SEED TECHNOLOGICAL STUDIES IN CARROT (*Daucus carota.* L.) cv. ZINO

Thesis submitted in part fulfilment of the requirements for the degree of Master of Science (Agriculture) in seed Technology to the Tamil Nadu Agricultural University Coimbatore

BY

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CERTIFICATE

This is to certify that the thesis entitled "SEED TECHNOLOGICAL STUDIES IN CARROT (*Daucus carota*.L.) cv. ZINO" submitted in part fulfilment of the requirements for the degree of MASTER OF SCIENCE (AGRICULTURE) IN SEED TECHNOLOGY to the Tamil Nadu Agricultural University, Coimbatore is a record of bonafide research work carried out by Mr. K. SUNDARALINGAM under my supervision and guidance and that no part of this thesis has been submitted for the award of any other degree, diploma, fellowship or other similar titles or prizes and that the work has not been published in part or full in any scientific or popular journal or magazine.

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Dedicated To My
Parents, Brothers
And Sisters

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ACKNOWLEDGEMENT

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ABSTRACT

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SEED TECHNOLOGICAL STUDIES IN CARROT
(Daucus carota.L) cv. Zino

By

K. SUNDARALINGAM

DEGREE : Master of Science (Agriculture) in Seed Technology

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Studies were undertaken at the Horticultural Research Station, Udhagamandalam, The Nilgiris and Department of Seed Technology, Tamil Nadu Agricultural University, Coimbatore to elicit information on methods of germination improvement (size grading of seeds and seed treatment with pyridoxine), seed development and maturation, steckling size and seed quality, nutrient application, seed threshing methods, embryo size variation and seed storage in carrot cv. Zino.

Studies on germination improvement of carrot seed revealed that seed germination can be improved by soaking - leaching the seeds in water for three days and then drying at 20°C. It appreciably enhanced the speed of germination.

Seed germination can be further improved by blowing the seed in the seed blower for 2 min. and then sieving them in BSS 12 x 12 wiremesh sieve.

Pyridoxine hydrochloride (Vit.B_6) treatment at 0.5 per cent for 12 h. enchanced the root length. It did not improve the germination of size graded seeds.

Seeds attained physiological maturity on seventh week after anthesis when the seed moisture was around 15.4 per cent and seed dry weight was at its maximum. The colour of primary umbel turn brown and the secondary umbel starts to brown which can be taken as a visible symptom of seed quality. Delaying the harvest beyond eighth weeks after anthesis results in shattering of seeds. Seed germination and vigour were maximum at eight weeks after anthesis.

Different size of steckling grades associated with pyridoxine treatment revealed the superiority of large size steckling soaked in 0.5 per cent pyridoxine solution for 12 h. which improved the seed yield and quality. It appreciably reduced the number of days to sprouting and umbel emergence, thereby increased the seed yield per umbel and per unit area.

Among the umbel orders, the secondary umbel contributed more than 50 per cent of the total seed yield. Highest seed germination was observed in seeds from primary umbel which subsequently decreased with increasing order of umbel.

The optimum and effective combination of nitrogen, phosphorus and potassium fertilizer schedule were 150:75:150 kg per hectare for achieving maximum recoverable seed yield with assured seed quality characteristics.

Ideal method for carrot seed threshing is hand threshing compared to mechanical means.

The embryo length increased with progressive increase in seed size. The percentage of embryolessness decreased with increase in seed size. Hence, for getting quality seeds with assured performance of growth, size grading is important.

Storage studies revealed that seeds stored better when treated with Thiram @ 2 g kg^{-1} and stored in 700 gauge polyethylene bag than untreated seeds.

Seeds from tertiary umbel were found to deteriorate faster than seeds from primary umbel under accelerated ageing conditions. This suggests selection of umbels for maintaining breeder, foundation and certified seeds.

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INTRODUCTION

CHAPTER I

INTRODUCTION

Carrot (**Daucus carota**. L), belonging to the family umbelliferae, is a popular root vegetable grown commercially in India. The area under carrot production is expanding as percapita consumption of vegetables in India is steadily maintaining an upward trend.

During recent years, carrot has assumed greater importance as it is a rich source of α and β carotene and a vital precursor of vitamin A. Addition of large amount of carrot to the diet has favourable effect on nitrogen balance. Seeds are aromatic stimulant and carminative and were reported to be useful for kidney and dropsy diseases. (Chopra, 1933; Kirtikar and Basu, 1935). Thus, production of carrot to meet the requirement will greatly depend upon the supply of quality seeds, in view of the new seed policy aswell.

The volume of vegetable seed export was estimated as Rs.9.66 crores in 1990-91 and Rs.16 crores in 1991-92, of which share of the carrot seed is substantiable. Hence, India has to develop the technology for the production, processing and packing of vegetable seeds. In view of the export of seeds and planting materials which are covered under the recent import-export policy, the seed production has to be streamlined.

In temperate area, carrot is grown during spring, summer and autumn: whereas in tropical and subtropical area it is grown only in winter.

From seed production point of view, carrot has two races viz., European or temperate or biennial and Asiatic or tropical or annual. In North Indian Plains, the oriental types set seed freely: whereas in temperate cultivars being a biennial in character remains vegetative in the first year and enters reproductive phase the following growing reason (Singh et al., 1960). In Tamil Nadu, hilly areas of Nilgiris provide an optimum climate for raising carrot for vegetable as well as seed production.

Seed production in biennial cultivars encounter certain problems.

i) Exposure of plant to temperature below a critical level 4.8-10°C during flower initiation called stratification (Vernalisation) is essential.

ii) Eventhough stage of seed stalk formation reaches its peak at 12° C - 22°C, flower primordia is retarded, if temperature remains constant at 22°C - 26°C, even for a couple of days.

iii) For better quality seeds, cool and moderate climate is a pre-requisite.

iv) Rainless summer is a must for proper seed development.

In India, out of the two distinct methods employed for carrot seed production, "Root to Seed" method seems to be more appropriate. Incidence of root rot is very high in "Seed to Seed" method and affords to less chance of selection of roots.

Several technological gaps are yet to be filled up for getting good quality seeds in this important root crop, as seed production of European carrot has been undertaken as a remunerative enterprise in the hills of Nilgiris

The seed production in carrot face several problems.

* the inherent poor and delayed germination of the seed.
* lack of scientific method of seed production
* shattering of mericarp leading to loss of seeds during delayed harvest and
* less knowledge on improvised storage techniques.

Poor germination is due to the presence of inhibitory substance present on the seed and their removal or leaching relieves their inhibitory effects. Fixation of optimum stage of maturity will reduce the shattering loss. Hence a knowledge of the development of seed from fertilization to maturity will be valuable. In addition, knowledge on nutrient requirement of a seed crop as distinct from a vegetable crop, seed treatment, suitable method of threshing and seed storage might prove immensely useful.

Against this background, investigations on carrot cv. Zino were carried out with the following objectives:

i) To improve seed germination through soaking leaching, grading and upgrading and seed treatment.

ii) To fix the physiological cum harvestable maturity for seed crop.

iii) To streamline steckling size on net reproductive effort and seed production spectrum.

iv) To find out the optimum level of nurtient application.

v) To standardise suitable threshing method with associated seed quality and

vi) To improve the shelf life of seeds.

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

2.1 GERMINATION IMPROVEMENT

Austin **et al.** (1969) reported that 3 cycles of hardening treatments involving soaking in water 20°C for 24 hours and then drying at 20°C resulted in quick germination and the seedlings emerged in the field 3-4 days earlier than untreated carrot seeds.

Ashton **et al.** (1987) registered increased germination of beet seeds by soaking and drying back for 0.5 to 16 hours.

Cseresnyes and Baleanu (1987) recommended 2 h of water soaking for coriander seed at room temperature for improvement in their germination potential.

According to Mandal **et. al.** (1987) when the seeds of coriander and fennel were soaked in water for 5-10 h, it registered higher germination of 80 and 82 per cent respectively.

Goobkin (1989) in carrot, onion and beetroot observed enhancement between 17-22% in germination potential of seed, through priming with polyethylene glycol 6000 or potassium nitrate + potassium phosphate.

Rajnpreht (1989) encounted difficulties in the expression of laboratory germination in some of the vegetables including carrot due to dormancy, mainly by the presence of inhibitors. Normal cold water and KNO_3 treatment were not found to be effective.

2.2 EFFECT OF SIZE OF THE SEED

The size and weight of the seed have great influence over their germinability and vigour.

a. Effect of the size of the seed on its germinability

The laboratory germination percentage of carrot seed increased with increasing seed size (Austin and Longden, 1967).

Bolder seeds of radish showed higher germination in the field (Gill and Harisingh, 1979).

According to Jacobsohn and Globerson (1980) relatively large seeds of carrot germinated better than small seeds.

Ponnuswamy and Ramakrishnan (1985) identified the BSS 7x7 as the sieve size, for size grading coriander seeds.

But larger seeds retained in BSS 6x6 were superior to those seeds both in viability and vigour irrespective of the umbel order.

b. Effect of the size of the seed on its vigour

Macchia and Magnani (1982) and Benjamin (1984) working on the size of the carrot seed could not find any influence over the vigour of the seed. In contrast, Austin and Longden (1967) working in carrot and Ponnuswamy and Ramakrishnan (1985) working in coriander had reported, production of more vigorous elite seedlings by planting large seeds than the small seeds.

c. Effect of sowing depth of the seed on its germinability

Schoneveld and Maldegem (1990) recorded the highest germination, when seeds were sown at a depth of 1.5-2.5 cm, achieved with oblique pressure.

2.3. USE OF PYRIDOXINE HYDROCHLORIDE

In 1939, Robbin and Schamidt reported that, pyridoxine (vitamin. B_6) beneficially affected the growth of excised tomato roots in a mineral sugar solution containing thiamine.

Bonner (1940) could not find any effect on excised roots of alfalfa, clover or cotton. However, beneficial results with excised roots of **Datura stramonium**, sunflower, carrot and five strains of tomato could be registered when soaked in pyridoxine.

According to Ansari et al. (1990b) field crop lentil responsed significantly to presowing seed treatment for 12h with various concentrations of pyridoxine solutions. The results indicated not only improved seedling establishment, growth and development but also enhanced N, P and K uptake in the treated plants which inturn led to higher seed yield and protein content. (Ansari et al. 1990a).

Treatment of Triticale seeds with 0.01per cent pyridoxine hydrochloride was the most effective in increasing activities of alfa amylase catalase and peroxidase and solubilizing the reserve food for germinating seeds. (Haque and Ahmed, 1990).

Samiullah et al. (1991) suggested that treatment of mustard seeds with 0.0125 per cent pyridoxine which exhibited the highest values for length of main (tap) root, leaf number, dry weight and also improved the capability of plants, resulting in 14.3 and 28.4 per cent more yields of seed and seed oil respectively.

Matrishwa, (1994) recommended pyridoxine treatment of 0.1 and 0.2 per cent for 12 h in setts and seeds of sugarcane respectively to increase the germination potential and seedling vigour.

2.4. PHYSIOLOGICAL MATURITY AND HARVESTABLE MATURITY

Klein and Pollock (1968) and Abdul-Baki and Baker (1973) reported major structural changes to occur in seed membranes during seed maturation, seed development, quiescence and subsequent germination.

According to Delouche (1973) seed maturation refers to morphological, physiological and functional changes that occur from the time of fertilization until the matured seeds are ready for harvest.

Garris and Hoftman (1946) concluded that best yields of high quality seeds could be produced only under the best possible environmental conditions. Maturity is the most important factor which affects the seed viability, seedling vigour and storability of the seed. Therefore, care must be taken to harvest the seed crop just at the right time.

According to Ogawa (1961), onion seed capable of germinating 15 days after flowering could reach 80% physiological maturity 25 days after flowering.

Anghel and Teodoresai (1962) harvested onion seeds at the green, pre-ripening and ripening periods and studied the germination. Onion seeds were found to germinate well at harvest time when gathered at the ripening stage compared to the green stage.

In onion, Nistor (1971) suggested the time for harvesting the inflorescence when substances ceased to accumulate in the seeds. This coincided with "capsule cracking" in 5-10 per cent of the inflorescence.

According to Prokhorov and Khomyakov (1972), the number of seeds in the inflorescence was determined by the time of flowering. The earliest the plants flowered, the greatest was the number of seeds, with the required quality standard.

Sandhu et al. (1972) obtained the onion seeds from 3 stages viz., fully matured, one week before maturity and 2 weeks before maturity and studied their germination capacity. The germination was the highest (89.8 per cent) when the seeds were collected from the fully matured stage.

Gray (1979) reported that the mean time to germination of carrot seeds decreased progressively with successive harvesting dates, but more rapidly for seeds from secondary than primary umbel and with increase in temperature over the range 5 -25°C of the environment.

According to Nowosielska (1980), seeds of capsicum, carrot, celery harvested at the slightly under-ripe stage resulted in poor germination.

Paul et al. (1980) reported mature seeds to germinate by 3.7 days earlier than the immature seed, with no difference in percentage germination. Similarly, the dry mature seed contained more protein and nucleic acid per unit dry matter than immature seed and proportions of nucleic acid and poly (A) RNA greater in the mature seed.

Carrot seeds were capable of germinating before the stage when maximum seed dry weight was reached (Gray and Steckel, 1982). They recorded improvement in seed germination with decreasing the moisture content of below 20 per cent. Drying the seeds on the umbels improved the percentage germination with associated reduced germination time.

Gray et al. (1988) reported an increase in temperature from $20^{D}/10^{N}$ to $30^{D}/20\ ^{N\circ}C$ to reduce mean weight per seed by 20 per cent.

According to Steckel et al. (1989), maximum seed dry weight occurred approximately 40-45 days after flowering;while maximum germination occurred 40-50 days after flowering in carrot.

2.5 Steckling size /weight

In onion, Green (1972) showed larger bulbs consistently to produce more inflorescence , more seed per inflorescence with greater weight of seed.

Onion seed yield on per hectare basis rose with increase in bulb size from small (30 g), medium (70 g) to larger (110 g) size bulb (Velichko and Lukometer (1976).

According to Rusev (1978), onion seed yield increased with increasing bulb weight and decreasing growing space of 70x6 centimeter.

Baldev singh et al. (1983) reported maximum yield by planting large bulb which decreased with decrease in bulb size.

In beet, Podlaski (1987) reported large stecklings of 600-700 g to give the highest seed yield of 1.77 t ha^{-1}.

In radish, Sharma and Gulshanlal (1987) recommended 15 cm long stecklings planted at 60 x 30 cm for realising high yield of good quality seeds.

Nascimento and Guedas (1988) could not get any significant diffferences with regard to carrot seed yield with the varying diameter of root.

In onion, Rudolph and Rudolph (1988) suggested bulb diameter as a reliable indicator of bulb weight, a result considered important in the breeding process in terms of selection of bulbs for appropriate shape.

Balan et al. (1989) reported small steckling of beetroot produce, single stemmed plants with uniformly developed tillers of the first order. In contrast, large stecklings produced multistemmed plants (3-12 stems) with non-uniformly developed tillers of the first, second and even in third order.

According to Singh et al. (1989) plant height, number of branches, number of siliquae, number of seeds per siliqua and total yield were favourably influenced with large size stecklings.

Saharan and Malik (1993) recommended large and medium size stecklings and pinching of second order umbels just at their emergence as the most effective for obtaining the highest seed yield in carrot.

2.6. PREPARATION OF STECKLING

Kruzilin (1967) recommended stecklings with 1/3 top cut and 1/4 root cut as superior for obtaining higher seed yield in carrot.

In carrot, Lal and Pandey (1980) registered higher average seed yield of 1.104 t ha^{-1} that can be obtained from plants spaced at 30x30cm using intact roots and with foliage cut to two thirds of the full size.

Sarnaik et al. (1987) reported that size of stecklings reduced by half before planting gave the highest seed yield (887 kg ha^{-1}) in radish var. Pusa Reshmi.

Matiar and Monowar (1988) suggested that 1/4th root and shoot cut method produced the highest seed yield (1094.3 kg/ha) in carrot followed by 1/2 and 3/4 root and shoot cut treatments. They also recorded the highest 1000 seed weight and percentage germination from 1/4th root and shoot cut treatment.

Digole and Shinde (1990) opined that 1/4 shoot cut and 1/2 root cut treatment gave significantly higher seed yield in carrot.

2.7. EFFECT OF NUTRIENTS ON SEED PRODUCTION

In sugarbeet, Kaw et al. (1978) recorded average seed yield to increase from 1.32 and 0.84 t ha^{-1} with no nitrogen application to 2.0 and 2.17 t ha^{-1} with application of 100 kg N ha^{-1} at root formation phase and 150 kg N ha^{-1} at seed formation phase respectively.

According to Lavato and Montanari (1980) carrot seed yield and seed quality were not improved by application of P and were impaired by potassium. But seed yield was increased by the application of nitrogen only.

Ghosh et al. (1985) reported highest NP rate to give the highest seed yield in coriander (20.6 quintol ha^{-1}).

Carrot seed yield per plant and per hectare were increased with increasing N rates but no improvement in yield was recorded by P and K application.(Madan and Saimbhi, 1986)

In radish, Mishra (1987) brought out increased P application which significantly increased the plant height, but reduced plant height and number of main branches with increasing K doses. In contrast, increased seed yield with increasing doses of N and P but K beyond 40 kg ha^{-1} significantly affected the yield.

Application of higher doses of N, P and K fertilizer to sugarbeet stecklings increased seed yields by 1.1 t ha^{-1} and increased seed weight and sowing qualities. (Organishchuk, 1987).

Polach (1987) reported that the highest yields produced by N as ammonium sulphate applied at the starts (Initiation) of leaf rosette formation stages. Phosphorus and potassium had only slight positive effects depending on their application rates.

Rastogi (1987) recorded the highest mean seed yield in radish (1.28 t ha^{-1}) through application of higher doses of Nitrogen at 20 cm below soil surface.

Rastogi et al. (1987) found 60x45cm to be the optimum spacing with 60 kg N ha^{-1} for getting the maximum seed yield in radish.

According to Bhati (1988) coriander seed yield rose with the highest N rate, with associated 706 kg ha^{-1}.

Nazeer-Ahmed and Tanki (1989) recorded the highest average seed yield in carrot with increasing nitrogen rate. As observed, phosphorus had less pronounced effect on the seed yield.

In coriander, Rahman et al. (1990) recorded an optimum seed yield of 931.5 kg ha^{-1} and essential oil yield of 10.7 kg ha^{-1} , by the application of nitrogen at the rate of 60 kg ha^{-1}. Out of the total nitrogen half a dose of nitrogen was applied as basal with P and K and the rest in two split doses on 30^{th} and 60^{th} day after sowing.

In radish, Sharma and Kanaujia's (1992) experimental results indicated that maximum values with respect to days to 50 per cent bolting and flowering, plant height, number of branches per plant, diameter of the main shoot, seed yield per plant and per hectare were recorded by nitrogen application at 200 kg per hectare.

2.8. EFFECT OF POSITION OF SEED IN THE MOTHER PLANT

The formation of seed is a very complex physiological process. The peculiarity of fertilization, the correspondence between the ovary and the vegetative part of the plant, the conditions of prevailing microclimate under the crop canopy and associated process determine the seed set and its development.

According to Ovcharov and Kizilova (1966) the position of seed on the plant creates heterogeneity in the quality. This is not only because such seeds were formed in slightly different kinds of micro-climate but also because they have a differential supply of the material essential for life.

The umbelliferous crops produce compound umbels (Lang, 1921). Irrespective of the order of branches, the umbels will be produced but at different times during the season and with progressive ageing of the plant. Thus, the seed produced at different positions on the plant would influence not only the yield but also the quality of the seeds produced.

a. EFFECT OF POSITION OF UMBEL ON SEED SET AND YIELD

Borthwick (1931) classified the umbels of carrot into four orders according to their location on the plant and recorded the first three orders of umbels to produce about 95 per cent of the total seed yield.

Singh et al. (1960) observed poor seed setting in the late formed umbels of carrot. The umbels of the higher order and the late ones which will be produced after the production of umbels of all other preceeding order.

According to Hawthorn et al. (1962) the umbels of the second order contributed more than 50 per cent of the total seed yield in carrot.

According to Gill et al. (1981) major contribution towards yield in carrot is primary, secondary umbels and their number per unit area.

b. EFFECT OF POSITION OF SEED ON SEED WEIGHT

Seeds harvested from central umbels produce the most productive plants (Shevtsova and Korol, 1976).

Gray and Steckel (1980), Malik et al. (1983) found that the primary umbels of the carrot plant produced the heaviest seeds compared with the umbels of other orders.

c. EFFECT OF POSITION OF SEED ON GERMINABILITY AND EMERGENCE

Borthwick , (1961) observed that seeds from third order umbel exhibited lower percentage of germination potential than the first and second order umbels.

Hawthorn et al. (1962) did not find highly significant differences in the germination of carrot seeds obtained from different order of umbels.

Gray and Steckel (1980) reported that the mean emergence time of the seeds decreased with an increase in the embryo length and observed that the seedling emergence and seedling weight were more closely related to embryo length than to seed weight.

The seeds of carrot from the primary umbels gave higher germination than those from the other umbels and recorded increased percentage of carrot seed germination with increase in seed size (Jacobsohn and Globerson, 1980).

Bujdoso and Hrasko, (1983) stated that the seeds harvested from the primary umbels recorded the highest germination rate.

d. EFFECT OF THE POSITION OF SEED ON THE PERFORMANCE OF THE SEEDLINGS

Usually the umbels of the lower orders produce larger and heavier seeds than those of higher order (Malik. et al., 1983).

According to Austin and Longden (1967) larger seeds of carrot gave bigger seedlings than smaller seeds.

Shevtsova and Korol (1976) reported that the carrot plants developed from the seeds of primary umbel were more productive in respect to root yield than those from the seeds of umbels of other orders.

e. EFFECT OF POSITION OF SEED ON EMBRYO SIZE

Krarup and Villanveva (1977) observed that the length of embryos in seeds obtained from the primary umbel was slightly greater than that of those in seeds from the secondary umbels in carrot.

Gray and Steckel (1983) reported that at 70 days after anthesis of the primary umbel, the seeds obtained from all umbels had similar embryo length.

Gray et al. (1983) traced that seed and embryo size largely associated with the duration of seed growth, the volumes of the ovary, ovule and embryo sac at the time of fertilization.

2.9. STORAGE

Evidences gathered by Dadlani and Agrawal, (1983) indicate leaching of sugars and electrolytes from carrot and okra seeds which increased with increase of temperature from 10 to 30°C. But increasing seed moisture content from 3 to 12 per cent, decreased leaching from the seed. The leakage of electrolytes from the seeds depended upon the pH of the seed.

Sekimura et al. (1986) recorded the germination rate of sugarbeet seeds to decline after three years storage under laboratory conditions, reaching almost zero after 11 years. Seeds stored at 4-5°C and 40-50 per cent relative humidity maintained a good germination rate for upto 20 years, after which it declined.

Increasing moisture level in carrot seed storage produced increased incidence of the storage fungi.(Suhag, et al.1987)

In carrot, Horky (1988) opined that wrapping materials of paper and biaxilly packets had no effect on seed moisture content, germination and seed microflora when the seeds were stored for 65 months under 22°C and 40-60 per cent relative humidity with 6-8 per cent moisture content. He also recorded the percentage germination to decrease with storage time.

Zhang et al. (1993) estimated 11 volatile compounds, produced by carrot seed during storage. The amount of volatile evolved increased with increasing period or temperature of storage suggesting that the compounds were produced metabolically even in dry seeds.

Accelerated ageing

Naturally aged seeds and artificially aged seeds (50°C and 100 per cent RH) of cucumber, onions and carrot were assessed for lipid contents and fatty acid composition. The seeds with high lipid content, no change or an increase in the amount of lipid was noted and no significant changes in fatty acid composition occured and seeds with low lipid contents in which the ageing process was followed by a decrease in the amount of the lipid fraction showed significant changes in fatty acid composition (Perl et al., 1987).

Karuna and Aswathiah (1989) reported that beet root and carrot seeds aged for 6 and 4 days respectively at 41+2 C and 100 per cent relative humidity showed little decline in germination.

Karuna and Aswathiah (1990) stated that accelerated ageing test predict the storability and storage life of a seed.

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

3.1. MATERIALS

Genetically pure seeds and roots of carrot cv. Zino obtained from the Horticultural Research Station, Vijayanagarũm, Udhagamandalam formed the base materials for the experimental studies. The morphological characteristics of the cultivar is appended .

