FRUIT MATURITY, METHOD OF SEED DRYING AND STORAGE CONDITIONS ON SEED QUALITY IN OKRA, (*Abelmoschus esculentus* (L.) Moench)

By

P. ANITHA.

THESIS

Submitted in partial fulfilment of the requirement for the degree of

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Faculty of Agriculture

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Department of Olericulture

COLLEGE OF HORTICULTURE

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DECLARATION

I hereby declare that the thesis entitled "**Fruit maturity, method of seed drying and storage conditions on seed quality in okra (*Abelmoschus esculentus* (L.) Moench.)**" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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Certified that this thesis, entitled "**Fruit maturity, method of seed drying and storage conditions on seed quality in okra** (*Abelmoschus esculentus* (L.) **Moench.**)" is a record of research work done independently by **Miss P. Anitha** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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We, the undersigned members of the Advisory Committee of **Miss P. Anitha**, a candidate for the Degree of Master of Science in Horticulture, agree that this thesis entitled "**Fruit maturity, method of seed drying and storage conditions on seed quality in okra (*Abelmoschus esculentus* (L.) Moench.)**" may be submitted by Miss P. Anitha, in partial fulfilment of the requirement for the degree.

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Introduction

1. INTRODUCTION

Okra (*Abelmoschus esculentus* (L.) Moench.) is a native of tropical Africa. It was grown in the Mediterranean region even in the distant past. The young tender pods are cooked in curries, stewed, cooked into soups and also canned and dried. Okra is rich source of calcium, potassium and other mineral matters. It contains moisture 84.6 g, carbohydrate 6.4 g, protein 1.9 g, fibre 1.2 g, calcium 66 mg, potassium 103 mg, vitamin A 88 I.U. and vitamin C 13 mg per 100 g of edible portion.

It is an important vegetable in the tropics and subtropics and is grown widely in whole of northern India both for vegetable and seed purpose. In Kerala, this is one of the popular vegetables grown round the year either in the garden land or in rice fallows.

In a seed crop, the pods are allowed to mature on the plant and harvested when they are dry. This practice, however, exposes the mature pod to a number of factors such as rain and insect pests which not only increase the damage to the seed but lower the quality also. In many crops, the physiological maturity of seeds is attained well before the fruits become dry. As the seeds have maximum germination and vigour at physiological maturity, identification of this stage is very important. The method of seed drying also influences the germination capacity and vigour of seeds. Another factor influencing the seed viability is the atmosphere in which it is stored.

Thus it can be seen that the physiological maturity of seed, the drying method employed and the storage atmosphere influence the seed quality parameters. These factors are found to change with atmospheric condition. Seed germination and quality of the seeds are reduced in a state like Kerala because of the high humidity and temperature prevailing in the state.

Therefore the present study was undertaken in the Department of Olericulture, College of Horticulture, Vellanikkara with the following objectives.

1. To study the physiological maturity of okra seeds.

2. To standardise the seed drying procedure in okra.

3. To standardise the seed storage with a view to find out the suitable containers and proper storage atmosphere.

Review of Literature

2. REVIEW OF LITERATURE

The review of literature on effect of maturity of fruits at harvest, effect of methods of seed extraction and drying and the effect of storage containers and storage conditions on seed quality in different vegetable crops is briefly dealt in this chapter.

2.1 Studies on physiological maturity of seeds

High seed quality in terms of viability and vigour is essential for seedling establishment in field as well as for good crop production. The stage of seed maturity at harvest is an important factor affecting seed quality and its subsequent performance. A seed is mature when it can be removed from the plant without impairing its germination. Seeds attain maximum quality at their physiological maturity (Helmer *et al.*, 1962). Usually it has reached a stage on the plant when no further increase in dry weight will occur (Austin, 1972). Information available on the seed maturity studies in various vegetable crops are reviewed hereunder:

2.1.1 Seed characters

When the fruits of cucurbits were allowed to remain on the vine until over ripe, the seeds will germinate promptly but if the fruits were picked at ripe stage, the germination would be delayed for several weeks (Odland, 1937). Seaton (1938) studied the relation of number of seeds to fruit size and reported that weight of fruits and number of good seeds had correlated significantly. McAlister (1943) and Garris and Hoffmann (1946) observed that prolonged field exposure after the stage of maturity would result losses in germinability, longevity and vigour of seedling produced. The term `physiological maturity' has been most frequently used to describe the point where the seed reaches its maximum dry weight (Shaw and Loomis, 1950).

Harrington (1959) observed that the stages of maturity of fruit had an extreme effect on germination of seeds. In musk melon 100 seed weight increased upto 37 d.a.a (37 days after anthesis) and beyond that there was a slight decrease in 100 seed weight. The seeds of 37, 42 and 47 days after d.a.a when subjected to germination showed no much difference in germination, but a slight difference was observed four months after harvest which persisted nine months after harvest.

Chauhan and Bhandari (1971) observed differences in germination among seeds obtained at various stages of maturity in okra. The seeds collected from apical, middle and basal portions of okra fruits collected 27 days after flower opening recorded 89.2 per cent, while those harvested at 30 days after flower opening recorded 85.5 per cent germination. In cucumber dry weight of seeds increased with increase in maturity (Potapova, 1972). The quality of seed is basically dependent on its filling and on the metabolic and synthetic efficiency during seed development and maturation. Sandhu *et al.* (1972) reported that in onion cv. Punjab Selection, seed germination was high when harvested at full mature stage while harvesting two weeks earlier resulted in poor germination of seeds. According to Delouche (1973) seed development and maturation refers to the morphological, physiological and functional changes that occur from the time of fertilization until the mature seeds are ready for harvest.

The difference between seed development and seed maturation was studied by Abdul-Bakai and Baker (1973) and confirmed that seed development is the period between fertilization of the ovule and its subsequent development to seed with maximum fresh weight whereas seed maturation begins at the end of seed development and continues upto harvest. Development of chilli fruits under high temperature and relative humidity resulted in viviparous germination of seeds (Mohideen *et al.*, 1973). In okra, seeds upto ten days of development do not germinate and subsequently increases in percentage of germination (Velumani and Ramaswamy, 1976). Shanmugaraj (1978) reported that lablab (*Lablap purpureus* L. Sweet) seeds attained the maximum dry weight and physiological maturity on the 27th d.a.a, ribbed gourd 60 d.a.a and bitter gourd 27 d.a.a (Varatharaj, 1979), bottlegourd at 65 d.a.a (Chandrasekaran, 1979) and ashgourd at 80 d.a.a

(Krishnaprasad, 1980). Chin (1981) reported that yard long bean *Vigna sesquipedalis* when subjected to storage, the germination percentage was lower in immature seeds and highest for fully matured seeds. According to Jayabarathi (1982) seeds attained physiological maturity at 45 d.a.a in soybean (*Glycine max* (L.) Merrilli) and in field bean (*Lablab purpureus* L.) it was at 35 d.a.a (Sandhan, 1982). Metha (1983) reported that in chilli, physiological maturity of seeds was obtained at 48 d.a.a and seeds from fruits harvested before attaining physiological maturity did not store well.

In watermelon best quality seeds were obtained from fruits harvested at 35 and 45 d.a.a and stored for four days (Alvarenga *et al*., 1984). Singh and Sidhu (1985) studied fruit maturity in aubergin cultivars Punjab Chamkila and Pusa Purple Long. Germination was highest (92%) in seeds from fully and half-ripe fruits. In chilli, early harvested seeds of cv. CO-1 showed poor emergence and harvesting at 20 and 30 d.a.a showed highest germination after 12 months of storage in cv. CO-1, it was in seeds from 40 and 50 d.a.a in cv. CO-2 (Metha and Ramakrishnan, 1986a), while harvesting after 48-120 d.a.a resulted in higher germination and vigorous seedling (Metha and Ramakrishnan, 1986b). Dharmatti and Kulkarni (1987) reported that in bell pepper cv. California Wonder seeds obtained from fruits harvested 52 d.a.a have the highest germination. In cowpea seeds become physiologically mature at 19 d.a.a (Lassim and Chin, 1987). Kanwar and Saimbhi (1987) observed that in okra cv. Punjab Padmini seeds attained physiological maturity at 35 d.a.a. According to Doijode (1988a) in chilli fruits harvested at ripe stage possess high germination capacity and seedling vigour. In musk melon seed quality was best when fruits were harvested at full-slip stage (Singh *et al.*, 1988). In cucumber cv. Bet Alfa, melon cv. Noy Yizre'el, watermelon cv. Sugar Baby and *Cucurbita pepo* cv. Vegetable Spaghetti, seed germinability was generally best from fruits which were 49-54 d.a.a (Nerson and Paris, 1988). Steckel *et al.* (1989) observed cultivar differences in days required for seed maturation in carrot, it took 40 days in cv. Chantenay and 45 days in cv. Amsterdam. Jayabarathi *et al.* (1990) investigated the influence of different stages of fruit maturity on seed yield and quality in brinjal cv. PKM-1 that fruits harvested at the completely yellow stage had the highest seed yield and quality. Chaudhari *et al.* (1992) suggested that in many cultivars seed yield and quality was greatest for seeds extracted from fruits at the red-ripe stage. Basavaraja and Dutta (1992) found that in brinjal line 22-1, fresh weight and dry weight of seeds were maximum on 49 d.a.a. While studying the fruit maturity in bell pepper Sanchez *et al.* (1993) suggested that seeds from red and over-mature-red fruits generally had greater dry matter and higher germination percentage. According to Demir (1994) seeds from fruits harvested at 52 d.a.a recorded maximum seed quality in okra measured as germination and emergence percentage. The influence of fruit ripeness at the time of seed extraction and on germination behaviour of pepper (*Capsicum annuum* L.) seeds studied by Cavero *et al.* (1995) showed that seeds from fully ripe fruits had improved germination. According to Suryavanshi and Patil (1995), seeds of mung bean (*Vigna radiata* L.) cv. K-851 attained physiological maturity at 25 d.a.a. In tomato highest seed quality was attained in seeds extracted from pink stage (Pandita *et al.*, 1996). Studies on seed quality parameters in ash gourd cv. BH-21 showed that seeds attained maximum dry weight, seed germination and vigour at 70 d.a.a (Kannath, 1996).

2.2 Method of seed extraction and drying

Seed moisture has a major role in determining the longevity of seeds in several vegetable species. Seed moisture attains equilibrium with advance in seed maturity. Seed moisture attains equilibrium with atmospheric humidity and changes with increase or decrease of atmospheric humidity and temperature of air. Thus moisture equilibrium varies in different cultivars and depends on composition of seed. Seed moisture is removed by process of evaporation from seed to atmosphere (Doijode, 1993). Information available on methods of drying of seeds of various vegetable crops are reviewed hereunder.

Harrington (1960) and Singh and Ojha (1972) could observe better performance of seeds dried by sun drying and shade drying. While studying the different methods of drying of onion seeds, Sandhu *et al.* (1972) observed that sun drying of seeds for two days significantly lowered germination compared to seeds dried in shade. The conventional methods of drying - sun drying is time consuming and dependent on atmospheric conditions. To overcome these, mechanical drying can be followed. In mechanical drying, air temperature and initial moisture content of the fruits are most important as they affect seed quality as observed by Vanraj and Kulkarni (1977) who reported thermal injury to the seeds when dried at high temperature with high initial moisture content. According to Araujo *et al.* (1984) drying bean seeds at 50 or 60°C decreased seed quality especially in seed with high initial moisture content, but drying at 40°C had no adverse effect. They further found that after 12 months of storage, germination was highest in naturally dried control seeds.

Nerson *et al.* (1985) reported that the effect of washing and drying seeds of cucumber, *Cucurbita pepo*, musk melon and water melon from fruits ranging in the age from 21-54 d.a.a. Seeds were handled with or without 15 minutes of washing and with or without air drying before subjected to germination. Germination of seeds harvested from ripe fruits (45-54 d.a.a) was not affected either by washing or drying. The rate of germination of these seeds was accelerated in musk melon and inhibited in *Cucurbita pepo* by drying. In Pea cv. Finale aerated drying at 15°C, 20°C or 35°C of seeds of different maturity stages and moisture contents indicated that high drying temperature markedly reduced germination in seeds of high moisture contents (Rachidian and Deunff, 1986). According to Rudolph (1987) among the different methods of umbell drying practised to allow after ripening of seeds in onion, like air at ambient temperature, hot air at 29°C ± 3°C or air at ambient temperature for 10 days followed by hot air for another 10 days drying on slatted shelves without forced ventillation had no differential effect on 100 seed weight, germination capacity or rate of emergence.

In general, okra seeds are dried in shade or with silica gel. However, rapid drying at higher temperature reduces germination. Initially seed germinability was affected by drying at 60°C (Doijode, 1988b). According to Selvaraj (1988) shade dried seeds in brinjal have higher germination percentage, thus better storage potential than sun dried seeds. Pandian (1988) reported that mechanical drying of okra seeds with hot air at 53 ± 0.5°C in a fluidised bed drier improved the germination and vigour when compared to sun drying. Neelamathi (1989) opined that natural drying of seeds over screen bottom tray, cowdung floor and gunny proved to be superior over the control (shade drying) in terms of germination, root length, seedling vigour and dry matter production of tomato.

According to Moreira *et al.* (1990) average seed germination percentage after drying was higher for seeds of *Phaseolus vulgaris* dried in static drier. Gowda *et al.* (1992) reported that combined sun and shade drying resulted in the highest seed germination and tomato seed could be safely dried at a temperature of 35°C or 40°C. Drying onion cv. Nasik Red seeds with silica gel and infra red rays were found best for maintaining high seed quality for longer storage (Doijode, 1990a). Dhanelappagol (1994) observed that there exists an interaction between harvesting stage and drying method in chilli. Highest germination was in seeds obtained from sun-dried fully ripe red coloured fruits followed by seeds obtained from fully ripe red coloured fruits dried at an air temperature of 40°C. According to Kannath (1996) seed quality in ashgourd cv. BH-21 was influenced by the method of seed extraction whereas different drying methods had no significant effect on various seed quality parameters.

2.3 Standardisation of seed storage

Proper storage of extracted seed is an essential ingredient of a successful seed production and distribution programme. Seed longevity is generally determined by pre-harvest factors. Storage environment plays an important role in determination of seed longevity. High temperature and relative humidity reduce storage life of seeds. Vegetable seed storage is a problem in warm humid climatic conditions of

Kerala which experience high temperature and high relative humidity throughout the year. In nature, loss of seed viability and vigour are associated with improper seed storage. Therefore, it is essential to preserve them in suitable containers under proper environmental conditions. The information available in various vegetable crops on these aspects is briefly reviewed here under:

According to Zink and Demendonea (1964) seeds of water melon recorded maximum germination (88%) after 18 months of storage in cloth bag at 20°C and 45 per cent RH. Seeds stored in air tight container maintained well only for 12 months. Miyagi (1966) reported that cucumber seeds maintained the viability when stored in metal foil bags upto 22 months. Villane al *et al.* (1972) found that the seeds of squash and bottlegourd when stored in cellophane and aluminium foil packets maintained germinability longer than those in polyethylene or paper packets. Loss in viability is the most widely accepted criterion of seed deterioration which is predominantly governed by storage conditions of seeds (Abdul-Bakai and Anderson, 1972). Seeds of watermelon and pumpkin recorded better germination when stored in polythene packets than in paper bags.

In okra, seed longevity varies in different cultivars and most of the cultivars remain viable for three months at 27°C and 90 per cent RH (Rao, 1974). Dharmalingam *et al.* (1976)

reported that when seeds of black gram were stored in paper-aluminium-polythene pouch, remained viable upto 24 months. According to Silva *et al.* (1976) the best storage method for okra seed is packing seeds (4.5% MC) in glass containers, these retained germination capacity for 29 months at all conditions like room temperature or cold storage. Kuchernko and Lebedeva (1976) has reported that seeds of water melon and pumpkin recorded high germination when stored in polythene packets than paper bags. Thulasidas *et al.* (1977) opined that storing seeds in aluminium foil pouches along with silica gel retained germination (50%) after 29 months of ambient storage.

Bogolepov (1980) observed that pumpkin seeds could be stored in best quality plastic bags without regulating humidity and temperature. Water melon and pumpkin seeds had a best storage conditions of 56 per cent RH at 18°C 65 per cent RH at 2°C.

According to Sandhan (1982) storage of field bean seeds in 700 gauge polythene was effective in preserving good germination. Seed quality is affected by improper storage and causes excessive leaching of electrolytes, soluble sugars and amino acids from seeds and decrease in dehydrogenase activity and peroxidase activity (Saxena *et al.*, 1987). Doijode (1988c) observed that french bean seeds stored in glass jars, laminated bags and polyethylene bags gave higher percentage of germination than those stored in butter paper or kraft paper. Different types of containers are used for storage depending upon duration and kind of seed material used. Retention of viability was greater in tomato seeds stored in aluminium laminated bags (Jayaraj *et al.*, 1988). While studying the seed viability in *Capsicum* cultivars, Thakur *et al.* (1989) observed that seeds stored in brown paper cover at 2-26°C; germination after storage for one year declined (cv. Russian Yellow Wonder) to 42.5 per cent and 29 per cent in California Wonder.

According to Doijode (1989a) packing onion seeds in polyethylene and laminated (paper-aluminium foil-poly) bags were effective for preserving viability for five years at 5°C or -18°C. Varrier and Agrawal (1989) reported that seeds of carrot, onion and tomato packed in cloth bag and stored under ambient conditions or dried to 5 per cent moisture content and kept over silica gel, loss of viability was greatest in onion and least in tomato. Doijode (1989b) investigated the storability of cluster bean (cv. Pusa Naubahar) seeds stored in polyethylene bags stored under conditions like -18°C and 40 per cent RH, 5°C and 40 per cent RH or 15-35°C and 25-90 per cent RH; after five years of storage gave 100 per cent, 97 per cent and zero germination respectively under the three conditions. Due to lower cost of seed storage at 5°C than at -18°C, the former is recommended.

Occurrence of rains during seed maturity in okra lowers the seed quality and reduces germination. Seed longevity can be enhanced by storing in laminated bags at 5°C or -18°C (Doijode, 1990b). While studying the effect of storage conditions and storage containers on onion seed quality, Doijode (1990c) reported that seed germination was high for seed stored in polyethylene, followed by glass and laminated bags, both at 5°C or -18°C; while storing the seeds in paper bags at 5°C reduced germination (27.0%) and at -18°C seeds were killed by freezing. Singh and Singh (1990) evaluated the efficiency of different storage containers for storage of onion seeds. The percentage germination decreased rapidly in seeds stored in cloth bag; while seeds stored in glass jars remained viable for longer than other containers.

According to Doijode (1990d) seeds of onion packed in 300 gauge polyethylene and stored under condition like sub zero temperature (-18°C and 85% RH), low temperature (5°C and 40% RH), or ambient condition (16-35°C and 25-90% RH) showed that storage under sub zero temperature was most effective. Palaniswamy and Karivaratharaju (1990) opined that low RH level of 35 per cent was found to be optimum for long term storage with minimum loss in vigour and viability of tomato seeds.

Verma *et al.* (1991) reported that under ambient conditions the most suitable storage container was laminated bags (paper-foil-polyethylene layers) for storage of cauliflower and tomato seeds. According to Doijode (1991) radish seed quality can be retained for six years when packed in polyethylene or laminated (paper-foil-poly) bags stored at 5°C or -18°C.

Nakagawa *et al.* (1991) observed that seed quality was better after storage under ambient conditions compared with dry storage in okra seeds. Studies on storage of onion seeds revealed that germination was maintained above 70 per cent after 360 days storage in moisture impermeable containers like plastic bags and aluminium foil packets (Shelar *et al.*, 1992). Kraak and Van (1993) opined that formaldehyde and other volatile substances originating from printing ink, paper or glue on seed packets may cause rapid decrease of seed germinability; lettuce seed appear particularly sensitive. Dourado and Carson (1994) found that all the low temperature storage of onion seeds resulted in good viability retention, whereas viability fell most rapidly in high moisture content seed stored at 30°C in aluminium foil packets or muslin bags. According to Ellis *et al.* (1994) low temperature (-20°C) storage maintained original germination (70) percentage throughout the period of trial than at ambient temperature (20°C) in onion seeds. Currah and Msika (1994) observed that onion seeds stored in air tight jars under ambient condition retained their viability and vigour while those packed in paper packets showed reduction in seed quality. According to

Gupta *et al.* (1994) chilli seeds stored in tin containers deteriorated less rapidly than in cloth bag.

