EFFECT OF FRUIT MATURITY, SEED PROCESSING AND STORAGE METHODS ON SEED QUALITY OF ASH GOURD (*Benincasa hispida* Thumb.)

BY

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THESIS

Submitted in partial fulfilment of the
requirement for the degree of

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Faculty of Agriculture
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1996

DECLARATION

I hereby declare that this thesis entitled **Effect of fruit maturity, seed processing and storage methods on seed quality of ash gourd (*Benincasa hispida* Thumb.)** is a bonafide record of research work done by me during the course of research and that this 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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BEJOY KANNATH

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

Introduction

INTRODUCTION

Ash gourd (*Benincasa hispida* Thumb.) is an important tropical cucurbit vegetable grown throughout the State. It is also known as Chinese preserving melon, wax gourd and white gourd. Ash gourd is grown on homestead level as well as on commercial scale for its valuable fruits. The fruits are used in culinary preparations, confectionaries and also used for various medicinal preparations. Fruit contains on an average 96.7% moisture, 1.9% carbohydrates, 0.4 g protein, 0.1 g fat, 0.06 mg thiamine, 0.01 mg riboflavin, 1 mg vitamin C, 30 mg Ca, 0.8 mg Fe and 10 calories of energy per 100 g of edible portion (Gopalan *et al.*, 1994).

Ash gourd fruits are used in Ayurvedic preparations and in naturopathy treatments. The medicinal properties of ash gourd are described by Chopra *et al.* (1956). The fruits are used in tonics and as laxative, diuretic, aphrodisiac and antipyretic and it is specific for haemoptysis and other haemorrhages for internal organs. Juice of the fruit is used in insanity, epilepsy and other nervous diseases and the seeds are used as anthelmetic.

Due to easiness in culture, wide adaptability, comparatively low susceptibility to serious pests and diseases and suitability to grow in all seasons, ash gourd has become very popular. However, ash gourd has been a neglected crop as far as research on crop and seed improvement are concerned.

Production of quality seeds and its maintenance till planting are important in commercial cultivation of any crop. Fruit maturity at harvest, seed extraction and drying methods, storage conditions like packing material and seed treatments assumes greater role in seed production and storage. The warm humid climatic conditions of the State promote growth of various seed microflora, enhance the rate of seed senescence and reduce the seed viability and vigour during storage. Unless proper seed packing and treatments are adopted, seeds cannot be stored for longer period. Seed production and storage techniques for ash gourd have not been standardised for Kerala conditions. Hence the present investigation was taken up at the Department of Olericulture, College of Horticulture, Vellanikkara during 1994-95 with the following objectives:

1. To find out the physiological maturity of ash gourd seeds in order to fix the optimum harvest stage of fruit for seed extraction,

2. To standardise the seed extraction and drying methods for optimum seed quality,

3. To find the effect of storage of intact fruits on seed quality and

4. To standardise the optimum storage conditions and seed treatments for maintaining the viability for longer period under ambient conditions.

Review of Literature

REVIEW OF LITERATURE

2.1 Studies on physiological maturity of seeds

The stage of seed maturity at harvest is an important factor affecting seed quality and its subsequent performance. Seeds attain maximum quality at their physiological maturity (Helmer *et al.*, 1962) and it is attained at a particular stage of development of seed on the plant. Information available on the fruit and seed maturity studies in various vegetable crops are reviewed hereunder.

2.1.1 Fruit characters

Anderson (1895) reported that the maximum rate of increase in weight of fruit in *Cucurbita pepo* was between 11 days after pollination and 11 days previous to the beginning of the ripening period. Mann and Robinson (1950) reported that in *Cucumis melo,* the rate of growth in fruit length was maximum between five and 12 days after anthesis and fruit reached maximum length on the 16th day. Showalter (1961) had confirmed that in watermelon the fruits after reaching the maximum weight started loosing weight accompanied by loss in

moisture content and this dehydration was an inherent phase of development. According to Prem Nath and Vashistha (1969), watermelon took 32 to 35 days for maturity. There was an appreciable increase in rate of growth during earlier period of fruit development. It was maximum at mid stage, but subsequently slowed down to almost constant at maturity.

In cucumber, Hammet and Malethong (1971) reported that linear fruit growth was relatively slow for the first four days and rapid for the next eight days after anthesis (d.a.a.), reaching the maximum on 18th day of development. Pratt *et al.* (1977) stated that in musk melon, the rate of growth was maximum between 10 and 20 d.a.a., and on 35th day the fruit reached maximum length.

Chandrasekaran (1979) observed maximum increase in weight of bottle gourd, LS-2 was between 10 and 25 d.a.a. and maximum weight was recorded on 40th d.a.a., whereas in fruit length maximum rate of increase was between 10th and 30th d.a.a. and the maximum fruit length was recorded on 35th d.a.a. While studying the fruit and seed development in ribbed gourd, Co-1 and bitter gourd 'Coimbatore Long', Varatharaj (1979) found that maximum weight, length and volume was recorded

at 42 and 24 days respectively after flowering. Krishnaprasad (1980) reported that in ash gourd Co-1, fruits reached maximum fresh weight and length by 60 d.a.a. Diaz (1990) reported that in *Phaseolus vulgaris* maximum pod weight and pod length was recorded at 20-25 and 15-20 days respectively after flowering.