3.2. METHODS

3.2.1. GERMINATION STUDIES

3.2.1.1. STUDIES ON IMPROVING THE GERMINATION POTENTIAL OF CARROT SEED.

Bulk seeds of carrot cv. Zino were collected and brought to homogeneity as per Anon, (1985). Seeds were soaked in water as detailed below to improve the germination potential of seed.

Treatments	Abbreviations used
1. Dry seeds (control)	I_0
2. One day water soaking (Leaching)	I_1
3. Two day water soaking (Leaching)	I_2
4. Three day water soaking (Leaching)	I_3

PLATE 1. MORPHOLOGICAL VIEW OF CARROT PLANT

Then the seeds were dried to original moisture content and placed for germination and observations recorded.

3.2.1.1.1. Germination (Anon, 1985)

Four replicates of 100 seeds in each treatment using paper medium (Roll towel) germination test was carried out at 20°C constant temperature and allowed to germinate in the step in germinator in the presence of continuous light. After 14 days, normal seedlings were counted and expressed in percentage.

3.2.1.1.2. Speed of germination

One hundred seeds in four replicates were germinated in roll towel medium. Number of seeds germinated was counted from nineth day onwards upto fourteen days. From the number of seeds germinated on each counting day speed of germination was computed adopting the formula of Maguire (1962) and expressed as number.

$$\text{Speed of germination} = \frac{X_1}{Y_1} + \frac{X_2 - X_1}{Y_2} + \ldots\ldots + \frac{X_n - (X_{n-1})}{Y_n}$$

where,

X_n - Number of seeds germinated at n^{th} count

Y_n - Number of days from sowing to n^{th} count

3.2.1.1.3. Root length

Ten normal seedlings per replicate were taken at random from the test sample at the end of the germination test period. The distance between the collar and the tip of the primary root was measured and the mean value was expressed as root length in centimetre.

3.2.1.1.4. Shoot length

The seedlings in which root length measured was taken, the distance between the collar and tip of the primary shoot was measured in centimetre. The mean value of shoot length was recorded in centimetre.

3.2.1.1.5. Dry matter production

The seedlings in which the seedling measurement was taken were dried under shade and then kept in a hot air oven maintained at 85°C for 24 hours. Then the seedlings were cooled in a silica gel desiccator for 30 minutes. The dry weight of seedlings was taken in an ASP balance model, Z 400 K-7 and expressed in milligram.

3.2.1.1.6. **Vigour index**

The vigour index (VI) was calculated using the formulae as detailed below (Abdul-Baki and Anderson, 1973) and expressed in whole number.

VI = Germination percentage x Mean length of seedling in centimetre.

3.2.1.2. **GRADING AND UPGRADING OF SEEDS**

Bulk seeds of carrot cv. Zino were graded and upgraded using seed blower and BSS sieves. The experimental details were as follows.

TREATMENTS	ABBREVIATIONS USED
1. Control (Bulk seed)	UG_0
2. Seed blown with seed blower at 0.5 inches of water pressure for 2 min.	UG_1
3. Seed retained in BSS 12 x 12 wiremesh sieve	UG_2
4. Seed retained in BSS 14 x 14 wiremesh sieve	UG_3
5. Seed passed in BSS 14 x 14 wiremesh sieve	UG_4
6. Seed blown with seed blower at 0.5 inches ofwater pressure + seed retained in BSS 12 x 12 wiremesh sieve	UG_5
7. Seed blown with seed blower at 0.5 inches of water pressure + seed retained in BSS 14 x 14 wiremesh sieve	UG_6

Seeds were soaked in water and leached for 3 days and dried to original moisture content and placed for germination and following parameters were recorded:

3.2.1.2.1 Thousand seed weight

Eight replicates of thousand seeds were counted treatmentwise and replicationwise, weighed in ASP balance model A 400 K-7 and expressed in grams.

3.2.1.2.2.Germination as detailed under 3.2.1.1.1.

3.2.1.2.3.Root length as detailed under 3.2.1.1.3.

3.2.1.2.4.Shoot length as detailed under 3.2.1.1.4.

3.2.1.2.5.Dry matter production as detailed under 3.2.1.1.5

3.2.1.2.6.Vigour index as detailed under 3.2.1.1.6.

3.2.1.3. EFFECT OF SIZE GRADES AND PYRIDOXINE HYDROCHLORIDE (VIT.B_6) ON PHYSIOLOGICAL PARAMETERS OF CARROT SEED CV.ZINO

Bulk seeds collected from the field were cleaned and size graded using the following wiremesh sieves.

S.NO.	GRADES	ABBREVIATIONS USED
i)	Ungraded	SG_0
ii)	BSS 10 x 10 Retained seeds	SG_1
iii)	BSS 12 x 12 Retained seeds	SG_2
iv)	BSS 14 x 14 Retained seeds	SG_3
v)	BSS 14 x 14 Passed seeds	SG_4

After size grading, each grade seeds were treated with Pyridoxine hydrochloride at different concentrations.

CHEMICAL USED	CONCENTRATIONS	ABBREVIATIONS USED
i) Dry seed		T_0
ii) Water		T_1
iii) Pyridoxine hydrochloride	0.1 %	T_2
iv) Pyridoxine hydrochloride	0.2 %	T_3
v) Pyridoxine hydrochloride	0.5 %	T_4

Soaking duration 12 h

Then seeds were dried to original moisture content and placed for germination, the following observations were recorded:

3.2.1.3.1. Germination as detailed under 3.2.1.1.1.

3.2.1.3.2. Root length as detailed under 3.2.1.1.3.

3.2.1.3.3. Shoot length as detailed under 3.2.1.1.4.

3.2.1.3.4. Dry matter production as detailed under 3.2.1.1.5.

3.2.1.3.5. Vigour index as detailed under 3.2.1.1.6

3.2.2. SEED PRODUCTION STUDIES

3.2.2.1. DETERMINATION OF PHYSIOLOGICAL CUM HARVESTABLE MATURITY FOR SEED QUALITY MAINTENANCE

Roots of 3 cm diameter with leaves were selected and 1/4 of the distal root and $3/4^{th}$ of the distal shoot portions were removed. These stecklings were trånsplanted

PLATE 2. FIELD VIEW OF THE TRIAL PLOT

on 19.10.1993, with a spacing of 75 x 75 cm. The seed crop was raised following the normal package of practices for the root crop.

The time of anthesis was delayed for 7 and 14 days respectively in secondary and tertiary umbel from the primary umbel's emergence. Irrespective of the gap between the umbel order emergence, the umbels of primary, secondary and tertiary order were tagged at the time of anthesis considering the time of anthesis as the main criterian for determination of physiological maturity of carrot cv. zino.

The umbels were collected from each order periodically at weekly intervals upto 8 weeks (W1, W2, W3, W4, W5, W6, W7 and W8).

Ten replications were taken at each stages and the following observations were recorded:

3.2.2.1.1. Umbel characters

3.2.2.1.1.1. Diameter of umbel

The longest distance covered by any two umbellets in the umbel was taken as diameter of umbel and recorded in centimetre.

3.2.2.1.1.2. Fresh weight of umbel

The fresh weight of umbel in each order in each replication was weighed and the mean weight per umbel was expressed in grams.

3.2.2.1.1.3. Fresh weight of umbellet

The fresh weight of ten umbellets in each order in each replication were weighed and the mean weight per umbellet was expressed in milligrams.

3.2.2.1.2. Fruit characters

3.2.2.1.2.1. Length of fruit (Schizocarp)

The length of ten fruits in each order and in each replication were measured individually from the stalk end to stylar end and the mean length of fruit was expressed in millimetre.

3.2.2.1.2.2. Breadth of fruit (Schizocarp)

The breadth of ten fruits in each order and in each replication were measured individually and the mean breadth of fruit was expressed in millimetre.

3.2.2.1.2.3. Fresh weight of 100 fruits

PLATE 3. OPTIMUM STECKLING SIZE OF CARROT FOR PLANTING

The fresh weight of 100 fruits in each order in each replication were weighed with the help of an Anamed ASP balance model Z.400 K-7 and expressed in milligrams.

3.2.2.1.2.4. Dry weight of 100 fruits

One hundred fruits in each order in each replication were sundried to bring the moisture content to 7 per cent and weighed in an Anamed ASP balance model Z 400 K-7 and expressed in milligram.

3.2.2.1.2.5. Volume of 100 fruits

The volume of 100 fruits in each order in each replication were estimated by water displacement method by the use of measuring cylinder and expressed in cubic centimetre.

3.2.2.1.2.6. Moisture content of fruits

The moisture content was determined by low constant temperature oven method. About five grams of fruits were taken in moisture weighing bottle and placed in a hot-air oven maintaining at 105°C for 16 ± 1 hours. The moisture loss in the fruit was calculated by using the following formulae and expressed as percentage (Anon, 1985).

$$\text{Moisture content} = \frac{M_2 - M_3}{M_2 - M_1} \times 100$$

where,

M_1 = weight of the bottle alone

M_2 = weight of the bottle + sample before drying

M_3 = weight of the bottle + sample after drying

3.2.2.1.3. Physiological characters

3.2.2.1.3.1. Germination as detailed under 3.2.1.1.1.

3.2.2.1.3.2. Root length as detailed under 3.2.1.1.3.

3.2.2.1.3.3. Shoot length as detailed under 3.2.1.1.4.

3.2.2.1.3.4. Dry matter production as detailed under 3.2.1.1.5.

3.2.2.1.3.5. Vigour index as detailed under 3.2.1.1.6.

3.2.2.1.4. Bio-chemical tests

3.2.2.1.4.1. Seed leachate tests

Four replicates of 25 seeds were taken from each sample and soaked in 25 ml of distilled water for 6 h.at room temperature. After the specified period, the seed leachate was used for estimating the following parameters:

a. Electrical conductivity (Presley, 1958)

The electrical conductivity of the seed leachate was determined in a digital conductivity meter with an electrode possessing a cell constant of 1.0. The electrical conductivity of seed leachate was expressed as dSm^{-1}.

W1 W2 W3 W4

PLATE 4. STAGES DURING MATURITY OF CARROT UMBEL

W5 W6 W7 W8

3.2.2.1.4.2. Protein content (Alikhan and Youngs, 1973)

For each treatment 100 g of powdered seed material were taken in a 50 ml polyethylene screw-cap bottle and 25 ml of 1N NaOH was added. The mixture was shaken for five minutes on a wrist action shaker to disperse the protein. Then 10 ml of the suspension were poured in to a graduated test tube and used as a blank to compensate for the differences in the amount of natural pigments extracted. To the remaining suspension in bottle, 0.25 ml of 10% $CuSO_4$ was added and the bottle was reshaken for an additional duration of five min. to develop the colour complex. The sample solution was then poured into a separate test tube and along with its blank left overnight to allow the dispersed material to settle down. The optical density of the clear supernatent solution was measured at 620 nm red filter against the blank in an Erma photo electric colorimeter. From the mean optical density (OD) value the protein percentage for each treatment was calculated as follows.

$$\text{Protein (\%)} = 3.78 + (61.6 \times \text{O.D value})$$

3.2.2.2. EFFECT OF STECKLING SIZE ON NET REPRODUCTIVE EFFORT AND SEED PRODUCTION SPECTRUM

Freshly harvested mother stecklings were graded into four grades based on their weight. The graded stecklings were soaked for 12 h. as detailed below.

A	STECKLING GRADE	ABBREVIATIONS
	70-99 g	G_1
	100-149 g	G_2
	150-199 g	G_3
	200 g and above	G_4

B	TREATMENTS	
	1) Control	T_0
	2) Water	T_1
	3) Pyridoxine hydrochloride 0.1%	T_2
	4) Pyridoxine hydrochloride 0.2%	T_3
	5) Pyridoxine hydrochloride 0.5%	T_4

Spacing	75 x 75 cm
Plot size	3 x 3 m
Replication	Four
Design	Factorial RBD

Date of transplanting : 19-10-93

Prepared stecklings were transplanted in respective plots and uniform cultural practices were followed for all the imposed treatments. Observations were recorded as detailed below.

3.2.2.2.1. GROWTH CHARACTERS

3.2.2.2.1.1. Days to sprouting of steckling

Based on daily counts made on randomly selected ten plants, the number of days taken from transplanting to sprouting in any one for the plant of each treatment was recorded.

3.2.2.2.1.2. Days to umbel emergence

Daily counts were taken to note the date on which the first umbel stalk emerged in each treatment after planting of stecklings.

3.2.2.2.1.3. Distribution of umbels in plant

The total number of primary, secondary, tertiary umbels and other orders were counted individually in ten randomly selected plants treatmentwise and replicationwise and mean number of umbels in each order per plant worked out.

3.2.2.2.1.4. Number of umbels per plant

The total number of umbels per plant were counted and expressed in number.

3.2.2.2.2. YIELD ATTRIBUTES

3.2.2.2.2.1. Seed yield umbel^{-1}

Ten primary, secondary and tertiary umbels were randomly selected treatmentwise and replicationwise and the mean seed yield was recorded and expressed in grams umbel^{-1}.

3.2.2.2.2.2. Distribution of seed yield in plant

Seed yield from primary, secondary, tertiary and other umbel orders were weighed individually, treatmentwise and replicationwise and recorded in grams.

3.2.2.2.2.3. Seed yield plant^{-1}

The seed yield plant^{-1} was recorded and expressed in grams.

3.2.2.2.2.4. Seed yield plot^{-1}

Total quantity of seeds harvested from the whole plot replicationwise was recorded and yield expressed in grams plot^{-1} and converted to kg ha^{-1}.

The seeds from each order were size graded using BSS 12 x 12 wiremesh sieve and seeds retained were considered for the following observations:

3.2.2.2.2.5. 1000 seed weight

Eight replications of 1000 seeds were counted treatmentwise and replicationwise in each order and was weighed in an Anamed ASP balance model A 400 K-7. and expressed in grams.

3.2.2.2.3. PHYSIOLOGICAL CHARACTERS

Seeds were soaked in water and leached for 3 days and dried to original moisture content and placed for germination.

3.2.2.2.3.1. Germination as detailed under 3.2.1.1.1.

3.2.2.2.3.2. Root length as detailed under 3.2.1.1.3.

3.2.2.2.3.3. Shoot length as detailed under 3.2.1.1.4.

3.2.2.2.3.4. Vigour index as detailed under 3.2.1.1.6.

3.2.2.2.4.2. Protein content as detailed under 3.2.2.1.4.2

3.2.2.3. EFFECT OF NUTRIENTS ON SEED QUALITY

Uniform weight of carrot stecklings (150-200 g) were used for planting, and 3 different nutrients viz., N, P, K schedule were applied as follows:

	N	P_2O_5	K_2O(kg/ha)
F_1	50	25	50
F_2	100	50	100
F_3	150	75	150

Spacing	75 x 75
Replication	Eight
Design	RBD
Plot size	3 x 3 m
Date of planting	20-10-93

Full doses of P and K and half of the N were applied as basal and the remaining N was applied at 2 split doses; One at the time of bolting and the other at the time of flowering. Uniform cultural practices were followed for all the treatments. The observations were recorded as detailed below.

3.2.2.3.1. GROWTH CHARACTERS

3.2.2.3.1.1. Days to sprouting of stecklings as detailed under 3.2.2.2.1.1.

3.2.2.3.1.2. Days to umbel emergence as detailed under 3.2.2.2.1.2.

3.2.2.3.1.3. Distribution of umbels in plant as detailed under 3.2.2.2.1.3.

3.2.2.3.1.4. Number of umbels plant^{-1} as detailed under 3.2.2.2.1.4.

3.2.2.3.2. YIELD ATTRIBUTES

3.2.2.3.2.1. Seed yield umbel^{-1} as detailed under 3.2.2.2.2.1.

3.2.2.3.2.2. Distribution of seed yield plant^{-1} as detailed under 3.2.2.2.2.2.

3.2.2.3.2.3. Seed yield plant^{-1} as detailed under 3.2.2.2.2.3.

3.2.2.3.2.4. Seed yield plot^{-1} as detailed under 3.2.2.2.2.4.

3.2.2.3.2.5. 1000 seed weight as detailed under 3.2.2.2.2.5.

3.2.2.3.3. PHYSIOLOGICAL CHARACTERS

3.2.2.3.3.1. Germination as detailed under 3.2.1.1.1.

3.2.2.3.3.2. Root length as detailed under 3.2.1.1.3.

3.2.2.3.3.3. Shoot length as detailed under 3.2.1.1.4.

3.2.2.3.3.4. Vigour index as detailed under 3.2.1.1.6.

3.2.2.3.4.2. Protein content as detailed under 3.2.1.4.2.

3.2.2.4. STANDARDISATION OF SEED THRESHING TECHNIQUE IN CARROT

3.2.2.4.1. DEBRISTLING

Debristling was done using defuzzing machine constructed by Sugarcane Breeding Institute, Coimbatore. It consists of a hopper which consisted of an ascending spiral disc rotating with a fine sand mass. The seeds of different quantities were mixed with variable quantities of sand in the machine and the seeds were separated. The experimental details were as follows:

Seed and sand ratio	Abbreviations used
Control (Hand Threshing)	SSR_0
10:500	SSR_1
10:1000	SSR_2
10:1500	SSR_3
20: 500	SSR_4
20:1000	SSR_5
20:1500	SSR_6
30: 500	SSR_7

30:1000	SSR_8
30:1500	SSR_9
40: 500	SSR_{10}
40:1000	SSR_{11}
40:1500	SSR_{12}
50: 500	SSR_{13}
50:1000	SSR_{14}
50:1500	SSR_{15}
Duration	15 minutes

The debristled seeds were sieved and separated from sand using appropriate sieve. Seeds were soaked in water for 3 days and dried to original moisture content and placed for germination.

The following observations were recorded:

3.2.2.4.1.1. Recovery percentage

Seed samples from each treatment were cleaned to eliminate bristles and sand using BSS 14 x 14 seeds the recovery percentage of seeds were calculated on weight basis.

3.2.2.4.1.2. Germination as detailed under 3.2.1.1.1.

3.2.2.4.1.3. Abnormal seedlings

The number of abnormal seedlings present at the time of evaluation of the standard germination test were counted and expressed in percentage.

3.2.2.4.1.4. Root length as detailed under 3.2.1.1.3.

3.2.2.4.1.5. Shoot length as detailed under 3.2.1.1.4.

3.2.2.4.1.6 Vigour index as detailed under 3.2.1.1.6.

3.2.2.5. INFLUENCE OF SIZE GRADES ON SEED QUALITY IN CARROT cv. Zino.

Seeds were size graded using the following wiremesh sieve:

i) BSS 10 X 10 Retained

ii) BSS 12 X 12 Retained

iii) BSS 14 x 14 Retained

iv) BSS 14 x 14 Passed

3.2.2.5.1. Seed length and breadth (mm)

The length and breadth measurements of each 100 seeds size fractions were taken with the help of caul zeiss Jena Zoom stereoscopic microscope using 10x and 3x magnification position. The maximum length and breadth of the seeds were measured using ocular scale for all grades of seeds. It was found that 1 mm was equal to 40 ocular divisions at the above mentioned magnification. The ocular readings were divided by 40 and thus the values were expressed in millimetre.

3.2.2.5.2. Embryo measurements

The seeds were soaked in water for 24 hours. A gentle cut was given near the embryonic end of the seed and by pressing with the thumb, the embryo was squeezed out without inflicting any damage. The embryo length was also measured in the similar manner.

3.2.2.5.3. Tetrazolium test

The embryos were soaked in 1 per cent tetrazolium chloride (2, 3, 5 Triphenyl tetrazolium chloride) for 2 hours in complete darkness at 40 1 C in an incubator. The embryos were categorised as viable and non-viable based on the staining pattern.

3.2.2.5.4. Embryolessness

One hundred seeds were taken and the percentage of embryoless seeds were counted gradewise, and expressed as percentage.

3.2.3. SEED STORAGE STUDIES

3.2.3.1. STUDIES ON THE EFFECT OF SEED TREATMENT AND STORAGE CONTAINERS ON SEED VIABILITY

Bulk seeds were cleaned and dried to uniform moisture content of 7 per cent. The bulk seed was size graded using BSS 12 x 12 and the retained seeds stored under ambient conditions. The details of seed treatment and storage containers employed with the respective abbreviations are given below.

SEED TREATMENTS

T_0 - Untreated (control)

T_1 - Thiram (Tetramethyl thiuram disulphide) 2 g per kg of seed

CONTAINERS

C_1 - Paper bag of size 15 cm x 13 cm

C_2 - 700 gauge polyethylene bag of 12cm x 10cm

The paper bags were hand sewn , while the polyethylene bags were heat sealed.

Seed samples were drawn at monthly intervals and the following observations were recorded and the periods of testing were represented as P_1, P_2, P_3, P_4, P_5 and P_6 while the initial evaluation as P_0.

3.2.3.1.1. Germination as detailed under 3.2.1.1.1.

3.2.3.1.2. Root length as detailed under 3.2.1.1.3.

3.2.3.1.3. Shoot length as detailed under 3.2.1.1.4.

3.2.3.1.4. Vigour index as detailed under 3.2.1.1.6.

3.2.3.1.5. Electrical conductivity as detailed under 3.2.1.4.1. (a)

3.2.3.1.6. Free sugars (Somogyi, 1952)

One ml of copper reagent was added to one ml of seed leachate and boiled for 15 minutes. Then cooled under running water and 4 ml of Nelson's Arsenomolybdate reagent was added and made up to a known volume with distilled water. The colour complex developed and measured with an authenticated blank in an ERMA photo-electric colorimeter (Model A.E.11) against a glucose standard using Red filter No.620 nm and expressed in μg $seed^{-1}$ m^{-1}.

3.2.3.1.7. Protein content as detailed under 3.2.1.4.2.

3.2.3.2. STANDARDISATION OF ACCELERATED AGEING TEST

Five grams of seed samples from each umbel order were taken in the perforated paper bags. The seeds were placed in a desiccator at 100 per cent relative humidity and kept in an incubator maintained at $40 \pm 2^{\circ}C$. Seed samples were removed upto 10 days and tested for germination.

The following observations were recorded:

3.2.3.2.1. Germination as detailed under 3.2.1.1.1.

3.2.3.2.2. Root length as detailed under 3.2.1.1.3.

3.2.3.2.3. Shoot length as detailed under 3.2.1.1.4.

3.2.3.2.4. Dry matter as detailed under 3.2.1.1.5.

3.2.3.2.5. Vigour index as detailed under 3.2.1.1.6.

STATISTICAL ANALYSIS

The data from field observations and laboratory tests were analysed by the 'F' test for significance following the methods described by Gomez and Gomez, 1984. Wherever necessary, the values recorded in percentage were tranformed into corresponding arc sin transformation before carrying out statistical analysis. The transformed value were given in parenthesis.

The critical difference (CD) was worked out at 5 per cent (P=0.05) level. Where `F' value is non-significant, it is denoted by the letters 'NS'.

ABBREVIATIONS USED

I_0 to I_3 :	Days of water leaching
UG_0 to U_6 :	Upgrading treatment
SG_0 to SG_4 :	Seed size grades
T_0 & T_1 :	control and water treatments
U_1, U_2, U_3, U_x :	Primary, Secondary, Tertiary and other Umbel orders
G_1 to G_4 :	Steckling grades
T_2 to T_4 :	Different concentration of Pyridoxine hydrochloride treatments
F_1, F_2, F_3 :	Nutrients levels
SSR_0 to SSR_{15} :	Seed and sand ratio
T_0 & T_1 :	Control & Thiram treatments
C_1 & C_2 :	Containers

RESULTS

CHAPTER IV

RESULTS

4.2.1. GERMINATION STUDIES

4.2.1.1. EFFECT OF LEACHING ON SEED QUALITY

4.2.1.1.1. Germination (%) (Table 1)

The germination percentage of seed varied significantly. I_3 had the highest germination (63%) followed by I_2 (50%). The lowest germination of 30% was recorded by I_0 only.

4.2.1.1.2. Speed of germination (Table 1)

There was significant difference among the treatments in their speed of germination. I_3 recorded the highest value of 18.89 followed by I_2 (10.30); while I_0 and I_1 recorded the lowest speed of germination of 4.22 and 6.92, respectively.

4.2.1.1.3. Root length (cm) (Table 1)

I_3 recorded the longest root with 7.18 ; while the shortest was recorded by I_0 (3.43) and I_1 (3.82) which were on par.