Pumpkin cv. Arka Chandan seeds packed in polyethylene bags showed high viability for two years under ambient conditions while seed storability was enhanced to five years at 5°C and -20°C (Doijode, 1995a).

Pandey (1995) reported that preservation of tomato seeds by immersing CALGLY ($CaCl_2$ in glycerol) or hexylene glycol is a simple and cost effective method for improving short or medium term longevity at ambient temperature. Palaniswamy *et al.* (1995) suggested that storing annual moringa seeds in 700 guage thick polyethylene bags showed less rapid decrease in viability under ambient conditions of storage than those packed in fresh gada cloth bags. Doijode (1995b) has reported that storage of onion (cv. Nasik Red) seed with silica gel in aluminium foil laminated pouches, glass or polyethylene bag is effective in retaining high seed germinability upto seven years without loss of seedling vigour.

According to Kannath (1996) packing seeds (ashgourd cv. BH-21) in moisture impervious 700 gauge polythene bag was the best in maintaining high germination, vigour and dehydrogenase activity during storage. Brown paper bag and gada cloth were not suitable to maintain the seed viability.

Materials and Methods

3. MATERIALS AND METHODS

The present investigation "Fruit maturity, method of seed drying and storage conditions on seed quality in Okra" was carried out in the Department of Olericulture, College of Horticulture, Vellanikkara during 1995 to 1997. The study consisted of the following experiments.

1. Effect of stage of maturity at harvest on seed quality in okra.

2. Effect of method of seed drying on seed quality in okra.

3. Effect of storage containers and storage conditions on seed quality.

3.1 Effect of stage of maturity at harvest on seed quality in okra

Okra cultivar Arka Anamika was used for the study. The crop was raised during August-November, 1996. Management practices were followed as per Package of Practices Recommendations of Kerala Agricultural University (1993).

Flowers were tagged on the day of anthesis. Fruits were harvested at an interval of 3 days upto the 39th day after anthesis. They were designated as S_1 to S_{13} to represent the fruits of different stages of maturity.

S_1 = 3 d.a.a

S_2 = 6 d.a.a

S_3 = 9 d.a.a

S_4 = 12 d.a.a

S_5 = 15 d.a.a

S_6 = 18 d.a.a

S_7 = 21 d.a.a

S_8 = 24 d.a.a

S_9 = 27 d.a.a

S_{10} = 30 d.a.a

S_{11} = 33 d.a.a

S_{12} = 36 d.a.a

S_{13} = 39 d.a.a

Seeds were extracted from each stage and dried to a moisture content of 8 per cent.

Number of replications = 3

Fruits/replication = 10

The following observations were recorded.

(i) Fruit weight (g)

(ii) Fruit length (cm)

The length of fruits was measured excluding the stalk and expressed in cm.

(iii) Total number of seeds per fruit

Seeds from fruits were separated and total number of seeds per fruit was recorded.

(iv) 100 seed weight (fresh seed weight)

One hundred fresh seeds were weighed to determine the fresh weight and expressed in grams.

(v) 100 seed weight (dry seed weight)

One hundred dried seeds were weighed to determine the 100 seed weight (dry seed) and expressed in grams.

(vi) Percentage of well filled seeds after drying

$$\text{Percentage of well filled seed} = \frac{\text{Number of well filled seed}}{\text{Total number of seeds}} \times 100$$

(vii) Percentage of germination

Twenty five seeds from each treatment were placed in sterilised sand medium and allowed to germinate under ambient conditions. There was three replications. The seedlings were watered daily. The following observations were recorded.

1. Days to germination
2. Percentage of germination
3. Root length of seedling (cm)

   This was taken on the fifth day after sowing

4. Shoot length of seedling (cm)

   This was taken on the fifth day after sowing

5. Speed of germination

   From the mean germination percentage recorded on each counting, speed of germination was calculated employing the following formula suggested by Maguire (1962).

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

where,

X_n = Per cent germination on n^{th} day

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

Cotyledons slipping out of the seed coat was taken as the criteria for germination of normal seedling.

6. Vigour index of seedling

Vigour index was computed using the following formula (Abdul-Baki and Anderson, 1970) and expressed as whole number.

Vigour index = Germination percentage x Mean length of root and shoot in cm

7. Seedling dry weight

Five normal seedlings were air dried first for six hours and then in hot air oven maintained at 85°C for 24 h and were cooled in a desiccator for 45 minutes; then dry weight per seedling was recorded in mg.

3.2 Effect of method of seed drying on seed quality in okra

Fully matured fruits of uniform size were selected from the seed production plot of okra cultivar Arka Anamika raised during August-November, 1996. Fruits were harvested when it was fully dried up. Fruits were subjected to three different drying methods before separation of seeds from harvested fruits.

The entire fruits harvested were divided into three equal parts and were subjected to the following methods of fruit drying.

1. FD1: Fruit drying under shade for one day.

The fruits were spread evenly on the floor under shade for one day.

2. FD2: Fruit drying under direct sun light for one day

The fruits were spread evenly on the floor fully exposed to sun for one day.

3. FD3: Fruit drying using hot air in an artificial drier for 6 hours at 35°C

The fruits were evenly spread in the mechanical drier for 6 hours, after regulating the temperature at 35°C.

From fruits dried under each method; seeds were extracted and dried under the following methods of drying.

Methods of seed drying employed in this study were:

1. SD1: Seed dried under shade till the seed moisture attained 8.0%.

2. SD2: Seed dried under direct sun light till seed moisture attained 8.0%.

3. SD3: Seed dried using hot air in a mechanical drier at 35°C till the seed moisture attained 8.0%.

4. SD4: Seeds initially dried in shade for one day and then under sun avoiding the peak hours (12 noon to 3 pm) till the seed moisture attained 8.0%.

All the combinations of three methods of fruit drying and four methods of seed drying were followed; thus a total of 12 treatment combinations were compared in this experiment. There were three replications. The processed seeds were stored under A/C (20±2°C) and the following observations were recorded.

1. Days to first germination
2. Germination percentage
3. Root length of seedling
4. Shoot length of seedling
5. Speed of germination
6. Vigour index of seedlings
7. Seedling dry weight
8. Electrical conductivity of seed leachate (Presley, 1958)

Three replicates of 25 seeds were taken and washed in distilled water to remove all dirt, soil or chemicals. The seeds were then soaked in 20 ml of distilled water for four hours by occasionally stirring the contents. Then the seed leachate was decanted and seeds were washed with distilled water and all seed leachate was collected. Then seed leachate was filtered and made upto 50 ml. The electrical conductivity of seed leachate was measured in a digital conductivity meter (Type CM 180) with cell constant of electrode, one. The electrical conductivity of seed leachate was expressed as dSm^{-1}.

3.3 Effect of containers and storage conditions on seed quality in okra

Fully matured fruits were harvested from the seed crop of okra cultivar Arka Anamika raised during August-November 1996, and seeds extracted from them were used in this experiment. Seeds were cleaned thoroughly and dried to bring the moisture content to 8 per cent. The samples were drawn and packed in different storage containers and stored under different storage conditions.

Different storage containers employed in this experiment were:

T_1 Brown paper cover
T_2 Butter paper cover
T_3 Cloth bag
T_4 Polythene bag of 700 gauge thickness
T_5 Polythene bag of 200 gauge thickness
T_6 Plastic container

All such containers employed for seed packing were subjected to three different storage conditions.

Different storage conditions employed in this experiment were:

C_1 Room temperature

C_2 Air conditioned storage (20+2°C)

C_3 Storage at 5°C temperature

Thus there were 18 treatment combinations of six packing materials x three storage conditions. Seed samples were drawn at monthly intervals and tested for various seed quality parameters.

1. 100 seed weight

Hundred seeds were packed in respective containers and stored under the different storage conditions. Weight of the seed along with the container was determined at monthly intervals.

2. Days to 50 per cent germination
3. Germination percentage
4. Root length of seedling
5. Shoot length of seedling
6. Speed of germination
7. Vigour index of seedlings
8. Seedling dry weight
9. Electrical conductivity of seed leachate

Statistical analysis

Statistical analysis of the data were performed in computer using M STAT-C package in factorial completely randomised design (CRD) for experiment 2 and 3 and CRD for experiment 1. Germination percentage was transformed to Arc-sinc by M STAT-C and transformed data were analysed.

Results

4. RESULTS

Results of the investigation are presented under the following heads.

4.1 Effect of stage of maturity at harvest on seed quality in okra.

4.2 Effect of method of seed drying on seed quality in okra.

4.3 Effect of storage containers and storage conditions on seed quality in okra.

4.1 Effect of stage of maturity at harvest on seed quality in okra.

Analysis of variance showed that there was significant difference among the treatments for the characters length of fruits, weight of fruit, 100 seed weight (fresh), 100 seed weight (dry) and percentage of well filled seeds after drying (Appendix I).

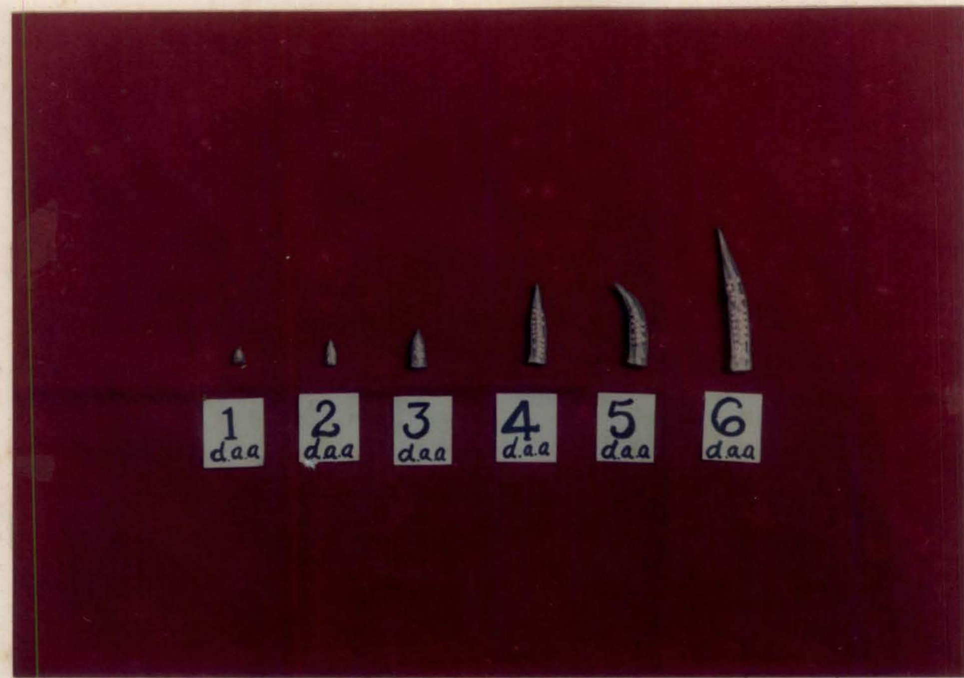
4.1.1 Fruit and seed characteristics of okra at various stages of maturity

Means of various fruit and seed characters of okra at various stages of development are given in Table 1.

Plate 1. Cross section of fruits at different maturity stages (one to six d.a.a)

Plate 2. Cross section of fruits at different maturity stages (three to 39 d.a.a)

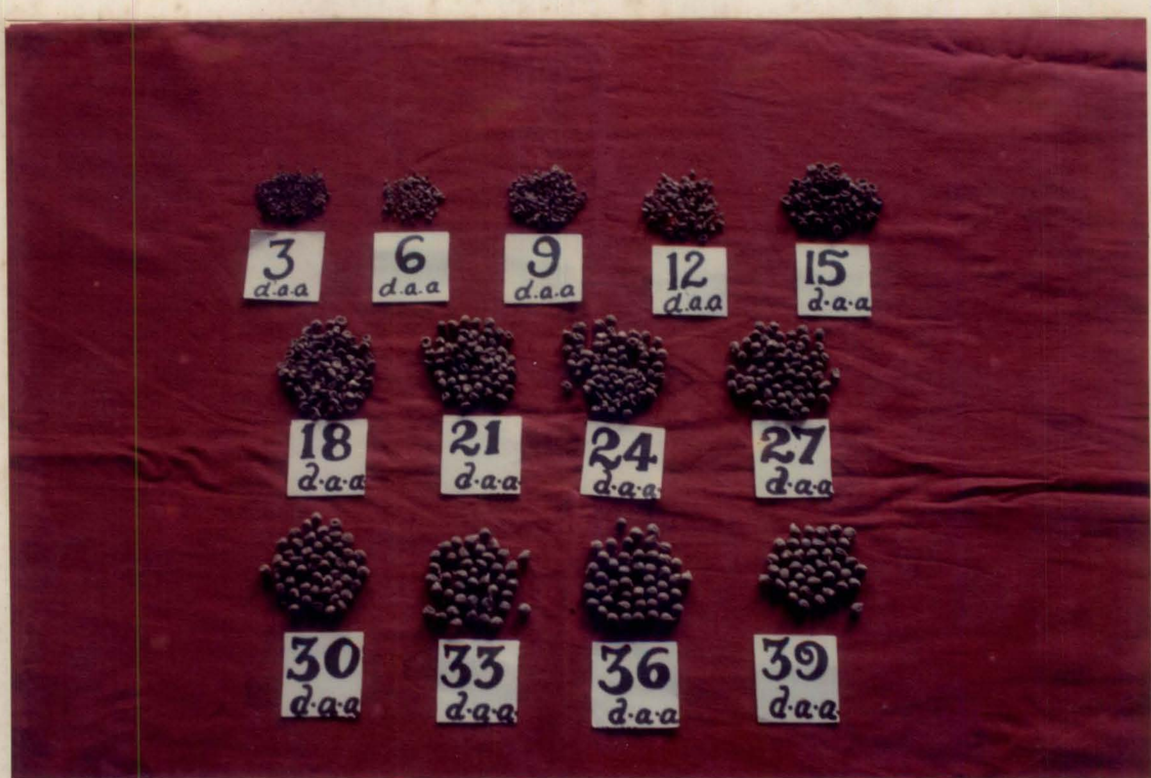
171196


1 d.a.a
2 d.a.a
3 d.a.a
4 d.a.a
5 d.a.a
6 d.a.a


3 d.a.a
6 d.a.a
9 d.a.a
12 d.a.a
15 d.a.a
18 d.a.a
21 d.a.a
24 d.a.a
27 d.a.a
30 d.a.a
33 d.a.a
36 d.a.a
39 d.a.a

Plate 3. Seed characteristics of okra at different maturity stages after drying (three 39 d.a.a)

171196


3 d.a.a
6 d.a.a
9 d.a.a
12 d.a.a
15 d.a.a
18 d.a.a
21 d.a.a
24 d.a.a
27 d.a.a
30 d.a.a
33 d.a.a
36 d.a.a
39 d.a.a

4.1.1.1 Length of fruit (cm)

The length of the developing fruits increased gradually from the day of anthesis. The mean length of developing fruits increased from 3.74 cm (3 d.a.a) to a maximum of 20.45 cm (36 d.a.a).

4.1.1.2 Weight of fruit

The weight of fruits increased gradually from the day of anthesis. Mean weight of developing fruits increased from 2.02 g (3 d.a.a) to 29.16 g (18 d.a.a). There after a decrease in fruit weight was observed.

4.1.1.3 Total numbers of seeds per fruit

The total number of developing seeds was high (63) at 3 d.a.a. Thereafter it showed gradual decrease to 52 (18 d.a.a).

4.1.1.4 100 seed weight (fresh)

100 seed weight was minimum (0.33 g) at 3 d.a.a and fresh weight of 100 seed was maximum (14.82 g) at 15 d.a.a. Thereafter it reduced to 6.6 g (39 d.a.a).

4.1.1.5 100 seed weight (dry)

100 seed weight (dry) showed a gradual increase from the

Table 1. Mean fruit and seed characteristics of okra at various stages of fruit maturity

Days after anthesis d.a.a.	Length of the fruit (cm)	Fruit weight (g)	Total no. of seeds per fruit	100 seed weight fresh (g)	100 seed weight (g)	Percentage of well filled seeds after drying
3	3.74	2.02	63.00	0.33	0.00	0.00 (0.010)
6	10.60	5.44	52.00	3.79	0.00	0.00 (0.010)
9	14.11	12.76	58.30	8.64	0.00	0.00 (0.010)
12	15.29	16.85	46.70	10.81	0.00	0.00 (0.010)
15	17.33	25.40	54.70	14.82	2.70	0.00 (0.010)
18	18.84	29.16	52.30	14.73	3.48	0.00 (0.010)
21	18.86	26.92	59.00	13.98	4.21	11.97 (0.124)
24	18.85	25.99	54.70	14.50	4.66	61.41 (0.687)
27	18.20	25.49	52.00	13.46	5.00	89.63 (1.128)
30	18.47	24.60	60.00	12.74	5.35	82.37 (0.968)
33	19.24	5.82	40.30	7.33	6.59	87.48 (1.073)
36	20.45	6.95	47.00	7.20	7.62	96.36 (1.319)
39	20.45	6.15	47.30	6.60	7.22	82.73 (0.979)
CD (0.01)	1.44	3.74	7.60	1.06	0.51	13.82

initial stages of fruit maturity and reached a maximum (7.62 g) at 36 d.a.a. Thereafter, it decreased.

4.1.1.6 Percentage of well filled seeds after drying

No well filled seeds were obtained upto 18 d.a.a. The percentage of well filled seeds increased from 11.97 per cent (21 d.a.a) to 96.36 per cent (36 d.a.a).

4.1.2 Seedling characteristics of okra seeds of various stages of maturity

Analysis of variance indicated significant difference among the treatments for days to first germination, germination percentage, root length, shoot length, speed of germination, vigour index and seedling dry weight (Appendix II).

4.1.2.1 Days to first germination

Seeds harvested upto 21 d.a.a did not germinate. Seeds of 24 days maturity took 4.77 days for the emergence of first seedling. Thereafter days to germination of seeds decreased and the lowest time was recorded for seeds of 33, 36 and 39 d.a.a (2.5 days) (Table 2).

4.1.2.2 Germination percentage

Germination percentage was maximum for seeds of 36 days maturity (Table 2). There was no germination for seeds upto a maturity of 21 days. Germination was minimum (4%) for seeds of 24 days maturity. Thereafter germination increased to 94.7 per cent (36 d.a.a) and then it decreased.

4.1.2.3 Root length (cm)

Root length was minimum (2.43 cm) for seeds of fruits harvested at 24 days maturity and maximum (7.57 cm) for seeds of fruits harvested at 36 days maturity. The seeds from fruits harvested at 33, 36 and 39 d.a.a recorded 6.38, 7.57 and 6.84 respectively and were on par with each other (Table 2).

4.1.2.4 Shoot length (cm)

Shoot length was minimum (13.10 cm) for seedlings raised from seeds of 24 days maturity and was maximum for seedling raised from seeds of 36 days maturity(14.48 cm) (Table 2).

4.1.2.5 Speed of germination

Speed of germination was lowest (2.0) for seeds of fruits harvested 24 days maturity and the maximum was recorded at 36 d.a.a (35.10). The speed of germination in seeds from fruits harvested at 33, 36 and 39 d.a.a were 34.23, 35.10 and 29.10 respectively and were on par with each other (Table 2).

Table 2. Seedling characteristics of okra at various stages of fruit maturity

Days after anthesis (d.a.a)	Days to first germi-nation	Germi-nation percen-tage	Root length (cm)	Shoot length (cm)	Speed of germi-nation	Vigour index	Seedling dry weight (mg/seed ling)
3	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-
15	-	-	-	-	-	-	-
18	-	-	-	-	-	-	-
21	-	-	-	-	-	-	-
24	4.77	4.00 (0.040)	2.43	13.10	2.00	62.00	5.42
27	4.73	16.00 (0.161)	2.59	12.45	2.00	62.00	5.42
30	3.07	30.70 (0.315)	2.59	13.68	10.25	516.67	43.61
33	2.50	85.30 (1.036)	6.38	13.14	34.23	1649.00	34.06
36	2.50	94.70 (1.264)	7.57	14.48	35.10	2135.33	36.06
39	2.50	80.00 (1.167)	6.84	13.18	29.10	1647.33	32.44
CD (0.01)	0.65	0.65	0.98	1.16	6.22	357.65	11.59

4.1.2.6 Vigour index

Minimum vigour index was recorded in the case of seeds extracted from fruits of 24 d.a.a (62.0) and maximum was recorded in the case of seeds extracted from fruits of 36 d.a.a (2135.33), thereafter it declined (Table 2).