2.1.2 Seed characters

Odland (1937) revealed that if the fruits of cucurbits were allowed to remain on the vine until 'overripe', the seed will germinate promptly, but if fruits were picked at ripe stage, the germination would be delayed for several weeks. 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.

Seed quality is being at its maximum at the physiological maturity stage, and depends on environmental conditions. Prolonged field exposure after the stage of maturity would result in losses in germinability, longevity and vigour of seedling produced (Mc Alister, 1943 and Garris and Hoffmann, 1946). Increase in fresh weight during the development of fertilized ovules into seeds was noticed by Young (1949)

in squash. The term 'physiological maturity' has been most frequently used to describe the point where the seed reaches its maximum dry seed weight (Shaw and Loomis, 1950).

Harrington (1959) studied the effect of days from anthesis to harvest in germination of muskmelon seeds. The 100 seed weight increased upto 37 d.a.a. and beyond that there was a slight decrease in 100 seed weight. The number of seeds per fruit did not change with time from anthesis. The stages of maturity of fruit had an extreme effect on germination of seeds. The seeds harvested at 37, 42 and 47 d.a.a. and immediately subjected to germination showed no much difference in germination between 37 and 47 d.a.a., but a slight difference had developed four months after harvest and it persisted nine months after harvest.

According to Chauhan and Bhandari (1971), the age of the fruits significantly affected germination in bhendi. The observed difference in germination among seeds obtained at varying period of maturity from apical, middle and basal portions of fruits in bhendi seeds collected 27 days after flower opening recorded 89.2%, while those harvested at 30 days recorded 85.8% germination. Potapova (1972) reported that the dry

weight of cucumber seed increased with increased maturity. The quality of the seed is basically dependent on its filling and on the metabolic and synthetic efficiency during seed development and maturation. 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 (Delouche, 1973). Abdul-Baki and Baker (1973) used the fresh weight of seed for differentiating between 'seed development' and 'seed maturation'. According to them, the seed development is a period between fertilization and maximum fresh weight of seeds, and maturation begins at the end of seed development and continues up to harvest.

Shanmugaraj (1978) reported that in lablab (*Lablab purpureus* (L) Sweet), seeds attained the maximum dry weight and physiological maturity on the 27th d.a.a. Studies conducted at the Tamil Nadu Agricultural University have shown that physiological maturity of seeds was obtained at 60 d.a.a. in ribbed gourd and 27 d.a.a. in bitter gourd (Varatharaj, 1979). Chandrasekaran (1979) reported that in bottle gourd, seeds attain maximum dry weight and maximum physiological maturity at 65 d.a.a. Krishnaprasad (1980) reported that in ash gourd, seeds became

germinable at 50 d.a.a. and seeds reached maximum physiological maturity and vigour potential at 80 d.a.a.

Chin (1981) observed that long bean (*Vigna sesquipedalis*) seeds subjected to storage, the germination percentage was lower in immature seeds and highest for fully matured seeds. Metha (1983) reported that in chilli, physiological maturity of seeds was attained at 48 d.a.a. and seeds from fruits harvested before attaining physiological maturity did not store well. The seeds from fruits harvested before attaining physiological maturity after storage for 12 months possessed relatively low germination and field emergence potential and produced seedlings with poor growth and vigour. In watermelon, physiological seed maturation occurred at 55 d.a.a. and the best quality seeds was obtained from fruits harvested at 35 and 45 d.a.a. and stored for four days (Alvarenga *et al.*, 1984).

Kanwar and Saimbhi (1987) reported that in okra, seed weight per pod and germination percentage were maximum from pods harvested at 35 d.a.a. Further delay in harvesting the pods increased the number of damaged seeds and reduced the seed weight and germination percentage. Hedayat (1987) reported that watermelon seeds attained maximum 100 seed weight and germination

at 42nd d.a.a. In muskmelon, seed quality was the best when harvested at "full slip" stage (Harisingh *et al.*, 1988). Nerson and Paris (1988) observed that seeds from immature fruits of cucumber (26 and 33 days past anthesis) had low germination and storability when compared to mature fruits (40 and 54 days past anthesis).

Jayabharathi *et al.* (1990) reported that brinjal fruits should be harvested at full yellow stage for maximum seed yield, germination and vigour parameters. Chaudhari *et al.* (1992) reported that in tomato, percentage germination, 100 seed weight, seedling height and vigour index increased with fruit maturity and were highest for seeds extracted from fruits at the red ripe stage. Demir (1995) reported that in okra cv. 'Akkoy', maximum seed quality was recorded at 52 d.a.a. At this stage, seeds were mature with a moisture of 12 per cent. Delaying harvest to 59 d.a.a. resulted in seed loss due to shattering.