4.2.1.1.4. Shoot length (cm) (Table 1)

Among the treatments, there was significant difference in shoot length. I_3 and I_2 had the highest values

Table 1:Effect of leaching on seed quality of carrot cv.Zino

	Germination (%)	Speed of germination	Root length (cm)	Shoot length (cm)	Drymatter production (mg per 10 seedling)	Vigour index
I_0	30 (32.95)	4.22	3.43	4.62	6.2	238
I_1	38 (37.81)	6.92	3.82	6.28	7.1	381
I_2	50 (45.22)	10.30	4.42	6.72	8.5	589
I_3	63 (52.66)	18.89	5.58	7.18	11.0	791
CD (P=0.05)	1.673	0.625	0.502	0.637	1.357	66.790

(Figures in paranthesis indicate arc sin values)

of 7.18 and 6.72, respectively which were on par, I_0 recorded the lowest shoot length of 4.62 indicating the need for leaching.

4.2.1.1.5. Drymatter production (mg/10 seedlings) (Table 1)

The dry matter production was significantly different among the treatments. I_3 had the highest of 11.0 followed by I_2 (8.5) as a component. I_0 and I_1 yielded the lowest of 6.2 and 7.1 respectively and were on par.

4.2.1.1.6. Vigour index (Table 1)

Among the treatments, there was significant difference in the vigour indicies. I_3 recorded the highest value of 791; while I_0 and I_1 recorded the lowest vigour index of 238 and 381, respectively.

4.2.1.2. EFFECT OF GRADING AND UPGRADING ON SEED QUALITY OF CARROT Cv. ZINO

4.2.1.2.1. 1000 seed weight (gm) (Table 2)

There existed a significant difference for thousand seed weight among different size grades. UG_5 recorded the maximum of 2.37; 1.82 recorded by UG_2 and 1.76 by UG_6 which were on par. UG_4 recorded the minimum weight of 1.07 only.

Table 2: Effect of grading and upgrading on seed quality of carrot cv. Zino.

	Seed recovery (%)	1000 seed weight (g)	Germination (%)	Root length (cm)	Shoot length (cm)	Drymatter production (mg per 10 seedlings)	Vigour index
UG_o	-	1.23	59 (50.00)	5.08	5.63	9.5	595
UG_1	72.5(58.32)	1.44	64 (53.15)	4.95	5.41	12.0	664
UG_2	62.4(52.18)	1.89	65 (53.94)	5.45	6.52	12.5	783
UG_3	27.8(31.85)	1.24	57 (49.22)	5.10	5.70	11.5	619
UG_4	9.8(18.19)	1.07	49 (44.61)	4.27	5.02	8.0	465
UG_5	52.2(46.27)	2.37	71 (57.22)	6.93	7.87	14.0	1047
UG_6	47.8(43.73)	1.76	59 (50.00)	5.21	5.31	11.5	617
CD (P=0.05)	2.70	0.154	4.088	0.667	0.714	1.793	124.90

(Figures in parenthesis indicate are sin values)

4.2.1.2.2. Germination (%) (Table 2)

Among the treatments, UG_5 registered the highest value (71%) followed by UG_2 (65%), which were on par. The least value of 49% was recorded by UG_4 only. The rest of the treatments were on par.

4.2.1.2.3. Root length (cm) (Table 2)

The root length was significantly different among the size grades. UG_5 had the highest root length of 6.93; while UG_4 with 4.27 recorded the lowest root length. The rest of the treatments were on par.

4.2.1.2.4. Shoot length (cm) (Table 2)

There was a significant difference among the size grades, in respect of shoot length. UG_5 and UG_2 yielded the longest shoot of 7.87 and 6.52 respectively; while the lowest was recorded in UG_4 (5.02) which was on par with rest of the treatments.

4.2.1.2.5. Dry matter production (mg/10 seedlings) (Table 2)

Among the size grades, UG_5 gave the highest value of 14.0 and the least value was recorded by UG_4 only. Among the included treatments, UG_2 and UG_1 were on par.

4.2.1.2.6. **Vigour index (Table 2)**

There was significant difference in the vigour indices. The grade, UG_5 recorded the highest value of 1047. The lowest vigour index of 465 was registered by UG_4 only.

4.2.1.3. EFFECT OF SIZE GRADES AND PYRIDOXINE TREATMENTS ON PHYSIOLOGICAL PARAMETERS OF THE SEED

4.2.1.3.1. **Germination (%) (Table 3)**

There was no significant difference in the germination percentage of different treatments.

There was significant difference in the germination percentage of different size graded seeds. Among the included treatments, SG_1 and SG_2 had the highest germination of 68% and 65%,respectively and SG_4 recorded the least (46%).

There was significant difference in the interaction also.

4.2.1.3.2. **Root length (cm) (Table 4)**

Among the treatments, there was significant difference in the root length of the seedlings, while T_4 recorded the highest value of 9.11. T_1 and T_0 recorded the lowest root length of 5.14 and 5.26, respectively. Treatments T_1, T_0 and T_2, were on par with each other.

Table 3: Effect of size grades and pyridoxine treatments on germination (per cent) of Carrot cv.Zino

	T_0	T_1	T_2	T_3	T_4	Mean
SG_0	58 (49.61)	60 (50.77)	60 (50.77)	58 (49.61)	62 (51.95)	60 (50.55)
SG_1	68 (55.55)	66 (54.34)	70 (56.80)	68 (55.59)	70 (56.80)	68 (55.82)
SG_2	66 (54.34)	62 (51.95)	66 (54.34)	66 (54.34)	66 (54.34)	65 (53.86)
SG_3	56 (48.46)	58 (49.61)	60 (50.77)	60 (50.77)	58 (49.61)	58 (49.84)
SG_4	44 (41.54)	46 (42.70)	48 (43.84)	44 (41.54)	46 (42.69)	46 (42.46)
Mean	58 (49.90)	58 (49.87)	61 (51.31)	59 (50.37)	60 (51.08)	

	T	SG	TxSG
CD(P=0.05)	NS	2.394	5.352

(Figures in paranthesis indicate arc sin values)

PLATE 5. NORMAL AND ABNORMAL SEEDLINGS IN CARROT

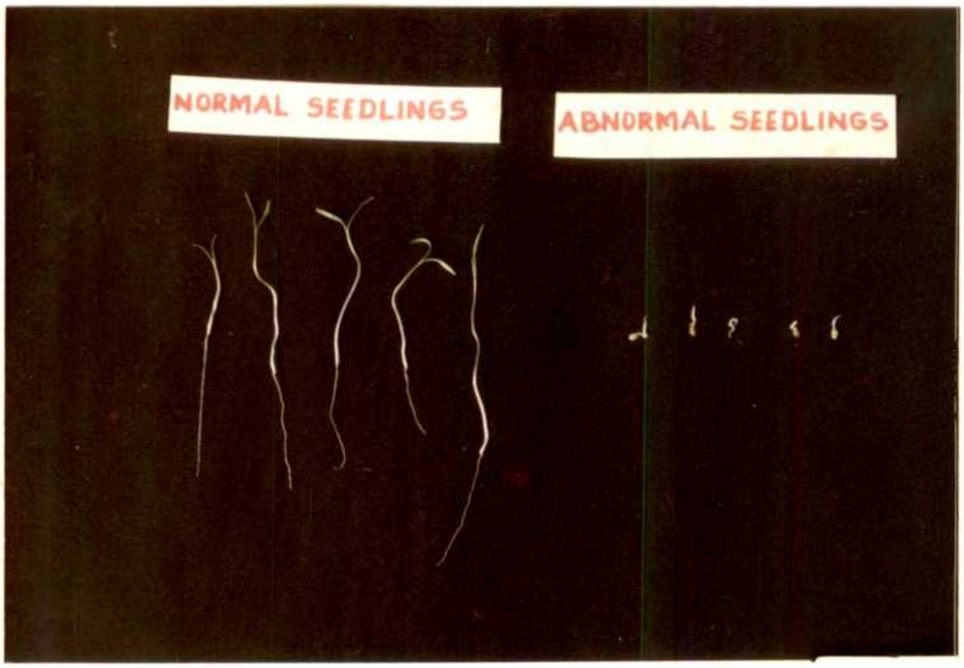


PLATE 6. EFFECT OF PYRIDOXINE ON SEEDLING QUALITY OF CARROT

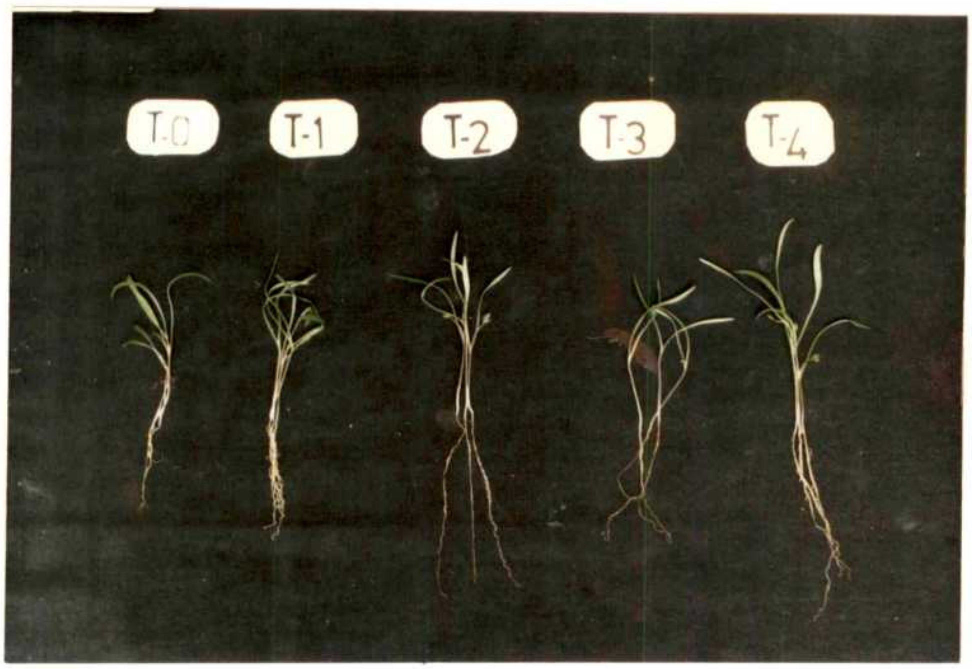


Table 4: Effect of size grades and pyridoxine treatments on root length (cm) and shoot length (cm) of carrot cv. Zino

	Root length						Shoot length					
	T_0	T_1	T_2	T_3	T_4	Mean	T_0	T_1	T_2	T_3	T_4	Mean
SG_0	5.68	4.93	6.30	8.51	9.98	7.08	6.34	6.67	8.45	8.35	8.12	7.59
SG_1	5.86	5.89	6.92	10.64	12.61	8.38	6.54	6.59	8.72	8.18	8.31	7.67
SG_2	6.07	6.14	5.37	9.31	10.79	7.54	6.80	6.88	8.43	8.33	8.30	7.75
SG_3	5.18	5.18	6.57	6.87	7.13	6.19	6.20	6.19	7.14	7.91	8.18	7.12
SG_4	3.52	3.54	4.07	4.18	5.02	4.07	2.90	2.98	4.09	3.93	4.02	3.58
Mean	5.26	5.14	5.85	7.90	9.11		5.76	5.86	7.37	7.34	7.39	
		T		SG	TxSG			T		SG		TxSG
CD(P=0.05)		0.941		0.941	2.103			0.272		0.272		0.607

The size grades differed significantly with respect of root length, of which SG_1 and SG_2 recorded the longest roots of 8.38 and 7.58, respectively. While SG_4 recorded the shortest root of 4.07 only. SG_2 and SG_0 were on par with each other.

The interaction between treatments and size grades differed significantly; T_4 recorded the highest values in all size grades of seed and SG_1 recorded the highest value irrespective of the treatments.

4.2.1.3.3. Shoot length (cm)(Table 4)

Among the treatments, T_4 recorded the longest shoot (7.39) but it was on par with T_2 and T_3. When evaluated the lowest value was recorded by T_0 which was on par with T_1.

Among the size grades, SG_2 recorded the longest shoot length of 7.75 followed by SG_1, SG_0 and SG_3; while SG_4 recorded the lowest shoot length (3.58).

Between interaction of TxSG, within size grades, irrespective of the included treatments SG_2 recorded the highest value and SG_4 recorded the lowest value. Irrespective of the size grades, the values were in increasing order from T_0 to T_4.

4.2.1.3.4. **Vigour index (Table 5)**

The vigour indices varied significantly among the treatments. The highest vigour index was registered by T_4 (1090), while the lowest was recorded by T_1 (658) and T_0 (666) and they were on par.

Among the size grades, the highest value was recorded by SG_1 and SG_2 with 1130, and 1025 respectively. The lowest vigour index of 367 was recorded by SG_4.

4.2.1.3.5. **Drymatter production (mg/10 seedlings) (Table 5)**

The treatments varied significantly in dry matter accumulation. The highest value was recorded by T_4 with 10.9; while the lowest drymatter production was recorded by T_1 (8.3) and T_0 (8.8).

There was also significant difference among the size grades. Highest value of 11.5 was recorded by SG_1 followed by SG_2 (10.3). The lowest value of 7.2 was recorded by SG_4 only.

Among the interaction significant difference existed; SG_1T_4 recorded the highest dry matter of 13.0 mg.

Table 5: Effect of size grades and pyridoxine treatments on vigour index and drymatter production (mg per 10 seedlings) of carrot cv. Zino

	T_0	T_1	T_2	T_3	T_4	Mean	T_0	T_1	T_2	T_3	T_4	Mean
SG_0	713	695	888	1033	1185	903	8.5	9.0	9.5	10.5	11.5	9.8
SG_1	843	825	1096	1352	1536	1130	10.5	9.5	12.0	12.5	13.0	11.5
SG_2	852	811	910	1229	1321	1025	9.5	9.0	9.5	11.0	12.5	10.3
SG_3	641	658	822	947	946	803	9.0	7.5	9.5	8.5	9.5	8.8
SG_4	283	300	389	399	464	367	6.5	6.5	7.5	7.5	8.0	7.2
Mean	666	658	821	992	1090		8.8	8.3	9.6	10.0	10.9	

	T	SG	TxSG	T	SG	TxSG
CD (P=0.05)	94.67	94.67	211.68	0.625	0.625	1.397

4.2.2. SEED PRODUCTION STUDIES

4.2.2.1. DETERMINATION OF PHYSIOLOGICAL CUM HARVESTABLE MATURITY FOR SEED QUALITY MAINTENANCE

4.2.2.1.1. UMBEL CHARACTERS

4.2.2.1.1.1. Diameter of umbel (cm) (Table 6)

In umbel orders, U_1 recorded the maximum diameter (16.4) and was followed by U_2 (15.4) and U_3 (11.3).

Among the weeks after anthesis, W_1 recorded the minimum value (11.6) and the maximum value of 16.4 was recorded by W_3 only. Interestingly W_4 and W_5 were on par; and while W_5 was on par with W_6 with 15 each. The diameter at W_8 recorded was 12.7 centimeter.

The interaction between umbel order and weeks after anthesis was also highly significant. Evidently U_1W_3, at U_2W_4, at U_3W_4 and U_3W_5 recorded the maximum values and the minimum value was by W_1 only.

4.2.2.1.1.2. Fresh weight of umbel (g) (Table 6)

The fresh weight of umbel increased steadily and recorded the highest at W_5 (19.54). The increase at W_5 was followed by a progressive decrease in values, W_4 and W_6 were on par and also W_4 and W_7 were on par. The lowest value was recorded by W_1 (11.56) which was significantly superior.

Table 6: Influence of umbel orders and stages of maturity on diameter (cm) and fresh weight of umbel (g) in carrot cv. Zino

Umbel order	Weeks after anthesis								
	W_1	W_2	W_3	W_4	W_5	W_6	W_7	W_8	Mean
				Diameter of umbel (cm)					
U_1	13.5	16.9	20.0	17.1	16.4	16.2	15.6	15.1	16.4
U_2	13.7	14.3	16.4	16.7	16.4	16.2	15.3	14.3	15.4
U_3	7.5	11.4	12.7	13.4	13.4	12.8	10.4	8.7	11.3
Mean	11.6	14.2	16.4	15.7	15.4	15.1	13.8	12.7	
CD(P=0.05)				W 0.513		U 0.313		WxC 0.890	
				Fresh weight of umbel (g)					
U_1	13.66	14.84	19.16	22.40	22.67	21.57	21.45	20.92	19.58
U_2	11.04	13.07	15.06	18.52	19.75	20.61	19.18	17.33	16.82
U_3	9.99	11.98	13.41	14.36	16.21	15.65	14.31	13.18	13.64
Mean	11.56	13.30	15.88	18.43	19.54	19.28	18.31	17.14	
CD(P=0.05)				W 0.844		U 0.519		WxC 1.467	

In umbel order U_1 recorded the maximum value (19.58), whereas U_2 (16.82), U_3 (13.64) recorded the minimum values.

Evaluating the interaction, U_1 at W_5, U_2 at W_6 and U_3 at W_5 registered the highest values of 22.67, 20.61 and 16.21, respectively.

4.2.2.1.1.3. Fresh weight of umbellet (mg) (Table 7)

Significant differences were observed in umbellet weight with advance in maturity.

In umbel orders, U_1 recorded the maximum umbellet weight (301.5) and was followed by U_2 (274) and U_3 (260).

Among the weeks after anthesis W_5 recorded the maximum value (390.3) and minimum value of 83.7 was recorded in W_1 only.

The interaction between umbel order and weeks after anthesis was also significant. Evidently at W_5, U_1, U_2 and U_3 recorded the maximum values, where as in all the umbels the minimum value was by W_1 only.

Table 7: Influence of umbel orders and stages of maturity on fresh weight of umbellet (mg) and length of fruit (Schizocarp) (mm) in carrot cv. Zino

Umbel order	W_1	W_2	W_3	W_4	W_5	W_6	W_7	W_8	Mean
					Weeks after anthesis				
					Fresh weight of umbellet (mg)				
U_1	103	206	277	318	407	388	376	337	301.5
U_2	79	195	256	285	381	367	328	301	274.0
U_3	69	190	231	285	383	332	297	292	260.0
Mean	83.7	197.0	254.7	296.0	390.3	362.3	333.7	310.0	
CD(P=0.05)				W 14.36		U 8.79		WxC 24.86	
					Length of fruit (Schizocarp) (mm)				
U_1	2.0	3.0	4.0	5.0	5.0	4.0	3.5	3.0	3.7
U_2	2.0	3.0	4.0	4.0	4.0	3.5	3.0	2.5	3.3
U_3	1.5	2.5	3.0	3.0	4.0	3.0	2.5	2.0	2.7
Mean	1.8	2.8	3.7	4.0	4.3	3.5	3.0	2.5	
CD(P=0.05)				W 0.47		U 0.29		WxC 0.81	

4.2.2.1.2. FRUIT CHARACTERS

4.2.2.1.2.1. Length of fruit (mm) (Table 7)

In umbel order U_1 recorded the maximum length (3.7), while U_2 (3.3) recorded the next. U_3 registered the minimum length of fruit (2.7).

Among the weeks after anthesis, W_1 recorded the minimum length of fruit, with advance in maturity, and had the maximum length at W_5. (4.3) and was on par with W_4 (4.0). Thereafter a decrease in values was noticed with advance in maturity. W_8 (2.5) and W_2 (2.8) were on par.

In interaction, all the umbel order attained maximum length of fruit at W_5.

4.2.2.1.2.2. Breadth of fruit (mm) (Table 8)

Significant variations were observed in breadth of fruit, for the weeks after anthesis and umbel order. Interaction between weeks after anthesis and umbel order were also significant.

Among the umbel order, U_1 had maximum breadth (2.5) which was on par with U_2 (2.2) only. When evaluated U_3 had minimum breadth which was also on par with U_2.

There was a significant difference among the week after anthesis. The maximum breadth was attained at W_4 only. There-after progressive decrease in value was noticed. Among

Table 8: Influence of umbel orders and stages of maturity on breadth (mm) and fresh weight of 100 fruits (mg) in carrot cv. Zino

Umbel order	Weeks after anthesis								
	W_1	W_2	W_3	W_4	W_5	W_6	W_7	W_8	Mean
				Breadth of fruit (Schizocarp) (mm)					
U_1	1.5	2.5	2.5	3.0	3.0	3.0	2.5	2.0	2.5
U_2	1.0	2.0	2.5	3.0	2.5	2.5	2.0	2.0	2.2
U_3	1.0	2.0	2.5	2.5	2.0	2.0	1.5	1.5	1.9
Mean	1.2	2.2	2.5	2.8	2.5	2.5	2.0	1.8	
CD(P=0.05)				W 0.58		U 0.36		WxC 1.01	
				Fresh weight of 100 fruits (mg)					
U_1	145	514	668	705	785	702	644	626	599
U_2	143	401	563	692	780	720	691	596	573
U_3	126	374	501	624	743	670	651	621	539
Mean	138	430	577	674	769	697	662	614	
CD(P=0.05)				W 15.21		U 24.83		WxC 43.01	

the weeks evaluated, W_5, W_6, and W_3 were on par and W_2, W_7, W_8 were on par.

In the interaction, maximum breadth of fruit was noticed at U_1W_4, U_2W_4 and U_3W_4; whereas minimum values were at U_1W_1, U_2W_1 and U_3W_1.

4.2.2.1.2.3.**Fresh weight of 100 fruits (mg) (Table 8)**

The differences in fresh weight of fruits recorded for umbel order and weeks after anthesis and their interaction were significant.

Of the umbel orders, U_1 and U_2 recorded the maximum weight of 599 and 573 respectively and minimum of 539 was recorded by U_3 in that category.

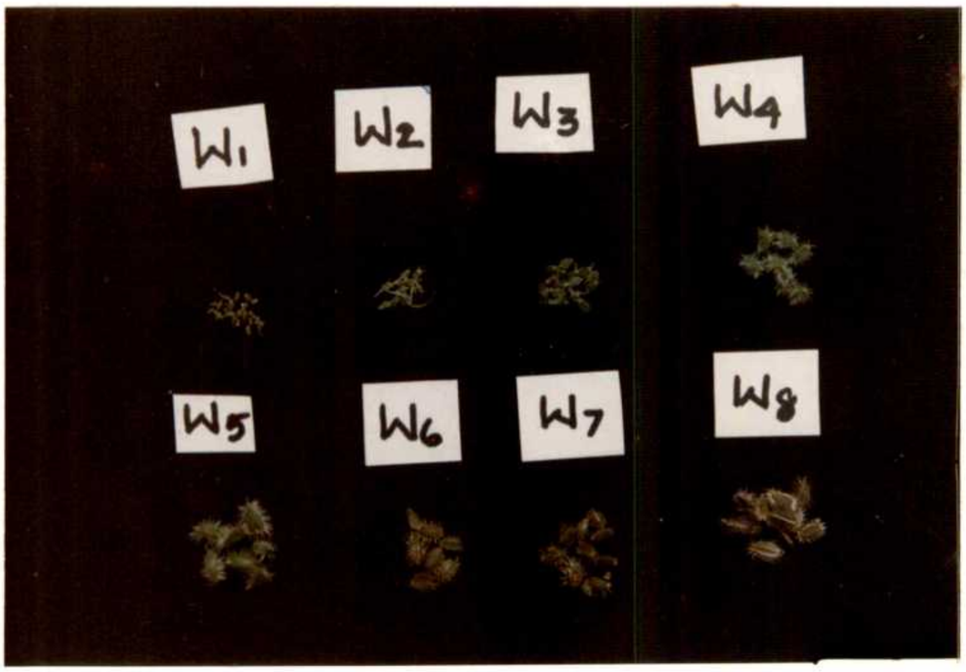
Among the weeks after anthesis, W_5 recorded the maximum (769) and W_1 recorded the minimum (138). W_4 and W_7 were on par.

In the interaction, the maximum fresh weight of 100 fruits were registered at U_1W_5, U_2W_5, and U_3W_5; whereas the minimum values at U_1W_1, U_2W_1 and U_3W_1.

4.2.2.1.2.4.**Dry weight of 100 fruits (mg) (Table 9)**

Significant difference was observed, between all parameters recorded in relation to dry weight of 100 fruits.

PLATE 7. STAGES DURING DEVELOPMENT AND MATURATION OF CARROT SEED



Among the umbels, U_1 yielded the maximum weight (305) but it was on par with U_2 (301). The minimum weight recorded by U_3 (296) and was on par with U_2.

Among the weeks after anthesis W_8 recorded the maximum value and W_1 recorded the minimum value irrespective of the umbels.