4.1.2.7 Seedling dry weight (mg/seedling)

Seedling from seeds of 24 days maturity had the minimum of dry matter (5.42 mg/seedling) and that from seeds of 36 days maturity recorded the maximum dry matter (36.06 mg per seedling) (Table 2).

4.2 Effect of different methods of seed drying on seed quality in okra

Studies were conducted in okra with a view to standardise the fruit drying and seed drying methods for getting good quality seeds. For this three methods of fruit drying and four methods of seed drying were tried and seeds were tested for seven months. Analysis of variance is given in Appendix III.

4.2.1 Days to first germination

There was no significant effect for different fruit drying and seed drying methods on days to first germination. The interaction effect was also not significant. However, the storage time had significant effect on days to first germination (Table 3a and 3b).

4.2.2 Germination percentage

The different methods of fruit drying had no significant effect on germination percentage.

The over all mean for different seed drying methods differed significantly. Seeds dried by direct sun light (SD2) recorded the highest overall germination (71.46%) and the lowest (61.66%) was recorded by the seeds dried using mechanical drier (Table 4a).

The overall mean for different months differed significantly. The highest (71.47%) germination was recorded immediately after the treatment, which gradually decreased to 59.67 per cent after seven months of storage (Table 4a and 4b).

The overall mean for different fruit drying x seed drying interaction was found to be significant. Among the different combinations the maximum germination percentage (78.17%) was recorded by the fruits initially dried using mechanical drier followed by seeds dried initially under shade followed by sun light avoiding the peak hours (12 noon to 3 pm), and the lowest (53.16%) was recorded for combination of fruits drying using mechanical drier followed by seeds dried using mechanical drier (Table 4b).

Table 3a. Overall mean effect of various methods of fruit drying and seed drying on days to first germination of the okra seeds

Treatments	Months after storage								
	0	1	2	3	4	5	6	7	Mean
FD_1	2.4	2.3	2.0	2.0	2.0	2.0	2.0	2.0	2.08
FD_2	2.6	2.2	2.0	2.3	2.1	2.1	2.0	2.0	2.90
FD_3	2.3	2.1	2.0	2.1	2.0	2.1	2.0	2.5	2.13
SD_1	2.3	2.1	2.0	2.1	2.0	2.1	2.0	2.3	2.08
SD_2	2.4	2.1	2.0	2.1	2.0	2.0	2.0	2.3	2.11
SD_3	2.3	2.2	2.0	2.1	2.1	2.0	2.0	2.3	2.12
SD_4	2.7	2.2	2.0	2.1	2.0	2.1	2.0	2.3	2.17
Mean	2.42	2.17	2.0	2.1	2.02	2.05	2.00	2.30	

CD for comparing means

Fruit drying N.S.
Seed drying N.S.
Month mean 0.14**

FD_1 - Fruit drying under shade for one day

FD_2 - Fruit drying under direct sunlight for one day

FD_3 - Fruit drying using hot air in an artificial drier for 6 hours, after regulating temperature at 35°C

SD_1 - Seed dried under shade till the seed moisture attained 8.0 per cent

SD_2 - Seed dried under direct sun light till the seed moisture attained 8.0 per cent

SD_3 - Seed dried using hot air at 35°C till the seed moisture attained 8.0 per cent

SD_4 - Seed initially dried in shade for one day and then under sun avoiding the peak hours (12 noon to 3 pm) till the seed moisture attained 8.0 per cent

Table 3b. Overall mean effect of various combination of fruit drying and seed drying on days to first germination in okra seeds

Treatment combination	Months after treatment								
	0	1	2	3	4	5	6	7	Mean
FD_1SD_1	2.7	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.08
FD_1SD_2	2.3	2.3	2.0	2.0	2.0	2.0	2.0	2.0	2.07
FD_1SD_3	2.0	2.3	2.3	2.0	2.0	2.0	2.0	2.0	2.03
FD_1SD_4	2.7	2.3	2.3	2.0	2.0	2.0	2.0	2.0	2.12
FD_2SD_1	2.0	2.3	2.0	2.3	2.0	2.0	2.0	2.3	2.07
FD_2SD_2	3.0	2.0	2.0	2.3	2.0	2.0	2.0	2.3	2.20
FD_2SD_3	2.7	2.3	2.0	2.0	2.0	2.0	2.0	2.3	2.16
FD_2SD_4	2.7	2.0	2.0	2.3	2.3	2.0	2.0	2.0	2.16
FD_3SD_1	2.3	2.0	2.0	2.0	2.3	2.0	2.0	2.0	2.07
FD_3SD_2	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.7	2.08
FD_3SD_3	2.3	2.0	2.0	2.3	2.0	2.0	2.0	2.7	2.16
FD_3SD_4	2.7	2.3	2.0	2.0	2.0	2.0	2.0	2.7	2.21
Mean	2.45	2.17	2.0	2.1	2.02	2.05	2.00	2.30	

CD for comparing means

Fruit drying x Seed drying interaction NS
Fruit drying x Seed drying x month interaction NS

Table 4a. Overall mean effect of various methods of fruit drying and seed drying on germination percentage of okra seeds

Treatments	Months after storage								
	0	1	2	3	4	5	6	7	Mean
FD_1	70.0 (0.784)	64.0 (0.714)	74.7 (0.853)	55.0 (0.593)	73.2 (0.827)	74.0 (0.840)	59.3 (0.643)	58.3 (0.632)	66.06 (0.735)
FD_2	71.7 (0.812)	60.3 (0.657)	74.0 (0.843)	54.0 (0.579)	71.7 (0.817)	73.0 (0.820)	58.0 (0.625)	55.0 (0.589)	64.71 (0.717)
FD_3	75.3 (0.866)	64.3 (0.741)	77.0 (0.893)	54.3 (0.594)	74.0 (0.856)	69.0 (0.781)	72.0 (0.839)	65.3 (0.725)	68.90 (0.736)
SD_1	73.3 (0.833)	58.7 (0.638)	72.0 (0.811)	47.1 (0.494)	76.9 (0.892)	68.4 (0.759)	65.8 (0.730)	62.2 (0.680)	65.55 (0.729)
SD_2	77.8 (0.896)	78.2 (0.913)	83.0 (0.988)	54.7 (0.589)	73.1 (0.840)	74.2 (0.847)	67.6 (0.760)	63.0 (0.695)	71.46 (0.816)
SD_3	61.8 (0.676)	52.0 (0.555)	72.0 (0.816)	61.3 (0.668)	69.8 (0.779)	70.2 (0.793)	52.9 (0.564)	53.3 (0.568)	61.66 (0.677)
SD_4	72.3 (0.877)	62.7 (0.709)	74.4 (0.836)	54.7 (0.603)	72.0 (0.821)	75.1 (0.855)	66.2 (0.756)	59.6 (0.652)	67.22 (0.763)
Mean	71.74 (0.820)	62.88 (0.703)	75.42 (0.862)	54.44 (0.588)	72.95 (0.833)	71.98 (0.813)	63.11 (0.702)	59.67 (0.648)	

CD for comparing means

Fruit drying N.S.
Seed drying 3.93**
Month mean 5.56**
NS - non-significant
** Significant at 1% level
Figures in brackets are arc-sine transformed values

Table 4b. Overall mean effect of various combination of fruit drying and seed drying on germination percentage in okra

Treatment combination	Months after treatment								
	0	1	2	3	4	5	6	7	Mean
FD_1SD_1	68.0 (0.748)	54.7 (0.579)	65.3 (0.712)	42.7 (0.444)	80.0 (0.927)	65.3 (0.714)	60.0 (0.649)	62.7 (0.690)	62.33 (0.682)
FD_1SD_2	76.0 (0.863)	84.0 (1.008)	82.7 (0.979)	58.7 (0.627)	76.7 (0.880)	77.3 (0.886)	64.0 (0.697)	58.7 (0.638)	72.26 (0.822)
FD_1SD_3	65.3 (0.739)	65.3 (0.719)	76.0 (0.868)	69.3 (0.770)	72.0 (0.807)	77.3 (0.888)	57.3 (0.617)	61.3 (0.669)	67.97 (0.759)
FD_1SD_4	70.7 (0.786)	52.0 (0.551)	74.7 (0.852)	49.3 (0.531)	64.0 (0.695)	76.0 (0.873)	56.0 (0.608)	50.7 (0.532)	61.67 (0.678)
FD_2SD_1	74.7 (0.861)	61.3 (0.668)	73.3 (0.835)	50.7 (0.532)	77.3 (0.909)	72.0 (0.805)	60.0 (0.646)	54.7 (0.583)	61.67 (0.729)
FD_2SD_2	74.7 (0.852)	72.0 (0.805)	80.0 (0.929)	53.3 (0.568)	66.7 (0.752)	69.3 (0.766)	60.0 (0.660)	58.7 (0.612)	66.83 (0.743)
FD_2SD_3	60.0 (0.644)	52.0 (0.549)	74.7 (0.858)	62.7 (0.677)	77.3 (0.886)	76.0 (0.863)	57.3 (0.614)	61.3 (0.532)	65.16 (0.702)
FD_2SD_4	77.3 (0.891)	56.0 (0.607)	68.0 (0.750)	49.3 (0.537)	65.3 (0.719)	74.7 (0.846)	54.7 (0.579)	57.3 (0.628)	62.82 (0.694)
FD_3SD_1	77.3 (0.891)	60.0 (0.670)	77.3 (0.885)	48.0 (0.506)	73.3 (0.840)	58.0 (0.759)	77.3 (0.894)	72.0 (0.811)	69.15 (0.781)
FD_3SD_2	82.7 (0.974)	78.7 (0.925)	86.7 (1.057)	52.0 (0.571)	76.0 (0.889)	76.0 (0.889)	78.7 (0.923)	70.7 (0.740)	75.18 (0.877)
FD_3SD_3	60.0 (0.646)	38.7 (0.398)	65.3 (0.723)	52.0 (0.558)	60.0 (0.644)	57.3 (0.628)	44.0 (0.460)	48.0 (0.540)	53.16 (0.577)
FD_3SD_4	81.3 (0.953)	80.0 (0.970)	78.7 (0.906)	65.3 (0.742)	86.7 (1.050)	74.7 (0.846)	88.0 (1.080)	70.7 (0.795)	78.17 (0.917)
Mean	71.74 (0.820)	62.88 (0.703)	75.70 (0.862)	54.40 (0.588)	73.30 (0.833)	71.00 (0.813)	62.11 (0.702)	59.60 (0.648)	

CD for comparing means
Fruit drying x Seed drying interaction 6.81**
Fruit drying x Seed drying x month interaction NS

NS Non significant
** Significant at 1% level

The overall mean for fruit drying x seed drying x month interaction was found to be non-significant.

4.2.3 Root length

Different methods of fruit drying as well as seed drying was found to be non-significant.

The overall mean for root length of seedling for different months differed significantly. The highest root length was recorded after seventh month (8.36 cm) and the lowest mean root length was recorded during first month (2.74 cm) of seed drying (Table 5a and 5b).

The overall mean for different fruit drying x seed drying x month interaction was not significant.

4.2.4 Shoot length

The different methods of fruit drying and seed drying had no significant effect on shoot length of seedling.

The overall mean for different months had significant effect on shoot length. Shoot length was maximum (14.81 cm) immediately after harvest and the lowest was recorded (12.92 cm) after seven months of storage (Table 6a and 6b).

Different methods of fruit drying x seed drying x month interaction was found to be non-significant.

Table 5a. Overall mean effect of various methods of fruit drying and seed drying on root length (cm) of okra seedlings

Treatments	Months after storage								
	0	1	2	3	4	5	6	7	Mean
FD_1	3.29	2.85	4.60	6.64	6.34	6.06	6.26	8.93	5.62
FD_2	3.27	2.91	4.62	6.60	6.20	5.61	6.43	8.41	5.50
FD_3	3.29	2.17	5.37	7.11	6.87	5.91	6.30	7.74	5.97
SD_1	3.36	2.78	4.45	6.90	5.98	5.60	6.81	9.39	5.65
SD_2	3.16	3.03	4.65	6.72	6.87	6.19	6.11	8.43	5.64
SD_3	3.23	2.79	5.09	6.79	6.54	5.62	6.28	5.79	5.51
SD_4	3.38	2.70	5.33	6.72	6.49	6.07	6.14	7.83	5.58
Mean	3.28	2.74	4.87	6.78	6.47	5.86	6.33	8.36	

CD for comparing means

Fruit drying NS
Seed drying NS
Month mean 0.57**
NS - non-significant
** Significant at 1% level

Table 5b. Overall mean effect of various combination of fruit drying and seed drying on rool length (cm) of okra seedlings

Treatment combination	Months after treatment								
	0	1	2	3	4	5	6	7	Mean
FD_1SD_1	3.33	3.12	4.66	3.77	6.38	5.83	5.72	10.83	5.81
FD_1SD_2	3.22	3.10	4.28	6.64	7.22	6.06	6.24	7.91	5.58
FD_1SD_3	3.36	2.86	5.13	7.22	6.48	5.98	7.17	8.90	5.89
FD_1SD_4	3.26	2.30	4.74	5.94	5.27	6.38	5.98	8.10	5.25
FD_2SD_1	3.13	2.88	4.38	6.70	5.23	5.45	6.95	9.63	5.54
FD_2SD_2	3.18	2.96	4.04	6.60	6.72	5.79	6.26	8.53	5.51
FD_2SD_3	3.06	2.93	4.92	6.41	5.86	5.46	6.19	7.45	5.29
FD_2SD_4	3.72	2.88	4.77	6.68	7.02	5.76	6.32	8.04	5.65
FD_3SD_1	3.63	2.33	4.51	7.23	6.34	5.54	7.76	7.72	5.63
FD_3SD_2	3.09	3.03	5.22	6.73	7.30	5.42	5.50	7.03	5.73
FD_3SD_3	3.26	2.58	5.22	6.73	7.30	5.42	5.50	7.03	5.38
FD_3SD_4	3.18	2.92	6.47	7.55	7.19	6.06	6.12	7.36	5.36
Mean	3.28	2.74	4.87	6.78	6.47	5.86	6.33	8.36	

CD for comparing means

Fruit drying x Seed drying interaction NS
Fruit drying x Seed drying x month interaction NS

NS Non significant

Table 6a. Overall mean effect of various methods of fruit drying and seed drying on shoot length (cm) of okra seedlings

Treatments	Months after storage								
	0	1	2	3	4	5	6	7	Mean
FD_1	15.10	13.03	15.42	14.04	14.37	15.85	13.84	13.10	14.34
FD_2	14.93	14.03	15.07	13.69	13.99	15.61	13.62	13.06	24.24
FD_3	14.43	13.66	14.93	13.85	14.19	15.97	13.60	12.66	14.16
SD_1	14.40	13.52	15.26	13.99	14.27	15.83	13.88	13.04	14.27
SD_2	15.22	13.86	15.41	13.70	14.28	16.03	13.81	13.37	14.46
SD_3	14.88	13.55	15.04	14.16	13.98	15.51	13.64	12.21	14.12
SD_4	14.77	13.77	14.88	13.59	14.10	15.86	13.46	13.08	14.18
Mean	14.81	13.63	15.14	13.86	14.16	15.80	13.68	12.92	

CD for comparing means

Fruit drying NS
Seed drying NS
Month mean 0.44**
NS - non-significant
** Significant at 1% level

Table 6b. Overall mean effect of various combination of fruit drying and seed drying on shoot length (cm) okra seedlings

Treatment combination	Months after treatment								
	0	1	2	3	4	5	6	7	Mean
FD_1SD_1	14.18	13.40	15.71	14.24	14.13	15.36	13.84	13.26	14.27
FD_1SD_2	14.99	12.96	15.43	13.72	14.35	16.10	14.16	13.13	14.36
FD_1SD_3	14.79	12.78	15.52	14.12	14.72	15.76	14.04	12.94	14.33
FD_1SD_4	16.44	14.05	15.04	14.07	14.26	16.18	13.30	13.08	14.68
FD_2SD_1	14.87	14.14	15.55	13.90	13.89	15.77	13.62	12.88	14.33
FD_2SD_2	15.42	14.40	15.04	13.52	14.69	15.84	13.69	13.50	14.51
FD_2SD_3	15.54	14.13	15.16	14.38	13.52	16.00	13.71	12.34	14.35
FD_2SD_4	14.27	13.46	14.53	12.98	13.86	14.83	13.48	13.35	13.85
FD_3SD_1	14.53	13.02	14.53	13.83	14.79	16.37	14.18	12.98	13.03
FD_3SD_2	15.26	14.23	15.76	13.86	13.80	16.15	13.58	13.48	14.58
FD_3SD_3	14.31	13.75	14.40	13.98	13.72	14.77	13.18	11.30	13.67
FD_3SD_4	13.60	13.66	15.07	13.74	14.44	16.58	13.47	12.83	14.17
Mean	14.81	13.63	15.14	13.86	14.16	15.80	13.68	12.32	

CD for comparing means

Fruit drying x Seed drying interaction	NS
Fruit drying x Seed drying x month interaction	NS

NS Non significant

4.2.5 Speed of germination

Different methods of fruit drying had significant effect on speed of germination. The highest speed of germination (20.73) was recorded in seeds from fruits dried using mechanical drier. The lowest speed of germination (18.79) was recorded for seeds from fruits dried under direct sun light (Table 7a).

Various methods of seed drying had significant effect on speed of germination. The highest speed of germination (21.37) was recorded for seeds dried by sun light (Table 7a).

The overall mean for different months differed significantly. The highest (23.60) was recorded immediately after drying and the lowest (12.57) was recorded after three months of storage.

The overall mean for different fruit drying x seed drying interaction was also found to be significant. The lowest speed of germination (16.60) was recorded for fruit drying using mechanical drier followed by seeds dried using mechanical drier. The highest speed of germination (23.06) was recorded for the combination of fruits dried using mechanical drier followed by seeds dried initially under shade followed by sun light avoiding the peak hours (12 noon to 3 pm) (Table 7b).

Table 7a. Overall mean effect of various methods of fruit drying and seed drying on speed of germination of okra seeds

Treatments	Months after storage								
	0	1	2	3	4	5	6	7	Mean
FD_1	22.68	16.27	21.79	13.18	23.31	19.98	21.86	18.19	19.65
FD_2	22.09	15.23	21.38	11.97	22.95	18.69	21.07	17.01	18.79
FD_3	25.74	16.10	21.73	12.56	24.03	19.00	26.86	19.87	20.73
SD_1	22.53	14.26	21.22	10.91	24.20	18.14	23.20	18.38	19.01
SD_2	26.47	20.21	23.53	12.97	23.69	20.29	24.42	19.38	21.37
SD_3	21.76	13.27	20.53	13.76	22.40	18.95	20.49	16.64	18.47
SD_4	23.25	15.74	21.25	12.64	23.43	19.51	24.95	18.88	20.48
Mean	23.60	15.86	21.63	12.57	23.43	19.22	23.12	18.33	

CD for comparing means

Fruit drying 1.07**
Seed drying 1.24**
Month mean 1.76**
** Significant at 1% level

Table 7b. Overall mean effect of various combination of fruit drying and seed drying on speed of germination in okra

Treatment combination	Months after treatment								
	0	1	2	3	4	5	6	7	Mean
FD_1SD_1	20.22	13.31	18.79	10.02	24.31	17.33	21.44	19.73	18.14
FD_1SD_2	26.32	20.98	23.80	14.65	24.60	21.15	22.82	17.37	21.14
FD_1SD_3	21.99	17.09	22.51	15.69	23.44	20.65	22.26	20.15	20.47
FD_1SD_4	22.19	13.71	22.06	12.37	20.89	20.79	20.93	15.51	18.55
FD_2SD_1	23.21	14.91	21.38	11.90	24.77	17.95	21.00	16.04	18.89
FD_2SD_2	23.80	19.22	24.06	11.94	21.91	19.69	20.44	17.06	19.69
FD_2SD_3	19.33	12.87	19.95	13.43	24.49	20.46	21.24	14.93	18.33
FD_2SD_4	21.99	13.93	20.15	10.63	20.64	17.26	21.62	20.02	18.28
FD_3SD_1	24.15	14.55	23.53	10.82	23.53	19.17	27.15	22.37	20.65
FD_3SD_2	29.25	20.44	22.73	12.31	24.55	20.62	30.00	21.18	22.63
FD_3SD_3	23.93	9.84	19.13	12.17	19.26	15.73	17.97	14.74	16.60
FD_3SD_4	25.77	17.58	21.53	14.93	28.77	20.48	32.31	21.11	23.06
Mean	23.60	15.86	21.63	12.57	23.43	19.22	23.12	18.33	

CD for comparing means

Fruit drying x Seed drying interaction 2.5**
Fruit drying x Seed drying x month interaction NS

NS Non significant
** Significant at 1% level

4.2.7 Vigour index

The overall mean for different fruit drying methods differed significantly. The highest vigour index was recorded for seeds from fruits dried using mechanical drier. The lowest vigour index was recorded by seeds from fruits dried under direct sun light (Table 8a).