2.2 Standardisation of seed extraction and drying methods

Quality of seeds is influenced by the method of seed processing also. Methods of seed extraction and seed drying are important in this context.

Harrington (1959) has reported that fermented seeds of muskmelon germinated better than that has been cleaned mechanically. Ritchie (1971) recorded satisfactory germination of tomato seeds extracted and cleaned with one per cent HCl and 0.1% pectinase for 24 hours at a temperature of 60°F. According to Lego and Zink (1976), seed germination of mechanically extracted tomato seeds decreased with increasing fermentation time from 24 to 48 h and the highest germination of 92 per cent was obtained after 12 months of storage from non-fermented seeds washed in warm water and dried naturally.

Seed weight, germination percentage, seedling growth and vigour were found to be superior for tomato seeds treated with concentrated HCl at 1:20 ratio by volume for 20 minutes than fermentation for 48 h and fermentation in alkali solution by adding 125 g sodium bicarbonate in 4.5 l of water at 1:1 ratio (v/v) and fermenting for 24 hours (Vadivelu and Ramaswamy, 1977). Stryapkova and Kononkov (1980) reported that in cucumber and tomato, mechanical seed extraction is considered to be the most promising method compared to acid and alkali methods of seed extraction. Harrington (1981) reported decreased germination percentage of tomato seeds with

increased concentration of HCl from one to 16%, which took increased duration for acid digestion that varied from 22.5 minutes to 300 minutes.

Silva *et al.* (1982) reported that natural fermentation of pulp (2 h at 21.1 ± 0.5°C) was not satisfactory in breaking down the gelatinous coating surrounding the tomato seeds and caused difficulties to clean the seeds properly which significantly reduced seed vigour but had no effect on germination. A satisfactory break down of gelatinous coating was obtained by enzyme procedure (8 mg pectinase dissolved in 8 ml of distilled water + 40 ml of slurry for 60 minutes) and no detrimental effect was observed on germination and vigour of seeds extracted by this method.

Seed extraction studies conducted in cucumber, melon and watermelon indicated that use of 2% NaoH or 2% HCl for 10-30 minutes or 0.03% pectinase enzyme for 5-12 h were very effective in removing the surrounding mucilage and produced seeds with good germination percentage (Kolev and Boyadzhev, 1983). Nerson *et al.* (1985a) studied the effect of fruit maturity and fermentation on the seeds of cucumber, *Cucurbita pepo*, *Cucumis melo* and watermelon. They observed that the

fermentation did not affect germination percentage, but it accelerated seed germination in watermelon and cucumber. Germination of seeds from unripe fruits was markedly increased by fermentation in watermelon and cucumber and to a lesser extent in *Cucumis melo*. However, fermentation decreased germination of seed from unripe *Cucurbita pepo*.

Nerson *et al.* (1985b) reported the effect of washing and drying seeds of cucumber, *Cucurbita pepo*, muskmelon and watermelon from fruits ranging in the age from 21-54 d.a.a. Seeds were handled with or without 15 min. of washing and with or without 48 h of air drying before being subjected to germination test at 25°C for seven days in dark. Germination of seeds harvested from ripe fruits (45-54 days) was not affected either by washing or drying. The rate of germination of these seeds was accelerated in muskmelon and inhibited in *Cucurbita pepo* by drying. Germination percentage and rate were markedly increased by air drying. Singh *et al.* (1985a) reported that the best fermentation time for tomato cultivars Punjab Chhuhara and Punjab Kesari were 24 h and 48 h respectively. Fermentation period of 24 h was found ideal for getting good quality seeds and percentage of germination was higher in seeds extracted

from fully matured fruits in muskmelon (Singh *et al.*, 1985b). Sitoula (1985) reported that in tomato, 30 g of citric acid in one litre of pulp with digestion duration of two hours had satisfactorily removed the gelatinous coating of seed with out affecting the germination and vigour of seeds. On comparing between citric acid, hydrochloric acid, alkali method and fermentation method of seed extraction, seed extracted using citric acid recorded higher germination and vigour index in fresh seeds but seeds lost vigour and viability potential rapidly, compared to other methods of seed extraction. Seeds obtained by hydrochloric acid method recorded relatively higher germination percentage and vigour index even after eight months of storage.

Edwards *et al.* (1986) showed that short fermentation duration of four days or below gave positive responses, but longer fermentation duration for eight and 12 days were deleterious on seed quality of cucumber. Hedayat (1987) from Tamil Nadu Agricultural University, Coimbatore reported that seeds extracted after maceration for two hours in hydrochloric acid (1:6 ratio) were the best in maintaining high germinability and vigour compared to seeds extracted by fermentation. Seeds extracted manually and soaked in 2% H_2SO_4 for 30 minutes were the next best.

Gill and Singh (1987) suggested that tomato pulp should not be fermented beyond 72 h,to get seeds of high germination, and preferably seeds should be washed free of pulp after 48 hours. They also found that acid treatment using 1.0 to 1.5 l HCl/q of tomato pulp for 10-15 minutes can be adopted if fermentation method is not followed.