Between umbel order and week after anthesis, U_1 at W_8, U_2 at W_8, U_3 at W_8 recorded the maximum and U_1 at W_1, U_2 at W_1 and U_3 at W_1 recorded the minimum values.

4.2.2.1.2.5. Volume of 100 fruits (cm^3) (Table 9)

Significant variation was observed in respect to volume of fruits for the umbel orders weeks after anthesis and their interaction.

Among the umbel order, U_1 registered the maximum volume (1.1) and U_3 registered the minimum volume (0.9).

Among the weeks after anthesis, W4 and W5 registered maximum value of 1.3 each while W_1 had the minimum value of 0.5, W_2 and W_8 were on par with 0.8 each.

Among the interaction, the highest volume was noticed in U_1W_5, U_2W_4 and U_3W_4 and lowest volume in U_1W_1 and U_3W_1.

Table 9: Influence of umbel orders and stages of maturity on dry weight (mg) and volume of fruit (cc) in carrot cv. Zino

Umbel order	Weeks after anthesis W_1	W_2	W_3	W_4	W_5	W_6	W_7	W_8	Mean
				Dry weight of fruits (mg)					
U_1	32	149	232	336	418	421	424	426	305
U_2	31	140	231	334	410	414	424	424	301
U_3	31	136	230	329	399	408	416	416	296
Mean	31	142	231	333	409	414	421	422	
				W		U		WxC	
CD(P=0.05)				10.41		6.37		18.03	
				Volume of fruit (cc)					
U_1	0.6	0.8	1.1	1.4	1.6	1.2	1.1	1.0	1.1
U_2	0.5	0.8	0.9	1.3	1.2	1.2	1.0	0.8	1.0
U_3	0.4	0.7	0.9	1.2	1.1	1.0	0.9	0.6	0.9
Mean	0.5	0.8	1.0	1.3	1.3	1.1	1.0	0.8	
				W		U		WxC	
CD(P=0.05)				0.13		0.08		0.23	

4.2.2.1.2.6. Moisture content (%) (Table 10)

The fruits differed significantly in the moisture content. The moisture content decreased with increase in the stages of development. It was at the highest in W_1 with 75% and the same gradually decreased to 15.1% at W_8 irrespective of the umbel orders.

4.2.2.1.3. PHYSIOLOGICAL CHARACTERS

4.2.2.1.3.1. Germination (%) (Table 10)

The germination of seeds was initiated only in W_5 at which it was only 9% and the same increased to 53% in W_8.

Among the umbel order, U_1 registered 46% germination, U_2 recorded 42% and 23% of germination was recorded in U_3.

In the interaction, U_1 W_8 gave highest germination percentage (62%).

4.2.2.1.3.2. Root length (cm) (Table 11)

Significant variations were observed in all treatment. Among the various stages of development, the root length of seedling was increased from W_5 (1.47) to W_8 (4.33). There was significant difference among the umbel

Table 10: Influence of umbel orders and stages of maturity on moisture content (%) and germination (per cent) in carrot cv. Zino

Umbel order	W_1	W_2	W_3	W_4	W_5	W_6	W_7	W_8	Mean
				Weeks after anthesis					
				Moisture content (%)					
U_1	78.5	71.0	64.1	53.0	44.5	35.5	23.4	15.4	48.2
	(62.35)	(57.39)	(55.47)	(46.67)	(41.81)	(36.54)	(28.89)	(23.10)	(44.03)
U_2	75.1	64.9	53.6	45.6	35.7	26.5	19.8	14.5	42.0
	(60.04)	(59.95)	(47.04)	(42.47)	(36.66)	(30.96)	(26.45)	(22.32)	(40.74)
U_3	71.3	68.2	51.6	43.0	38.7	30.6	21.8	15.5	42.6
	(57.63)	(55.65)	(45.92)	(41.01)	(38.44)	(33.59)	(27.83)	(23.18)	(40.41)
Mean	75.0	68.0	56.4	47.2	39.6	30.9	21.7	15.1	
	(60.01)	(57.66)	(49.48)	(43.38)	(38.97)	(33.70)	(27.72)	(22.87)	
				W		U		WxC	
CD(P=0.05)				1.895		1.161		3.284	
				Germination (%)					
U_1	-	-	-	-	15	46	60	62	46
					(22.78)	(42.51)	(50.76)	(51.74)	(41.95)
U_2	-	-	-	-	12	42	58	56	42
					(20.56)	(40.39)	(49.60)	(48.45)	(39.75)
U_3	-	-	-	-	-	13	38	41	23
						(21.11)	(38.05)	(39.82)	(24.75)
Mean	-	-	-	-	9	34	52	53	
					(14.45)	(34.67)	(46.14)	(46.67)	
				W		U		WxC	
CD(P=0.05)				1.618		1.400		2.802	

(Figures in paranthesis indicate arc sin values)

order, U_1 recorded the longest root length (4.01) and U_3 recorded the shortest root length (2.30).

4.2.2.1.3.3. **Shoot length (cm) (Table 11)**

Significant variations were observed in umbel order weeks after anthesis and interaction. Among the weeks W_8 recorded the highest value (5.50) and U_5 recorded the lowest value (2.56).

Among the umbel order, U_1 had registered the longest shoot (5.20) and the shortest shoot was recorded by U_3 (2.95).

In the interaction, the maximum values were recorded by the U_1W_8, U_2W_8 and U_3W_8 and the minimum length of shoot was recorded at U_1W_5, U_2W_5 and U_3W_5.

4.2.2.1.3. **Vigour index (Table 12)**

There was a significant difference which was noticed in all the parameters with advance in maturity.

Of the umbel order, U_1 recorded the maximum vigour index (454) and the minimum value recorded by U_3 (173).

Among the weeks, W_8 registered the maximum vigour index (529) and the minimum of 55 was recorded by W_5.

Interaction was also significant.

Table 11: Influence of umbel orders and stages of maturity on root length (cm) and shoot length (cm) in carrot cv. Zino

Umbel order	Weeks after anthesis								
	W_1	W_2	W_3	W_4	W_5	W_6	W_7	W_8	Mean
				Root length					
U_1	-	-	-	-	2.27	4.13	4.55	5.09	4.01
U_2	-	-	-	-	2.13	3.94	4.15	4.23	3.61
U_3	-	-	-	-	-	2.03	3.47	3.68	2.30
Mean	-	-	-	-	1.47	3.37	4.06	4.33	
CD(P=0.05)				W 0.081		U 0.071		WxC 0.141	
				Shoot length					
U_1	-	-	-	-	4.22	4.32	5.82	6.41	5.20
U_2	-	-	-	-	3.43	3.65	4.93	5.11	4.28
U_3	-	-	-	-	-	3.23	3.57	4.99	2.95
Mean	-	-	-	-	2.56	3.73	4.77	5.50	
CD(P=0.05)				W 0.083		U 0.083		WxC 0.166	

Table 12: Influence of umbel orders and stages of maturity on vigour index and drymatter production (mg per 10 seedlings) in carrot cv. Zino

Umbel order	Weeks after anthesis								
	W_1	W_2	W_3	W_4	W_5	W_6	W_7	W_8	Mean
				Vigour index					
U_1	-	-	-	-	97	386	622	710	454
U_2	-	-	-	-	69	319	528	523	360
U_3	-	-	-	-	-	68	268	355	173
Mean	-	-	-	-	55	258	473	529	
CD(P=0.05)				W 21.45		U 18.58		WxC 37.17	
				Drymatter production					
U_1	-	-	-	-	2.1	3.8	4.6	5.5	4.0
U_2	-	-	-	-	1.8	3.3	3.9	4.6	3.4
U_3	-	-	-	-	-	1.7	2.6	3.9	2.1
Mean	-	-	-	-	1.3	2.9	3.7	4.7	
CD(P=0.05)				W 0.844		U 0.761		WxC 0.143	

4.2.2.1.3.5. Dry matter production (mg/10 seedlings) (Table 12)

Among umbel orders, maturity stages and their interaction, there existed a significant difference. U_1 and U_2 though on par revealed the superiority of U_1 (4.0). Matured seed at W_8 recorded 4.7 which interaction brought the better result of U_1W_8 (5.5).

4.2.2.1.4. BIO-CHEMICAL TESTS

4.2.2.1.4.1. Electrical conductivity (dSm^{-1}) (Table 13)

There existed a significant difference between all parameters recorded in relation to electrical conductivity.

Among the weeks after anthesis, increasing trend was noticed with advance in maturity.

In umbel order, U_1 recorded the minimum and U_3 recorded the maximum.

The interaction was also significant.

4.2.2.1.4.2. Protein content (%) (Table 13)

Significant variations were registered in protein content.

Among the weeks, W_7 recorded the maximum value (10.91%) which was on par with W_8 and W_3 recorded the minimum value (3.96%).

Table 13: Influence of umbel orders and stages of maturity on electrical conductivity (dSm^{-1}) and protein content (per cent) in carrot cv. Zino

Umbel order	Weeks after anthesis								
	W_1	W_2	W_3	W_4	W_5	W_6	W_7	W_8	Mean
	Electrical conductivity (dSm^{-1})								
U_1	-	-	-	0.024	0.029	0.041	0.045	0.066	0.041
U_2	-	-	-	0.025	0.028	0.041	0.044	0.075	0.043
U_3	-	-	-	0.025	0.020	0.044	0.055	0.077	0.045
Mean	-	-	-	0.024	0.028	0.042	0.048	0.073	
				W		U		WxC	
CD(P=0.05)				0.004		0.002		0.006	
	Protein content (per cent)								
U_1	-	-	4.37	6.60	9.79	10.63	11.74	11.24	9.06
U_2	-	-	3.82	5.24	7.34	10.05	10.95	10.27	7.95
U_3	-	-	3.70	5.25	6.63	9.37	10.05	9.91	7.49
Mean	-	-	3.96	5.70	7.92	10.02	10.91	10.47	
				W		U		WxC	
CD(P=0.05)				0.743		0.525		1.285	

The umbel orders differed significantly. U_1 recorded the highest value of 9.06%; the lowest value of protein was recorded by U_3 (7.49%) which was on par with U_2 (7.95%).

4.2.2.2. EFFECT OF STECKLING SIZE ON NET REPRODUCTIVE EFFORT AND SEED PRODUCTION SPECTURM

4.2.2.2.1. GROWTH CHARACTERS

4.2.2.2.1.1. Days to sprouting of stecklings (Table 14)

Significant variations were observed in days to sprouting of stecklings for the treatments and steckling grades. Interaction between treatments and steckling grades was also significant.

Among the chosen treatments, T_4 took less number of days to sprouting. However, it was on par with T_3, T_2 and T_0; while more days were registered by T_1 (5.6).

There was a significant difference among the steckling grades. The lowest value was recorded by G_4 (5.0) and G_3 (5.2). The highest of 5.5 recorded by the steckling grades G_2, and G_1 (5.7).

The interaction was also significant. Among TxG interaction, T_4G_4 had the minimum value of 4.3 which was significantly superior from other treatments.

Table: 14 Influence of pyridoxine treatments and steckling grades on days to sprouting and days to umbel emergence in carrot cv. Zino

	G_1	G_2	G_3	G_4	Mean	G_1	G_2	G_3	G_4	Mean
T_0	6.0	5.7	5.3	5.3	5.6	80.5	79.0	72.5	72.0	76.0
T_1	6.0	5.7	5.3	5.3	5.6	79.5	77.5	72.0	71.0	75.0
T_2	5.7	5.7	5.3	5.0	5.4	78.0	80.0	73.0	71.0	75.5
T_3	5.3	5.3	5.3	5.0	5.2	80.0	78.0	72.5	70.0	75.0
T_4	5.3	5.3	5.0	4.3	5.0	74.0	78.0	73.0	70.0	74.0
Mean	5.7	5.5	5.2	5.0		78.4	78.5	72.6	71.0	

	T	G	TxG	T	G	TxG
CD (P=0.05)	0.54	0.48	1.08	NS	2.29	5.12

4.2.2.2.1.2. Days to umbel emergence (Table 14)

The differences in umbel emergence recorded for steckling grades were significant. There was no significant variation among the treatments. However, the interaction between TxG was significant.

Of the grades, G_4 and G_3 recorded the minimum of 71.0 and 72.6 respectively to umbel emergence. However, G_4 was on par with G_3 only. The maximum value of 78.5 recorded by G_2 and was on par with G_1 only.

4.2.2.2.1.3. Distribution of umbels (Table 15)

Significant difference was observed between all parameters recorded in relation to distribution of umbels.

Among the treatments, T_4 recorded the maximum value (16.7) but it was on par with T_2 and T_3; while T_0 recorded the minimum value (15.5) and was on par with G_4 (17.4). The minimum value of 14.0 was obtained in G_1 only.

Among the orders U_3 recorded the maximum value (31.4) and significantly differed from U_1, U_2 and U_x.

Between interaction TxG, within the treatment and in all the grades T_4 recorded the maximum value and T_0 recorded the minimum value. Among the grades, the values were increasing from G_1, to G_3; G_3 was on par with G_4.

Table 15: Influence of pyridoxine treatments and steckling grades on distribution of umbels in carrot cv. Zino

	G_1	G_2	G_3	G_4	U_1	U_2	U_3	U_x	Mean
T_0	14.5	15.8	17.0	16.8	1.0	12.9	28.6	19.6	15.5
T_1	12.8	14.5	17.9	17.0	1.0	12.8	30.9	19.4	16.0
T_2	14.0	14.9	17.3	17.5	1.0	13.1	31.4	18.1	16.0
T_3	14.4	14.8	17.9	17.8	1.0	13.3	32.5	18.0	16.2
T_4	14.5	16.0	18.3	17.8	1.0	12.9	33.4	19.3	16.7
Mean	14.0	15.2	17.7	17.4	1.0	13.0	31.4	18.9	
U_1	1.0	1.0	1.0	1.0					
U_2	12.0	12.5	13.7	13.7					
U_3	29.0	29.5	34.3	32.6					
U_x	14.1	17.7	21.6	22.1					

	T	G	U	TxG	TxU	GxU
CD (P=0.05)	0.779	0.618	0.618	1.557	1.557	0.981

Between GxU, in all the grades, the values decreased from U_3 to U_1 and U_x recorded lesser value than U_3.

Between TxU, in all treatment the umbel order were in the sequence of U_3, U_x, U_2 and U_1. Among the umbel orders T_4 and T_0 recorded the maximum and minimum values, respectively.

4.2.2.2.1.4. Number of umbels plant^{-1} (Table 16)

Significant variations were observed in number of umbels, for the steckling grades and interaction between steckling grades and treatments.

A nonsignificant result was obtained among the treatments; however, T_4 was arithmatically superior to others.

Among the steckling grades, G_3 and G_4 recorded the maximum with 69.4 each, G_1 recorded the minimum (56.1) number of umbels. The interaction was also significant.

4.2.2.2.2. YIELD ATTRIBUTES

4.2.2.2.2.1. Seed yield umbel^{-1} (g) (Table 17)

Significant difference was observed between all parameters recorded in seed yield per umbel.

Table 16: Influence of pyridoxine treatments and steckling grades on the number of umbels in carrot cv. Zino

	G_1	G_2	G_3	G_4	Mean
T_0	51.0	58.0	71.5	68.0	62.1
T_1	58.0	63.0	68.0	67.0	64.0
T_2	56.0	59.5	69.0	70.0	63.6
T_3	57.5	59.0	71.5	71.0	65.0
T_4	58.0	64.0	67.0	71.0	65.0
Mean	56.1	60.7	69.4	69.4	

	T	G	TxG
CD (P=0.05)	NS	4.274	9.560

Among the included treatments, T_4 recorded the maximum value of 2.84 but it was on par with T_2 and T_3. The minimum value of 2.64 was recorded by T_0 which was on par with T_1 and T_2.

There was significant difference among the grades. The maximum value of 2.96 was recorded in G_4 and was followed by G_3, G_2 and G_1.

The umbel order differed significantly in the seed yield. U_1 gave the highest seed yield of 4.40. The lowest seed yield of 1.39 was recorded by U_3.

Between TxG interaction, within treatment, in all the involved treatments, T_4 recorded the maximum value and T_0 recorded the minimum value. Among the grades, the values were increasing from G_1 to G_4.

Between GxU, in all grades, values decreased from U_1 to U_3. Among the orders values were increased from G_1 to G_4.

Between TxU, in all treatments the umbel order were in the sequence of U_1, U_2 and U_3. Among the umbel order T_4 and T_0 recorded the maximum and minimum values respectively.

Table 17: Influence of pyridoxine treatments, steckling grades and order of umbel on seed yield umbel^{-1} (g) in carrot cv. Zino

	G_1	G_2	G_3	G_4	U_1	U_2	U_3	Mean
T_0	2.44	2.53	2.72	2.88	4.38	2.22	1.32	2.64
T_1	2.46	2.69	2.72	2.89	4.38	2.36	1.34	2.69
T_2	2.46	2.71	2.83	2.93	4.33	2.52	1.36	2.74
T_3	2.42	2.68	2.94	3.02	4.41	2.46	1.42	2.76
T_4	2.62	2.75	2.89	3.09	4.52	2.50	1.50	2.84
Mean	2.48	2.67	2.82	2.96	4.40	2.41	1.39	
U_1	4.04	4.39	4.49	4.69				
U_2	2.25	2.29	2.53	2.56				
U_3	1.15	1.32	1.46	1.63				

	T	G	U	TxG	GxU	TxU
CD (P=0.05)	0.139	0.131	0.113	0.294	0.227	0.255

4.2.2.2.2.2. Distribution of seed yield (g) (Table 18)

Distribution of seed yield showed significant variation among the treatments, steckling grades and umbel orders. Their interactions also varied significantly with one another.

Among the treatments T_4 and T_0 recorded the maximum (10.44) and minimum (9.52) yield, respectively. T_3, T_2 and T_1 were on par. T_1 also on par with T_0 (9.52).

Among the steckling grade G_4 recorded the maximum value (11.73) and the grades G_3 (11.09), G_2 (8.85), follows in a decreasing trend.

Among the umbel order, U_2 recorded the maximum yield of 17.73 and was followed by U_3 (9.90), U_x (7.67) and U_1 (4.35).

The interaction between treatments and steckling grades revealed, the superiority of G_4 in all treatments.

Treatment and umbel order interaction exposed the superiority of U_2 among all the treatments; among the treatments, T_4 recorded the maximum value.

Between steckling grade and umbel orders, U_2 proved superior in all grades.

Table 18: Influence of pyridoxine treatments, steckling grades and order of umbel on distribution of seed yield (g) in carrot cv. Zino

	G_1	G_2	G_3	G_4	U_1	U_2	U_3	U_x	Mean
T_0	7.91	8.35	10.68	11.14	4.28	18.21	8.78	6.82	9.52
T_1	7.73	8.32	11.21	11.85	4.32	17.72	9.34	7.73	9.78
T_2	7.89	8.38	11.33	11.73	4.22	16.65	10.69	7.77	9.83
T_3	8.01	9.30	11.09	11.51	4.16	17.57	10.79	7.41	9.98
T_4	8.34	9.90	11.12	12.41	4.77	18.52	9.89	8.60	10.44
Mean	7.98	8.85	11.09	11.73	4.35	17.73	9.90	7.67	
U_1	4.19	4.08	4.36	4.77					
U_2	15.02	16.23	19.04	20.64					
U_3	7.62	8.43	11.85	11.69					
U_x	5.09	6.67	9.10	9.80					

	T	G	U	TxG	TxU	GxU
CD(P=0.05)	0.475	0.426	0.426	0.951	0.951	0.852

4.2.2.2.2.3. **Seed yield(g plant^{-1}) (Table 19)**

The differences in seed yield recorded for different steckling grade were significant. G_4 and G_3 recorded the highest seed yield of 43.0 , and 41.9 respectively and were on par with each other. G_1 recorded the lowest seed yield of 32.8 ; whereas G_2 recorded the seed yield of 37.5 grams.

Among the treatments there was no significant difference in terms of seed yield. There was significant difference in interaction also.

4.2.2.2.2.4. **Total seed yield plot^{-1} (kg ha^{-1}) (Table 19)**

No significant differences existed for the total seed yield for different treatments.

There was significant difference in the plot seed yield. Of the grades G_4 and G_3 had the highest seed yield of 767 and 756, respectively which were on par. The lowest value of 583 recorded by G_1.

The interaction also varied significantly in the seed yield. In all treatments, G_3 and G_4 recorded the highest seed yield per plot.

Table: 19 Influence of pyridoxine treatments and steckling grades on seed yield (g $plant^{-1}$) and seed yield $plot^{-1}$ (kg ha^{-1}) in carrot cv. Zino

	G_1	G_2	G_3	G_4	Mean	G_1	G_2	G_3	G_4	Mean
T_0	34.3	38.0	42.3	41.3	39.0	608	678	733	733	688
T_1	29.5	38.8	44.0	43.5	39.0	524	689	764	774	688
T_2	33.5	37.0	42.8	42.3	38.9	596	595	725	766	671
T_3	32.8	34.3	41.0	44.5	38.2	582	612	791	791	694
T_4	34.0	39.5	39.5	43.3	39.1	604	702	769	769	711
Mean	32.8	37.5	41.9	43.0		583	655	756	767	

	T	G	TxG	T	G	TxG
CD (P=0.05)	NS	3.686	8.240	NS	65.78	147.10

4.2.2.2.2.5.1000 seed weight (g) (Table 20)

Significant differences were observed among the steckling grades, treatments, umbel orders and their interactions.

Among the treatments, T_3 recorded the maximum weight (1.69) which was on par with T_4 (1.68). The minimum value of 1.50 was recorded by T_1.

Among the steckling grades, G_4 recorded the maximum value (1.76) and was followed by G_3, G_1 and G_2.

Among the umbel orders, U_1 (1.87) was superior and was followed by U_2 and U_3, with 1.57 and 1.37 respectively.

The interaction between treatment and steckling grade revealed the superiority of G_4 and G_3 in all treatments.

Between TxU, in all treatments the umbel order were in the sequence of U_1, U_2 and U_3. Among the umbel orders, T_4 and T_0 recorded the maximum and minimum values respectively.

Between GxU in all grades value decreased from U_1 to U_3. Among the umbel orders, values increased from G_1 to G_4.

Table 20: Influence of pyridoxine treatments, steckling grades and order of umbels on 1000 seed weight (g) of carrot cv. Zino

	G_1	G_2	G_3	G_4	U_1	U_2	U_3	Mean
T_0	1.49	1.62	1.62	1.62	1.85	1.58	1.33	1.59
T_1	1.51	1.52	1.38	1.58	1.72	1.48	1.30	1.50
T_2	1.52	1.48	1.60	1.73	2.00	1.51	1.24	1.58
T_3	1.56	1.58	1.74	1.88	1.88	1.65	1.54	1.69
T_4	1.48	1.65	1.61	1.99	1.93	1.65	1.47	1.68
Mean	1.51	1.57	1.59	1.79	1.87	1.57	1.37	
U_1	1.76	1.77	1.89	2.07				
U_2	1.49	1.59	1.50	1.73				
U_3	1.29	1.34	1.30	1.46				

	T	G	U	TxG	TxU	GxU
CD ($P=0.05$)	0.042	0.038	0.032	0.083	0.071	0.065

4.2.2.2.3. PHYSIOLOGICAL CHARACTERS

4.2.2.2.3.1. Germination (%) (Table 21)

Germination of seed showed significant variation among the steckling grades and umbel orders. Their interaction also varied significantly with one another. Non significant difference were observed among the treatments.

G_3 recorded the maximum value (58%) and the grades G_2 (57%) G_4 (56%) and G_1 (53%) followed in a decreasing trend.

Among the umbel orders, U_1 recorded the maximum value of 63% and was followed by U_2 (58%), and U_3 (47%).

The interaction between treatment and steckling grade revealed the superiority of G_3, G_2, G_4 grades in all the included treatments.

Treatment and umbel order's interaction exposed the superiority of U_1 among all the treatments.

Between steckling grade and umbel orders U_1 proved superior in all grades.

4.2.2.2.3.2. Root length (cm) (Table 22)

Significant variations were observed in root length for the treatments, steckling grades, and umbel orders.