Different methods of seed drying had significant effect. The highest, vigour index was recorded (1432.88) for seeds dried under direct sun light. The minimum vigour index was recorded for seeds dried using mechanical drier.

The overall mean for different months was found to be significant. The highest vigour index was recorded (1307.67) immediately after drying. The lowest vigour index was recorded one month after storage.

The overall mean for different combination of fruit drying x seed drying was found to be significant. The highest vigour index was recorded (1549.88) for fruits dried using mechanical drier followed by seeds dried initially in shade followed by direct sun light avoiding the peak hours. The lowest vigour index (1086.27) was recorded by the combination of fruits dried using mechanical drier followed by seeds dried using mechanical drier (Table 8b).

Table 8a. Overall mean effect of various methods of fruit drying and seed drying on vigour index of okra seedling

Treatments	Months after storage								
	0	1	2	3	4	5	6	7	Mean
FD_1	1276.8	1050.2	1499.8	1155.7	1520.4	1584.1	1178.9	1307.3	1321.65
FD_2	1285.8	1008.2	1465.9	1125.8	1436.3	1534.8	1172.2	1178.3	1275.91
FD	1360.5	1059.4	1579.6	1184.3	1564.0	1589.0	1451.9	1340.7	1391.17
SD_1	1279.3	953.2	1421.6	1024.0	1572.4	1446.7	1363.8	1394.8	1309.22
SD_2	1390.3	1346.2	1681.3	1140.1	1543.8	1628.0	1336.1	1397.8	1432.88
SD_3	1142.3	837.6	1467.1	1258.2	1424.1	1573.8	1067.3	1090.8	1232.55
SD_4	1400.7	1020.1	1490.3	1198.8	1487.3	1628.8	1303.4	1238.7	1346.01
Mean	1307.67	1039.27	1515.08	1155.27	1506.69	1569.30	1267.50	1278.30	

CD for comparing means

Fruit drying 83.10**
Seed drying 95.90**
Month mean 135.71**
** Significant at 1% level

Table 8b. Overall mean effect of various combination of fruit drying and seed drying on vigour index in okra

Treatment combination	Months after treatment								
	0	1	2	3	4	5	6	7	Mean
FD_1SD_1	1191.3	897.0	1324.7	8767.0	1638.3	1294.0	1137.0	1537.0	1237.00
FD_1SD_2	1281.3	1456.7	1633.0	1210.0	1642.7	1716.0	1265.0	1253.3	1432.25
FD_1SD_3	1152.3	1015.7	1569.7	1490.7	1533.7	1679.3	1217.3	1368.3	1378.37
FD_1SD_4	1482.0	831.3	1471.3	1045.3	1267.0	1647.0	1069.3	1070.3	1235.43
FD_2SD_1	1316.0	1045.3	1467.0	1049.0	1531.3	1542.7	1236.3	1162.0	1293.70
FD_2SD_2	1366.3	1220.7	1565.0	1092.7	1395.7	1499.3	1205.7	1273.3	1327.33
FD_2SD_3	1102.3	864.7	1507.0	1246.0	1495.8	1507.0	1165.3	984.7	1233.28
FD_2SD_4	1358.0	902.3	1330.7	1115.7	1323.0	1590.3	1081.3	1293.0	1249.32
FD_3SD_1	1384.7	917.3	1473.0	1146.3	1547.7	1503.3	1718.0	1485.3	1396.95
FD_3SD_2	1523.3	1361.3	1845.7	1117.7	1593.0	1668.7	1537.0	1605.3	1531.50
FD_3SD_3	1172.3	632.3	1330.7	1038.0	1243.3	1535.0	819.3	919.3	1086.27
FD_3SD_4	1361.7	1326.7	1669.0	1435.3	1872.0	1649.0	1732.7	1352.7	1549.88
Mean	1307.07	1309.27	1515.08	1155.27	1506.69	1569.30	1267.56	1278.30	

CD for comparing means

Fruit drying x Seed drying interaction 166.21**
Fruit drying x Seed drying x month interaction NS

NS Non significant
** Significant at 1% level

4.2.8 Seedling dry weight

Different methods of fruit drying and seed drying had no significant effect on seedling dry weight.

The overall mean of seedling dry weight for different months differed significantly. Seeds immediately after harvest had the maximum seedling dry weight (35.23) while the minimum was recorded (26.61) after four months after storage (Table 9a and 9b).

The overall mean for different combination of fruit drying x seed drying had no significant effect on seedling dry weight.

4.2.9 Electrical conductivity of seed leachate

There was no significant difference for the overall mean electrical conductivity of seed leachate under different methods of fruit drying.

The overall mean for different seed drying methods had significant effect on electrical conductivity of seed leachate. The highest mean electrical conductivity (0.176 dSm^{-1}) was recorded for seeds dried using mechanical drier, the lowest (0.161 dSm^{-1}) was recorded for seeds dried under shade (Table 10a).

Table 9a. Overall mean effect of various methods of fruit drying and seed drying on seedling dry weight mg per seedling in okra

Treatments	Months after storage								
	0	1	2	3	4	5	6	7	Mean
FD_1	31.65	28.53	30.76	29.03	27.56	31.67	29.71	27.21	29.51
FD_2	38.73	28.35	30.73	28.65	25.34	30.65	30.36	27.49	30.03
FD_3	35.31	29.57	31.58	28.84	26.95	30.98	30.63	27.02	30.11
SD_1	34.07	28.22	30.70	29.02	26.56	29.86	30.40	28.14	29.62
SD_2	36.62	30.32	31.57	28.76	27.39	30.23	28.48	28.18	30.14
SD_3	35.79	28.97	31.40	29.01	26.43	31.28	30.91	25.13	29.86
SD_4	34.44	27.74	30.42	28.39	26.10	30.56	31.13	27.57	29.54
Mean	35.23	28.81	31.02	28.80	26.61	30.74	30.23	27.28	

CD for comparing means

Fruit drying NS
Seed drying NS
Month mean 1.94**
NS - non-significant
** Significant at 1% level

Table 9b. Overall mean effect of various combination of fruit drying and seed drying on seedling dry weight (mg per seedling) in okra

Treatment combination	Months after treatment								
	0	1	2	3	4	5	6	7	Mean
FD_1SD_1	35.60	29.32	31.21	29.83	27.06	30.10	29.60	26.99	29.96
FD_1SD_2	32.04	29.52	30.72	26.06	27.47	34.00	28.46	24.68	29.48
FD_1SD_3	21.21	27.23	30.61	30.42	28.19	31.20	32.98	27.62	28.68
FD_1SD_4	30.06	28.04	30.52	29.80	27.51	29.35	27.80	26.58	28.70
FD_2SD_1	38.43	26.20	29.79	30.35	24.52	28.82	29.88	28.66	17.36
FD_2SD_2	38.57	29.32	31.42	29.46	26.54	31.82	28.22	27.43	30.34
FD_2SD_3	41.25	30.56	37.97	27.86	26.64	31.42	31.90	26.82	31.05
FD_2SD_4	36.68	27.32	29.63	26.94	23.67	30.56	31.43	27.06	27.16
FD_3SD_1	28.48	29.16	31.01	27.42	28.07	30.66	31.71	28.78	29.41
FD_3SD_2	39.26	32.13	32.57	30.76	28.18	30.26	28.78	29.30	31.40
FD_3SD_3	36.93	29.14	31.63	28.74	24.46	31.22	27.86	20.95	28.86
FD_3SD_4	36.60	27.85	31.13	28.42	27.11	31.67	34.17	29.06	30.14
Mean	35.23	28.81	31.02	28.80	26.61	30.74	30.23	27.28	

CD for comparing means

Fruit drying x Seed drying interaction NS
Fruit drying x Seed drying x month interaction NS

NS Non significant

Table 10a. Overall mean effect of various methods of fruit drying and seed drying on electrical conductivity (dSm^{-1}) of seed leachate of okra seeds

Treatments	Months after storage								
	0	1	2	3	4	5	6	7	Mean
FD_1	0.134	0.170	0.204	0.133	0.124	0.184	0.213	0.189	0.188
FD_2	0.154	0.169	0.194	0.134	0.139	0.157	0.204	0.193	0.168
FD_3	0.135	0.164	0.167	0.154	0.139	0.163	0.202	0.199	0.165
SD_1	0.136	0.168	0.170	0.145	0.132	0.156	0.193	0.189	0.161
SD_2	0.140	0.178	0.198	0.131	0.124	0.166	0.215	0.186	0.167
SD_3	0.152	0.160	0.206	0.143	0.150	0.186	0.217	0.200	0.176
SD_4	0.135	0.164	0.184	0.141	0.130	0.162	0.201	0.191	0.163
Mean	0.167	0.140	0.189	0.181	0.164	0.167	0.206	0.168	

CD for comparing means

Fruit drying NS
Seed drying 0.006**
Month mean 0.009**
NS - non-significant
** Significant at 1% level

Table 10b. Overall mean effect of various combination of fruit drying and seed drying on (dSm^{-1}) of seed leachate of okra

Treatment combination	Months after treatment								
	0	1	2	3	4	5	6	7	Mean
FD_1SD_1	0.119	0.162	0.189	0.151	0.116	0.169	0.206	0.191	0.166
FD_1SD_2	0.155	0.211	0.214	0.131	0.141	0.187	0.225	0.199	0.182
FD_1SD_3	0.137	0.140	0.222	0.134	0.130	0.201	0.211	0.178	0.169
FD_1SD_4	0.127	0.166	0.193	0.115	0.110	0.178	0.211	0.189	0.161
FD_2SD_1	0.172	0.189	0.164	0.128	0.157	0.156	0.198	0.190	0.168
FD_2SD_2	0.146	0.159	0.197	0.114	0.109	0.156	0.206	0.187	0.159
FD_2SD_3	0.156	0.162	0.221	0.138	0.155	0.172	0.210	0.187	0.175
FD_2SD_4	0.140	0.166	0.193	0.156	0.144	0.142	0.203	0.208	0.169
FD_3SD_1	0.116	0.154	0.157	0.156	0.132	0.144	0.174	0.185	0.152
FD_3SD_2	0.120	0.164	0.168	0.149	0.122	0.150	0.215	0.202	0.161
FD_3SD_3	0.165	0.179	0.175	0.158	0.166	0.185	0.228	0.235	0.186
FD_3SD_4	0.168	0.159	0.167	0.153	0.136	0.166	0.188	0.175	
Mean	0.167	0.140	0.189	0.181	0.164	0.167	0.206	0.168	

CD for comparing means

Fruit drying x Seed drying interaction 0.011**
Fruit drying x Seed drying x month interaction NS

NS Non significant
** Significant at 1% level

The overall electrical conductivity of seed leachate at different months of treatment had significant effect. The highest (0.206 dSm^{-1}) was recorded after six months of storage and the lowest (0.140 dSm^{-1}) was recorded after one month of storage (Table 10a and 10b).

The overall mean for different fruit drying x seed drying did not differ significantly (Table 10b).

4.3 Effect of storage containers and storage conditions on seed quality in okra

Studies were conducted in okra with a view to find out the effect of the packing materials and storage conditions on seed quality in okra. For this six packing materials were used. They were stored under three storage conditions. Analysis of variance of the data is given in Appendix IV.

4.3.1 Hundred seed weight

Overall mean for effect of different storage containers on hundred seed weight of okra differed significantly. It was seen that seeds stored in 200 gauge polythene bag had the lowest (6.22 g) 100 seed weight. The highest 100 seed weight (6.9 g) was recorded for seeds stored in plastic container (Table 11a).

Table 11a. Overall mean effect of various storage containers, storage conditions on 100 seed weight in okra

Treatments	Months after storage								
	0	1	2	3	4	5	6	7	Mean
T_1	6.71563	6.71398	6.71593	6.84820	6.61073	6.80200	6.96837	7.48175	6.85
T_2	6.84605	6.78007	6.78665	6.32710	6.76980	6.77098	6.60447	7.19707	6.76
T_3	6.16987	6.16918	6.16918	6.22708	6.31825	6.41035	6.41062	6.95043	6.35
T_4	6.28880	6.28047	6.28052	6.28373	6.28522	6.30302	6.30820	6.38355	6.30
T_5	6.25423	6.25447	6.25465	6.25318	6.17742	6.16308	6.16325	6.30503	6.22
T_6	6.86250	6.86083	6.8608	6.70228	6.88478	6.96972	7.03550	7.05783	6.90
C_1	6.47116	6.46922	6.47022	6.41674	6.46332	6.47678	6.59243	6.68768	6.43
C_2	6.39712	6.39362	6.39230	6.39748	6.43488	6.40442	6.40459	6.7337	6.43
C_3	6.69967	6.66667	6.67005	6.50667	6.62491	6.83088	6.74793	7.06645	6.71
Mean	6.51	6.50	6.51	6.43	6.50	6.56	6.56	6.80	

CD for comparing means

Storage containers 0.051**
Storage conditions 0.036**
Month mean 0.029**

** Significant at 1% level

T_1 - Brown paper cover
T_2 - Butter paper cover
T_3 - Cloth bag
T_4 - Polythene bag of 700 gauge thickness
T_5 - Polythene bag of 200 gauge thickness
T_6 - Plastic container
C_1 - Room termperature
C_2 - Air conditioned storage (20 ± 2°C)
C_3 - Storage at 5°C temperature

Table 11b. Overall mean effect of various combination of storage containers and storage conditions on 100 sed weight in okra

Treatment combination	Months after storage								
	0	1	2	3	4	5	6	7	Mean
T_1C_1	6.6209	6.6160	6.6211	6.6419	6.8791	6.3880	6.8837	7.5223	6.76
T_1C_2	6.7884	6.7883	6.7885	6.7892	6.8389	6.8294	6.8330	7.3803	6.81
T_1C_3	6.7376	6.7376	6.7381	7.1141	6.1141	7.1885	7.1884	7.5426	6.91
T_2C_1	6.6941	6.6941	6.6942	6.2964	6.3862	6.4311	6.4319	6.9673	6.23
T_2C_2	6.6415	6.6415	6.6413	6.6404	6.7696	6.7386	6.7383	7.1429	6.74
T_2C_3	7.2025	7.0045	7.0244	6.0444	7.1555	7.1432	6.6431	7.4809	6.96
T_3C_1	5.9733	5.9714	5.9713	6.0086	6.1705	6.2510	6.2529	6.9791	6.19
T_3C_2	5.9120	5.919	5.9120	5.9366	6.0230	6.0736	6.0706	6.6690	6.66
T_3C_3	6.6242	6.6242	6.6242	6.7360	6.7611	6.9064	6.9082	7.2032	6.80
T_4C_1	6.2861	6.2861	6.2862	6.2934	6.2715	6.3014	6.3013	6.3633	6.30
T_4C_2	6.3596	6.3347	6.3347	6.3362	6.3323	6.3206	6.3212	6.3514	6.33
T_4C_3	6.2206	6.2205	6.2205	6.2215	6.2517	6.3019	6.3020	6.4359	6.27
T_5C_1	6.2981	6.2983	6.2988	6.2971	6.0696	6.1807	6.1808	6.3004	6.24
T_5C_2	6.2923	6.2927	6.2928	6.2899	6.2679	6.1618	9.1618	6.3554	6.26
T_5C_3	6.1722	6.1723	6.1723	6.1725	6.1946	6.1467	6.1470	6.2592	6.18
T_6C_1	6.0543	6.9493	6.9494	6.7630	7.0027	7.3083	7.5038	7.1936	7.10
T_6C_2	6.3924	6.3924	6.3923	6.3924	6.3793	6.3023	6.3025	6.5030	6.37
T_6C_3	7.2407	7.2407	7.2406	6.7514	7.2722	7.2984	7.2986	7.4768	7.22
Mean	6.51	6.50	6.51	6.43	6.50	6.56	6.56	6.80	

CD for comparing means
Storage container x Storage condition interaction 0.0896**
Storage container x Storage condition x month interaction 0.252**

** Significant at 1% level

The overall mean for 100 seed weight on different storage conditions showed that there was significant difference among different storage conditions. The highest 100 seed weight of 6.71 g (Table 11a) was recorded for seeds stored under low temperature of 5°C.

The overall mean for different months of storage differed significantly. The highest 100 seed weight of 6.80 g (Table 11a) was recorded after seventh month of storage, whereas, the lowest (6.43 g) 100 seed weight was recorded after three months of storage.

Influence of storage container x storage condition was found to be significant. The seeds packed in 200 gauge thickness polythene bag and kept under low temperature 5°C recorded the lowest (6.18 g) 100 seed weight.

Influence of storage container x storage condition x month interaction showed significant effect on 100 seed weight in okra. Seeds at the time of storage had the highest 100 seed weight of 6.52 g and after sixth month of storage had the lowest 100 seed weight of 6.17 g (Table 11b).

4.3.2 Days to 50 percentage germination

Overall mean for different storage containers, storage conditions on days to 50 percentage germination of okra seeds did not differ significantly.

Overall mean for days to 50 percentage germination had significant effect. Days to 50 percentage germination was highest (4.73) at the time of storage which decreased to the least (3.07 days) after sixth month of storage (Table 12a).

Storage container x month, storage condition x month, storage container x storage condition x month interaction was non-significant (Table 12b).

4.3.3 Germination percentage

Different storage containers had significant effect on germination percentage of okra seeds. Overall mean for various containers showed that seeds packed in 700 gauge thickness had the maximum germination percentage (89.53%). The seeds stored in cloth bag had the lowest germination percentage of 80.75 (Table 13a).

There was no significant effect for different storage conditions on germination of seeds.

The overall mean for different month differed significantly. At the time of storage germination percentage was maximum (96%) which declined to a lowest (72.16%) after seven months of storage (Table 13b).

The overall mean for various storage container x storage condition x month interaction was non significant.

