higher seed yield and quality in carrot seed production.
- 3) The spacing 40 x 15 cm would be beneficial to get higher seed yield in carrot seed production.
- 4) The foliar application of, GA<sub>3</sub> (200 ppm) found effective to obtain higher seed yield and quality during seed production.

## FUTURE LINE OF WORK

In continuation of the present investigation the following future line of works are suggested for further research

- 1) Long term studies on integrated nutrient management schedule for higher seed yield and seed quality may be initiated in carrot.
- 2) Studies on date of sowing or steckling planting at different environments may be initiated to obtain higher seed yield and quality.
- 3) There is a scope to standardize the different growth regulators and their concentrations both as seed treatment and foliar spray with stages in carrot seed production.
- 4) Effect of seed pelleting on storability and field performance can be studied.

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## APPENDIX I.

### Physical and chemical properties of the soil in the experimental site

Properties	Value	Method employed
<b>I. Physical properties</b>		
Coarse sand (%)	6.28	International pipettee method (Piper, 1966)
Fine sand (%)	14.27	International pipettee method (Piper, 1966)
Silt (%)	27.52	International pipettee method (Piper, 1966)
Clay (%)	51.99	International pipettee method (Piper, 1966)
Bulk density ( $\text{mg m}^{-3}$ )	1.33	Core samples method (Dastane, 1967)
<b>II. Chemical properties</b>		
Soil pH (1:2.5 soil : water)	7.6	pH meter (Piper , 1966)
Electrical conductivity ( $\text{dSm}^{-1}$ )	0.28	Conductivity Bridge (Jackson, 1973)
Organic carbon (%)	0.52	Walkley and Black wet oxidation method (Jackson, 1967)
Available nitrogen ( $\text{kg ha}^{-1}$ )	221.00	Modified Kjeldahl method (Jackson, 1967)
Available phosphorus ( $\text{kg ha}^{-1}$ )	32.4	Olsen's method (Jackson, 1967)
Available potassium ( $\text{kg ha}^{-1}$ )	310.7	Flame photometer (Jackson, 1967)

## APPENDIX II.

Monthly meteorological data for the experimental year (*kharif*, 2005) and the mean of past 55 years (1950-2004) as recorded at the Meteorological Observatory, Main Agricultural Research Station, University of Agricultural Sciences, Dharwad (Karnataka)

Month	Rainfall (mm)		Temperature (°C)				Relative humidity (%)	
			Mean maximum		Mean minimum			
	2005	Mean*	2005	Mean*	2005	Mean*	2005	Mean*
January	Trace	0.1	29.9	29.6	12.9	14.8	52	63
February	Trace	1.1	33.4	32.5	14.83	16.4	62	51
March	Trace	0.1	36.0	36.5	18.9	19.6	42	56
April	75	48.9	36.3	37.4	21.3	19.9	53	76
May	29.4	80.5	37.0	33.7	21.5	21.4	55	66
June	151	109.9	30.9	28.8	21.4	21.5	76	81
July	290.2	148.3	27.4	29.2	21.5	21.0	83	87
August	138.8	96.1	27.1	27.0	20.4	20.3	81	86
September	194.5	102.2	27.5	28.6	20.3	19.9	85	82
October	89.4	130.2	29.6	30.1	19.1	18.4	70	76
November	38	32.1	29.4	30.2	14.9	15.9	51	68
December	0	53.5	28.9	29.4	13.1	12.5	53	63
<b>Total</b>	<b>1006.3</b>	<b>802.52</b>						

\* Mean of 55 years (1950-2004)

# STUDIES ON SEED PRODUCTION IN CARROT Cv. Pusa Kesar

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2007

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## ABSTRACT

Two experiments were laid out in two factorial RBD design at MARS, UAS, Dharwad. First experiment has 20 treatment involving four dates of sowing ( $D_1$  – August 15<sup>th</sup>,  $D_2$  – September 1<sup>st</sup>,  $D_3$  – September 15<sup>th</sup>,  $D_4$  – October 1<sup>st</sup>) and five different nutrition levels ( $N_1$  – Recommended dose of fertilizer,  $N_2$  – 50% RDF + 50% FYM,  $N_3$  – 100% vermicompost,  $N_4$  – 50% RDF + 50% vermicompost,  $N_5$  – 100% VC). The results revealed that 1<sup>st</sup> September (Early) sowing exhibited significantly increased the growth parameters viz., plant height (88.12 cm), number of leaves (14.40), days to 50% flowering (121.50) and yield parameters root length (23.44), root diameter (12.38), root weight (76.02), number of umbels (38.39/plant), seeds/umbel (25.56), 1000-seed weight (4.20 g), seed yield/plant (38.86) and seed yield/hectare (46.40 kg/ha) and seed quality parameters viz., germination (86.72%), root length, shoot length, vigour index (1674), seedling dry weight (11.72), field emergence (80.88), when compared to delay in sowing. The growth, yield and seed quality parameters were significantly higher in nutrition dose of 50% RDF + 50% VC treatment.

Second experiment with 15 treatment combinations involving three spacings ( $S_1$  – 30 × 20 cm,  $S_2$  – 40 × 15 cm,  $S_3$  – 60 × 10 cm) and five different concentration of growth regulator [ $G_1$  – GA<sub>3</sub> (200 ppm),  $G_2$  – GA<sub>3</sub> (300 ppm),  $G_3$  – NAA (200 ppm),  $G_4$  – NAA (300 ppm) and  $G_5$  – Water spray (control)] significantly increased growth parameters viz., plant height, number of leaves per plant and days to 50% flowering were observed in 40 × 15 cm spacing and yield parameters viz., root length, root weight, root diameter, number of umbels/plant, umbel diameter, 1000-seed weight, seed yield/plant, seed yield/ha were significantly higher in spacing 40 × 15 cm apart from seed quality attributes. Application of GA<sub>3</sub> (200 ppm) recorded significantly increased growth, yield and seed quality parameters over unsprayed control.