Table 21: Influence of pyridoxine treatments, steckling grades and order of umbel on germination (per cent) in carrot cv. Zino

	G_1	G_2	G_3	G_4	U_1	U_2	U_3	Mean
T_0	54	58	59	58	63	59	50	57
	(47.33)	(49.67)	(50.07)	(49.64)	(52.30)	(50.23)	(44.99)	(49.17)
T_1	53	55	57	59	62	60	47	56
	(46.94)	(47.69)	(49.27)	(50.01)	(51.67)	(50.79)	(42.97)	(48.48)
T_2	51	58	63	56	68	58	46	57
	(45.78)	(49.67)	(52.48)	(48.55)	(55.64)	(49.32)	(42.40)	(49.12)
T_3	57	55	53	53	62	57	46	55
	(48.85)	(48.10)	(46.92)	(46.98)	(51.70)	(49.04)	(42.41)	(47.71)
T_4	49	59	57	53	64	55	46	55
	(44.23)	(50.50)	(49.30)	(46.92)	(52.92)	(47.88)	(42.40)	(47.73)
Mean	53	57	58	56	63	58	47	
	(46.62)	(49.13)	(49.61)	(48.42)	(52.85)	(49.45)	(43.03)	
U_1	60	64	65	64				
	(50.80)	(53.46)	(53.94)	(53.19)				
U_2	56	59	60	57				
	(48.24)	(50.07)	(50.57)	(48.92)				
U_3	43	48	49	47				
	(40.83)	(43.85)	(44.31)	(43.15)				

	T	G	U	TxG	TxU	GxU
CD (P=0.05)	NS	1.374	1.200	3.075	2.663	2.381

(Figures in parantheses indicate arc sin values)

Among the treatments, the maximum value of 5.48 was recorded by T_4 but it was on par with T_3, T_2, and T_1. The minimum value of 5.00 was recorded by T_0 only.

There was significant difference among the steckling grades. The maximum value of 5.86 recorded in G_4 and was on par with G_3 (5.71). The minimum value of 4.59 was recorded by G_1 which was significantly different from G_2 (4.91).

The umbel order differed significantly in the root length. U_1 had 6.31 followed by U_2 (5.63) and U_3 (3.86).

Between interaction TxG, within treatment, in G_2 and G_3, T_4 recorded the maximum value. Among the grades, in T_2, T_3 and T_4, G_4 recorded the maximum value. Among the grades, the values were increasing from G_1 to G_4.

Between GxU, in all grades value increased from U_3 to U_1; while the order value decreased from G_4 to G_1.

Between TxU in all treatments, the umbel order were in the sequence of U_1, U_2 and U_3. Among umbel order T_4 and T_0 recorded the maximum and minimum values.

4.2.2.2.3.3. Shoot length (cm) (Table 22)

Significant variations were observed in shoot length due to steckling grade, umbel order and their interactions.

Table 22: Influence of pyridoxine treatments, steckling grades and order of umbel on root length (cm) and shoot length (cm) in carrot cv. Zino

	Root length								Shoot length							
	G_1	G_2	G_3	G_4	U_1	U_2	U_3	Mean	G_1	G_2	G_3	G_4	U_1	U_2	U_3	Mean
T_0	4.25	4.65	5.70	5.40	5.91	5.39	3.70	5.00	6.11	5.71	7.10	6.83	7.62	7.25	4.45	6.44
T_1	4.73	4.88	5.55	5.45	6.25	5.47	3.74	5.15	5.91	5.80	6.83	7.80	8.17	6.92	4.67	6.59
T_2	5.12	4.82	5.48	5.80	6.16	5.64	4.12	5.31	6.40	5.64	7.09	6.98	7.42	7.48	4.69	6.53
T_3	4.60	4.63	5.86	6.50	6.65	5.61	3.92	5.39	6.04	6.32	7.00	6.91	7.64	7.70	4.36	6.57
T_4	4.25	5.55	5.96	6.16	6.59	6.04	3.81	5.48	5.17	6.84	7.02	7.25	7.93	7.23	4.64	6.60
Mean	4.59	4.91	5.71	5.86	6.31	5.63	3.86		5.93	6.06	7.01	7.15	7.76	7.32	4.56	
U_1	5.19	5.51	7.21	7.33					6.99	6.83	8.52	8.69				
U_2	5.01	5.09	5.94	6.48					6.49	6.65	7.78	8.36				
U_3	3.56	4.12	3.98	3.77					4.31	4.72	4.77	4.42				

	T	G	U	TxG	TxU	GxU	T	G	U	TxG	TxU	GxU
CD (P=0.05)	0.434	0.388	0.336	0.867	0.752	0.672	NS	0.354	0.306	0.792	0.686	0.613

Non significant difference were observed among the treatments.

Among the steckling grades, G_4 recorded the longest shoot (7.15) but it was on par with G_3 (7.01). The shortest shoot of 5.93 was recorded by G_1 and was on par with G_2 (6.06).

Among the umbel orders U_1 recorded the maximum value (7.76) followed by U_2 (7.32). The minimum shoot length of 4.56 was recorded by U_3.

The interaction between treatments and steckling grades revealed the superiority of G_4 and G_3 in all treatments.

Treatment and umbel orders interaction exposed the superiority of U_1 among all the treatments.

Between steckling grades and umbel orders U_1 proved superior in all grades.

4.2.2.2.3.4. Vigour index (Table 23)

Significant variations were observed in vigour index for the treatments, steckling grades, umbel orders and also their interactions.

Table 23: Influence of pyridoxine treatments, steckling grades and order of umbels on vigour index in carrot cv. Zino

	G_1	G_2	G_3	G_4	U_1	U_2	U_3	Mean
T_0	514	620	756	674	858	693	372	641
T_1	600	585	695	806	912	709	393	671
T_2	576	658	757	733	871	768	404	681
T_3	635	579	738	758	838	785	410	678
T_4	502	732	832	764	971	767	385	708
Mean	565	365	756	747	890	745	393	
U_1	730	792	1025	1013				
U_2	627	689	823	842				
U_3	338	423	425	385				

	T	G	U	TxG	TxU	GxU
CD (P=0.05)	50.052	50.135	43.418	112.102	97.083	86.834

Among the treatments, the highest value of 708 recorded by T_4 which was on par with T_3, T_2 and T_1. The lowest value of vigour index recorded by T_0 (641).

There was significant difference among the steckling grades. The highest value of 756 recorded in G_3 followed by G_4 were on par. The minimum value was recorded by G_1 with 565.

The vigour indices of different umbel orders were significant. The highest value was recorded by U_1 with 890 whereas U_3 registered the lowest value of 393.

Between interaction TxG, in G_3 and G_4, T_4 recorded the maximum value. Among the grades in all treatments G_4 and G_3 registered the highest values. Among the grades, the values were increasing from G_1 to G_4.

Between TxU in all treatments, the umbel orders were in the sequence of U_1, U_2 and U_3. Among umbel orders T_4 and T_0 recorded the maximum and minimum values.

Between GxU, in all grades the value decreased from U_1, to U_3. Among the orders, values increased from G_1 to G_4.

Table 24: Influence of pyridoxine treatments, steckling grades and order of umbels on Protein (per cent) of seed in carrot cv. Zino

	G_1	G_2	G_3	G_4	U_1	U_2	U_3	Mean
T_0	10.04	9.96	10.05	9.95	11.29	10.26	8.45	10.00
T_1	10.03	10.08	10.04	10.09	11.35	10.18	8.65	10.06
T_2	10.00	10.00	10.01	10.01	11.12	10.27	8.62	10.00
T_3	10.04	9.96	10.06	10.03	11.23	10.23	8.62	10.02
T_4	10.04	10.03	10.01	9.95	11.29	10.19	8.55	10.01
Mean	10.03	10.00	10.03	10.01	11.25	10.23	8.58	
U_1	11.23	11.21	11.28	11.28				
U_2	10.22	10.25	10.22	10.21				
U_3	8.63	8.55	8.60	8.53				

	T	G	U	TxG	TxU	GxU
CD (P=0.05)	NS	NS	0.185	NS	0.414	0.370

4.2.2.2.4.2. Protein content (%) (Table 24)

Non significant difference were recorded with regard to protein content of pyridoxine treatments, steckling grades and their interaction.

Significant variations were noticed among the umbel orders.

The highest protein content of seed was recorded by U_1 (11.25%) and the lowest was by U_3 (8.58%).

The interaction between TxU and GxU were also significant.

4.2.2.3. EFFECT OF NUTRIENTS ON SEED QUALITY

4.2.2.3.1. GROWTH CHARACTERS

4.2.2.3.1.1. Days to sprouting of steckling (Table 25)

Non significant difference was observed in relation to days to sprouting of stecklings.

4.2.2.3.1.2. Days to umbel emergence (Table 25)

Significant differences were observed in relation to days to umbel emergence. Evaluation indicated that F_3 took minimum number of days (74) and F_1 took maximum number of days (92).

Table 25: Influence of nutrient levels on days to sprouting of stecklings, days to umbel emergence and total number of umbels in carrot cv. Zino

	Days to sprouting of stecklings	Days to umbel emergence	Total number of umbels
F_1	6	92	58
F_2	6	83	67
F_3	5	74	71
CD (P=0.05)	NS	1.93	4.84

Table 26: Influence of nutrient levels on distribution of umbels in carrot cv. Zino

	U_1	U_2	U_3	U_x	Mean
F_1	1	13.0	30.5	14.3	14.7
F_2	1	15.3	34.0	16.3	16.7
F_3	1	15.0	38.0	17.8	17.9
Mean	1	14.5	34.2	16.0	
	F	U	FxU		
CD (P=0.05)	1.42	1.64	2.84		

4.2.2.3.1.3. Total number of umbels (Table 25)

There was a significant difference among the treatments. In general, F_3 registered the maximum number of umbels (71) which was on par with F_3 (67). F_1 recorded the minimum value of 58.

4.2.2.3.1.4. Distribution of umbels (Table 26)

Significant variations were observed due to nutrient levels, umbel orders and their interaction.

Among the nutrient levels, F_3 recorded the maximum number of umbels (17.9) and was on par with F_2 (16.7). F_1 gave minimum value.

Among the umbel orders, U_3 recorded the highest umber of umbels (34.2) followed by U_x (16.0), U_2 (14.5), and U_1 (1.0).

Their interactions were also significant.

4.2.2.3.2. YIELD ATTRIBUTES

4.2.2.3.2.1. Seed yield umbel^{-1} (g) (Table 27)

Significant differences were observed in relation to all the parameters studied.

Among the nutrient levels, F_3 yielded the highest weight (3.20) which was on par with F_2 (3.13). Lowest seed yield per umbel was recorded by F_1 (2.81).

Table 27: Influence of nutrient levels and order of umbels on seed yield $umbel^{-1}$ and distribution of seed yield $plant^{-1}$ (g) in carrot cv. Zino

	U_1	U_2	U_3	Mean	U_1	U_2	U_3	U_x	Mean
F_1	4.31	2.41	1.72	2.81	4.10	18.372	11.05	9.37	10.72
F_2	4.66	2.60	2.12	3.13	4.46	·25.94	13.31	8.24	12.99
F_3	4.66	2.77	2.18	3.20	4.66	26.19	13.29	8.85	13.25
Mean	4.54	2.59	2.01		4.41	23.50	12.55	8.82	
	F	U	FxU		F	U	FxU		
CD (P=0.05)	0.135	0.135	0.264		1.872	2.161	3.744		

Of the umbel orders, U_1 recorded the highest value (4.54) and U_3 registered the lowest value (2.01).

There was significant difference in the interaction also.

4.2.2.3.2.2.Distribution of seed yield plant^{-1} (g)(Table 27)

Significant differences were recorded for nutrient levels, umbel orders and their interaction. Of them F_3 had the highest seed yield of 13.25 followed by F_2 (12.99). However F_3 and F_2 were on par. The least was recorded by F_1 (10.72).

Among the umbel orders, U_2 was superior with a seed yield of 23.50 followed by U_3 (12.55) and U_x (8.82) U_1 had the lowest value of 4.41 grams.

The interaction also varied significantly for the distribution of seed yield.

4.2.2.3.2.3.Total seed yield plant^{-1} (g) (Table 28)

Among the chosen treatments, F_3 and F_2 recorded the highest seed yield of 53.7 and 52.8 which were significantly different from F_1 (42.8).

Table 28: Influence of nutrient levels on total seed yield plant^{-1} (g) and total seed yield plot^{-1} (kg ha^{-1}) in carrot cv. Zino

	Total seed yield plant^{-1}	Total seed yield plot^{-1}
F_1	42.8	759
F_2	52.8	939
F_3	53.7	955
CD (P=0.05)	1.943	42.01

PLATE 8. CARROT SEEDS WITH BRISTLES

PLATE 9. CARROT SEEDS FROM DIFFERENT UMBEL ORDERS

4.2.2.3.2.4. Total seed yield plot^{-1} (kg ha^{-1}) (Table 28)

The highest seed yield was obtained by the F_3 (955) which was on par with F_2 (939). F_1 registered the lowest seed yield of 759.

4.2.2.3.2.5. 1000 seed weight (g) (Table 29)

There was no significant difference in the 1000 seed weight of different nutrient levels.

There was significant difference in the 1000 seed weight from different orders of umbel. Among the umbel orders, U_1 recorded the highest weight of 1.87, and U_3 recorded the lowest (1.40 g).

The interaction also varied significantly in the 1000 seed weight.

4.2.2.3.3. PHYSIOLOGICAL CHARACTERS

4.2.2.3.3.1. Germination (%) (Table 29)

The germination percentage for different nutrient levels did not show significant difference. The average germination percentage was 56 only.

The differences in germination recorded for different umbel order were significant. It varied from 48 to 62 per cent. U_1 and U_2 were superior with 62 and 59

Table 29: Influence of nutrient levels and order of umbel on 1000 seed weight (g) and germination (%) in carrot cv. Zino

	U_1	U_2	U_3	Mean	U_1	U_2	U_3	Mean
F_1	1.85	1.56	1.35	1.59	62 (51.67)	58 (49.61)	48 (43.84)	56 (48.32)
F_2	1.86	1.57	1.44	1.62	63 . (52.55)	59 (50.20)	46 (42.69)	56 (48.48)
F_3	1.90	1.59	1.40	1.63	60 (50.78)	58 (49.61)	49 (44.42)	56 (48.27)
Mean	1.87	1.57	1.40		62 (51.67)	59 (49.80)	48 (43.69)	
	F	U	FxU		F	U	FxU	
CD (P=0.05)	NS	0.093	0.160		NS	2.407	4.169	

(Figures in paranthesis are indicate arc sin values) respectively and were on par with each other. U_3 registered the least of all the umbels with 48 per cent only.

The FxU interaction also differed significantly.

4.2.2.3.3.2. Root length (cm) (Table 30)

There was no significant difference in the root length of the seedlings obtained from seeds of different nutrient levels, with all of them registering a mean value of 5 cm each.

Among the umbel orders, U_1 was superior with 5.85; while U_2 and U_3 were 5.05 and 4.13 respectively.

The FxU interaction varied significantly in the root length of the seedling.

4.2.2.3.3.3. Shoot length (cm) (Table 30)

The different levels of nutrients did not show any significant difference in the shoot length of the seedling and the mean value ranged from 6.20 to 6.69.

The umbel order varied significantly. U_1 had the longest shoot length of 7.42 and U_2 had 6.93, which were on par. The shortest shoot of 5.01 was recorded by U_3.

The interaction significantly differ in respect to their shoot length.

Table 30: Influence of nutrient levels and order of umbel on root length (cm) and shoot length (cm) in carrot cv. Zino

	U_1	U_2	U_3	Mean	U_1	U_2	U_3	Mean
F_1	5.83	5.00	4.25	5.03	7.10	6.50	5.00	6.20
F_2	5.73	5.10	4.30	5.04	7.43	7.13	4.85	6.47
F_3	5.98	5.05	3.83	4.95	7.73	7.15	5.18	6.69
Mean	5.85	5.05	4.13		7.42	6.93	5.01	
	F	U	FxU		F	U	FxU	
CD (P=0.05)	NS	0.464	0.803		NS	0.609	1.055	

Table 31: Influence of nutrient levels and order of umbel on vigour index and Protein (per cent) in carrot cv. Zino

	U_1	U_2	U_3	Mean	U_1	U_2	U_3	Mean
F_1	795	667	445	636	11.30	10.40	8.60	10.10
F_2	828	722	424	658	11.23	10.05	8.63	9.97
F_3	842	707	437	662	11.43	10.13	8.65	10.07
Mean	822	699	435		11.32	10.19	8.63	
	F	U	FxU		F	U	FxU	
CD (P=0.05)	NS	58.95	102.11		NS	0.322	0.557	

4.2.2.3.3.4. Vigour index (Table 31)

Nutrient levels did not strike any difference for the mean vigour index value.

Among the umbel orders, U_1 was superior with a value of 822, U_2 and U_3 had a vigour index of 699 and 435, respectively.

In the interaction, F_3 U_3 was significant in their vigour index.

4.2.2.3.4.2. Protein content (%) (Table 31)

There was no significant difference in the protein content of different nutrient levels.

Among the umbel orders, the highest value was recorded by U_1 (11.32) and followed by U_2 (10.19) and U_3 (8.63).

There was also significant difference in the interaction.

4.2.2.4. EFFICIENCY OF DIFFERENT METHODS OF THRESHING ON SEED QUALITY OF CARROT Cv. ZINO.

4.2.2.4.1. Recovery (%) (Table 32)

In respect to the treatments imposed to remove the bristles from the seed, the seeds in which the highest recovery percentage was recorded in SSR_4 (90%) followed by

PLATE 10. DEFUZZING MACHINE

SSR_0, SSR_1, and SSR_{13} which were on par. SSR_6 recorded the lowest recovery of 61 percentage.

4.2.2.4.2. Germination (%) (Table 32)

The germination percentage from different treatments differed significantly. The seeds in which hand threshing (SSR_0) was done recorded the highest germination percentage of 68 followed by mechanically threshed seeds SSR_{15}, SSR_6, and SSR_3 which were on par. The lowest germination of 39% was recorded by SSR_1.

4.2.2.4.3. Abnormal seedlings (%) (Table 32)

With regard to different methods of threshing 1:150 seed sand ratio combination (SSR_3) recorded the highest percentage of abnormal seedlings followed by SSR_2, SSR_6 and SSR_9 which were on par. The lowest percentage of abnormal seedlings recorded by SSR_0 was 5% only.

4.2.2.4.4. Root length (cm) (Table 32)

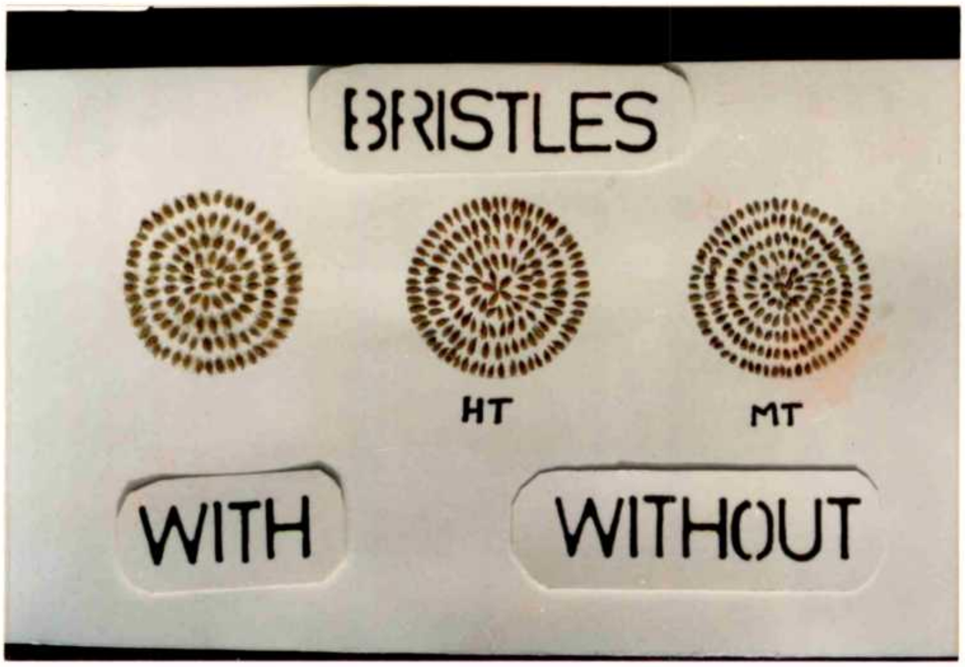
The root length of seedlings varied significantly among different threshing combinations. The longest root of 5.87 was recorded by hand threshing (SSR_0) which was followed by the mechanical threshing treatments of SSR_7, SSR_5, SSR_4, and SSr_{14}. The shortest root length was obtained in SSR_{15}.

Table 32: Efficiency of different methods of threshing on seed quality attributes of carrot cv. Zino

Treatments	Recovery %	Germination %	Abnormal seedlings %	Root length (cm)	Shoot length (cm)	Vigour index
SSR_0	86(68.00)	68(55.58)	5(13.17)	5.87	7.12	822
SSR_1	85(67.50)	39(38.77)	11(18.99)	4.48	5.66	393
SSR_2	71(57.63)	44(41.54)	15(22.48)	4.73	6.62	497
SSR_3	66(54.13)	64(53.15)	16(23.58)	3.45	7.56	708
SSR_4	90(71.60)	44(41.54)	11(18.99)	4.91	6.16	487
SSR_5	78(61.73)	48(43.85)	12(20.27)	4.99	6.83	569
SSR_6	61(51.16)	64(53.15)	15(22.48)	4.44	6.17	678
SSR_7	81(64.42)	41(39.98)	9(17.71)	5.49	6.16	480
SSR_8	71(57.09)	45(42.32)	11(18.99)	4.13	5.96	457
SSR_9	68(55.56)	53(46.91)	15(22.48)	3.88	6.82	571
SSR_{10}	80(63.51)	44(41.54)	11(18.99)	4.32	5.99	454
SSR_{11}	67(55.16)	49(46.61)	12(20.27)	4.67	6.57	555
SSR_{12}	66(54.29)	61(51.56)	12(20.27)	3.69	6.69	636
SSR_{13}	84(66.17)	37(37.66)	9(17.71)	4.29	6.87	379
SSR_{14}	73(58.57)	56(48.45)	11(18.99)	4.90	6.09	613
SSR_{15}	66(54.21)	64(53.15)	12(20.27)	3.13	6.89	639
CD (P=0.05)	3.06	3.559	3.037	1.043	0.813	92.23

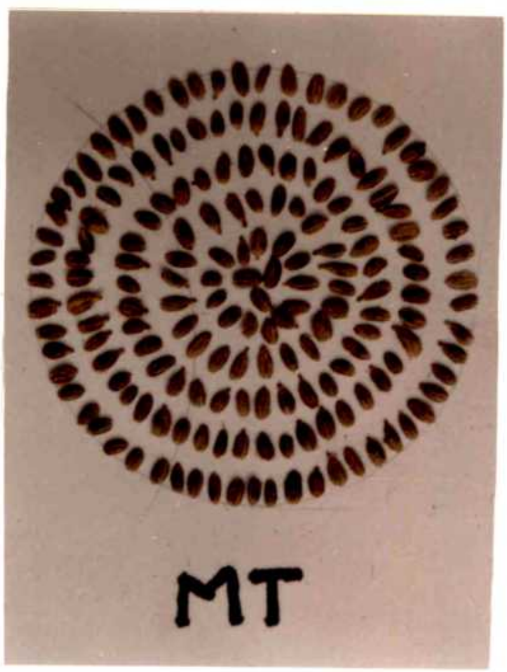
(Figures in paranthesis indicate arc sin values)

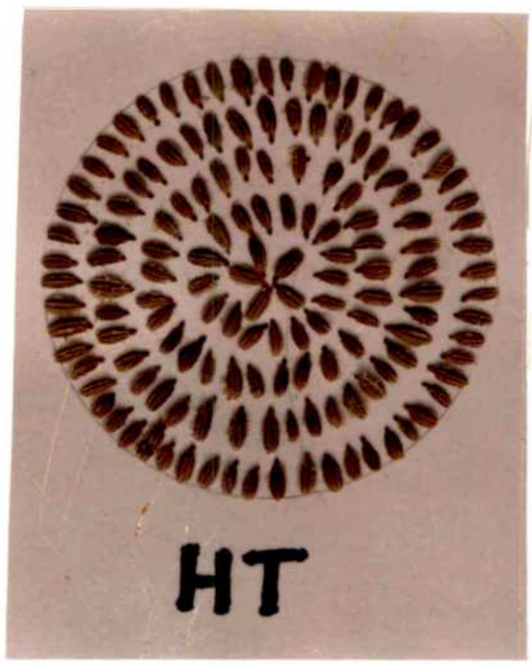
PLATE 11. CARROT SEEDS BEFORE AND AFTER DEBRISTLING



MECHANICALLY THRESHED SEEDS

HAND THRESHED SEEDS





4.2.2.4.5. Shoot length (cm) (Table 32)

Among the different threshing treatment combinations, SSR_3 recorded the maximum shoot length of 7.56 followed by SSR_0, SSR_{15}, SSR_5, and SSR_9 which were on par. SSR_1 recorded the minimum of 5.66 cm.