Table 12a. Overall mean effect of various storage containers, storage conditions on days to 50 per cent germination in okra

Treatments	Months after storage								
	0	1	2	3	4	5	6	7	Mean
T_1	4.5	4.7	4.0	4.0	3.0	3.2	3.0	4.2	3.83
T_2	4.5	5.0	4.0	4.2	3.0	3.2	3.0	1.2	3.51
T_3	5.2	3.8	3.7	3.5	3.0	3.2	3.2	4.3	3.74
T_4	4.3	3.0	4.0	4.2	2.7	3.2	3.2	3.7	3.54
T_5	5.2	3.8	4.2	4.2	3.2	3.3	3.3	2.8	3.75
T_6	4.7	2.8	4.3	4.2	2.5	3.2	2.7	4.7	3.64
C_1	4.8	3.9	3.9	4.3	3.0	3.0	2.8	3.2	3.61
C_2	5.1	4.1	3.9	4.1	3.0	3.1	3.3	3.9	3.81
C_3	4.3	3.6	4.3	3.8	2.7	3.5	3.2	3.3	3.59
Mean	4.73	3.85	4.03	4.07	2.90	3.21	3.07	3.48	

CD for comparing means

Storage containers NS
Storage conditions NS
Month mean 0.074*

NS Non significant
* Significant at 5% level

Table 12b. Overall mean effect of various combinations of storage containers and storage conditions on days to 50 per cent germination in okra

Treatment combination	Months after storage								
	0	1	2	3	4	5	6	7	Mean
T_1C_1	4.5	5.0	4.0	4.5	3.0	3.0	3.0	4.5	3.94
T_1C_2	5.0	5.0	4.0	4.0	3.0	3.5	3.0	3.5	3.88
T_1C_3	4.0	4.0	4.0	3.5	3.0	3.0	3.0	4.5	3.63
T_2C_1	5.0	4.0	4.0	3.0	3.0	3.0	3.0	2.0	3.38
T_2C_2	4.5	5.0	4.0	4.5	3.0	3.0	3.0	1.5	3.50
T_2C_3	3.5	6.0	4.0	5.0	3.0	3.5	3.0	6.0	4.25
T_3C_1	3.5	5.5	3.5	3.5	3.0	3.0	3.0	4.0	3.63
T_3C_2	6.0	3.0	4.0	3.0	3.0	3.0	3.0	4.5	4.06
T_3C_3	6.0	3.0	3.5	4.0	3.0	3.5	3.5	4.5	3.88
T_4C_1	5.5	2.5	4.0	4.5	3.0	3.0	3.0	1.5	3.38
T_4C_2	4.0	4.5	4.0	4.5	3.0	3.0	3.0	5.5	3.94
T_4C_3	3.5	2.0	4.0	3.5	2.0	3.5	3.5	4.0	3.25
T_5C_1	5.5	2.5	4.0	5.5	3.0	3.0	3.0	2.0	3.56
T_5C_2	5.5	5.5	3.5	5.0	3.0	3.0	4.0	4.0	4.19
T_5C_3	4.5	3.5	5.0	2.0	3.5	4.0	3.0	2.5	3.63
T_6C_1	4.5	4.0	4.0	4.5	3.0	3.0	1.5	5.0	3.19
T_6C_2	5.5	1.5	4.0	3.5	3.0	3.0	3.5	4.5	3.56
T_6C_3	4.0	3.0	5.0	4.5	1.5	3.5	3.0	4.5	3.63
Mean	4.73	3.85	4.03	4.07	2.90	3.21	3.07	3.48	

CD for comparing means

Storage container x Storage condition interaction NS
Storage container x Storage condition x month interaction NS

NS Non significant

Table 13a. Overall mean effect of various storage containers, storage conditions on germination percentage in okra seeds

Treatments	Months after storage								
	0	1	2	3	4	5	6	7	Mean
T_1	96.0 (1.287)	96.0 (1.173)	90.0 (1.124)	84.7 (1.024)	84.0 (1.018)	79.3 (0.932)	76.7 (0.880)	66.3 (0.734)	83.63 (0.916)
T_2	96.0 (1.287)	92.0 (1.177)	88.7 (1.094)	82.7 (0.989)	87.3 (1.063)	84.7 (1.031)	75.3 (0.855)	68.3 (0.757)	84.38 (1.030)
T_3	96.0 (1.287)	86.0 (1.039)	84.7 (1.016)	84.0 (1.004)	81.3 (0.967)	79.3 (0.919)	70.7 (0.789)	64.0 (0.697)	80.75 (1.093)
T_4	96.0 (1.287)	92.0 (1.184)	93.3 (1.208)	91.3 (1.164)	89.3 (1.117)	88.7 (1.104)	85.3 (1.035)	80.3 (0.937)	89.53 (1.120)
T_5	96.0 (1.287)	86.7 (1.064)	88.0 (1.091)	84.3 (1.019)	84.7 (1.024)	83.3 (1.989)	80.0 (0.931)	75.3 (0.801)	84.79 (1.150)
T_6	96.0 (1.287)	90.7 (1.149)	92.7 (1.192)	88.7 (1.123)	88.7 (1.104)	87.3 (1.075)	83.3 (0.993)	79.3 (0.923)	88.34 (1.100)
C_1	96.0 (1.287)	89.0 (1.048)	89.3 (1.101)	86.3 (1.044)	86.7 (1.007)	85.0 (1.021)	77.0 (0.893)	67.7 (0.788)	84.63 (1.020)
C_2	96.0 (1.287)	90.3 (1.132)	90.3 (1.117)	85.7 (1.036)	85.7 (1.077)	83.3 (0.959)	81.0 (0.924)	71.5 (0.813)	85.84 (1.040)
C_3	96.0 (1.287)	90.3 (1.212)	89.0 (1.143)	86.0 (1.081)	85.3 (1.061)	83.0 (1.044)	79.7 (0.925)	76.7 (0.853)	85.75 (1.070)
Mean	96.0 (1.287)	89.89 (1.130)	89.56 (1.120)	85.97 (1.054)	85.89 (1.048)	83.77 (1.119)	78.78 (0.913)	72.16 (0.814)	

CD for comparing means

Storage containers	2.64**
Storage conditions	NS
Month mean	1.52**

NS Non significant
* Significant at 5% level
** Significant at 1% level

Table 13b. Overall mean effect of various combintion of storage containers and storage conditions on germination (%) percentage in okra

Treatments	Months after storage								
	0	1	2	3	4	5	6	7	Mean
T_1C_1	96.0 (1.287)	90.0 (1.122)	90.0 (1.037)	88.0 (1.142)	86.0 (1.142)	82.0 (1.076)	82.0 (0.866)	61.0 (0.559)	84.37 (0.028)
T_1C_2	96.0 (1.287)	92.0 (1.168)	92.0 (1.168)	84.0 (1.002)	84.0 (0.863)	80.0 (0.834)	78.0 (0.997)	78.0 (0.838)	85.50 (1.019)
T_1C_3	96.0 (1.287)	94.0 (1.228)	88.0 (1.168)	82.0 (0.927)	82.0 (1.048)	76.0 (0.885)	70.0 (0.776)	60.0 (0.806)	81.00 (1.015)
T_2C_1	96.0 (1.287)	90.0 (1.076)	88.0 (1.037)	86.0 (0.895)	86.0 (1.016)	86.0 (1.016)	70.0 (0.838)	62.0 (0.804)	83.00 (0.996)
T_2C_2	96.0 (1.287)	92.0 (1.228)	90.0 (1.076)	82.0 (0.930)	88.0 (1.076)	86.0 (0.970)	80.0 (0.863)	74.0 (0.762)	86.00 (1.024)
T_2C_3	96.0 (1.287)	94.0 (1.228)	88.0 (1.168)	80.0 (1.142)	88.0 (1.076)	82.0 (1.107)	76.0 (0.866)	69.0 (0.705)	84.12 (1.072)
T_3C_1	96.0 (1.287)	86.0 (0.997)	86.0 (0.997)	86.0 (1.002)	84.0 (0.927)	80.0 (0.930)	68.0 (0.834)	58.0 (0.724)	80.50 (0.962)
T_3C_2	96.0 (1.287)	88.0 (0.997)	84.0 (1.122)	82.0 (0.962)	80.0 (1.107)	78.0 (0.863)	70.0 (0.811)	68.0 (0.724)	80.75 (0.984)
T_3C_3	96.0 (1.287)	84.0 (1.222)	84.0 (0.927)	84.0 (1.048)	80.0 (0.866)	80.0 (0.962)	74.0 (0.724)	66.0 (0.644)	81.00 (0.960)
T_4C_1	96.0 (1.287)	84.0 (1.083)	84.0 (1.168)	90.0 (1.037)	80.0 (0.866)	90.0 (0.962)	80.0 (0.724)	77.0 (0.644)	87.87 (0.983)
T_4C_2	96.0 (1.287)	94.0 (1.181)	92.0 (1.168)	92.0 (1.228)	88.0 (1.048)	86.0 (1.107)	90.0 (0.762)	82.0 (0.962)	90.50 (1.092)
T_4C_3	96.0 (1.287)	92.0 (1.287)	94.0 (1.287)	92.0 (1.228)	90.0 (1.228)	90.0 (1.037)	86.0 (0.962)	84.0 (0.886)	86.25 (1.157)
T_5C_1	96.0 (1.287)	88.0 (1.927)	90.0 (1.048)	82.0 (1.083)	88.0 (0.927)	86.0 (0.962)	84.0 (0.927)	76.0 (0.749)	84.75 (1.113)
T_5C_2	96.0 (1.287)	86.0 (1.037)	88.0 (1.048)	86.0 (1.048)	84.0 (0.962)	82.0 (0.970)	80.0 (0.863)	76.0 (0.834)	83.50 (1.006)
T_5C_3	96.0 (1.287)	86.0 (1.228)	86.0 (1.083)	86.0 (0.927)	82.0 (1.181)	82.0 (1.037)	76.0 (1.002)	74.0 (1.002)	85.75 (1.093)
T_6C_1	96.0 (1.287)	90.0 (1.083)	90.0 (1.228)	86.0 (1.107)	88.0 (0.962)	86.0 (1.037)	78.0 (0.997)	72.0 (0.930)	88.00 (1.078)
T_6C_2	96.0 (1.287)	90.0 (1.181)	84.0 (1.122)	88.0 (1.048)	88.0 (1.228)	88.0 (1.083)	88.0 (1.048)	82.0 (0.838)	89.75 (1.104)
T_6C_3	96.0 (1.287)	92.0 (1.181)	94.0 (1.228)	92.0 (1.213)	90.0 (1.123)	88.0 (1.107)	84.0 (1.082)	82.0 (1.002)	89.75 (1.291)
Mean	96.00 (1.287)	89.78 (1.130)	88.89 (1.120)	86.00 (1.054)	85.88 (1.048)	88.77 (1.119)	78.56 (1.913)	72.28 (0.814)	

CD for comparing means

Storage container x Storage condition interaction NS
Storage container x Storage condition x month interaction NS

NS Non significant
Figures in bracket arc-sine transformed values

4.3.4 Root length

Overall mean for root length of seedlings indicated that different storage containers, storage conditions had no significant effect on root length of okra seedlings.

The overall mean for different month differed significantly. The lowest root length of 2.75 cm was observed one month after storage, and the highest root length 7.56 cm was recorded after seven month of storage (Table 14a).

Overall mean effect of storage containers x storage condition had no significant effect. Overall mean effect of various storage containers x storage condition x month interaction was found to be significant (Table 14b).

4.3.5 Shoot length

The overall mean for different storage containers, storage condition had no significant effect.

The overall mean for shoot length for different months differed significantly. The highest shoot length (15.59 cm) was recorded five months after storage and the lowest shoot length (12.88 cm) was observed three month after storage (Table 15a and 15b).

The overall mean for shoot length for different storage container x storage condition was found to be non significant.

Table 14a. Overall mean effect of various storage containers, storage conditions on root length (cm) of okra seedlings

Treatments	Months after storage								
	0	1	2	3	4	5	6	7	Mean
T_1	3.25	2.65	4.78	6.49	7.19	5.58	7.34	7.01	5.54
T_2	3.29	2.42	5.24	7.42	7.32	6.21	7.21	7.92	5.88
T_3	3.27	2.98	5.21	7.45	7.95	5.86	6.87	7.66	5.91
T_4	3.63	2.55	5.42	7.42	7.60	6.61	6.08	7.62	5.87
T_5	3.58	3.07	4.77	7.29	7.52	7.02	6.90	7.30	5.93
T_6	3.05	2.83	5.84	7.24	6.43	6.21	7.51	7.18	5.78
C_1	3.27	2.71	4.94	7.53	7.17	6.25	6.53	7.86	5.78
C_2	3.40	2.81	5.12	6.70	7.39	6.33	7.77	7.65	5.89
C_3	3.36	2.72	5.57	7.42	7.44	6.16	6.65	7.83	5.89
Mean	3.34	2.75	5.21	7.21	7.33	6.24	6.98	7.56	

CD for comparing means

Storage containers NS
Storage conditions NS
Month mean 1.27**

NS Non significant
** Significant at 1% level

Table 14b. Overall mean effect of various combinations of storage containers and storage conditions on root length (cm) of okra seedlings

Treatment combination	Months after storage								
	0	1	2	3	4	5	6	7	Mean
T_1C_1	3.35	6.21	4.39	6.21	6.87	6.40	6.19	7.46	5.83
T_1C_2	3.41	6.47	4.53	6.47	7.78	6.66	8.25	7.34	6.36
T_1C_3	3.01	6.79	5.43	6.79	6.94	3.68	7.60	6.24	5.81
T_2C_1	2.92	7.57	4.74	7.57	6.68	4.47	6.25	10.01	6.27
T_2C_2	3.21	6.63	5.74	6.63	7.52	6.87	8.48	6.38	6.43
T_2C_3	3.75	8.06	5.25	8.06	7.70	7.30	6.90	7.39	6.80
T_3C_1	3.31	7.93	5.21	7.93	7.62	6.69	7.83	5.93	6.55
T_3C_2	3.33	7.22	4.37	7.22	7.62	5.41	7.86	7.15	6.27
T_3C_3	3.19	7.21	6.06	7.21	8.61	5.48	4.92	9.90	6.57
T_4C_1	3.39	8.31	5.20	8.31	8.19	6.62	5.85	7.81	6.71
T_4C_2	3.78	6.75	5.50	6.75	7.71	5.96	5.53	11.02	6.62
T_4C_3	3.74	7.25	5.61	7.25	6.91	7.26	6.87	10.03	6.86
T_5C_1	3.65	7.20	4.52	7.20	7.92	7.03	6.30	9.24	6.63
T_5C_2	3.73	6.96	4.57	6.96	7.05	7.47	7.86	6.98	6.50
T_5C_3	3.38	7.10	5.22	7.71	7.60	6.57	6.56	5.70	6.22
T_6C_1	3.04	7.98	5.61	7.98	5.77	6.32	6.80	6.74	6.21
T_6C_2	2.98	6.20	6.05	6.20	6.69	5.64	8.65	7.06	6.18
T_6C_3	3.14	7.54	5.86	7.54	6.83	6.67	7.08	7.74	6.55
Mean	3.34	7.52	5.21	7.21	7.33	6.24	6.98	7.56	

CD for comparing means

Storage container x Storage condition interaction NS
Storage container x Storage condition x month interaction 2.06*

NS Non significant
* Significant at 5% level

Table 15 a. Overall mean effect of various storage containers, storage conditions on shoot length (cm) of okra seedlings

Treatments	Months after storage								
	0	1	2	3	4	5	6	7	Mean
T_1	13.32	13.91	14.61	12.68	13.94	15.72	13.54	12.99	13.84
T_2	14.11	13.86	14.16	13.18	14.00	15.47	13.44	13.14	13.92
T_3	13.17	14.32	14.48	13.35	14.01	15.11	13.31	13.39	13.89
T_4	13.63	13.99	14.60	12.72	13.95	15.82	13.24	13.64	13.95
T_5	12.75	14.10	14.54	12.67	13.87	15.79	13.25	12.94	13.74
T_6	13.54	13.92	14.21	12.66	14.26	15.69	13.39	14.67	13.97
C_1	13.78	14.25	14.24	12.66	14.26	15.69	13.39	14.07	13.94
C_2	13.05	14.10	14.45	12.81	14.20	15.41	13.73	13.69	13.93
C_3	13.42	13.96	14.60	13.14	13.70	15.25	13.20	13.26	13.82
Mean	13.42	14.05	14.43	12.88	14.01	15.59	13.36	13.36	

CD for comparing means

Storage containers	NS
Storage conditions	NS
Month mean	0.592**

NS Non significant
** Significant at 1% level

Table 15b. Overall mean effect of various combinations of storage containers and storage conditions on shoot length (cm) of okra seedling

Treatment combination	Months after storage								
	0	1	2	3	4	5	6	7	Mean
T_1C_1	13.37	13.32	13.96	12.04	13.66	16.70	13.32	13.20	13.60
T_1C_2	12.65	14.49	14.65	12.57	14.57	16.43	13.35	13.67	14.04
T_1C_3	13.95	13.93	15.23	13.45	13.61	14.04	13.95	12.12	13.78
T_2C_1	15.39	14.63	13.67	13.18	13.64	15.15	12.67	13.89	14.02
T_2C_2	13.63	13.71	14.67	12.07	14.44	15.69	14.03	12.83	13.85
T_2C_3	13.33	13.24	14.16	13.66	13.92	15.59	13.62	12.72	13.78
T_3C_1	13.42	14.64	13.95	13.42	14.53	16.70	13.10	12.17	13.99
T_3C_2	12.86	14.39	14.21	13.83	13.77	14.45	14.35	13.96	13.99
T_3C_3	13.23	13.94	15.28	12.80	13.74	14.20	12.50	14.04	13.71
T_4C_1	13.52	14.30	14.59	12.19	13.66	15.98	13.34	12.47	13.75
T_4C_2	14.01	13.97	14.61	12.98	14.35	15.37	12.73	14.46	14.06
T_4C_3	13.70	13.70	14.62	13.00	13.86	16.13	13.66	13.99	14.08
T_5C_1	11.54	14.26	14.30	11.96	14.95	15.92	13.55	13.14	13.70
T_5C_2	13.00	14.59	14.69	12.99	13.69	15.83	13.67	13.02	13.93
T_5C_3	13.71	13.54	14.63	13.07	13.44	15.62	12.54	12.66	13.65
T_6C_1	15.46	14.37	15.02	13.30	14.74	16.38	12.92	13.93	14.51
T_6C_2	12.20	13.47	13.90	11.97	14.38	14.72	14.30	14.25	13.64
T_6C_3	12.96	13.93	13.71	12.91	13.66	15.97	12.95	14.05	13.76
Mean	13.44	14.05	14.46	12.88	14.01	15.59	13.36	13.36	

CD for comparing means

Storage container x Storage condition interaction NS
Storage container x Storage condition x month interaction NS

NS Non significant

4.3.6 Speed of germination

The overall mean of speed of germination for different storage containers was found to be non-significant.

The overall mean for speed of germination for different storage conditions differed significantly. Among the different storage conditions seeds kept under room temperature had the highest speed of germination (23.4) and that kept under low temperature storage 5°C had the lowest (21.42) speed of germination (Table 16a and 16b).

The overall mean of speed of germination for different months differed significantly. The highest speed of germination was recorded after sixth month of storage (26.54) and the lowest speed of germination was recorded after seventh month of storage.

The overall mean for different storage containers and storage conditions was found to be non significant. The overall mean for speed of germination for different storage containers x storage condition x month interaction was found to be significant. Seeds stored in plastic container and kept under low temperature 5°C had the lowest speed of germination (20.58) and the highest speed of germination (24.26) was recorded by seeds stored in butter paper cover and kept under room temperature.

Table 16a. Overall mean effect of various storage containers, storage conditions on speed of germination of okra seeds

Treatments	Months after storage								
	0	1	2	3	4	5	6	7	Mean
T_1	23.79	16.56	21.99	19.32	27.05	25.75	27.71	20.40	22.82
T_2	23.39	17.69	21.14	22.08	29.21	28.16	27.11	15.15	22.99
T_3	20.99	15.98	22.44	22.88	27.19	26.47	27.16	17.09	22.53
T_4	24.75	18.45	21.78	20.07	22.25	24.83	27.15	20.29	22.45
T_5	21.36	14.36	21.19	17.52	25.26	24.83	25.13	16.45	20.76
T_6	24.29	15.94	20.98	17.09	24.21	24.47	24.96	18.43	18.84
C_1	22.40	18.32	23.31	20.69	28.42	28.51	26.16	18.07	23.40
C_2	21.49	15.77	22.19	17.64	26.85	25.63	26.98	17.01	21.69
C_3	24.89	15.39	19.23	21.15	22.32	23.11	26.46	18.83	21.42
Mean	23.03	16.49	21.58	19.83	25.86	25.75	26.54	17.96	

CD for comparing means

Storage containers NS
Storage conditions 1.03**
Month mean 1.31**

NS Non significant
* Significant at 5% level
** Significant at 1% level

Table 16b. Overall mean effect of various combinations of storage containers and storage conditions on speed of germination of okra seeds

Treatment combination	Months after storage								
	0	1	2	3	4	5	6	7	Mean
T_1C_1	21.97	17.73	19.66	17.02	25.66	26.99	30.00	20.83	22.48
T_1C_2	24.92	14.11	24.89	17.64	29.50	24.46	27.90	24.23	23.45
T_1C_3	24.48	17.83	21.43	23.30	26.00	25.79	25.23	16.13	22.57
T_2C_1	21.65	18.89	25.23	26.13	28.67	31.29	24.66	17.63	24.26
T_2C_2	17.62	18.31	19.22	20.03	32.00	30.23	30.00	18.56	23.14
T_2C_3	27.91	15.86	18.98	20.08	26.97	22.96	26.66	19.27	21.08
T_3C_1	24.56	18.78	23.53	21.83	28.33	29.66	26.16	16.96	23.71
T_3C_2	20.40	12.23	21.26	22.68	27.40	25.19	29.33	17.65	22.01
T_3C_3	18.02	16.94	22.53	24.13	25.83	24.56	26.00	16.66	21.83
T_4C_1	20.95	19.68	23.96	18.85	28.13	28.39	27.16	18.37	23.18
T_4C_2	26.36	16.01	23.16	15.91	20.90	24.56	26.50	17.63	21.37
T_4C_3	26.95	19.68	18.23	25.46	17.73	21.56	27.80	24.88	22.70
T_5C_1	22.40	19.81	24.23	20.07	30.73	27.23	29.50	17.03	23.87
T_5C_2	19.23	11.78	21.38	17.30	26.16	26.03	19.83	18.65	20.04
T_5C_3	22.46	11.48	17.96	15.20	18.90	21.23	20.06	13.68	17.62
T_6C_1	22.90	15.03	23.28	20.23	29.00	27.50	19.50	17.59	21.87
T_6C_2	20.43	22.22	23.23	12.32	25.13	23.30	28.33	16.28	21.40
T_6C_3	29.56	10.58	16.27	18.72	18.50	22.60	27.04	21.43	20.58
Mean	23.03	16.49	21.58	19.83	25.86	25.75	26.54	17.96	

CD for comparing means

Storage container x Storage condition interaction NS
Storage container x Storage condition x month interaction*

NS Non significant

4.3.7 Vigour index

The overall mean for vigour index for different containers differed significantly (Table 17a and 17b). The highest vigour index (1788.37) was recorded by the seeds stored in 700 gauge polythene bags. The lowest (1593.65) vigour index was recorded by the seeds stored in cloth bag.