Pandian (1988) reported that mechanical drying of bhendi seeds with hot air at 53±0.5°C in a fluidised seed drier improved the germination and vigour when compared to sun drying. Selvaraj (1988a) reported that shade dried seeds in brinjal have better storage potential when compared to sun dried seeds. Nerson and Paris (1988) observed that fermentation of seeds from immature and mature fruits of cucumber, melon and watermelon were either beneficial or at least not harmful; however fermentation of seeds from immature fruits of squash resulted in no germination.

Neelamathi (1989) reported that natural drying (sun 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. Irrespective of drying surfaces, time intervals

between 8-11 am and 2-5 pm and irrespective of different drying methods, temperature range of 38-45°C proved to be the best. Seed extraction studies conducted in cucumber indicated that seed losses could be reduced by machine extraction, fermentation of 4-6 days at 16-18°C gave the best seeds and the optimum drying time was 14 hours at 30°C (Furtak, 1989).

Gowda *et al.* (1990) reported that in tomato while studying the optimum drying method, combined sun and shade drying resulted in the highest seed germination and tomato seeds could be safely dried at temperature of 35 or 40°C maintaining high percentage germination. Gowda *et al.* (1991) reported that in tomato, among the different seed extraction methods, soaking in 5% HCl for 45 min. or 4% H_2SO_4 for 30 min. recorded the highest germination (96 and 94% respectively) and vigour index (594 and 550 respectively), but the extraction cost was high (Rs.21/kg and Rs.23/kg respectively). Mechanical extraction was the optimum method in terms of seed quality and extraction costs resulting in 85% germination and vigour index of 457 at a cost of Rs.7.50/kg. Javaregowda *et al.* (1994) reported that in brinjal, 36 h of fermentation of fruit pulp or treating

with four per cent HCl for 60 minutes was optimum for seed extraction. The alkali treatment with NaoH was not suitable for brinjal seed extraction.

2.3 Storage of intact fruits after harvest

Post-harvest storage of cucurbit fruits for seed purpose is an age-old practice followed by farmers. The effect of such storage on seed quality parameters are reviewed hereunder:

Young(1949) recorded that in butternut squash the 100 seed weight increased during fruit storage both in mature and immature fruits. The seeds removed from mature squash at the start of the storage had an average germination of 90.8 per cent whereas four months after storage, it increased to 98.4 per cent; the germination of seeds of the immature squash which was 19 per cent in the beginning of storage had increased to a maximum of 67.2 per cent, after four months of storage. It was concluded that, to obtain seeds with good germination only very mature butternut squash fruits should be harvested and stored for four months. Petrov and Dojkov (1970) reported that in brinjal storage of mature fruits for 3, 5 and 7 days increased the percentage germination of seeds but did not affect the absolute seed weight.

Madalageri *et al.* (1977) reported that in cucumber type BK-1, upto 17 per cent viviparous germination was observed.

Quagliotti *et al.* (1981) reported that in chilli post-harvest ripening of the seeds is essential and it increased percentage of fruits containing viable seeds. Araujo *et al.* (1982) reported that seed germination in cucurbits was increased with increasing fruit age and storage length. Nagy (1987) reported that in *Cucurbita pepo,* fruits stored in airy loft after harvest for two weeks produced best results in terms of germination. Buriev (1987) reported that in cucumber, after ripening improved seed quality and best quality seeds were obtained from 40 day old fruits after ripened for 10 or 15 days. Krishnaswamy (1991) reported in bitter gourd, seeds continue to mature in fruits which were harvested before ripening and stored under ambient conditions. Harvesting of fruits three days before full ripening and storing under ambient conditions for four days before extracting produced high quality seeds.

Experiments were conducted in chilli to investigate whether seed viability can be prolonged by storing seeds in fruits itself. Four varieties of chilli viz., Pusa Sadabahar, LGP, Pant C-1 and G-3 were used for the

study. During initial periods of ageing, extracted seeds showed a higher reduction in mean germination, compared to seeds stored within fruits. However at later periods of ageing, differences in germination reduction were negligible. Similar trend was observed in three of the varieties except in variety G-3, where storing seeds within fruits had some advantage in prolonging viability and vigour (Vasanthakumar and Singhal, 1994).

2.4 Storage of extracted seeds

Maintenance of high seed quality from harvesting to subsequent planting is as important as the production of quality seeds. Vegetable seed storage is a problem in warm humid climatic conditions of Kerala which experience high temperature and high relative humidity conditions throughout the year. Seeds are hygroscopic and during storage, they are subjected to fluctuations in moisture content. Seeds are infested with various micro-organisms and pests during storage. It is a well known fact that materials employed for seed treatment and containers used for storage exert a great influence on various seed quality parameters. Information available on the various seed treatments and packaging are reviewed here under.