4.2.2.4.6. Vigour index (Table 32)

The computed vigour index values showed significant difference among different threshing treatments. Hand threshing (SSR_0) recorded the highest vigour of 822. The seed sand ratio at 5:50 (SSR_{13}) recorded the lowest vigour index of 379.

4.2.2.5. INFLUENCE OF SIZE GRADE ON SEED QUALITY IN CARROT cv. ZINO.

4.2.2.5.1.a. Seed length (mm) (Table 33)

Significant differences was broughtout for the seed length of different size grades. BSS 10 x 10 R recorded the higher mean seed length of 3.9 followed by BSS 12 x 12 R (3.6), which were on par. Other two grades (BSS 14 x 14 R and BSS 14 x 14 P) recorded lower length of seed and were on par with each other.

4.2.2.5.1.b. Seed breadth (mm) (Table 33)

There existed a significant difference for the breadth of seed of various grades with the highest value of

Table 33: Influence of size grading on seed quality in carrot cv. Zino

Grades	Seed length (cm)	Seed breadth (mm)	Embryo length (mm)	Viability %	Embryo-lessness %
BSS 10x10 R	3.9	2.3	2.0	61 (51.25)	21 (27.38)
BSS 12x12 R	3.6	1.8	1.8	58 (49.84)	20 (26.53)
BSS 14x14 R	2.7	1.7	1.7	50 (44.77)	27 (31.43)
BSS 14x14 P	2.5	1.2	1.5	38 (37.81)	26 (30.90)
CD (P=0.05)	0.55	0.44	0.21	1.978	2.114

(Figures in parenthesis are arc sin values)

2.3 for BSS 10x10 R. BSS 14x14 P registered the lowest breadth of 1.2 which was on par with BSS 14x14 P (1.7).

4.2.2.5.2. Embryo length (mm) (Table 33)

The seeds varied in their embryo length significantly, the difference between the highest and lowest values being 0.5. BSS 10x10 R and BSS 12x12 R had higher embryo length of 2.0 and 1.8 which were on par. BSS 14x14 R and BSS 14 x14 P were inferior in their embryo length recording 1.7 and 1.5 respectively which were on par.

4.2.2.5.3. Viability percentage (Table 33)

Viability percentage varied significantly for different grades. A viability of 61% was recorded by BSS 10x10 R which was on par with BSS 12x12 R (58%). The lowest viability of 38% was recorded by the samll seeds (BSS 14x14 P).

4.2.3.5.4. Embryolessness (%) (Table 33)

Different size grades of seeds varied significantly for the embryolessness. The minimum of 20% embryolessness was registered in BSS 12x12 R followed by BSS 10x10 R (21%) which was on par. The maximum percentage of embryolessness present in BSS 14x14 R (27%) which was on par with BSS 14x14 P, (26%).

PLATE 12. STAINING PATTERN IN CARROT SEED EMBRYO

PLATE 13. SIZE VARITION IN CARROT SEED EMBRYO

4.2.3. SEED STORAGE STUDIES

4.2.3.1. STUDIES ON THE EFFECT OF SEED TREATMENT AND STORAGE CONTAINERS ON SEED VIABILITY

4.2.3.1.1. Germination (%) (Table 34)

The differences in germination due to treatment, storage periods and containers were found to be significant.

The interactions between treatment x periods, treatment x containers and periods x containers were also significant.

Seeds of T_1 recorded higher germination (57) and it was the lowest in T_0 (55%).

Among the periods, P_0 had the highest germination of 62 followed by P_1 with 61. The lowest germination was recorded by P_0 (49).

Seeds in C_2 had higher germination value (58) than C_1 (54).

Significant differences also noticed in the interactions also.

4.2.3.1.2. Root length (cm) (Table 35)

There was no significant differences in the root length of different treatment and control.

Table 34: Effect of seed treatment, storage periods and containers on germination (per cent) in carrot cv. Zino

	C_1	C_2	T_0	T_1	Mean
P_0	63 (52.60)	61 (51.36)	63 (52.59)	61 (51.37)	62 (51.98)
P_1	61 (51.36)	60 (50.78)	59 (50.19)	62 (51.95)	61 (51.07)
P_2	59 (50.19)	60 (50.77)	59 (50.19)	60 (50.77)	60 (50.48)
P_3	58 (49.61)	58 (49.61)	58 (49.61)	58 (49.61)	58 (49.61)
P_4	53 (46.73)	59 (50.19)	54 (47.31)	58 (46.61)	56 (48.46)
P_5	43 (42.96)	55 (47.88)	46 (42.69)	52 (48.15)	49 (45.42)
P_6	44 (41.55)	54 (47.30)	47 (43.27)	51 (45.58)	49 (44.43)
Mean	54 (47.85)	58 (49.70)	55 (47.98)	57 (49.58)	
T_0	53 (47.00)	57 (48.95)			
T_1	55 (48.71)	59 (50.44)			

	T	P	C	TxP	TxC	PxC
CD (P=0.05)	0.942	1.764	0.942	2.495	1.333	2.495

(Figures in paranthesis indicate arc sine vlaues)

Table 35: Effect of seed treatment, storage periods and containers on root length (cm) in carrot cv. Zino

	C_1	C_2	T_0	T_1	Mean
P_0	5.75	5.96	5.65	6.07	5.86
P_1	5.44	5.45	5.47	5.42	5.45
P_2	5.39	5.51	5.53	5.36	5.44
P_3	4.77	5.64	5.12	5.30	5.21
P_4	4.40	5.58	5.05	4.93	4.99
P_5	4.53	4.94	4.70	4.77	4.74
P_6	4.56	4.79	4.66	4.70	4.68
Mean	4.98	5.41	5.17	5.22	
T_0	4.90	5.43			
T_1	5.05	5.39			

	T	P	C	TxP	TxC	PxC
CD (P=0.05)	NS	0.519	0.277	0.733	0.393	0.733

Significant variations were noticed due to periods of storage and containers. The interactions of period x treatment, periods x containers and treatment x containers were also significant.

Among the periods, P_0 recorded the highest root length of 5.86, while the lowest was recorded by P_6 (4.68).

Among the containers C_2 (5.41) recorded the highest and C_1 registered the lowest value of 4.98.

The interaction also varied significantly.

4.2.3.1.3. Shoot length (cm) (Table 36)

Regarding shoot length, significant variations were registered between treatment and periods of storage. Non significant difference was observed in containers.

Among the treatments, T_1 had the highest value of 7.66 and the lowest of 7.36 cm by T_0.

In the interactions PxT, PxC, and TxC varied significantly in the shoot length.

4.2.3.1.4. Vigour index (Table 37)

Among the different treatments, T_1 recorded the highest vigour index of 742 while the lowest was recorded by T_0 (699).

Table 36: Effect of seed treatment, storage periods and containers on shoot length (cm) in carrot cv. Zino

	C_1	C_2	T_0	T_1	Mean
P_0	7.91	8.05	8.11	7.85	7.98
P_1	8.07	7.94	8.04	7.97	8.01
P_2	7.95	8.05	8.05	7.94	8.00
P_3	7.67	7.72	7.64	7.76	7.70
P_4	7.64	7.82	7.65	7.80	7.73
P_5	6.96	7.54	6.77	7.73	7.25
P_6	5.48	6.40	5.29	6.59	5.94
Mean	7.38	7.65	7.36	7.66	
T_0	7.16	7.56			
T_1	7.60	7.72			

	T	P	C	TxP	TxC	PxC
CD (P=0.05)	0.252	0.471	NS	0.665	0.356	0.665

There was significant difference among the different storage periods. P_0 recorded the maximum value of 857, while the minimum of 524 by P_6.

The containers varied significantly in their vigour indicies. C_2 recorded the highest value of 761 and the lowest of 680 by C_1.

There was also significant differences in the vigour indices of different interactions.

4.2.3.1.5. Electrical conductivity (dSm^{-1}) (Table 38)

The electrical conductivity of the seed leachate of different treatments varied significantly. The highest value was recorded by T_0 (0.071) while the lowest was registered by T_1 (0.066).

Among the storage periods, the highest value was recorded by P_6 (0.096) and the lowest was recorded by P_0 (0.051).

The containers registered significant differences in their electrical conductivity. C_2 recorded the lowest value (0.064) and the highest value of 0.073 was recorded by C_1.

Table 37: Effect of seed treatment, storage periods and containers on vigour index in carrot cv.Zino

	C_1	C_2	T_0	T_1	Mean
P_0	859	855	865	849	857
P_1	825	805	798	832	815
P_2	786	813	802	798	800
P_3	711	775	739	747	743
P_4	638	789	688	739	714
P_5	498	687	532	653	593
P_6	444	604	470	578	524
Mean	680	761	699	742	
T_0	655	742			
T_1	704	780			

	T	P	C	TxP	TxC	PxC
CD (P=0.05)	28.54	58.38	28.54	75.50	40.35	75.50

Table:38 Effect of seed treatment, storage periods and containers on electrical conductivity (dSm^{-1}) of seed leachate in carrot cv. Zino

	C_1	C_2	T_0	T_1	Mean
P_0	0.051	0.050	0.051	0.051	0.051
P_1	0.053	0.052	0.053	0.053	0.053
P_2	0.056	0.057	0.055	0.056	0.056
P_3	0.073	0.058	0.069	0.062	0.066
P_4	0.078	0.067	0.077	0.068	0.073
P_5	0.096	0.076	0.093	0.080	0.086
P_6	0.103	0.090	0.101	0.092	0.096
Mean	0.073	0.064	0.071	0.066	
T_0	0.076	0.067			
T_1	0.070	0.061			

	T	P	C	TxP	TxC	PxC
CD (P=0.05)	0.002	0.004	0.002	0.004	0.002	0.004

The interactions also differ significantly in their electrical conductivity.

4.2.3.1.6.Free sugars (ug) (Table 39)

The treatment did not varied significantly in the leaching of sugars.

Among the periods of storage, there was significant difference in the leachate of free sugars. P_6 recorded the higher value of 0.40. The lowest was recorded by P_0 (0.21).

The containers registered significant differences in their free sugars values. C_2 recorded the lowest value with 0.26 and C_1 registered a value of 0.32 ug which was highest.

The interactions also differed significantly in the leaching of free sugars

4.2.3.1.7.Protein content (%) (Table 40)

The protein content of the seed of treatment and control varied significantly. The highest value was recorded by Tr_1 (10.71%) when the lowest was registered by Tr_0 (10.45%).

Table 39: Effect of seed treatment, storage periods and containers on free sugars (ug) in carrot cv. Zino

	C_1	C_2	T_0	T_1	Mean
P_0	0.21	0.21	0.21	0.21	0.21
P_1	0.22	0.22	0.23	0.21	0.22
P_2	0.28	0.22	0.26	0.24	0.25
P_3	0.34	0.26	0.32	0.28	0.30
P_4	0.35	0.27	0.32	0.30	0.31
P_5	0.41	0.32	0.37	0.35	0.36
P_6	0.44	0.35	0.41	0.38	0.40
Mean	0.32	0.26	0.30	0.28	
T_0	0.33	0.27			
T_1	0.30	0.26			

	T	P	C	TxP	TxC	PxC
CD (P=0.05)	NS	0.008	0.004	0.012	0.006	0.012

Table:40 Effect of seed treatment, storage periods and containers on protein content (per cent) of carrot seed cv. Zino

	C_1	C_2	T_0	T_1	Mean
P_0	11.19	11.23	11.23	11.20	11.21
P_1	11.13	11.30	11.17	11.25	11.21
P_2	11.07	11.20	11.11	11.16	11.14
P_3	10.92	11.10	10.98	11.04	11.01
P_4	10.30	10.98	10.33	10.95	10.64
P_5	9.21	10.03	9.33	9.90	9.62
P_6	8.83	9.65	8.97	9.51	9.24
Mean	10.38	10.78	10.45	10.71	
T_0	10.11	10.78			
T_1	10.64	10.78			

	T	P	C	TxP	TxC	PxC
CD (P=0.05)	0.043	0.075	0.043	0.105	0.061	0.105

Among the storage periods, which were significant, the highest value was recorded by P_0 followed by P_1, and the lowest was by P_6 (9.24).

The containers registered significant differences in their protein content. C_2 recorded the highest value of 9.65% and C_1 registered the lowest value of 8.83%.

The interactions also differed significantly in their protein content.

4.2.3.2. STANDARDISATION OF ACCELERATED AGEING

4.2.3.2.1. GERMINATION (%) (Table 41)

There existed a significant difference among umbel orders, periods of storage under accelerated ageing and their interaction.

Regarding umbel orders, U_1 recorded the maximum germination of 37%, followed by U_2 and U_3 25 and 18%. There was no germination in U_1, U_2 and U_3 after 8, 7 and 6 days of accelerated ageing respectively.

As the storage (ageing) period proceeded the germination percentage declined. At 9^{th} day of ageing there was no germination at all in all the three umbel orders.

Table 41: Influence of umbel orders and periods of storage under accelerated ageing conditions on germination (%) of carrot cv. Zino.

	U_1	U_2	U_3	Mean
A_1	70 (56.80)	56 (48.45)	50 (45.00)	59 (50.08)
A_2	64 (53.13)	54 (48.30)	46 (42.70)	55 (48.04)
A_3	60 (50.79)	50 (45.00)	38 (38.05)	49 (44.61)
A_4	56 (48.45)	44 (41.54)	24 (29.33)	41 (39.77)
A_5	52 (46.15)	28 (31.89)	18 (25.08)	33 (34.37)
A_6	42 (40.39)	12 (20.02)	4 (11.54)	19 (23.98)
A_7	22 (27.95)	10 (18.35)	-	11 (15.43)
A_8	8 (16.43)	-	-	3 (5.48)
A_9	-	-	-	-
Mean	37.0 (34.01)	25.0 (25.36)	18.0 (19.17)	

	A	U	AxU
CD(P=0.05)	3.128	1.713	5.419

(Figures in paranthesis are arc sin values)

Table 42: Influence of umbel orders and periods of storage under accelerated ageing conditions on root length (cm) and shoot length (cm) of carrot cv. Zino

	U_1	U_2	U_3	Mean		U_1	U_2	U_3	Mean
A_1	6.00	5.82	4.34	5.39	A_1	7.79	7.32	4.57	6.65
A_2	5.66	5.62	4.34	5.21	A_2	7.72	7.32	4.53	6.52
A_3	5.56	5.45	3.97	4.99	A_3	7.65	7.25	4.53	6.48
A_4	5.06	5.00	3.53	4.53	A_4	7.59	7.17	4.23	6.33
A_5	4.94	4.69	2.96	4.20	A_5	6.89	6.10	3.29	5.43
A_6	3.97	3.14	2.18	3.10	A_6	6.37	5.38	3.28	5.01
A_7	3.96	3.00	-	2.32	A_7	5.32	5.01	-	3.44
A_8	3.13	-	-	1.04	A_8	5.30	-	-	1.77
A_9	-	-	-	-	A_9	-	-	-	-
Mean	3.83	3.27	2.13		Mean	5.46	4.56	2.44	
	U	A	UxA			U	A	UxA	
CD(P=0.05)	0.104	0.190	0.329			0.123	0.224	0.387	

Among the interactions, U_1A_1 recorded the maximum germination of 70% and it was significantly higher than any other combinations.

4.2.3.2.2. Root length (cm) (Table 42)

Results of ageing, umbel orders and their interaction revealed the significant difference for root length.

The longest root of 3.83 was recorded by U_1 followed by 3.27 and 2.13 by U_2 and U_3. Proceeding in the ageing period, decreased the root length. The interaction of the factors had also the significant effect.

4.2.3.2.3. Shoot length (cm) (Table 42)

Significant differences existed for the shoot length of different days of ageing, umbel orders and their interaction.

Among the umbel orders, U_1 recorded the highest shoot length of 5.46 followed by U_2 and U_3 (4.56 and 2.44). Ageing results indicated that as the duration of ageing proceeds, the shoot length decreased. Upto 4^{th} day of ageing the shoot lengths were on par.

Table 43: Influence of umbel orders and periods of storage under accelerated ageing conditions on drymatter production (mg per 10 seedling) and vigour index of carrot cv. Zino

	U_1	U_2	U_3	Mean		U_1	U_2	U_3	Mean
A_1	11.0	10.5	9.0	10.2	A_1	965	736	446	716
A_2	10.5	9.5	8.0	9.3	A_2	857	699	408	655
A_3	9.5	9.0	7.5	8.7	A_3	793	635	323	584
A_4	9.5	9.0	6.5	8.3	A_4	709	535	186	477
A_5	8.5	8.5	5.0	7.3	A_5	617	303	118	346
A_6	8.5	7.5	3.5	6.5	A_6	435	103	22	187
A_7	6.5	4.0	-	3.5	A_7	204	81	-	95
A_8	4.5	-	-	1.5	A_8	67	-	-	22
A_9	-	-	-	-	A_9	-	-	-	-
Mean	6.9	5.8	4.0		Mean	465	309	150	
	U	A	UxA			U	A	UxA	
CD(P=0.05)	0.500	0.913	1.582			30.81	56.26	97.44	

The interaction among the duration of ageing and umbel orders revealed the significant difference for shoot length.

4.2.3.2.4. Drmatter production (mg 10 seedling^{-1})(Table 43)

U_1 recorded the highest drymatter of 6.9 which was significantly different from the other umbel orders. U_1 was able to withstand 8 days of ageing whereas U_2 and U_3 were able to withstand 7 and 6 days only. The interaction among the factors also had a significant difference.

4.2.3.2.5. Vigour index (Table 43)

Significant differences existed for the umbel orders, duration of ageing and their interaction. U_1 recorded the highest computed vigour index value of 716 which was significantly higher than other two umbel orders. As the ageing prolonged, the vigour indices declined. The interaction between the two factors showed a significant difference and highest was recorded by A_1U_1 (965).

DISCUSSION

CHAPTER V

DISCUSSION

The results obtained from various investigations are discussed in the light of available literature in this chapter.

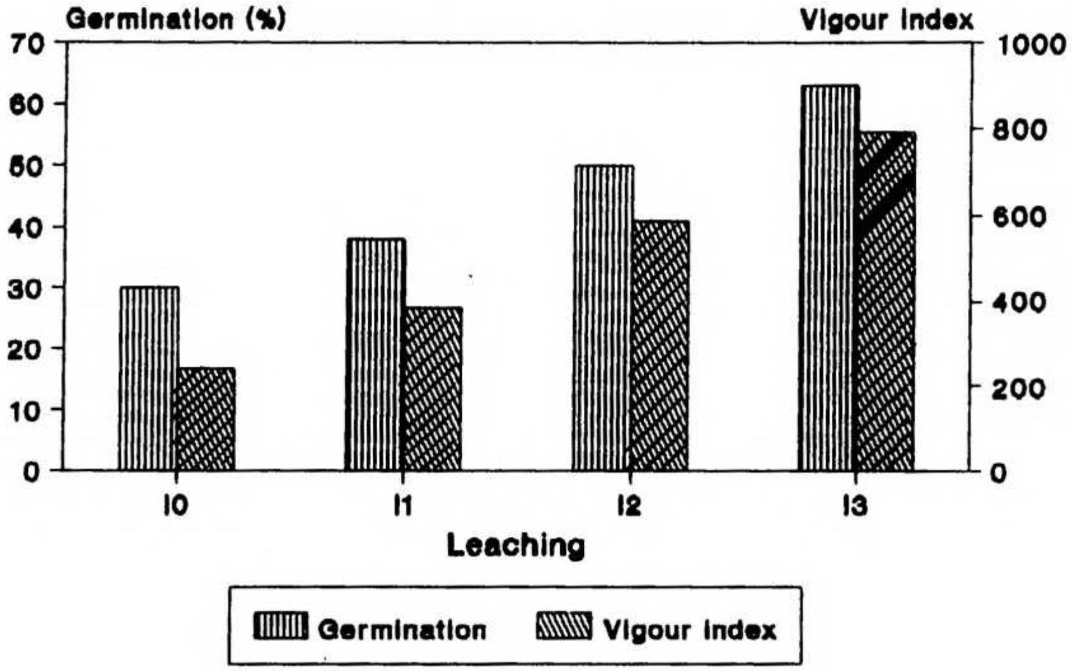
With a view to elicit information for augmenting quality attributes in germination of carrot seed, experiments encompassing the area of soaking (leaching) treatment, grading and upgrading and seed treatment with pyridoxine hydrochloride (Vit. B_6) were conducted and the salient findings are discussed here under.

Seed management practice from sowing to fruiting causes early and enhanced germination and growth rate of seedling. Treatment of seed before they are sown and exposed to the field condition confers in the crop a good start (Austin et al., 1973) has aroused interest.

Soaking (leaching) of seeds helps the seeds to tide over soil moisture stress, removal of germination inhibitiors which is present on the seed and get rid of the pathogens during initial stages of seedling establishment.

Germination in carrot is very slow and usually 15-20 days are required for seedling to emerge. This is because of presence of germination inhibitor on the seed coat, which

Fig.1 Effect of leaching on seed quality of carrot cv.Zino



has been named as "carrotal" by Aki and Watanabe (1961). Normally immature seeds contain maximum level of carrotal .

In the present investigation three days water leaching showed the highest germination, speed of germination, root length, shoot length, dry matter production and vigour index when compared with the other treatments and control (Fig.1).

The results of the present study are in conformity with the works of Austin et al. (1969), Goobkin (1989) and Rajnpreht (1989) in carrot, Ashton et al. (1987) in beet, Cseresnyes and Baleanu (1987) and Mandal et al. (1987) in Fennel and Coriander. It is plausible due to the complete removal of germination inhibitor (carrotal) which adheres on the surface of the seed coat.

The low germination of the seeds might be due to the high concentration of water soluble inhibitor present in the seed and the ungerminated seeds were found to be fresh and contain viable embryo (Malik and Kanwar, 1969).

One of the desirable attributes of quality seed is uniformity in size. Optimum sieve size for seed processing of a particular variety is normally fixed based on recovery percentage as well as quality of the seed retained by it (Paul and Ramasamy, 1979).

In the present investigation, grading of seed was carried out by sieves and it was upgraded by seed blower worked at 0.5 inches of water pressure for 2 min. uniformly.

Seed weight exhibited linear relationship with seed size.

Large sized seed (seed blown with seed blower + seed retained in BSS 12x12 wiremesh sieve), recorded 52 percent increase in weight than small seeds (seeds passed in BSS 14x14 wiremesh sieves).

Increase in seed weight corresponding to its size was reported by Dhesi et al. (1965), Austin and Longden (1967) on turnip and carrot, respectively; Senthilkumar and Dharmalingam (1980)in sorghum, Smittle (1982) in radish and Ponnuswamy and Ramakrishnan (1985) in coriander.

Better germination of the larger seeds recorded in the present study could be related to the initial capital theory of Ashby (1936) attributing an initial advantage over smaller seeds. Probable reason for low germination in the smallest grade might be the presence of immature and shrivelled seeds (Austin and Longden, 1967; Paul and Ramasamy, 1979).