The different storage conditions had no significant effect on vigour index. Overall mean for various combinations of storage containers x storage conditions interaction was not significant. Also different storage containers x storage conditions x month interaction was not significant.

4.3.8 Seedling dry weight

The overall mean of seedling dry weight for different storage containers had no significant effect. Also overall means for different storage conditions had no significant effect on seedling dry weight.

Overall means of seedling dry weight for different months of storage differed significantly. The maximum seedling dry weight (31.76 mg per seedling) was recorded after six months of storage. The minimum was recorded after seven month of storage (Table 18a and 18b).

Table 17a. Overall mean effect of various storage containers, storage conditions on vigour index of okra seedlings

Treatments	Months after storage								
	0	1	2	3	4	5	6	7	Mean
T_1	1588.02	1524.97	1743.29	1618.93	1763.44	1701.15	1598.38	1326.89	1608.73
T_2	1661.60	1497.97	1721.96	1687.61	1857.61	1813.78	1560.36	1439.23	1654.83
T_3	1582.59	1492.72	1669.70	1745.44	1812.69	1664.05	1425.83	1346.21	1593.65
T_4	1657.44	1521.52	1871.28	1848.72	1896.53	1987.97	1547.25	1876.31	1788.37
T_5	1568.50	1483.18	1699.92	1666.74	1813.18	1899.44	1599.66	1536.06	1658.34
T_6	1688.96	1520.93	1857.24	1762.18	1836.78	1580.90	1672.25	1687.84	1712.13
C_1	1638.89	1508.18	1716.34	1739.44	1844.49	1723.68	1523.10	1434.04	1641.02
C_2	1635.62	1535.22	1771.30	1657.98	1844.33	1812.27	1730.59	1643.78	1703.89
C_3	1599.04	1477.24	1794.05	1767.39	1801.07	1787.19	1543.17	1533.45	1662.82
Mean	1624.53	1506.88	1760.56	1721.60	1829.96	1774.38	1598.95	1537.09	

CD for comparing means

Storage containers 86.75**
Storage conditions NS

** Significant at 1% level
NS Non significant

Table 17b. Overall mean effect of various combinations of storage containers and storage conditions on vigour index of okra seedlings

Treatment combination	Months after storage								
	0	1	2	3	4	5	6	7	Mean
T_1C_1	1605.12	1441.16	1650.00	1595.36	1765.88	1898.49	1600.36	1262.64	1602.37
T_1C_2	1530.80	1635.76	1769.16	1602.56	1838.90	1852.24	1682.40	1638.52	1693.79
T_1C_3	1628.16	1498.00	1810.72	1658.88	1685.56	1352.72	1512.40	1071.52	1528.24
T_2C_1	1757.76	1518.72	1618.60	1736.96	1745.24	1620.28	1320.76	1504.20	1602.81
T_2C_2	1638.24	1498.72	1839.20	1587.96	1932.48	1941.16	1800.80	1424.86	1707.92
T_2C_3	1588.80	1476.48	1708.08	1737.92	1893.76	1876.92	1559.20	1388.64	1653.76
T_3C_1	1612.83	1488.28	1657.00	1831.84	1878.48	1869.48	1425.36	1058.48	1602.71
T_3C_2	1558.64	1611.44	1560.80	1726.80	1771.20	1549.08	1566.20	1439.36	1597.94
T_3C_3	1576.32	1378.44	1791.30	1677.68	1788.40	1573.60	1285.90	1570.80	1580.30
T_4C_1	1623.36	1527.72	1820.20	1867.80	1919.84	2031.00	1535.20	1574.50	1737.52
T_4C_2	1734.24	1537.40	1890.76	1815.36	1899.48	1828.56	1639.56	2086.80	1737.52
T_4C_3	1614.72	1499.44	1902.40	1863.00	1870.28	2104.36	1767.00	1967.56	1823.59
T_5C_1	1458.32	1508.64	1696.20	1568.92	1952.80	1975.28	1667.60	1719.36	1693.39
T_5C_2	1606.56	1454.92	1693.40	1639.20	1761.52	1911.32	1679.80	1526.16	1659.11
T_5C_3	1640.64	1486.00	1710.16	1792.12	1725.24	1811.72	1451.60	1362.68	1622.52
T_6C_1	1776.00	1564.56	1855.60	1885.80	1804.72	947.59	1589.32	1485.00	1607.79
T_6C_2	1745.28	1473.12	1874.48	1576.00	1862.44	1791.28	2014.80	1747.00	1760.55
T_6C_3	1545.60	1525.12	1841.64	1874.76	1843.49	2003.36	1682.64	1831.52	1768.54
Mean	1624.52	1506.88	1760.56	1721.60	1829.96	1774.38	1598.95	1537.09	

CD for comparing means

Storage container x Storage condition interaction NS
Storage container x Storage condition x month interaction NS

The overall mean of seedling dry weight for different storage containers x storage condition was found to be non significant.

The overall mean of seedling dry weight for different storage container x storage condition x month interaction was found to be significantly different. The highest (30.53 mg per seedling) overall mean of seedling dry weight was recorded in seeds stored in 700 gauge polythene bag and stored under low temperature 5°C. The lowest overall mean of seedling dry weight (27.39 mg per seedling) was recorded by the seeds stored in plastic containers and stored under air conditioned storage (Table 18a and 18b).

4.3.9 Electrical conductivity of seed leachate

The overall means of electrical conductivity of seed leachate for different storage containers differed significantly. Among the different containers, seeds stored in plastic container had the lowest conductivity of seed leachate (0.154 dSm^{-1}) and the maximum electrical conductivity of seed leachate (0.183 dSm^{-1}) was recorded for seeds stored in 700 gauge polythene bags.

The overall mean for different storage condition on electrical conductivity of seed leachate had no significant effect.

Table 10a. Overall mean effect of various storage containers, storage conditions on seedling dry weight per seedling (mg) of okra seedlings

Treatments	Months after storage								
	0	1	2	3	4	5	6	7	Mean
T_1	26.92	28.91	31.62	29.70	30.38	27.43	31.98	21.67	28.52
T_2	26.97	28.36	29.5	30.32	28.80	28.18	31.19	23.87	28.39
T_3	24.40	26.70	27.61	31.82	29.96	26.36	31.60	23.89	27.79
T_4	27.63	30.46	29.06	30.55	28.90	27.80	32.11	25.53	29.00
T_5	28.56	26.86	30.35	29.11	27.18	29.38	32.04	24.62	28.50
T_6	28.78	31.16	28.82	30.70	27.51	25.58	31.68	22.74	28.37
C_1	28.35	29.07	29.13	31.19	29.33	27.92	31.18	23.88	28.75
C_2	26.96	27.73	28.73	30.23	28.33	27.06	32.96	22.17	28.01
C_3	26.31	29.42	30.61	29.67	28.71	27.42	31.15	25.12	28.55
Mean	27.20	28.74	29.47	30.36	25.64	27.45	31.76	23.22	

CD for comparing means

Storage containers NS
Storage conditions NS
Month mean 2.00**

NS Non significant
** Significant at 1% level

Table 18b. Overall mean effect of various combinations of storage containers and storage conditions on seedling dry weight per seedling (mg) of okra seedlings

Treatment combination	Months after storage								
	0	1	2	3	4	5	6	7	Mean
T_1C_1	30.08	30.23	32.75	31.09	31.41	29.98	30.84	24.07	30.02
T_1C_2	26.27	26.50	27.66	27.91	30.29	30.20	34.57	20.55	27.99
T_1C_3	24.41	30.00	34.47	30.11	29.45	22.13	30.54	20.14	27.65
T_2C_1	26.30	29.75	29.83	31.86	29.75	25.55	29.14	25.31	28.46
T_2C_2	27.31	27.35	28.89	31.85	26.25	30.06	32.73	17.09	27.69
T_2C_3	27.30	28.00	29.78	27.27	30.25	28.95	31.70	29.03	29.03
T_3C_1	24.40	26.60	23.80	32.66	28.90	30.85	31.10	24.48	27.84
T_3C_2	24.60	26.11	29.23	31.95	30.25	22.05	34.02	24.67	27.78
T_3C_3	24.20	27.40	29.80	30.87	30.75	26.20	29.69	22.53	27.68
T_4C_1	23.30	32.70	26.65	28.60	30.30	25.55	33.13	25.85	28.20
T_4C_2	27.60	28.40	29.35	30.70	29.05	26.66	29.06	25.23	28.25
T_4C_3	32.00	30.30	31.20	32.35	27.37	31.40	34.15	25.51	30.53
T_5C_1	31.40	25.10	31.95	31.00	28.85	28.82	31.05	22.07	28.74
T_5C_2	28.30	28.50	29.75	29.12	25.76	31.82	33.39	25.95	29.06
T_5C_3	26.00	27.00	29.35	27.22	26.95	28.05	31.70	25.86	27.72
T_6C_1	34.65	30.09	29.80	31.95	26.77	26.80	31.86	21.30	29.15
T_6C_2	27.70	29.55	27.55	29.90	28.40	22.15	34.03	19.54	27.35
T_6C_3	24.00	33.85	29.10	30.25	27.37	27.80	29.15	27.40	28.61
Mean	27.20	28.74	29.47	30.36	25.64	27.45	31.76	23.22	

CD for comparing means

Storage container x Storage condition interaction NS
Storage container x Storage condition x month interaction 5.97*

NS Non significant
* Significant at 5% level

Table 19 a. Overall mean effect of various storage containers, storage conditions on conditions on electrical conductivity (dSm^{-1}) of okra seed leachate

Treatments	Months after storage								
	0	1	2	3	4	5	6	7	Mean
T_1	0.148	0.202	0.166	0.148	0.131	0.159	0.231	0.185	0.171
T_2	0.155	0.185	0.170	0.162	0.145	0.170	0.193	0.172	0.169
T_3	0.160	0.174	0.169	0.172	0.150	0.167	0.204	0.173	0.172
T_4	0.156	0.164	0.162	0.147	0.128	0.176	0.206	0.169	0.183
T_5	0.123	0.190	0.178	0.151	0.127	0.184	0.185	0.172	0.163
T_6	0.124	0.140	0.158	0.152	0.118	0.189	0.180	0.174	0.154
C_1	0.144	0.198	0.152	0.153	0.132	0.183	0.216	0.174	0.169
C_2	0.145	0.173	0.173	0.156	0.131	0.161	0.186	0.180	0.163
C_3	0.143	0.156	0.176	0.157	0.136	0.176	0.197	0.169	0.163
Mean	0.144	0.175	0.167	0.155	0.133	0.173	0.199	0.174	

CD for comparing means

Storage containers 0.0083**
Storage conditions NS
Month mean 0.0074**

NS Non significant
** Significant at 1% level

Table 19b. Overall mean effect of various storage containers and storage conditions on electrical conductivity of seed leachate of okra (dSm^{-1})

Treatment combination	Months after storage								
	0	1	2	3	4	5	6	7	Mean
T_1C_1	0.133	0.263	0.161	0.130	0.124	0.160	0.241	0.177	0.161
T_1C_2	0.163	0.169	0.176	0.150	0.138	0.159	0.228	0.198	0.172
T_1C_3	0.147	0.174	0.162	0.165	0.132	0.159	0.225	0.179	0.167
T_2C_1	0.158	0.193	0.151	0.160	0.149	0.173	0.209	0.166	0.169
T_2C_2	0.148	0.185	0.182	0.150	0.135	0.144	0.188	0.186	0.164
T_2C_3	0.160	0.175	0.179	0.176	0.153	0.194	0.182	0.163	0.172
T_3C_1	1.154	0.191	0.129	0.151	0.160	0.203	0.222	0.174	0.173
T_3C_2	0.149	0.162	0.170	0.180	0.128	0.133	0.191	0.177	0.167
T_3C_3	0.179	0.170	0.207	0.185	0.162	0.167	0.199	0.169	0.179
T_4C_1	0.167	0.163	0.156	0.166	0.109	0.168	0.243	0.175	0.169
T_4C_2	0.159	0.187	0.154	0.141	0.151	0.179	0.155	0.171	0.181
T_4C_3	0.141	0.143	0.176	0.135	0.124	0.165	0.220	0.161	0.158
T_5C_1	0.106	0.213	0.152	0.148	0.134	0.194	0.189	0.170	0.163
T_5C_2	0.141	0.188	0.189	0.160	0.131	0.172	0.182	0.181	0.160
T_5C_3	0.121	0.170	0.192	0.147	0.117	0.188	0.185	0.166	0.167
T_6C_1	0.146	0.166	0.166	0.166	0.117	0.204	0.194	0.181	0.148
T_6C_2	0.113	0.150	0.165	0.156	0.107	0.182	0.174	0.167	0.144
T_6C_3	0.114	0.103	0.144	0.136	0.131	0.182	0.174	0.174	0.112
Mean	0.144	0.175	0.167	0.154	0.133	0.173	0.199	0.174	

CD for comparing means

Storage container x Storage condition interaction NS
Storage container x Storage condition x month interaction NS

NS Non significant

The overall means of electrical conductivity at different months of storage differed significantly. The highest conductivity for seed leachate was recorded after six month of storage (0.199 dSm^{-1}) (Table 19a and 19b).

The overall mean of electrical conductivity for different storage container x storage condition interaction was found to be non significant and also the interaction effect of storage containers x storage condition x month was also non significant.

Discussion

5. DISCUSSION

Production of quality seeds and their storage life depend on many factors like stage of harvest, post harvest handling, processing of seeds, seed treatment, storage containers and seed storage conditions. In order to standardise these aspects in okra cultivar Arka Anamika three experiments were conducted in 1996-97 in the Department of Olericulture, College of Horticulture, Vellanikkara. The results obtained are discussed here under.

5.1 Effect of stage of maturity at harvest on seed quality in okra

Physiological maturity of the seeds is the stage at which the seed attains its maximum dry weight (Harrington, 1972). The change that occurred in the seeds beyond physiological maturity was mainly dehydration without accumulation of reserves. Allowing the seeds to dehydrate on the mother plant till the harvest maturity did not bring any additional improvement in the seed quality than that attained at physiological maturity in case of pigeon pea (Singh *et al.*, 1987).

The study showed that length of the fruit, weight of the fruit, 100 seed weight (fresh) 100 seed weight (dry) number of well filled seeds after drying, germination percentage, vigour index of seedling and seedling dry weight were found to increase from the day of anthesis onwards.

Length of the fruit was found to increase from day of anthesis. The developing fruits upto 21 d.a.a contained high amount of mucilage and seed separation was difficult. Such seeds were white in colour. From 24th day onwards colour changed to yellowish to ash colour at later stages.

The weight of the developing fruit increased upto 18 d.a.a. As the fruit maturity increased beyond 18 d.a.a reduction in weight was observed owing to loss of moisture. Similar result has been reported in bottlegourd (Chandrasekharan,1979) and in bittergourd (Varatharaj, 1979). Loss in weight of fruits was associated with changes in moisture content in maturing fruits (Martin *et al.*, 1923, Manohar and Sachan, 1974). In the present study also a similar trend was observed.

Considering the fresh weight of seeds, there was increase in fresh weight of seeds upto 15 d.a.a. Fresh weight of seed is an important character that determines the seed quality. Beyond 15 d.a.a there was a gradual decrease in fresh weight of seeds. Development studies of various parts of *Dolichos lablab* (L.) pod showed that the fresh as well as dry weight of developing seeds remained significant for about 9 days after the flowers were open and there after they began to increase with very high rate till the seeds are 30 days old and thereafter it decreased (Manohar, 1970). Thereafter seeds began to loose moisture. A similar trend was observed in present study also.

Shaw and Loomis (1950) and Harrington (1972) defined physiological maturity as the stage when the seed attained its maximum dry weight. In the present study an increasing trend in dry weight of 100 seed was observed from the initial stages of fruit maturity upto 36 d.a.a where dry weight of 100 seed was maximum. Similarly, the percentage of well filled seeds after drying was maximum from seeds of fruits harvested 36 d.a.a.

Germination percentage, speed of germination, and seedling vigour are also important parameters for determining the physiological maturity of seeds (Helmer *et al.*, 1962; Chin, 1981 and Singh and Sidhu, 1985). In the present study all these parameters showed a gradual increase from 24 d.a.a upto 36 d.a.a where it was maximum and thereafter it declined. Maximum germination (94%) was recorded for seeds of 36 days maturity (Fig.Ia). Speed of germination increased from 2.0 (24 d.a.a) to 35.10 (36 d.a.a) and thereafter it decreased (Fig.Ib). Seeds had a maximum vigour index of 2135.33 at 36 d.a.a (Fig.Ic). Maximum seedling dry weight was recorded at 30 d.a.a. This was on par with 33, 36 and 39 d.a.a (Fig.Id).