2.4.1 Cucurbits

The germination and vigour of cucumber seeds did not change significantly in 36 months when seed moisture was 5.3% or less at 32°C or less. Seeds with 9.5% moisture became worthless in three months at 32°C, but held viability and vigour well for 30 months at 15.6°C (Asgrow Seed Co., 1954). Waller *et al.* (1960) recorded a significant increase in emergence of cucumber and squash seeds by slurry treatment with thiram. Arnoux (1962) reported enhanced germination in cucumber seed by treatment with methoxy ethyl mercuric silicate, thiram, copper oxinate or phallan. Zink and Demendonca (1964) recorded maximum germination of 88 per cent in watermelon after 18 months of storage in cloth bag, at 20°C and 45 per cent relative humidity. However, seeds stored in airtight 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. Macias *et al.* (1969) reported that seed dressing with 50 per cent thiram at 3-5 g per kg and captan at 5-10 g per kg improved germination besides stimulating growth and development of cucumber seedlings. Villaneal *et al.* (1972) found that the seeds

of squash and bottle gourd when stored in cellophane and aluminium foil packets maintained germinability longer than those in polythene or paper packets.

A package which is moisture proof or moisture resistant can be of value in prolonging germination and vigour of seeds. However, it has been found absolutely essential to pack only dry seeds in those type of containers (Harrington, 1973). Seeds of watermelon and pumpkin recorded better germination when stored in polythene packets than paper bags (Kuchernko and Lebedeva, 1976). Buydoso (1979) reported that in cucumber seeds treated with thiram, captan and ceredan gave more than 87% germination whereas in untreated seeds germination decreased to 36%. Chandrasekaran (1979) reported that storing seeds at 8% moisture content in paper aluminium polythene laminated pouches after treating with bavistin was the best method for maintaining germination and vigour of bottle gourd seeds for more than 12 months. Bogolepov (1980) observed that pumpkin seeds could be stored in best quality in plastic bags without regulating temperature and humidity.

Krishnaprasad (1980) reported that ash gourd seeds treated with thiram and stored in moisture vapour

proof container at 8% moisture content would maintain viability and vigour of seeds with minimum loss for a period of eight months.

Watermelon and pumpkin had a best storage conditions of 50% relative humidity at 18°C and 65% RH at 2°C. For storing the seeds in polythene bags, the optimum moisture contents were 7% for watermelon, 6% for melon and 6% for squash (Lebedeva, 1981). Pesis (1983) reported that in muskmelon there was a significant decline in germination prior to any significant increase in electrolytic leakage from seeds, indicating that electrolytic leakage is not a suitable test for seed quality in muskmelon. Fursa and Zhukova (1985) observed decreased viability with increased abnormality in watermelon seeds after 4-5 years of open storage, while viability was maintained in hermetically sealed containers over 15 to 23 years of storage.

Hedayat (1987) reported seeds of watermelon treated with thiram or activated clay and stored under ambient conditions in 700 gauge polythene bag recorded high germination and vigour after eight months of storage. Renugadevi (1992) reported that seed treatment with a slurry of captan @ 2.5 g/kg of seed was the best followed by bavistin, in maintaining viability of

ash gourd, bitter gourd and ribbed gourd seeds upto 10 months; with respect to containers 700 gauge polythene bags was proved superior to cloth bags.

2.4.2 Other crops

Dharmalingam *et al.*(1976) reported that when seeds of blackgram were stored in paper-aluminium-polythene pouch, they remained viable upto 24 months, recording 78% germination. Treating the seeds before and storage in cloth bags or paper-aluminium-polythene pouch was helpful in minimizing the loss of viability and vigour. Seeds of lablab treated with thiram and stored in aluminium foil pouches recorded high germination and field emergence after storage (Shanmugaraj, 1978). According to Vadivelu and Ramaswamy (1983), freshly extracted tomato seeds when dried to seven per cent moisture content and treated with thiram or captan and packed in cloth bags or moisture proof paper-aluminium-polythene laminated pouches could be stored upto 30 months. However, at the end of storage, germination in untreated control, thiram and captan treatments was 32-48 per cent, 38-48 per cent and 50-70 per cent respectively.

Jacqueline and Ramaswamy (1983) reported that captan treated bhendi seeds registered better seed vigour than thiram and untreated control, besides maintaining seed viability. Vanangamudi (1986) reported that cowpea seeds dried to 7-8% moisture content, dry treated with captan two g per kg of seed and stored in 700 gauge polythene recorded high germination and vigour after storage. Seeds of field bean when treated with captan registered higher field emergence and vigour potential (Vanangamudi and Karivaratharaju, 1987).

Pandian (1988) reported that combined application of captan at two g + cytozyme seed plus at two cc per kg of seeds as an effective seed treatment for storing bhendi seeds. Selvaraj (1988b) reported that a combined application of thiram and bavistin and storing in paper-aluminium-polythene pouch recorded the maximum germination and vigour of brinjal seeds over a period of 18 months of storage. Jayaraj *et al.* (1988) reported that seeds of tomato,capsicum, brinjal, and okra treated with captan and stored in aluminium foil pouches recorded high germination at the end of storage. Krishnaswamy and Ramarajapalaniappan (1989) reported that in tomato and brinjal there was a significant association of seed leachate electrical conductivity and field emergence of

seeds. Soaking brinjal seeds for two hours and tomato seeds for four hours was found to be optimum for measuring seed leachate electrical conductivity.