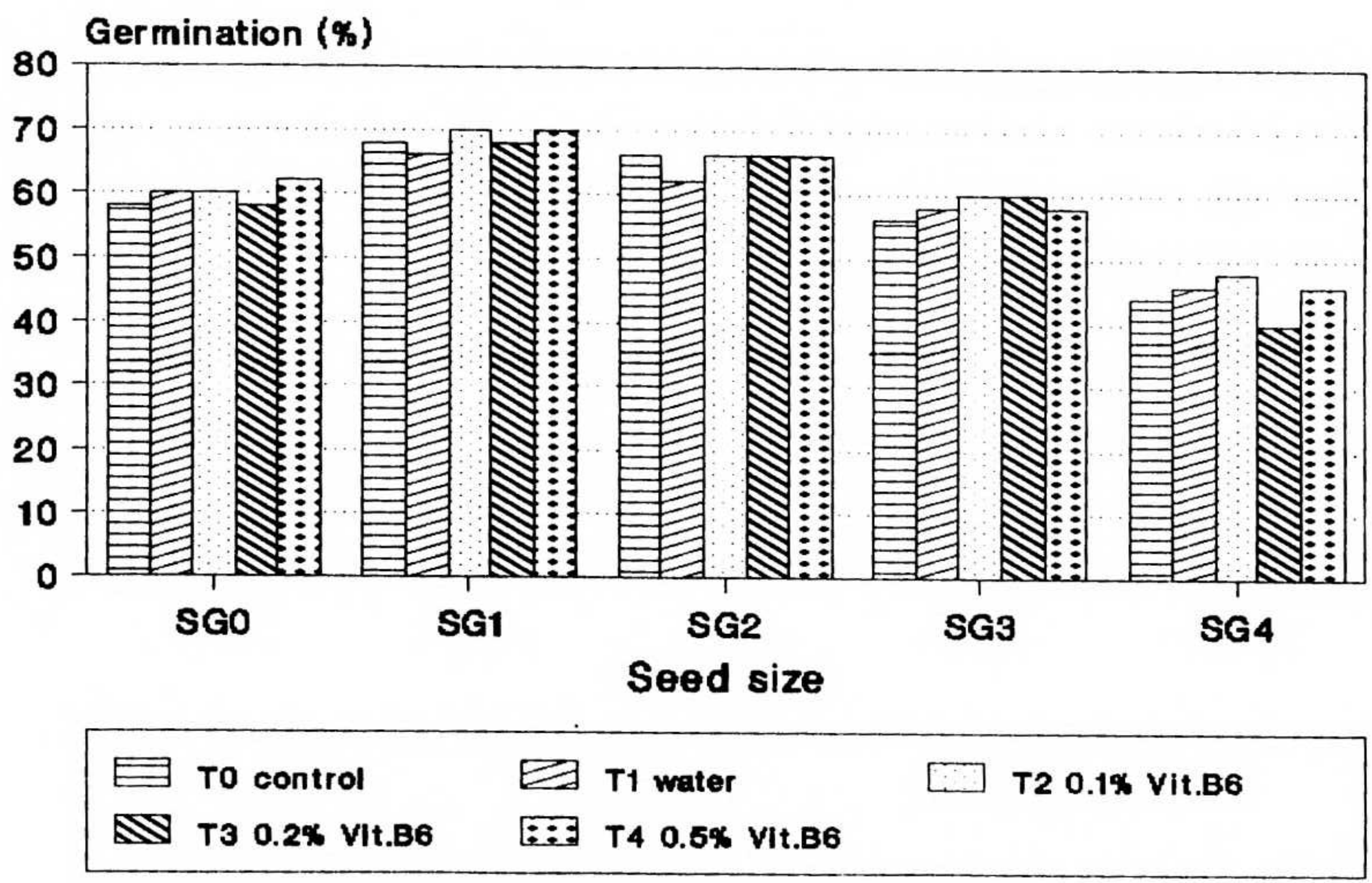
Root and shoot length and vigour index showed similar variation as that of germinability. Sowing heavy seeds resulted in early and uniform shoot appearence than light weighted seeds. Lower values obtained for smaller seeds could be perhaps be due to the inclusion of higher proportion of immature and under developed seeds resulting from incomplete seed development and in part to the lack of initial capital (Brenchley, 1923).

Dry weight of seedlings obtained from seeds of different size grades, had clearly established the superiority of larger seeds in the production of vigorous seedlings as (Gill and Harisingh, 1979) in radish. The increase in weight of the seedlings was due to the gain in thickness of the seedlings and not due to the increase in length of the seedlings. Bolder the seed, higher was the dry weight of the seedlings as measured after 14 days of germination.

The relatively high vigour associated with the large seed could be ascribed to the mature embryo containing adequate nutrient reserves both contributing to physiological stamina or vigour factor residing in it (Heydeker, 1972, and Pollock and Roos, 1972).

Thus, the study amply revealed that carrot seeds inspite of its size variations need grading and upgrading to eliminate the small, immature, unfilled and shrivelled seeds, otherwise would lead to low viability and vigour of seeds bringing down the quality of the seedlot. It may be pointed out that the carrot seed which passed through BSS

Fig.2 Effect of seed size & pyridoxine (Vit.B6) on germination of carrot seed



14x14 wiremesh may be rejected for sowing. Therefore to obtain good quality seed in carrot, the seeds should be processed using BSS 12x12 wire mesh sieve and in case of seed industry, use of seed blower + BSS 12x12 wiremesh sieve is the added advantage to obtain bolder seeds for sowing.

The performance of a crop is the manifestation of various interacting factors. Among such interaction, the soil root system plays a dominent role in determining productivity. Any impairement in this relationship may result in a poor crop performance . Thus, it is imperative to evolve such root system of a crop that could efficiently explore soil for water and nutrients. This can be achieved to a large extent by the exogenous application of certain vitamins like Vit. B_6 which are responsible for the performance of root growth (Samiullah et al., 1988).

In fact, for an enhanced growth of juvenile root system, seeds require a balanced supply of vitamins, especially of pyridoxine (Vit. B_6), during seed germination. Such a balanced supply can be expected to not only favour the successful establishment of the young seedlings but also stimulate the absorption of additional quantities of nutrients and water from the soil (Samiullah et al., 1988).

The carrot seedlings produced from 0.2 and 0.5per cent pyridoxine treated seeds exhibited the higher values for all growth parameters, when compared to the control and

Fig 3 Effect of seed size & pyridoxine (Vit.B6) on root length in carrot

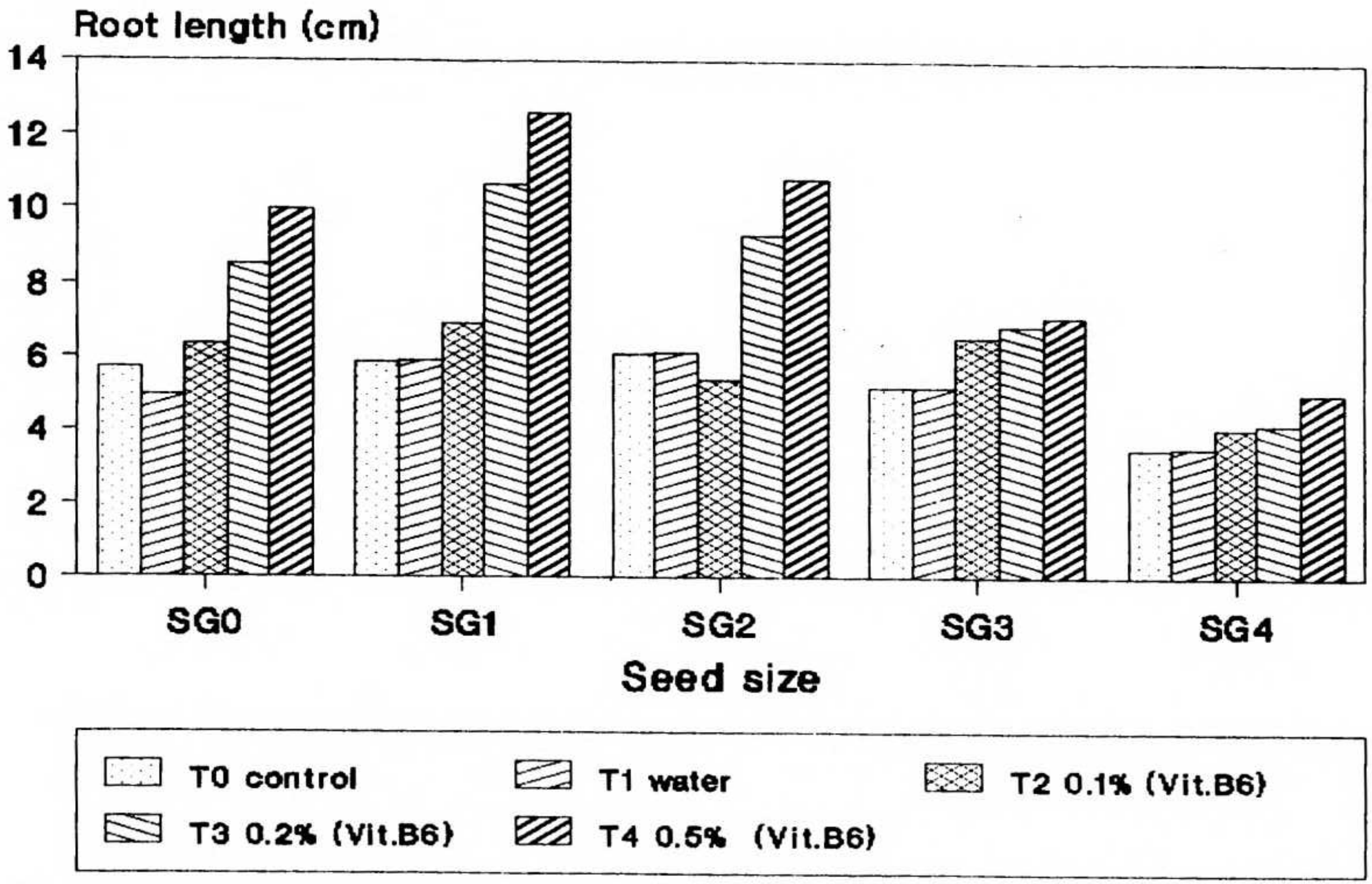
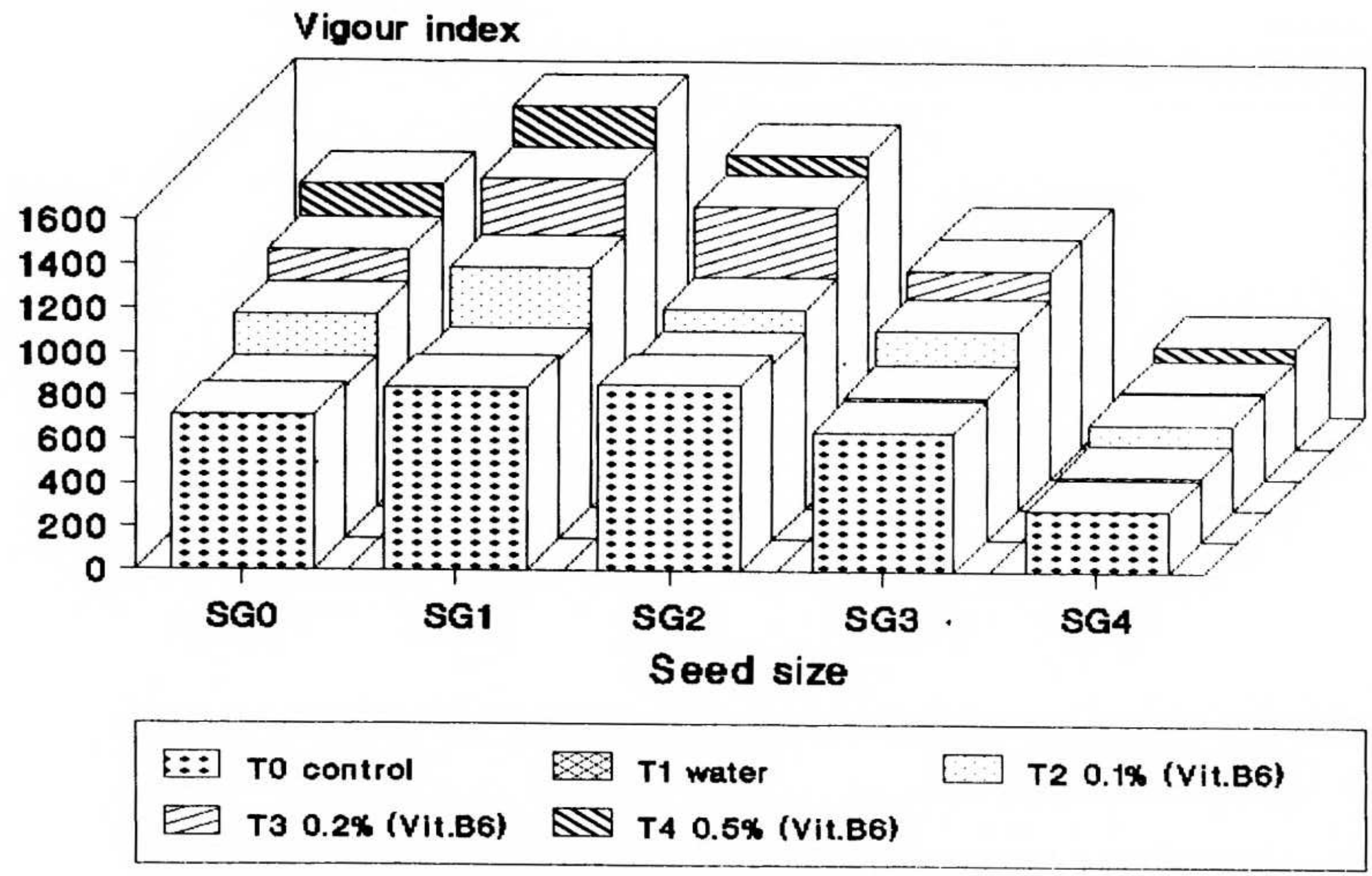


Fig.4 Effect of seed size & pyridoxine (Vit.B6) on vigour index of carrot



other treatments. The findings are in agreement with that of Noggle and Wynd (1943) in Orchids; Bonner and Bonner (1948) in alfalfa, clover , sunflower, carrot and five strains of tomato; Ansari et al. (1990) in lentil; and Samiullah et al. (1991) in mustard.

This might be due to the greater supply of nutrients that promoted assimilatory activities of the treated seeds, resulting is high values for various growth parameters.

The quality of a seed is basically dependent on seed filling and on the metabolic and/or synthetic efficiency during seed development and maturation, which in turn is reflected upon the germination and vigorous growth of the resultant seedling. The state of maturity of the seed crop when harvested is known to be a major factor responsible for size of seed, variation in viability and vigour. The decision when to harvest is therefore, of greater importance. The seed harvested at optimum maturity will be possessing maximum germination and vigour and thereafter it declines due to various reasons, for example senescence and eventually no longer able to germinate (Harrington, 1972). Besides, precise information on optimum stage of harvest based on physiological indices will enable to overcome adverse effect of bad weather and thereby the seed losses. For determining optimum stage of harvest, it is essential to know the physical, physiological changes that occur during seed development and maturation under varying period and harvesting conditions, are the first and foremost factors that affect vigour, viability and storability, besides size, shape and uniformity (Pollock and Roos, 1972).

Hence, investigations were carried out with the carrot cultivar zino, to determine the optimum period of seed maturation and stage of harvest of seeds that would enable the collection of maximum quantity of uniform sized seeds possessing very high quality in terms of germinability, vigour and storability.

Seed maturation refers to the morphological, physiological and functional changes that occur from the time of fertilization until the matured ovules (seeds) are ready for harvest, (Delouche, 1973; Abdul-Baki and Baker, 1973) further differentiated seed development and maturation.

Seed development is the period between fertilization and maximum fresh weight of seed and seed maturation begins at the end of seed development and continues up to harvest.

Physiological maturity is normally understood as occurring when the seed reaches its maximum dry weight (Harrington, 1972) at which nutrients are not flowing in to the seed from the mother plant.

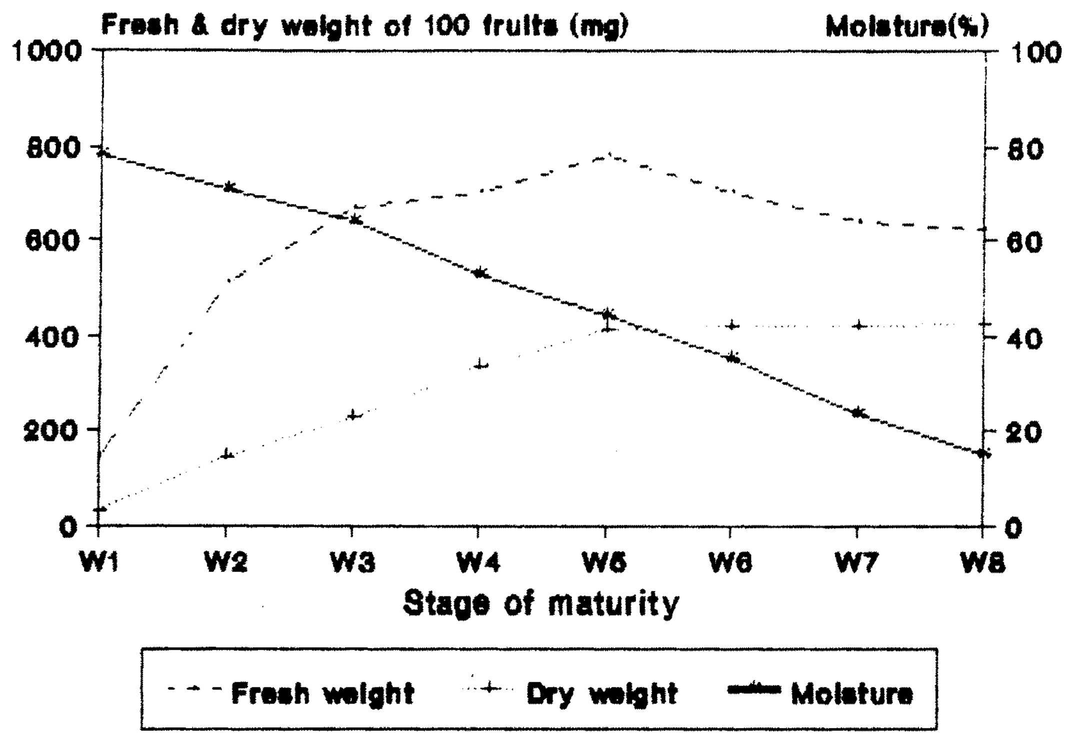
The vascular connection to the seed is broken by the formation of an abscission layer at physiological maturity (Eastin et al., 1973).

Physiological deterioration might set in, if the seeds are retained in the mother plant for longer duration after physiological maturity (Ovcharov and Kizilova, 1966).

The flowers of carrot are produced in compound umbels borne terminally on the branches. The habit of flowering permits one to segregate the inflorescence into several groups, according to their position on the plant. The main axis of the plant terminates in a compound umbel which may be called first order or primary umbel. From this main stalk, several lateral branches arise producing secondary umbels. Lateral branches from the main stems bearing the secondary umbels form tertiary umbels and so on. Usually however, only a few quarternary umbels are formed. Anthesis in any one umbel lasts about 6 1/2 days and stigma receptivity, which begins with a fourth day, lasts more than a week (Bohart and Toole, 1960).Fertilization in a primary umbel is usually completed before the flowers open on the second order umbel, and fertilization in these are completed before flowers open in the third order umbel.

In the present study of physiological cum harvestable maturity irrespective of umbel order, the diameter of umbel was maximum on fifth week after anthesis

Fig 5. Influence of maturity stage on fruit weight & moisture of primary umbel in carrot

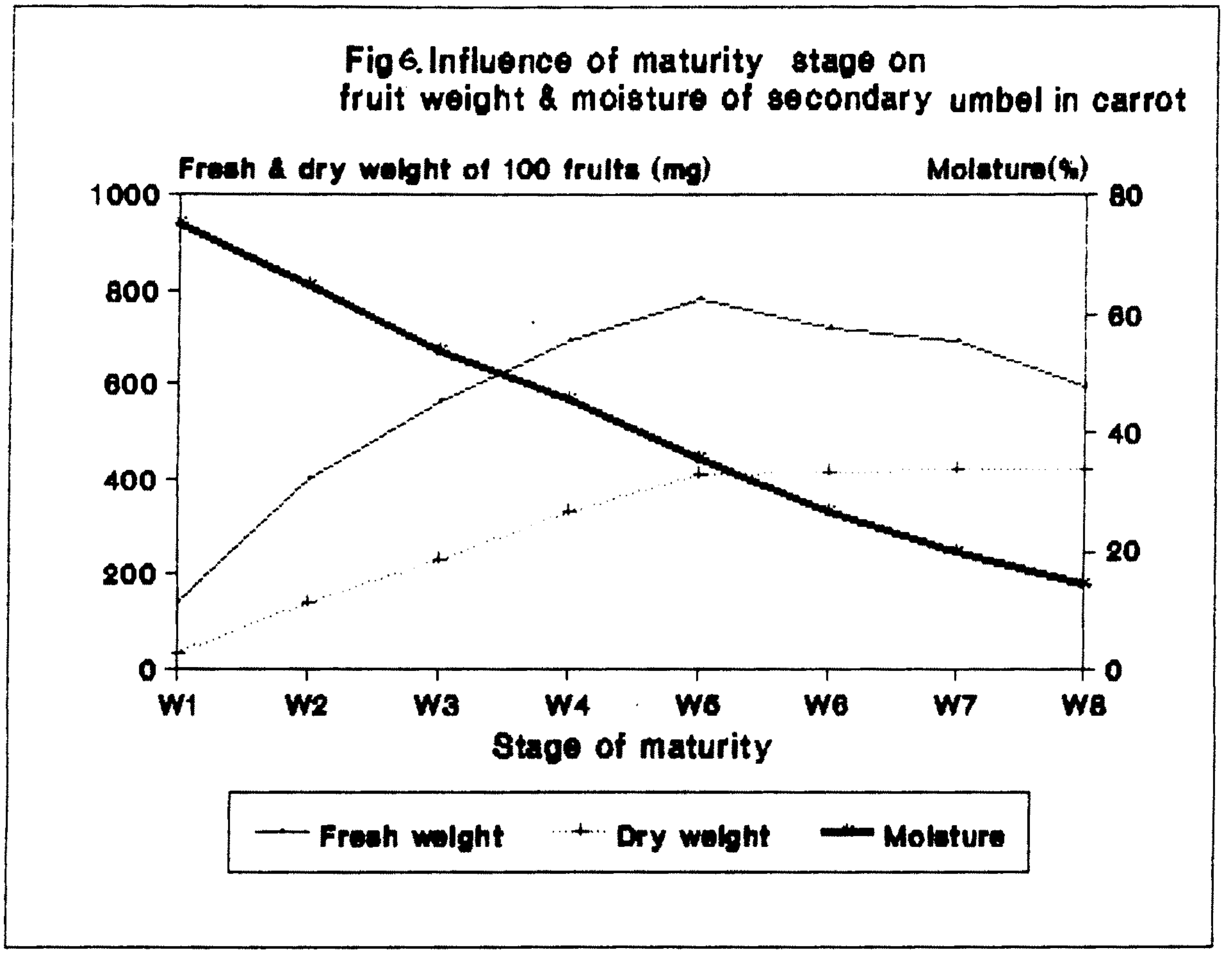


and it decreased during subsequent stages of development. It might be due to the reduction in moisture content tend to shrinkage of umbel towards its centre.

Maximum fresh weight of umbel and fresh weight of umbellet was recorded fifth week. Later a gradual decrease followed reaching the lowest at eight week which might be ascribed to dessication and dehydration resulting in the reduction of fresh weight of umbel.

The length and breadth of the seed (schizocarp) showed a rapid increase, reaching the maximum on fifth and fourth weeks, respectively subsequently a slight reduction was noticed. According to Rao et al. (1978) the initial increase in seed size is quite rapid, due to cell expansion. This is followed by accumulation of drymatter with the seeds acting as sinks. At maturity ,the physiological activity dwindles considerably with a slight reduction in seed size.

Seed weight is an important factor that determines seed quality. Abdul-Baki and Baker (1973) used the fresh weight of seed for differentiating the "seed development" and "seed maturation". According to them, seed development is the period between fertilization and maximum fresh weight of seeds. Maximum rate of increase in fresh weight of fruit (schizocarp) was recorded on second and third week of development. The maximum fresh weight was recorded on fifth week and thereafter, the weight decreased in the subsequent


Fresh & dry weight of 100 fruits (mg)
Moisture(%)
1000
800
600
400
200
0
80
60
40
20
0
W1
W2
W3
W4
W5
W6
W7
W8
Stage of maturity
Fresh weight
Dry weight
Moisture

stages of development with a maximum reduction between fifth and sixth weeks after flowering.

Physiological maturity is normally occurring when the seed reaches its maximum dry weight (Harrington, 1972).

The dry weight of developing seeds can be used to assess its maturity (Delouche, 1973). In the present study maximum dry weight was recorded in eight week and it was on par with seventh week.

Maximum increase in dry weight was observed between fifth and sixth week indicating that this period is most critical in the development of carrot seed. Decrease in moisture was found to accompany with increase in dry weight indicating thereby continuous accumulation of reserve nutrients in the developing seeds.

An increase in volume was observed upto fourth week after anthesis and later a gradual decrease was discernable with advance in maturity.