Fig.1. Seed quality parameters in okra at different stages of seed maturity
a. Effect on seed germination percentage

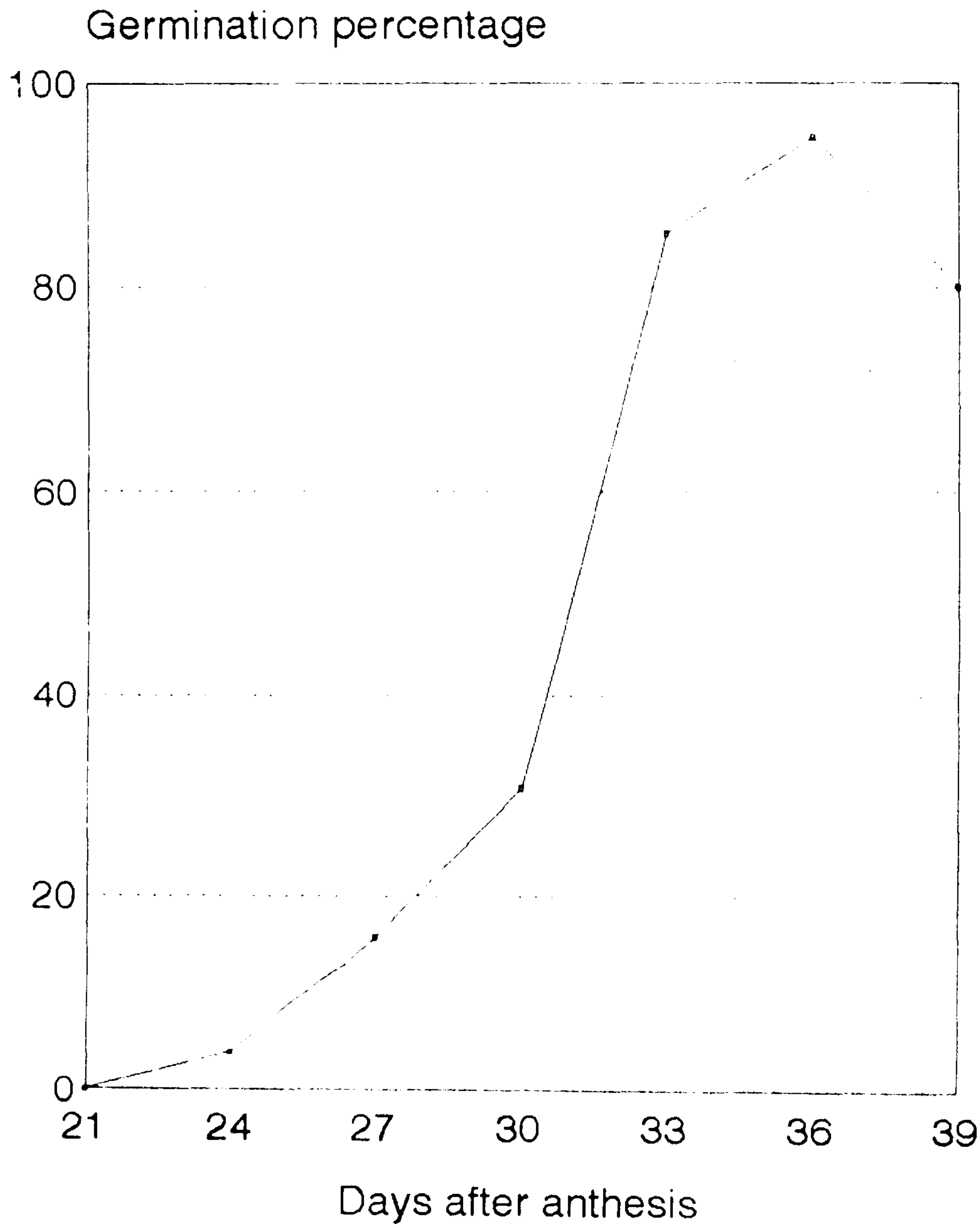


Fig.1. Seed quality parameters in okra at different stages of seed maturity
b. Effect on speed of germination

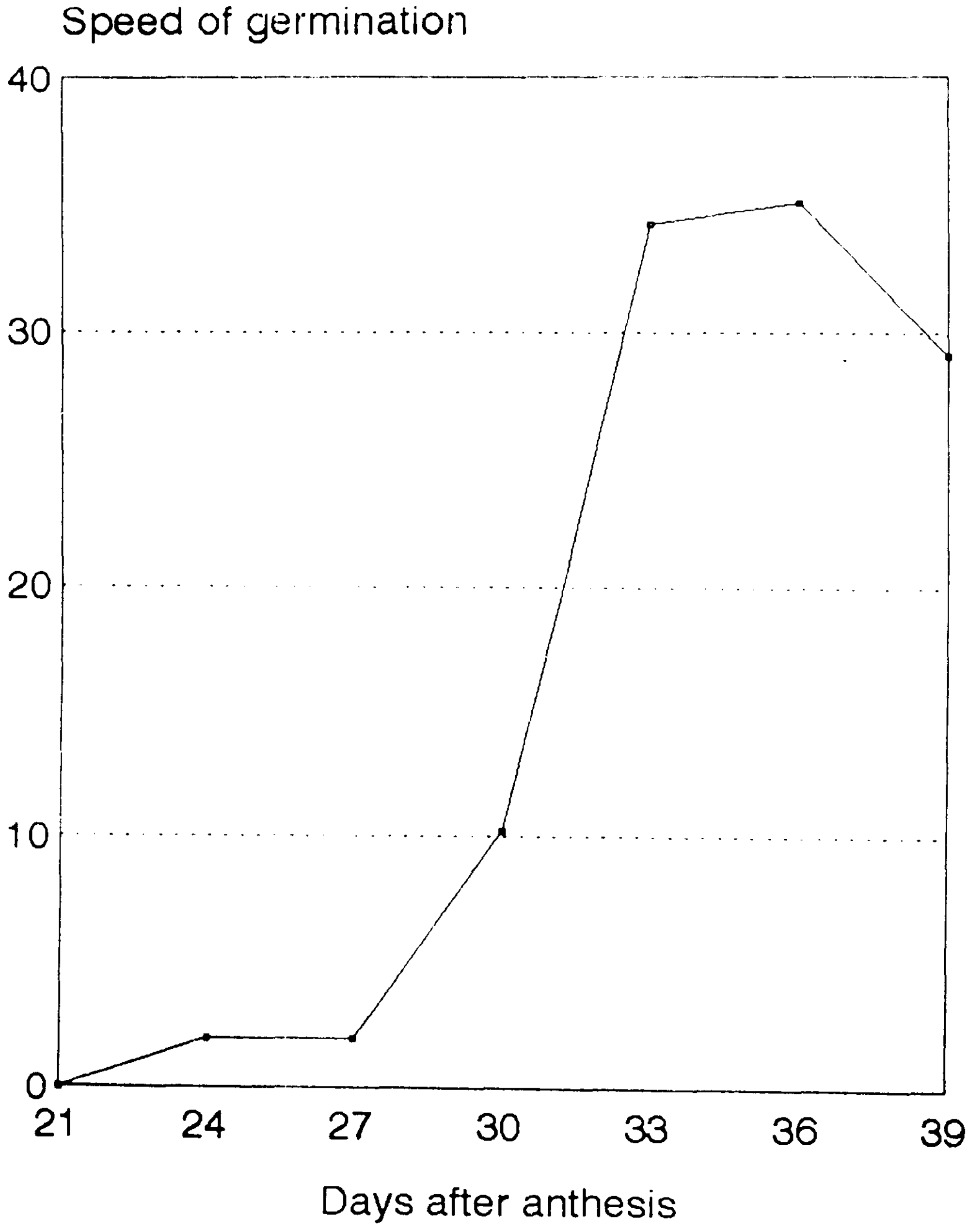


Fig.1. Seed quality parameters in okra at different stages of seed maturity
c. Effect on vigour index

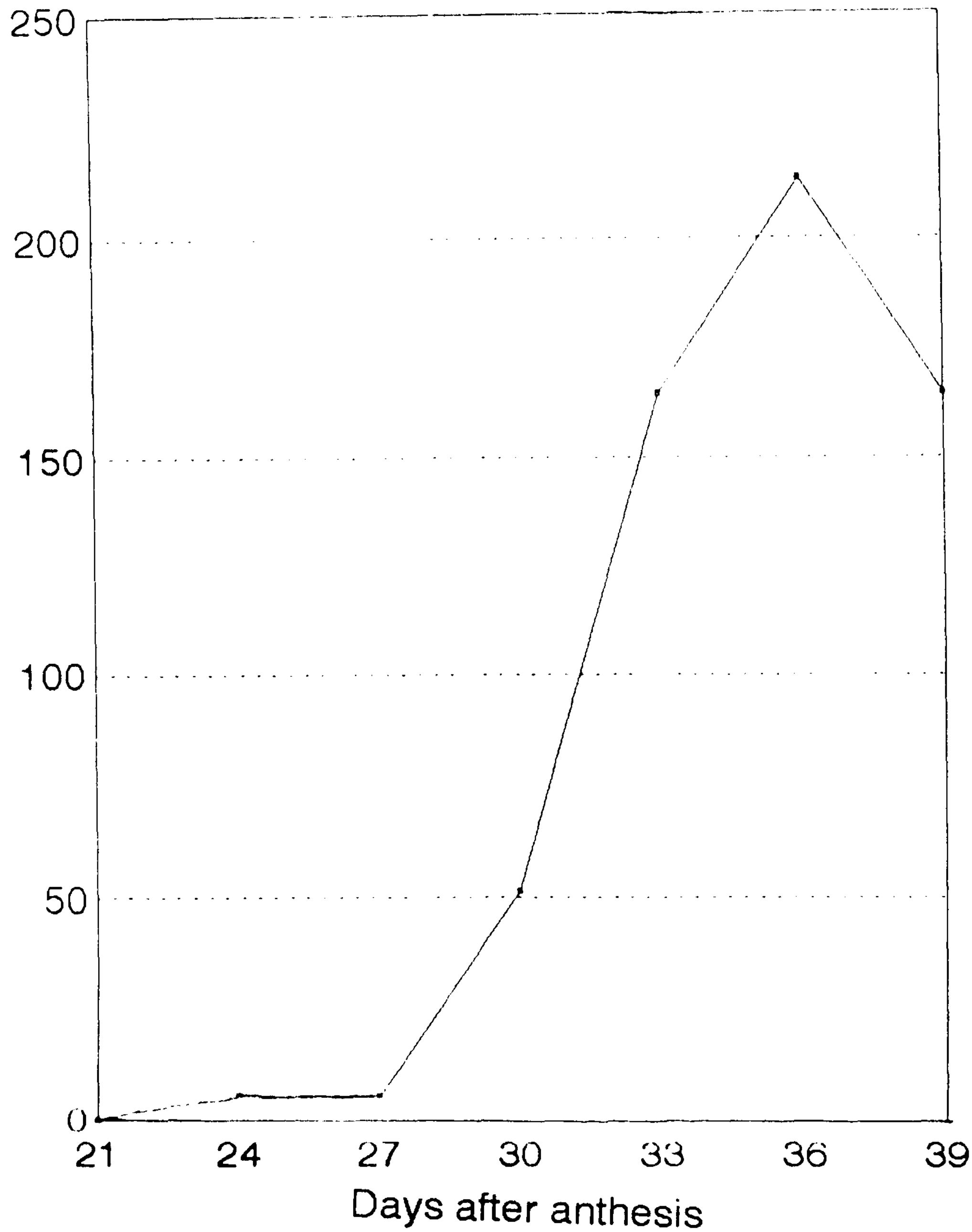
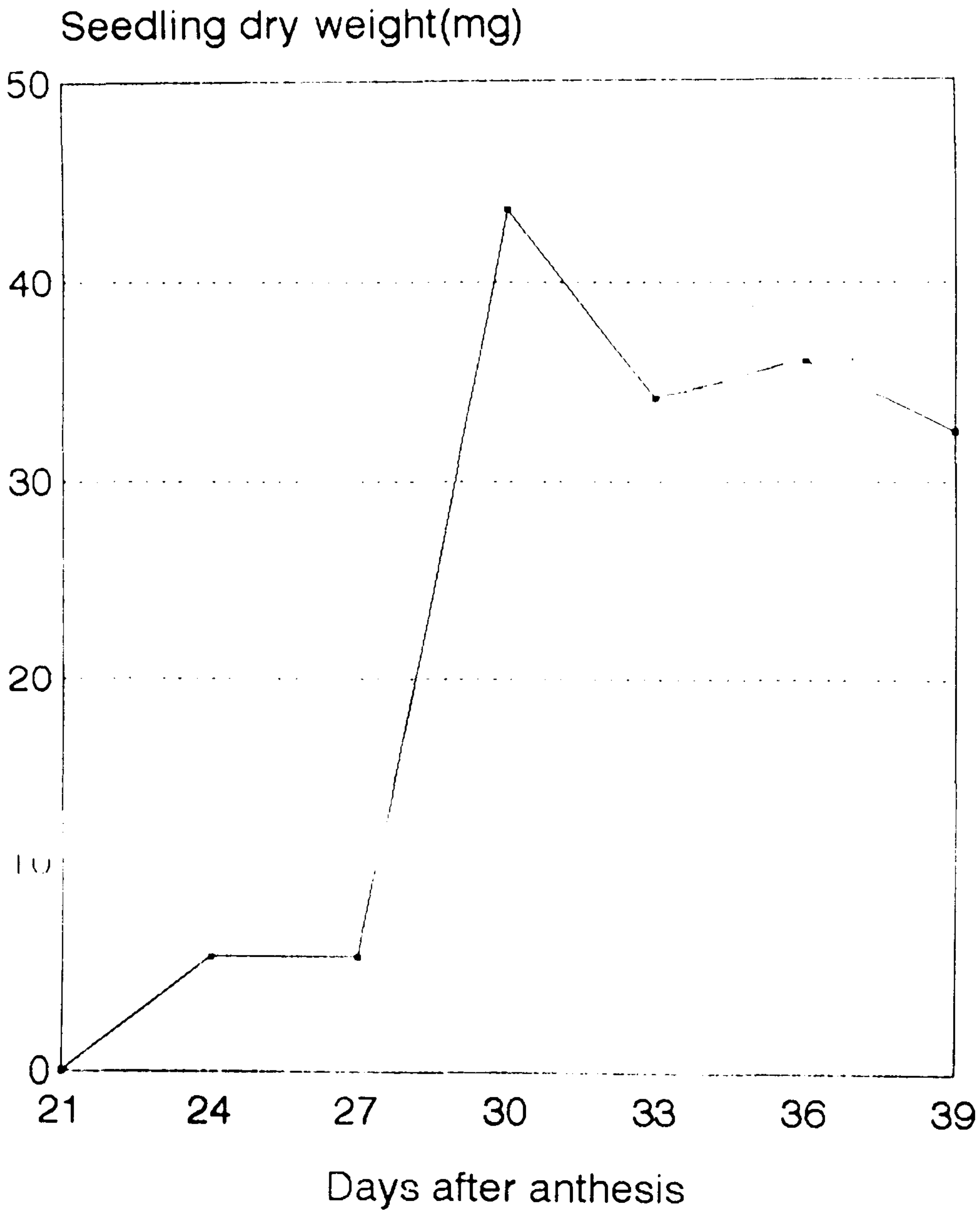


Fig.1. Seed quality parameters in okra at different stages of seed maturity
d. Effect on seedling dry weight



From the present study it can be seen that the physiological maturity in okra cultivar Arka Anamika is attained 36 days after anthesis. The germination percentage, vigour index, speed of germination, root length and shoot length were maximum at this stage.

5.2 Effect of method of seed drying on seed quality in okra

In order to standardise the method of seed drying for optimum seed quality during storage. For this, three methods of fruit drying with a combination of four methods of seed drying were tested for seven months.

In the present study, days to germination was not influenced by the drying methods. A combination of fruit drying in mechanical drier + seed drying initially under shade for one day and then sun drying avoiding peak hours of radiation had the maximum overall germination. This can be due to the following reasons. Drying in mechanical drier immediately after harvest helps in lowering the moisture content of fruits irrespective of the atmospheric condition. This helps in reducing the microbial population. Further avoiding sunlight of peak hours avoids the U.V. rays of sun which is detrimental to seed. This finding in the present study is in conformity with the studies of Doijode (1990a) who observed highest percentage germination in seeds dried under silica gel, shade, and sun drying.

Seeds are susceptible to drying injury in several ways. First, they are sensitive to high temperatures, generally above 110°F. They may also be injured by drying too rapidly or by over drying. Though sun drying showed better performance, the quality attributes were comparatively poor, this may be due to the direct exposure of seeds to ultra violet high energy radiation associated with faster rate of drying. The better performance of sun and shade drying could be due to slow drying without exposure to continuous radiation effects. This was also observed by Singh *et al.* (1972) and Harrington (1960). Shade drying was found to be too slow and the equilibrium moisture content could not be reduced to safe level of 8.0 per cent.

In the present study the root and shoot length of seedlings was not influenced by drying methods. The maximum vigour index of seedling was obtained when fruits were dried in mechanical drier and the seed initially dried in shade followed by sun avoiding the peak hours of sunshine. Highest seedling dry weight was for seedlings raised from seeds dried under sun. A high value for electrical conductivity of seed leachate was recorded in seeds of fruits dried by mechanical drying and seeds dried using mechanical drier. Excessive seed leakage is associated with poor emergence (Nerson and Parris, 1988). The rapid leakage of electrolytes during very early period of imbibition might be due to loss of integrity of semi permeable membrane (tonoplast and plasma membrane) while drying. This may be due to disturbances in architecture of phospholipid molecules in membrane. Finean (1969) indicated that about 20 per cent moisture in the membrane (dry weight basis) is required for the maintenance of lipo-protein association.

So in the present study, it can be seen that a combination of fruit drying in mechanical drier at 35°C for six hours combined with seed drying initially under shade for one day followed by direct sun light avoiding the peak hours of radiation till moisture content reaches 8 per cent was best for getting maximum germination. These seeds also had maximum vigour index.

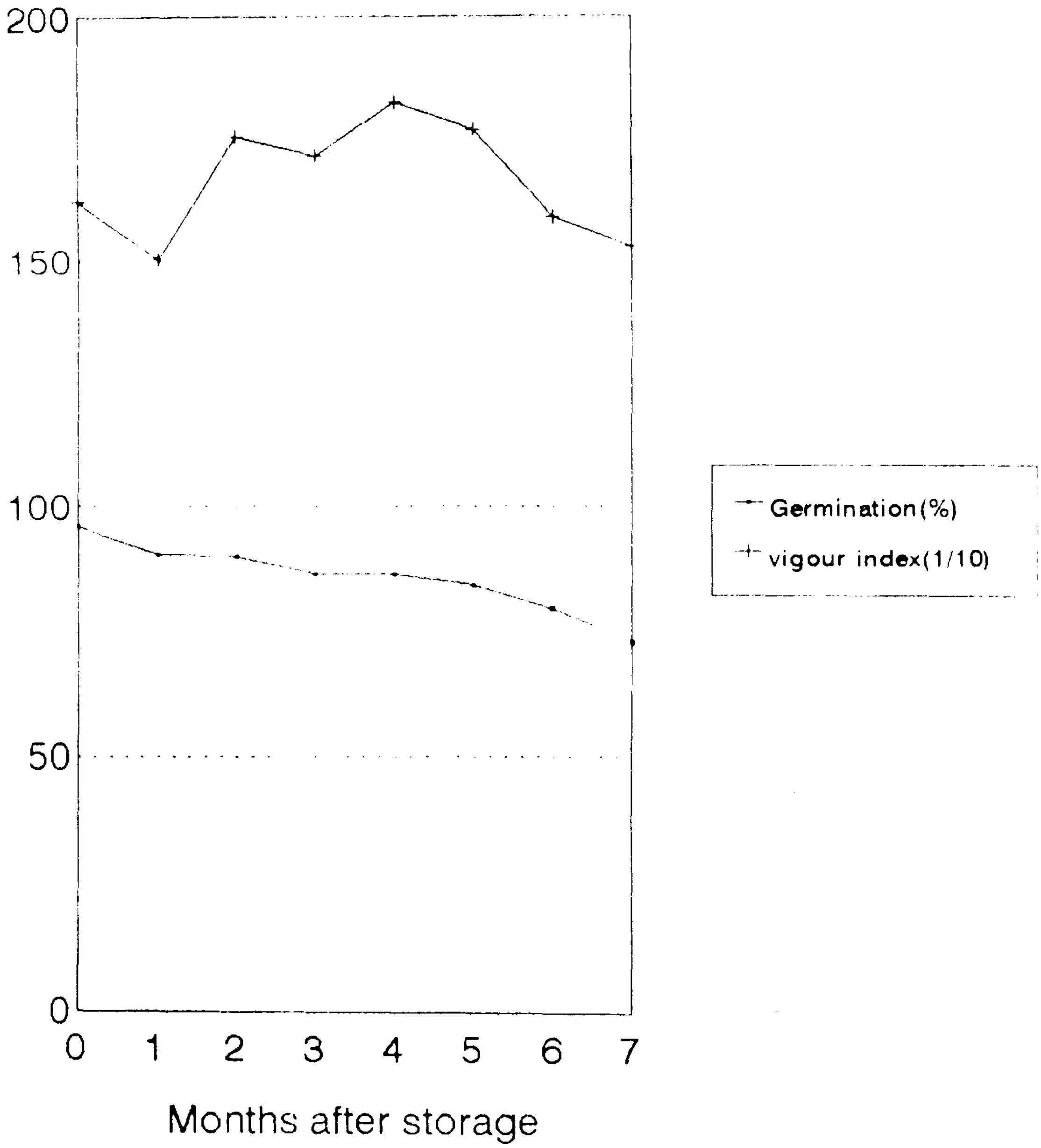
5.3 Effect of storage containers and storage conditions on seed quality in okra

Good seed storage is a basic requirement for any seed production programme. Seed is a biological entity and senescence or deterioration is inevitable and irreversible during storage. A number of factors influence the storage life of seeds which include seed moisture content, maturity status etc. The environmental factors like temperature and relative humidity play an important role in seed storage. Hot weather, rainfall, infestations by pests and diseases, alternate wetting and drying on the plant are some other factors which may reduce the quality from the time of maturity till the seeds are harvested. Deterioration of a seed encompasses all the progressive detrimental changes that occur in seed as they die (Delouche, 1968). Seed deterioration is: irreversible, minimal at time of maturity, and variable among seed kinds, lots of the same kind and individual seed with in a lot (Delouche, 1968). Deterioration of seed cannot be prevented although its rate can be closely controlled. Seeds of high quality can be maintained by proper control of storage environment.