Vyas *et al.* (1990) reported that in soyabean seeds, a decrease in germination percentage was accompanied by an increase in leaching of electrolytes and electrical conductivity of seed leachate is a good indicator of seed storability and germinability. Verma *et al.* (1991) reported that cauliflower and tomato seeds stored in paper-aluminium foil-polythene pouches recorded high germination and vigour during storage.

Materials and Methods

MATERIALS AND METHODS

The present investigation, "Effect of fruit maturity, seed processing and storage methods on seed quality of ash gourd" was carried out at the Department of Olericulture, College of Horticulture, Vellanikkara during 1994 to 1995. The study consisted of four experiments.

1. Studies on physiological maturity of seeds
2. Standardisation of seed extraction and drying methods
3. Storage of intact fruits after harvest
4. Storage of extracted seeds

3.1 Studies on Physiological maturity of seeds

Ash gourd culture BH-21 was grown in the research fields of the Department of Olericulture during two distinct seasons - rainy season and summer season. The rainy season crop was sown on first August 1994 and the summer season crop on 27th December 1994. During the period of crop growth, the recommended cultural operations and plant protection measures (KAU, 1993) were carried out (Plate 1).

Plate 1. Field view of the experimental plot


EFFECT OF FRUIT MATURITY AND SIZE PROCESSING
AND STORAGE METHODS ON SIZED QUALITY OF
Variety RH 21

During the period of flowering, female flowers were tagged by noting on the label, the date of anthesis. Such marked flowers were observed for various parameters of fruit and seed development and maturation. Fruits were harvested at five days intervals from the date of flower opening to full maturity or ripening of fruits. The fruit samples were collected till the complete yellowing and drying of vines. The fruits thus collected at different intervals were designated serially from S_1 to S_{15} to represent five day to 75 day old fruits. A total of fifteen fruits were examined in each stage of development (in three replicates of five fruits each) and the following observations were recorded.

3.1.1 Morphological description of fruits and seeds

Morphological description of fruits and seeds at various stages of fruit development such as colour of fruit skin, persistence of corolla on stylar end, ashy coating etc. were recorded for fruits of each stage. Similarly, the nature and colour of seeds were also recorded.

Fruit characters

3.1.2 Fruit weight

Immediately after harvest, fruits were weighed individually and their weight was recorded in grams.

3.1.3 Volume

The volume of the fruit was measured by water displacement method and expressed in cm^3.

3.1.4 Length

The fruit was cut longitudinally into two equal halves and length of fruit excluding the stalk was measured from base to the tip and expressed in centimetres (cm).

3.1.5 Diameter

Breadth of fruit at the middle of the longitudinal halves was measured as diameter and expressed in cm.

Seed characters

3.1.6 Number of seeds

Seeds from the fruits were separated and counted and number of well filled seeds was recorded.

3.1.7 Fresh weight of filled seeds

Seeds were extracted from the fruits and weighed immediately to determine the fresh weight and expressed in grams.

3.1.8 Dry weight of filled seeds

Seeds after extraction were dried under shade for a constant period and weighed again to constant weight to arrive at the dry weight of seeds.

3.1.9 Fresh weight of unfilled seeds

The underdeveloped and unfilled seeds were weighed separately at time of seed extraction and expressed in grams.

3.1.10 100-seed weight

Determination of 100-seed weight was done as per the International Rules for Seed Testing (ISTA, 1985).

3.1.11 Germination percentage

A total number of 3 x 25 seeds selected at random from each stage of fruit development were placed in sterilized sand medium and allowed to germinate under ambient conditions. The seedlings were watered daily. The seedlings were evaluated on the tenth day of the emergence of the first seedling (final count day) and the total number of normal seedlings were recorded. The mean number of normal seedlings produced to the total number of seeds sown was expressed as germination percentage.

3.1.12 Speed of germination

From the samples sown for recording germination, number of seedlings emerged was recorded daily until the tenth day of the emergence of first seedling. Cotyledons slipping out of the seed coat was taken as the criteria for germination of normal seedling. From the mean

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

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

where X_n = per cent germination on n^{th} day

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

Seedling characters:

3.1.13 Root length of seedling

At the end of the germination test period ie. on the final count day, five normal seedlings were carefully uprooted at random from the test sample and measured the root length and computed the mean. The length between collar and tip of the root was measured as root length and expressed in cm.

3.1.14 Shoot length of seedling

From the sample after measuring root length, the length between collar and tip of the leaf was measured in cm and the mean value was recorded as shoot length.

3.1.15 Vigour index of seedling

Vigour index was computed adapting 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

3.1.16 Seedling dry weight

Five normal seedlings, after measuring their length 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 the dry weight of seedlings was recorded in mg.