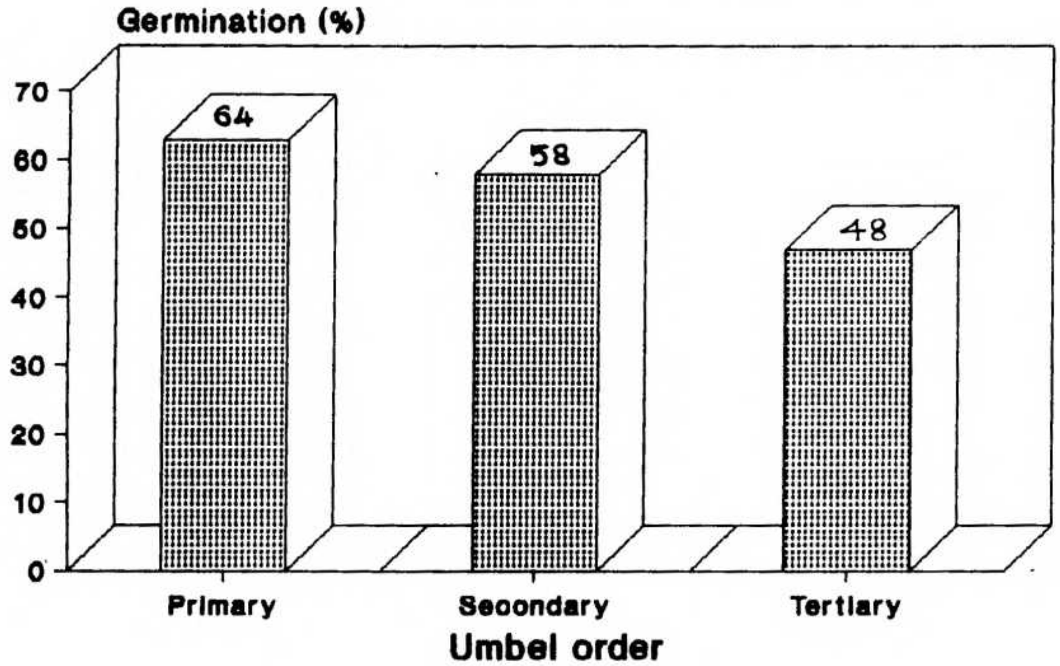
The moisture content showed rapid reduction with the advancement in the development of seeds upto eighth week of maturation in all umbel orders. The reduction in moisture content might be due to desiccation and dehydration (Abdul Baki and Baker, 1973) and oxidations and volatilization (Harrington, 1972).

As the volume increased fresh weight also increased thereby indicating that the volume positively influences the fresh weight. The fruit expansion during initial stages of maturity might be due to more uptake of water, while the intake of C and N low and seed growth was negligible (Pate et al., 1977).

A critical study of germination of seeds revealed an interesting feature that seeds started to germinate only five weeks after anthesis, while there was nil germination in the earlier stages. The reason for nil germination, recorded earlier might be due to the fact that the seeds had not fully developed. Eventhough the seeds started germinating in the later stages of development, it was increasing with increase in maturity of seed. Maximum germination of 62 per cent was in primary umbel, 56 and 41 per cent in secondary and tertiary umbels respectively on eighth week after anthesis.

Delouche (1973) stated that although seeds are capable of germinating during the early stages of their development, seed vigour reached the maximum only when the seeds attained the maximum dry weight. Bishnoi (1974) showed that maximum germination and vigour coincided with the achievement of maximum dry weight of seed.

Fig 7. Variation in seed germination among umbel orders of carrot cv.Zino



In the present study, the root and shoot length, dry weight of seedling and vigour index established the superiority of the fully matured seeds.

Though the seed attained maximum dry weight on eighth week but the germination though statistically on par showed the numerical improvement on the eighth week as compared to seventh week.

However leaving the seeds on the plant beyond eighth week leads to shattering resulting in the loss of seed. Hence it could be concluded that the carrot seeds should be harvested at eighth week after anthesis. It suggested that harvesting the crop when the primary umbel have turned brown and the secondary umbels starts to brown is adviceable to get quality seeds.

One of the important factors which can affect crop growth is the initial vigour, in the form of seed or carrot root size. This is in conformity with studies on the steckling size in carrot by Harrington (1951) and Hawthorn (1951) that large size stecklings are likely to produce more seed per unit area than small ones. The initial vigour of the roots at the time of replanting appears to have a major role in increasing seed yields. These factors lead to higher quality seed yields, indicating there by plants from large and medium sized stecklings had a greater potential for better seed yields.

In onion, seed yield was maximum in larger bulbs and it decreased with decrease in bulb size. This shows that large mother bulbs have more stored food for producing large plant size which in turn increases related characters concerned with higher seed production (Green, 1972).

One of the important operation in seed production of carrot is root and shoot cut treatment. This operation is usually done before the transplanting of root. The common problem among the farmers is unknowing/ignorance of the amount of shoot and root to be retained to maximise seed yield.

Cutting the upper half induced the emergence of more number of seed stalks, thereby increases the seed yield (Singh et al., 1965).

In the present investigation different steckling size were used with 3/4 shoot and 1/4 root cut treatment.

Number of days required for sprouting gradually and significantly decreased with increased steckling size and shoot and root cut treatment. The presence of old leaves on steckling at the time of planting inhibited earlier sprouting which may be due to covering of adventitious buds on the top of steckling, preventing the required amount of light and temperature. Early sprouting and further vegetative growth might be due to presence of high amount of food reserve in the steckling. These findings are in conformity with those results of Premnath and Kalvi (1969), Lal and Pandey (1986) and Digole and Shinde (1990). Bolting as influenced by size was recorded earliest. It might be due to the reason that large sized steckling had maximum food reserve material. The findings are similar to that of Singh et al. (1989) in turnip.

Days to umbel emergence, number of umbels per plant, distribution of umbels, seed yield per umbel, distribution of seed yield, seed yield per plant, thousand seed weight and germination percentage were significantly influenced by steckling size. This might be due to the high amount of food material present in the larger stecklings. The smaller steckling, weighing less, have less food reserves initially which resulted into delay in sprouting and ultimately affecting flowering and maturity of seed as compared to larger steckling. Arya and Saini (1977) reported that it might be due to the initial vigour of roots at the time of replanting appears to have a major role in increasing seed yields. Vigorous growth of plant from the large sized stecklings produce more number of umbels which led to significant variation of higher seed yields.

Superiority of large sized mother bulbs for producing more number of seed stalks has also been reported by Green (1972), and Pall and Padda (1972) in onion. The reason might be more number of vegetative buds present in the mother bulbs which give rise to seed stalks.

Higher seed yield with larger root size might be due to effect on initial vigour of the crop as a result of availability of more nutrients from roots which might have given better vegetative and root growth and ultimately resulted in better seed production of carrot.

Higher vegetative growth supported better development and more number of umbels. These results are similar to those reported by Harrington (1951) Hawthorn (1951) and Arya and Saini (1977) in carrot.

In the present study significant difference of seed yield and its germination behaviour were recorded among the umbel orders. The variability in yield and quality of carrot is a common phenomenon. It is because the carrot seed is harvested from different order of umbels and viability and yield of seeds vary from primary, secondary and tertiary umbels. For the production of good quality seed, the seed collection should be made from primary and secondary umbels, (Borthwick, 1931; Watanabe et al., 1955; Miyagi, 1956 and Hawthorn et al., 1962), because primary, secondary umbels and their number per unit area are the major contribution towards good quality seed yield. The third and the fourth order umbels not only gave significantly poor seed yield, but it was drastically low (Gill et al., 1981).

In the interaction large sized steckling produce more number of umbels tend to increase the yield. There was a significant difference among the umbel order seed yield due to the larger steckling size. This results in conformity with works of Hawthorn et al. (1962), Gray (1979) and Gill et al. (1981).

Hence it could be concluded that 150-200 gram of steckling size is ideal for quality seed production.

Seed being one of the vital inputs in vegetable production and more so in seed production, needs adequate nutrient elements. To obtain maximum seed yield with better seed quality, proper growth of the plant and its fruits is desired. This can be achieved to a great extent by the use of optimum levels of fertilizers.

In the present investigation in carrot cv. Zino showed that varying the dose of N, P_2O_5 and K_2O did not make any difference in the sprouting of stecklings, but it produced a significant variation in days to umbel emergence, total number of umbels, distribution of umbels, seed yield per umbel and seed yield per plant.

The reason lies in the fact that plants receiving higher doses of nitrogen are capable of greater photosynthetic activity and therefore, more photosynthetic products are directed for the development of seeds.(Nazeer-Ahmed and Tanki, 1988).

All levels of nitrogen significantly increased number of umbels per plant. It might be due to enhanced cell division and elongation as well as greater chlorophyll synthesis under higher nitrogen application which helped in increasing the height of the plants (Asif and Greig, 1972). Beneficial effects of nitrogen on plant size and branches in Asiatic turnip have also been reported (Sandhu et al., 1965).

The application of nitrogen seems to have resulted in greater synthesis of carbohydrates in plants which accelerated seed formation as compared to those which received lower amount of nitrogen.The application of phosphorous showed some beneficial effects in turnip on number of siliquae per plant and number of seeds per siliqua (Nazeer-Ahmed and Tanki. 1988).

Nitrogen application exert tremendous influence on the growth and yield characters.In general, nitrogen nutrition delays the bolting and flowering processes which may be attributed to the fact that extensive vegetative growth. The maximum height of the main shoot was recorded at the highest level of nitrogen applied (200 kg/ha). The increase in height of the main shoot corresponding to the increasing level of nitrogen was because of higher photosynthetic efficiency at higher nitrogen doses. It is because of its involvement in physiological processes of the plant 'that stimulates vegetative growth and thus there was found to be greater at high levels of nitrogen. This increase in the diameter of the main shoot with the increasing level of nitrogen application may be due to increased synthesis as well as utilization of carbohydrates to form more protoplasm which in turn promoted more cell division and thus resulting in the increased diameter of the main shoot (Sharma and Kanaujia, 1992). These results are in conformity with those reported by Malik and Kanwar (1969), Malik (1973) in carrot and Shandhu et al .(1965) and Nazeer-Ahmed and Tanki (1988) in turnip; Chakrabarti et al. (1979), Sharma and Singh(1981), Singh et al . (1981) , Saini et al. (1982) and and Asif and Greig (1972) in Okra.

Additional supply of nitrogen helped in the production of bold seeds. In the present study as evidently revealed the 1000 seed weight of primary, secondary and tertiary umbels as well as mixed seed of these umbels was maximum at higher dose of nitrogen. The increase in weight due to the application of nitrogen could be due to protein synthesis which ultimately increased the plumpiness of the seed (Sharma and Singh, 1976).

The germination of seeds was not significantly influenced by the levels of nitrogen.

Hence it could be concluded that the fertilizer schedule of 150:75:150 kg NPK is the best fertilizer dose for producing high quality carrot seed.

Debristling is a major problem in carrot. The fruit of carrot called schizocarp whose external wall, bristling with spikes is in fact the wall of receptacle. When mature, the fruit divides into two halves called mericarp. The bristles which is present on the seed coat affect the seed flow during cleaning. Moreover, the bristles may also hinder the germination of seeds if they are sown as such. So the bristles have to be removed to get clean seeds. Since there is no work on debristling or debearding in carrot, experiments were planned.

In this study, the seeds were debristled using defuzzing machine, constructed by Sugarcane Breeding Institute, Coimbatore, with a constant moisture content of 8per cent. The machine has a principle of two spiral disc rotating with a fine sand mass. Due to the scarification of the bristles with the fine sand for 15 min. the seeds were debristled and separated from sand using appropriate sized sieves to remove both the bristles and sand.

The rate and extent of debristling depends on the quantity of sand used. Higher the sand ratio, higher will be the debristling out turn which ultimately lead to abrasion of seed coat with the resultant more mechanical damage.

The experiment was tried with three different quantities of sand viz., 500, 1000, 1500 g and each quantity of sand was used to debristle the seeds of 10, 20, 30, 40 and 50 g. The recovery percentage was more in case of 500 g sand used. It might be due to the poor quality of debristling. The scarification of the bristles by sand was very low. and associated with more bristles on the sieve . Ultimately the germination was also very poor. The recovery percentage was medium and low in case of 1000 and 1500 g and used. The scarification of the bristles by sand was severe (1500 g). So abrasion of seed coat was more that resulted in complete removal of bristle, ultimately resulting improved germination.However, the seeds produced more number of abnormal seedlings. In may perhaps be due to mechanical injury of the seeds. Seedling length and vigour index was low.

Hence, it is suggested that for carrot seed threshing, mechanical method is not advisable. Seeds can be debristled effectively by hand threshing, eventhough it is a time consuming, labour oriented process, we can get good quality seeds with high germinability.There is scope for streamlining machine in this direction.

Variation in seedling characters at emergence is associated with difference in the embryonic material. In carrot seeds, smaller embryos germinate later than those with larger embryos (Gray, 1979). Use of seed with uniformly sized embryos would be one of the management techniques necessary, for the production of high yields of uniform sized roots.

In the present investigation, length and breadth of seeds and the length of embryo, from the seeds of BSS 10x10 R and BSS 12x12 R were more than those seeds of 14x14 R and BSS 14x14 P, the seeds of latter registering the lowest values.

According to Gray et al.(1986) the embryos of the seeds from the primary umbels of carrot were longer than those of the seeds from the secondary umbels. Also in the present study, the highest and lowest embryo length were associated with the seeds bolder and smaller respectively.

In the umbelliferae, the occurrence of seeds without embryos but with apparently normal endosperm is common and may reach a frequency of 50 per cent or more. These embryoless seeds in many cases accounted for the great variation in the germinative capacity of fresh seeds.

Besides embryoless seeds in the umbelliferae many lots contain immature embryos, which are frequently in-capable of germination. The occurrence and incidence of embryolessness due to toxic feeding of lygus bugs (Florence and Henrickson,1949) at the seed development stage. This toxic material might affect the development of embryos, resulting in embryolessness and immature embryos of seeds of carrot. The approximate average of embryolessness found in celery and parsnip is 8 per cent, carrot 16 per cent, parsley 20 per cent, dill 24 per cent and fennel 34 per cent . In addition approximately 4 per cent of the carrot and parsley seeds and 14 per cent of the celery seeds contained immature embryos.

A well preserved seed is an asset in successful seed trade. The investment made on production will go a waste if the seed produced with so much care is not properly stored until planting. After physiological maturity, as the seeds age they maintain germinability for sometime and subsequently enter a period of decline. It is a well known fact that the materials employed for seed treatment, container selected, for storing and the environment in which the seeds are kept stored exert a profound influence on the viability and vigour of seeds in storage. In addition, temperature and relative humidity play an important role in maintaining the seed viability. Seed deterioration during storage is an irreversible process (Heydecker, 1969; Perry, 1969) and is ascribed to variety of reasons like genotypic difference, seed size, seed treatment and seed moisture content.

Germinability and vigour are the two important facets of seed quality. Vigour is considered in relation to the seed's strength or power of germination, its ability to send out a strong root and shoot even under conditions of stress and its freedom from attack by micro-organisms (Justice and Bass, 1978).

In the present study, the germination decreased with increase in storage periods. This was more in case of untreated seeds than treated seeds. The loss in viability was more in the case of seeds stored in paper bag than in high density polythene bag. It could be due to natural deterioration associated with respiration.

The decrease in the germinability of seeds as the storage period advanced is in conformity with the findings of Anuradhavarier and Agrawal (1989), in carrot.

The beneficial effect of anti-pathogenic treatment with fungicide (thiram) maintained its viability or with a minimal loss which could be related to their ameolarative influence on the seed. The rapid loss in germinability of untreated seeds is in agreement with the findings of Shanmugaraj (1986) and Vanangamudi (1986)

The effectiveness of polythene bag over cloth bag in maintaining the viability could be attributed to the reduced moisture absorption during storage by the seeds stored in polythene bag.

The decrease in shoot and root length with increase in the periods of storage could be ascribed to the deteriorative process occurring in seeds due to ageing in storage (Suneeta et al., 1988). The decrease in seedling vigour is in conformity with earlier work of Byrd and Delouche (1971).

Increased leaching of inorganic salts and organic compounds from deteriorating seed has been suggested as an index of viability and field emergence (Hibbard and Miller., 1928). Electrical conductivity of leachate from a seed is a good indicator of vigour (Grabe, 1967).

The increase in electrical conductivity from the leachate might be due to degradation of cellular membrane (Kalavathi, 1985).

Leaching of sugar has been observed as an index of loss of viability (Abdul-Baki and Anderson, 1970). The amount of sugar exuded from untreated seeds is more than that of treated seeds and also it was more in paper bag than in polythene bag conforming with the early works of Agrawal and Siddiqui (1973).

Protein estimation of the seed is another method of determining the seed vigour and viability. In the present study, a decrease in protein was recorded as the periods of storage advanced. Similar decrease in protein content was recorded by Ching and Schoolcraft (1968) in cereals, Jones et al. (1942) in corn .

Hence it could be concluded that carrot seeds are better storer. Treated seeds retained better viability when treated with thiram at 2 gm kg^{-1} of seeds and stored in 700 gauge polythene bag than untreated seeds.

The process of ageing in seed is accompanied by gradual deterioration and loss of vigour. The reduction in the physical and physiological manifestation of vigour during ageing could be attributed to the irreversible deteriorative changes occurring in seeds.

Accelerated ageing accelerates the senescence of seed and bring deterioration in viability and vigour (Heydecker, 1972); helps to predict its storability (Delouche and Baskin, 1973). The decline in viability and vigour in aged seeds may be attributed to its initial physiological potential or stamina of the seed (Desai, 1976).

Seed deterioration as has been well established that the various components are impaired fairly in indefinite sequence as it dies and metabolic activity diminishes (Ching and Schoolcraft, 1968).

In the present study, reduction in germination was faster as ageing advances when compared to control, and the seeds from primary, secondary and tertiary umbels lost their complete life within 8, 7, and 6 days ,respectively.

Karuna and Aswathaiah (1989) recorded the decline in seed germination from 74 per cent to 63 per cent after 4 days of accelerated ageing in carrot. Similar results were recorded in carrot and Pea (Savino et al., 1979 and Perl et al., (1978) observed that seed germination declined from 100 per cent to 20 per cent after 60 days of accelerated ageing in tomato. In beet root, germination of 82 per cent was declined to 69 per cent after 6 days (Karuna and Aswathaiah, 1989). Among the physiological manifestations of seed deterioration, reduced germinability is the best indicator of the extent of deterioration in seeds.

The decline in germination in aged seeds may be due to an increase in seed moisture content (Mc Donald, 1977); depletion of food reserves (Kovalenko et al., 1977); loss of membrane integrity (Kooshi, 1978); denaturation of proteins and enzyme system and ultra structural changes (Roberts, 1973) and increased chromosomal abnormalities (Abdalla and Roberts, 1969).

Reduction in seedling growth was one of the excellent vigour parameters to predict the level of physiological deterioration of seeds. Seed deterioration associated with decrease in root length was reported by (Abdul-Baki and Anderson, 1973a)

Reduction in root length was more prominent than shoot length during earlier periods of ageing. This was in conformity with the results of Santha (1991) wherein deterioration in the length of shoot took relatively longer time than root. The present study clearly revealed that the reliability of root length as an criterion to predict the level of deterioration in seed lot .

In the present investigation dry weight reduced over duration of ageing. Generally, the rate of reduction in seedling drymatter production was relatively faster than the rate of reduction in germination under ageing. This is in conformity with the findings of Santha (1991) in onion, bhendi and lablab.

The study clearly indicated that with increase in period of accelerated ageing there was decrease in germination, seedling length, vigour index and, drymatter of seed. Similar results have been reported by Doijode (1985) in onion .

SUMMARY

CHAPTER - VI

SUMMARY

The present work entitled "SEED TECHNOLOGICAL STUDIES IN CARROT (**Daucus carota** L) cv. Zino" was carried out at the Horticultural Research Station, Udhagamandalam, The Nilgiris and the Department of Seed Technology, Tamil Nadu Agricultural University, Coimbatore to elicit information on the following aspects in carrot :

1. Germination improvement
2. Determination of physiological cum harvestable maturity for seed quality maintenance
3. Steckling size on net reproductive effort and seed production spectrum
4. Effect of different dosage of nutrients on seed quality improvement in carrot
5. Different methods of threshing on seed quality of carrot
6. Effect of fungicide treatment and packaging material in extending the shelf life of seeds
7. Standardisation of accelerated ageing technique in relation to viability and vigour of carrot seed

Studies on germination improvement of carrot seed revealed that seed germination can be improved by soaking-leaching the seeds in water, for three days and then drying at 20°C. It appreciably enhanced the speed of germination. Seed germination can be further improved by blowing the seed in seed blower for 2 min. and then sieving them in BSS 12 x 12 wire mesh sieve. Large size seeds were highly superior than small seeds. It is suggested to upgrade the seeds using seed blower and BSS 12 x 12 wire mesh sieve for obtaining the highest quality seeds with better performance.

Pyridoxine (Vit. B_6) treatment at 0.5 per cent for 12 h. improved the root length. It did not improve the germination of size graded seeds.

Seed development and maturation studies spread over to eight weeks from the time of anthesis and resolved in three umbel orders namely, primary, secondary and tertiary. The attainment of physiological maturity differed among the umbel orders. The time of maturation was delayed for seven and fourteen days for secondary and tertiary umbel, respectively from the primary umbel's maturity. So, at harvest the seeds contain different physiological stages of development. Maximum dry weight accumulation of seed occurred at eighth week but the germination showed the numerical improvement on the eighth week as compared to seventh week after anthesis. However, leaving the seeds on the plant beyond eight weeks leads to shattering due to excessive desiccation resulting in the loss of seeds.

To conclude, the investigations revealed the attainment of physiological maturity of seeds on seventh week after anthesis and the harvestable maturity at eighth week after anthesis, before shattering starts.

It is suggested that harvesting the seed crop can be done when the primary umbel turns brown and the secondary umbel starts brown to get quality seeds.

Studies carried out with steckling size and different concentrations of pyridoxine (Vit B_6) treatment on growth, yield and seed quality parameters revealed the superiority of large sized steckling (150-199 g and 200 g and above weight of steckling) soaked in 0.5 per cent pyridoxine solution for 12.hours.

The various growth attributes showed their additive effect in influencing the seed yield per plant as well as on hectare basis. It was interesting to note that each increase in size of steckling resulted in corresponding increase in seed yield per hectare. The large sized steckling with 0.5 per cent pyridoxine (Vit. B_6) treatment was effective in terms of net-reproductive effort and seed production spectrum. Among the umble orders secondary umbel contributed more than 50 per cent of the total seed yield.

An investigation was conducted with three different nutrient levels with a view to find out an optimum and effective combination of nitrogen, phosphorus and potassium for achieving maximum recoverable seed yield with assured seed quality characteristics.

It is apparent that 150:75:150 Kg NPK ha^{-1} application exerts tremendous influence on the growth and yield characters. However, nutrient application did not influence the germination of resultant seeds. Hence, application of 150 kg N, 75 kg P_2O_5 and 150 kg K_2O per hectare is recommended as the best fertilizer level for carrot seed production.

Carrot seed debristling with sugarcane defuzzer revealed that scarification with sand causes abrasion to the seed coat and results in the mechanical injury, by producing more number of abnormal seedlings. Hence, for effective debristling, the ideal method recommended is hand threshing.

Embryo length in the seeds of the chosen size grades increased with progressive increase in seed size. The percentage of embryolessness decreased with increase in seed size. However, the viability percentage increased with increasing seed size.

The treated seeds stored better than untreated seeds. Untreated seeds had a higher rate of deterioration than seeds treated with Thiram. Seeds stored in 700 gauge polyethylene bag maintained better viability and vigour when compared to paper bag.

Seeds from tertiary umbels were found to deteriorate faster than seeds from primary umbel under ageing test.

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* Original not seen

APPENDIX

APPENDIX

MORPHOLOGICAL CHARACTERISTICS OF CARROT cv. ZINO

Average root length	:	15-17 cm
Average root weight	:	65.5 - 130 g
Shape of root	:	conical with slightly blended tip
Flesh colour	:	Orange
Flesh thickness	:	0-92-1.95 cm
Core colour	:	Light yellow (self colured core)
Core size	:	0.97 - 1.35 cm
Shoot length	:	20 - 35 cm
Days to root formation	:	95 - 110 days
Days to seed formation	:	310 - 330 days
Average root yield	:	10 - 12 t/ha
Average seed yield	:	650 - 700 kg/ha