In the present study, the seeds were stored in different storage containers and stored under different conditions. Evaluation of seed quality parameters showed that days to first germination was least in seeds stored under ambient conditions. Similarly, days to 50 per cent germination was least in seeds stored under ambient conditions. This may be due to the fact that changes associated with germination are occurring within the seeds stored under ambient conditions of storage.

Results on germination percentage revealed that percentage germination decreased irrespective of the storage container or storage conditions as the period of storage prolonged (Fig.II). Initial germination percentage at the time of storage was 96 per cent. It was reduced to 72.16 per cent after seven months of storage. This shows that seed

Fig.2. Changes in overall germination percentage and vigour index during storage of okra seeds

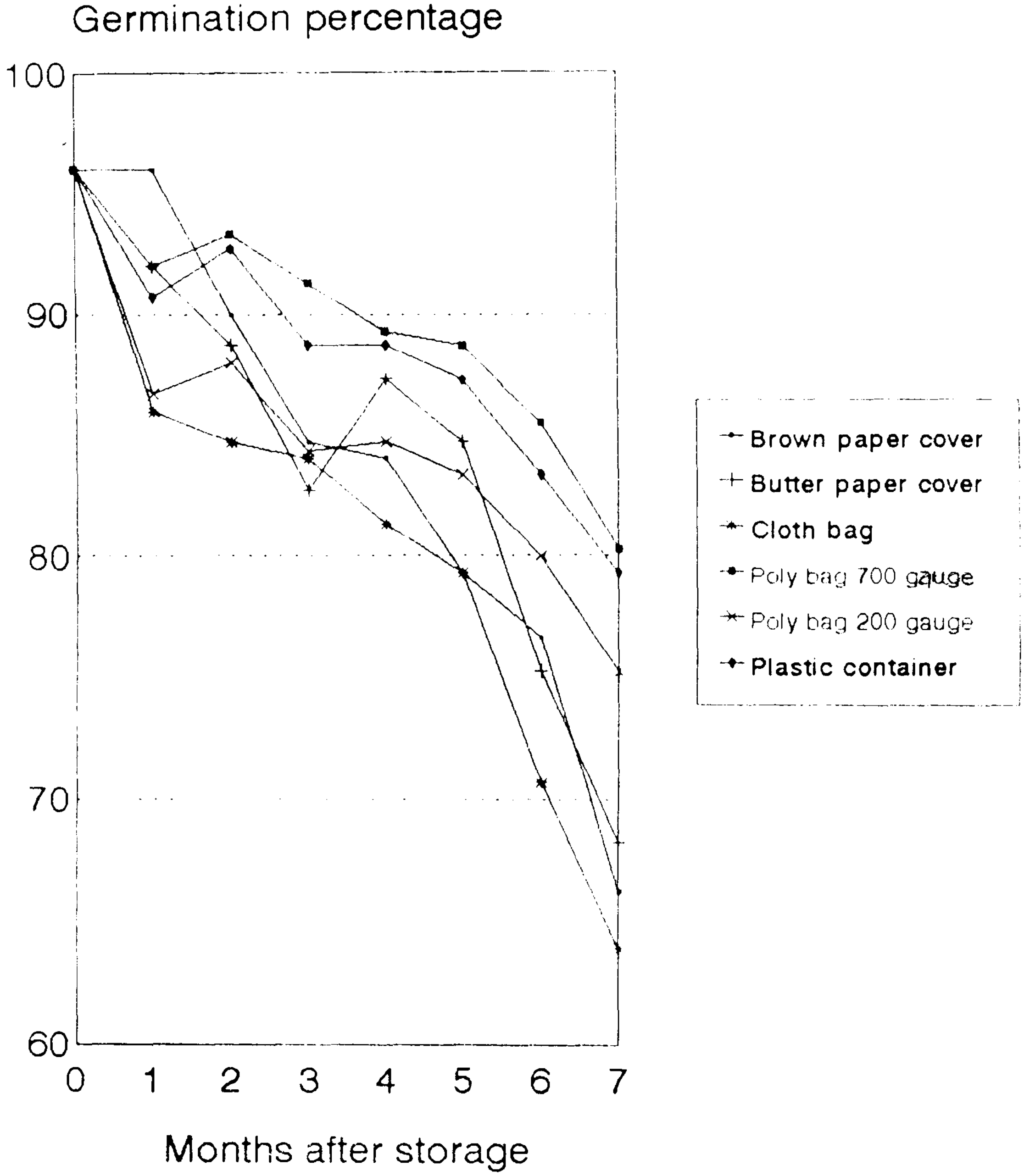


deterioration is inevitable irrespective of the storage condition of storage container.

Seeds stored in 700 gauge polythene bags had the maximum overall mean germination percentage (89.53). The per se germination percentage of these was also maximum even after seven months storage (80.3%). Packing of seeds in 700 gauge polythene helps in maintaining the moisture level of the seed as it is impermeable to moisture. This fact is further confirmed by the fact that the germination percentage is only 64 per cent after seven months of storage, when the seeds of the same lot were stored in cloth bags. Thus it can be seen that packing material has a profound influence on the storage life of okra seeds(Fig.III).

The result is in conformity with the finding like seeds of annual moringa seed packed in 700 gauge polythene gave high germination (Palaniswamy *et al.*, 1995). Verma *et al.* (1991) observed considerable reduction in germination percentage in tomato and cauliflower seed stored in laminated bags (paper-foil-poly) stored under ambient conditions. Seeds of pumpkin cv. Arka Chandan were preserved in polyethylene bags at ambient, 5°C and -20°C for five years. Seeds remained viable for four years, but high germination was maintained for 2 years only under ambient conditions. Seed storability was enhanced to five years at 5°C and -20°C storage (Doijode, 1995). The germination of seeds was high when stored in

Fig.3. Effect of storage containers on seed germination percentage



polyethylene bag at low temperature and low relative humidity and these bags were effective under dry conditions (Villareal *et al.*, 1972; Kucherenko and Labedeva, 1976).

The overall mean germination percentage of okra seeds was not significantly influenced by the three storage conditions in the present study viz., storage at room temperature, in an air conditioned room at 20 ± 2°C and in B.O.D. incubator at 5°C. But the per se germination percentage showed variation under different storage conditions. The germination percentage was 76.7 per cent after seven months of storage in the case of seeds stored at 5°C. But it was only 67.7 per cent when the seeds were stored at room temperature.

The overall mean storage container x storage condition interaction was also not significant. the range of germination was from 58 per cent to 84 per cent after seven months of storage. After seven months of storage, maximum germination percentage was recorded for seeds packed in 700 gauge polythene bag and stored at 5°C.

In the present study, germination percentage was significantly influenced by storage containers. But the influence of storage condition and storage container x storage condition interaction on seed germination during storage was not significant. This shows that the packing material is more important than the storage condition in maintaining the germinability of okra seeds.

The effect of different storage containers and storage conditions on root length and shoot length of seedlings was found to be non significant. Similar results have been reported by Kannath (1996) in ash gourd.

The overall mean of speed of germination was non significant in the case of different storage containers used in the present study. But the storage condition significantly influenced this character. The highest mean speed of germination was recorded when the seeds were stored at 5°C.

In the present study maximum overall mean for vigour index was obtained for the seeds stored in 700 gauge polythene bag. The same seeds had the maximum germination percentage also. This shows that irrespective of the storage atmosphere, packing the seeds in 700 gauge polythene bags is ideal for maintaining viability and vigour of okra seeds.

In the present investigation, the lowest electrical conductivity of seed leachate was recorded when seeds were packed in plastic containers. The maximum was recorded when seeds were packed in 700 gauge polythene.

Summary

6. SUMMARY

Seed technological aspects of okra cultivar Arka Anamika were investigated at Department of Olericulture, College of Horticulture, Vellanikkara during the period 1996 to 1997 to find out stage of physiological maturity of seeds, standardise the seed drying method and to find out the suitable storage container and storage condition for getting maximum seed quality and germination of seeds. The study revealed the following informations.

1. Seeds harvested from fruits of upto 21 days maturity did not germinate. Seed germination started from seeds of 24 days maturity (4%). The germination percentage increased thereafter and reached a maximum of 94.7 per cent at 36 days maturity. Then it decreased to 80.0 per cent at 39 days maturity.

2. The maximum 100 seed weight (6.72 g) was recorded at 36 d.a.a. The percentage of well filled seeds was also maximum at this stage (96.36%).

3. Seeds of 24 days maturity took 4.77 days for the emergence of first seedling. Thereafter the days to germination decreased and the lowest time was recorded for seeds of 33, 36 and 39 d.a.a.

4. Root length and shoot length of seedling were maximum (7.57 cm and 14.48 cm respectively) for seeds of 36 days maturity. Speed of germination and vigour index were also maximum in this case.

5. There was no effect for different fruit drying and seed drying methods on days to first germination. Among the different combinations of fruit drying and seed drying, the maximum overall mean germination percentage was recorded by the fruits initially dried using mechanical drier (at 35°C) for six hours followed by seed drying under shade for one day and thereafter in direct sunlight avoiding the peak hours till the seeds attained 8 per cent moisture.

6. Different methods of fruit drying, seed drying and their interaction were not significant for root length and shoot length of seedlings.

7. The highest speed of germination (20.73) was recorded in seeds from fruits dried using mechanical drier. Among the various methods of seed drying, maximum speed of germination (20.04) was recorded for seeds dried in direct sunlight. Among the treatment combinations, fruit drying in mechanical drier + seed drying under shade followed by direct sunlight avoiding peak hours recorded maximum speed of germination (23.06).

8. The maximum vigour index was recorded in seeds dried in mechanical drier. Among the different seed drying methods, the highest vigour index was recorded for seeds dried in sunlight. Among the different treatment combinations, 'Fruit drying in mechanical drier + seed drying in shade followed by seed drying in direct sunlight avoiding peak hours' recorded maximum vigour index.

9. Different methods of fruit drying, seed drying and the treatment combinations had no significant effect on seedling dry weight.

10. It was seen that the seeds packed in 200 gauge polythene bag and kept under low temperature of 5°C recorded the lowest 100 seed weight. The days to 50 per cent germination was not influenced by storage container and storage conditions.

11. Overall means for various containers showed that seeds packed in 700 gauge polythene bag had the highest germination percentage (80.30%) after seven months of storage. The seeds stored in cloth bag had the lowest germination.

12. Among the different storage conditions seeds stored at low temperature of 5°C had the highest germination percentage.

13. The storage container or storage condition did not influence the root length or shoot length of the seedlings.

14. Maximum overall mean for vigour index was recorded for seeds stored in 700 gauge polythene and the minimum for seeds stored in cloth bag.

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* Orginals not seen.

Appendices

APPENDIX-I

General analysis of variance for various fruit and seed characters in okra at different stages of maturity

Source	d.f.	Mean sum of squares		
		Length of the fruit	Weight of the fruit	Total number of seeds per fruit
Stages of fruit development	12	66.56**	310.76**	124.82**
Error	26	0.735	4.96	20.53

Source	d.f.	Mean sum of squares	
		100 seed weight (fresh)	100 seed weight (dry)
Stages of fruit development	12	65.57**	24.36**
Error	26	0.401	0.094

Source	d.f.	Mean sum of squares
		Percentage of well filled seed after drying
Stages of fruit development	12	5588.84** (0.864)
Error	26	67.80 (0.015)

APPENDIX-II

General analysis of variance for seedling characteristics of okra at different stages of maturity

Source	d.f.	Mean sum of squares	
		Days of first germination	Germination percentage
Stages of fruit development	5	3.70**	4662.22** (0.910)
Error	12	0.135	77.33 (0.023)

Source	d.f.	Mean sum of squares				
		Root length	Shoot length	Speed of germination	Vigour index	Seedling dry weight
Stages of fruit development	5	15.99**	1.401**	709.61**	2283530.46**	535.08**
Error	12	0.300	0.422	12.22	40422.57	42.42

APPENDIX-III

General analysis of variance for effect of different methods of fruit drying and seed drying on seed quality parameters in okra

a. Days of first germination

Source	d.f.	Mean sum of squares
Fruit drying	2	0.211806
Seed drying	3	0.060185
Fruit drying x Seed drying	6	0.049769
Month	7	0.847222**
Fruit drying x month	14	0.152282
Seed drying x month	21	0.052249
Fruit drying x Seed drying x month	42	0.117229
Error	192	0.093750

b. Germination percentage

Source	d.f.	Mean sum of squares
Fruit drying	2	443.041667
Seed drying	3	1170.828704**
Fruit drying x Seed drying	6	1241.634259**
Month	7	2056.839286**
Fruit drying x month	14	127.041667
Seed drying x month	21	249.897487**
Fruit drying x Seed drying x month	42	69.337963
Error	192	145.16667

e. Speed of germination

Source	d.f.	Mean sum of squares
Fruit drying	2	90.417203**
Seed drying	3	101.410320**
Fruit drying x Seed drying	6	87.608635 **
Month	7	577.723678 **
Fruit drying x month	14	16.623077
Seed drying x month	21	15.888702
Fruit drying x Seed drying x month	42	10.373372
Error	192	14.529060

f. Vigour index

Source	d.f.	Mean sum of squares
Fruit drying	2	323387.322917**
Seed drying	3	485871.133102**
Fruit drying x Seed drying	6	448483.591435**
Month	7	1261208.047123**
Fruit drying x month	14	31041.517361
Seed drying x month	21	104249.230985
Fruit drying x Seed drying x month	42	56172.907573
Error	192	86322.965278

c. Root length

Source	d.f.	Mean sum of squares
Fruit drying	2	0.678961
Seed drying	3	0.314068
Fruit drying x Seed drying	6	1.672072
Month	7	123.446186**
Fruit drying x month	14	1.300151
Seed drying x month	21	1.354098
Fruit drying x Seed drying x month	42	0.872078
Error	192	1.553376

d. Shoot length

Source	d.f.	Mean sum of squares
Fruit drying	2	1.115489
Seed drying	3	1.540768
Fruit drying x Seed drying	6	1.845249
Month	7	31.487196**
Fruit drying x month	14	0.679233
Seed drying x month	21	0.577569
Fruit drying x Seed drying x month	42	0.771709
Error	192	0.946298

e. Speed of germination

Source	d.f.	Mean sum of squares
Fruit drying	2	90.417203**
Seed drying	3	101.410320**
Fruit drying x Seed drying	6	87.608635**
Month	7	577.723678**
Fruit drying x month	14	16.623077
Seed drying x month	21	15.888702
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Fruit drying x Seed drying x month	42	56172.907573
Error	192	86322.965278

g. Seedling dry weight

Source	d.f.	Mean sum of squares
Fruit drying	2	12.574722
Seed drying	3	10.804910
Fruit drying x Seed drying	6	22.830624
Month	7	262.306003**
Fruit drying x month	14	23.754798**
Seed drying x month	21	8.454648
Fruit drying x Seed drying x month	42	12.549607
Error	192	12.617281

h. Electrical conductivity of seed leachate

Source	d.f.	Mean sum of squares
Fruit drying	2	0.000360
Seed drying	3	0.003474**
Fruit drying x Seed drying	6	0.002540**
Month	7	0.026643**
Fruit drying x month	14	0.001658**
Seed drying x month	21	0.000587
Fruit drying x Seed drying x month	42	0.000528
Error	192	0.000439

APPENDIX-IV

General analysis of variance for effect of various storage containers and storage conditions seed quality parameters in okra

a. 100 seed weight

Source	d.f.	Mean sum of squares
Month	7	0.701**
Error	8	0.004
Condition	2	2.000**
Month x Condition	14	0.037**
Container	5	4.472**
Month x Container	35	0.124**
Condition x Container	10	0.906**
Month x Condition x Container	70	0.051**
Error	136	0.017

b. Days to 50% germination

Source	d.f.	Mean sum of squares
Month	7	13.333*
Error	8	2.326
Condition	2	1.628
Month x Condition	14	0.93
Container	5	0.856
Month x Container	35	2.295
Condition x Container	10	0.749
Month x Condition x Container	70	1.437
Error	136	1.679

c. Germination percentage

Source	d.f.	Mean sum of squares
Month	7	1912.379**
Error	8	10.958
Condition	2	59.014
Month x Condition	14	39.046
Container	5	496.847**
Month x Container	35	42.155
Condition x Container	10	42.547
Month x Condition x Container	70	11.95
Error	136	43.87

d. Root length

Source	d.f.	Mean sum of squares
Month	7	131.365**
Error	8	7.612
Condition	2	0.400
Month x Condition	14	1.348
Container	5	1.78
Month x Container	35	1.565
Condition x Container	10	0.685
Month x Condition x Container	70	0.644*
Error	136	1.113

e. Shoot length

Source	d.f.	Mean sum of squares
Month	7	26.007**
Error	8	1.646
Condition	2	0.704
Month x Condition	14	1.251
Container	5	0.346
Month x Container	35	0.522
Condition x Container	10	1.009
Month x Condition x Container	70	0.958
Error	136	0.894

f. Speed of germination

Source	d.f.	Mean sum of squares
Month	7	523.506**
Error	8	8.158**
Condition	2	102.487**
Month x Condition	14	40.27*
Container	5	36.966
Month x Container	35	15.58
Condition x Container	10	22.13
Month x Condition x Container	70	19.372*
Error	136	13.823

g. Vigour index

Source	d.f.	Mean sum of squares
Month	7	507769.71**
Error	8	68368.18
Condition	2	97816.67
Month x Condition	14	42553.72
Container	5	247750.09**
Month x Container	35	49548.32
Condition x Container	10	48679.42
Month x Condition x Container	70	46939.23
Error	136	47032.17

h. Seedling dry weight

Source	d.f.	Mean sum of squares
Month	7	209.932**
Error	8	18.93
Condition	2	13.761
Month x Condition	14	10.31
Container	5	7.473
Month x Container	35	10.951
Condition x Container	10	13.724
Month x Condition x Container	70	13.174*
Error	136	8.49

j. **Electrical conductivity of seed leachate**

Source	d.f.	Mean sum of squares
Month	7	0.016**
Error	8	0.000
Condition	2	0.001
Month x Condition	14	0.002**
Container	5	0.002**
Month x Container	35	0.001**
Condition x Container	10	0.001
Month x Condition x Container	70	0.001
Error	136	0.000

FRUIT MATURITY, METHOD OF SEED DRYING AND STORAGE CONDITIONS ON SEED QUALITY IN OKRA, (*Abelmoschus esculentus* (L.) Moench)

By

P. ANITHA.

ABSTRACT OF A THESIS

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Department of Olericulture

COLLEGE OF HORTICULTURE

VELLANIKKARA - THRISSUR

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ABSTRACT

An investigation on "Fruit maturity, methods of seed drying and storage conditions on seed quality in okra, *Abelmoschus esculentus* (L.) Moench" was undertaken in the Department of Olericulture, College of Horticulture, Vellanikkara, during the period 1996-1997. The findings are briefed below.

In the present study it was found that seed germination started only after a seed maturity of 24 days. The germination percentage, 100 seed weight, root length, shoot length, speed of germination and vigour index was maximum at 36 days after anthesis which represented the physiological maturity stage in okra.

Among the different fruit drying and seed drying methods, the maximum overall mean germination was recorded by the fruits initially dried using mechanical drier (35°C) for six hours followed by seed drying under shade for one day and thereafter in direct sun light avoiding the peak hours till the seeds attained 8.0 per cent moisture level. Among the various methods of seed drying maximum speed of germination and vigour index was recorded for these seeds.

Overall means for various containers showed that seeds packed in 700 gauge polythene bag had the highest germination percentage (80.30%) even after seven months of storage. The seeds stored in cloth bag had the lowest germination. Among the different storage conditions seeds stored at 5°C had the highest germination percentage. Neither the storage container nor the storage condition influenced the root length or shoot length of the seedling.