3.2 Standardisation of seed extraction and drying methods

Fully matured fruits of uniform size were selected from the seed production plots of ash gourd culture BH-21 raised during August-January, 1994-95 season. Seeds were extracted from the fruits by seven methods and seeds obtained from each method were subjected to four drying treatments.

Methods of seed extraction employed in the study were:

1. Manual extraction (E_1)

The fruits were cut longitudinally and seeds were removed manually.

2. Manual extraction + with 48 hours of fermentation (E_2)

The fruits were cut longitudinally and seeds along with fruit pulp were scooped out from the centre and kept in a container for 48 hours under ambient conditions to ferment. Then seeds were washed thoroughly in water to remove the adhering pulp and cleaned.

3. Machine extraction with no fermentation (E_3)

The fruits were cut longitudinally into small pieces and such pieces along with the seeds were immediately passed through an axial flow vegetable seed extracting machine. The seeds were separated manually from the pulp obtained from the extractor, washed thoroughly in water and cleaned.

4. Machine extraction with 48 hours of fermentation (E_4)

The seeds along with fruit pulp obtained by machine extraction was kept in a container for 48 hours under ambient conditions to ferment. Then seeds were separated and washed thoroughly in water to remove the adhering pulp and cleaned.

5. Machine extraction + acid treatment @ 1% HCl of the pulp for 30 minutes (E_5)

The fruit pulp along with seeds obtained by machine extraction was treated with concentrated HCl @ one per cent weight of the pulp, mixed thoroughly and kept for 30 minutes. Then the seeds were washed thoroughly in running water to remove the adhering pulp and cleaned.

6. Machine extraction + acid treatment @ 2% HCl of the pulp for 30 minutes (E_6)

The fruit pulp along with seeds after machine extraction was treated with concentrated HCl @ two per cent weight of the pulp, mixed thoroughly and kept for 30 minutes. Then the seeds were washed thoroughly in water to remove the adhering pulp and cleaned.

7. Machine extraction + alkali treatment (E_7)

The fruit pulp along with seeds after machine extraction was mixed with one per cent NaOH solution equal to weight of the pulp and kept for one night. The seeds were washed thoroughly in water to remove the adhering pulp and cleaned.

The seeds obtained by the various extraction methods were dried in different ways as mentioned below:

1. Drying under shade (D_1)
2. Drying under direct sunlight (D_2)
3. Drying using hot air at 35°C in a mechanical seed drier (D_3)
4. Initial drying in shade for one day and then in sun avoiding the peak hours ie. 12 noon to 3 pm

Thus a total of 28 treatment combinations (seven methods of seed extraction and four methods of seed drying) were compared in this experiment. The processed seeds were stored under ambient conditions and quality was tested at monthly intervals for six months. The following observations were recorded in each month.

3.2.1 Germination percentage

A total number of 2 x 25 seeds from each treatment were placed in sterilized sand medium and allowed to germinate under ambient conditions. The seedlings were watered daily and evaluated on the tenth day of emergence of first seedling and the total number of normal seedlings were recorded. The mean number of normal seedlings produced was expressed as germination percentage.

3.2.2 Speed of germination

From the samples kept for germination, number of seedlings emerged were recorded daily upto the tenth day of emergence of the first seedling and the speed of germination was estimated as described under item 3.1.12.

3.2.3 Root length of seedling : Recorded as detailed under item 3.1.13.

3.2.4 Shoot length of seedling : Recorded as detailed under item 3.1.14.

3.2.5 Vigour index of seedling : Recorded as detailed under item 3.1.15.

3.2.6 Seedling dry weight : Recorded as detailed under item 3.1.16.

3.2.7 Electrical conductivity of seed leachate (Presley, 1958)

Two replicates of twenty five 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 up to 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 μ mhos/cm.

3.2.8 Time and man hour required for seed extraction

A total of five fruits were taken under each method of seed extraction. Time taken for cutting the fruits, extraction, washing and cleaning of seeds under each method were recorded separately.

3.3 Storage of intact fruits after harvest

For this study, uniform mature fruits of similar size,harvested from the seed crop raised from January to May 1994 were used for storage. Fruits were stored under ambient conditions. Seeds were extracted from two fruits in each month, dried uniformly in shade and their viability and vigour was assessed for one year at monthly intervals. The following observations were recorded from each fruit.

3.3.1 Fruit weight at the time of harvest

The freshly harvested fruits were tagged and their weight was recorded in kg and kept for storage.

3.3.2 Fruit weight at the time of extraction

At the time of extraction, fruits were weighed individually and weight recorded in kg.

3.3.3 Percentage weight loss of fruits

The weight loss of fruits when compared to their fresh weight at the time of harvest was calculated and expressed in percentage.

3.3.4 Fresh weight of seeds per fruit:

Recorded as detailed under item 3.1.7.

3.3.5 Dry weight of seeds per fruit:

Recorded as detailed under item 3.1.8.

3.3.6 Germination percentage:

Recorded as detailed under item 3.2.1.

3.3.7 Speed of germination:

Recorded as detailed under item 3.2.2.

3.3.8 Root length of seedling:

Recorded as detailed under item 3.1.13.

3.3.9 Shoot length of seedling:

Recorded as detailed under item 3.1.14.

3.3.10 Vigour index of seedling:

Recorded as detailed under item 3.1.15.

3.3.11 Seedling dry weight:

Recorded as detailed under item 3.1.16.

3.3.12 Percentage of viviparous seeds

Percentage of viviparous seeds in fruits at the time of seed extraction was calculated using the formula:

$$\frac{\text{Number of seeds germinated/fruit}}{\text{Total number of seeds/fruit}} \times 100$$

3.4 Storage of extracted seeds

Fully matured uniform fruits were selected from the seed crop of ash gourd, BH-21 raised during September-February 1993-94 season and seeds extracted from them were used for the storage studies. The seeds before storage was cleaned and dried to bring the moisture content to 8.2 per cent. The sample seeds were drawn and treated with selected seed protectants and packed separately in moisture pervious and moisture-vapour proof containers on 28.03.1994 and stored under ambient temperature and relative humidity in the laboratory. The following were the seed treatment and packing material employed in the study.

Seed treatments:

T_1 - Captan (N-trichloromethyl-thio-4 cyclohexene-1,2-dicarboximide) 50% W.P. 2.5 g/kg seed

T_2 - Thiram (Tetra methyl thiuram disulphide) 75% W.P. at 2.5 g/kg of seed

T_3 - Bavistin (2-methoxy carbomyl-benzimidazole) 50% W.P. 2.5 g/kg seed

T_4 - (Cowdung+ash slurry) and drying in smoke - farmers practice

T_5 - Control - untreated seeds

All such treated seed lots were packed in three different packing material noted below.

Packing materials:

P_1 - Brown paper bag

P_2 - Polythene bag (700 gauge)

P_3 - Gada cloth bag

Thus there were 15 treatment combinations of five treatments x three packing materials. Ten grams of the treated seeds were packed in respective seed packets. The seed sample packets were drawn at monthly intervals to evaluate their quality in storage and following observations were recorded.

3.4.1 Germination percentage - recorded as detailed under item 3.2.1.

3.4.2 Speed of germination - recorded as detailed under item 3.2.2.

3.4.3 Vigour index of seedling - recorded as detailed under item 3.2.15.

3.4.4 Seedling dry weight - recorded as detailed under item 3.2.16.

3.4.5 Electrical conductivity of seed leachate - recorded as detailed under item 3.2.7.

3.4.6 Hydrogenase enzyme activity

Hydrogenase activity was measured as per the procedure suggested by Kittock and Law (1968). For measuring hydrogenase enzyme activity, two replicates of 10 seeds were soaked in distilled water over night to allow imbibition. The next day, seed coat was removed carefully and cotyledons were split longitudinally and placed in 10 ml of 0.5% tetrazolium solution for four hours for the development of red coloured formazan. Then excess tetrazolium solution was decanted and seeds were washed thoroughly in distilled water. Red coloured formazan was extracted in 20 ml methylcellosolve (2 methoxy-ethanol) by soaking the cotyledons for 22 hours until the cotyledons became colourless. Then the red coloured methylcellosolve was made upto 20 ml and absorbance was read at 480 nm using a spectrophotometer.

Statistical analysis

Statistical analysis of the data was performed in computer using MSTAT-C package in factorial completely randomised block design (CRBD) for experiments 2 and 4, and in simple CRBD for experiments 1 and 3. Germination percentage was transformed to Arc-sine by MSTAT-C and the transformed data were analysed.

Results

RESULTS

4.1 Studies on physiological maturity of seeds season I and season II

4.1.1 Morphological description of fruits

Morphological description of fruits and seeds recorded at various developmental stages is furnished in Table 1 and exhibited in Plates 2 to 9.

Means of fruit and seed characteristics during various developmental stages of fruit in the first (rainy) and second (summer) seasons are furnished in Tables 2 and 3 respectively. Details of statistical analysis are furnished in Appendix I and II.

4.1.2 Fruit weight

The weight of developing fruits increased gradually from the day of anthesis. Mean weight of developing fruits increased from 184.17 g on five d.a.a. and reached maximum by 30 d.a.a. (5011.11 g) in season I, whereas in season II, it increased from 193.33 g (five d.a.a.) and reached maximum of 4302.78 g on 40 d.a.a. After attaining the maximum weight, a slight decrease in

Table 1 Morphological description of fruits and seeds at various stages of development

Stages of development days after anthesis (d.a.a.)	Description
5	Green fruits with whitish spots. Dark green colour towards the pedicel end and light green with whitish tinge towards the stylar end. Pedicel colour dark green. Fruits highly pubescent. Corolla persistent at the stylar end. Grooves seen on surface of fruit. Developing ovules can be seen inside the fruit.
10	Greenish fruits with whitish colour towards the stylar end. Whitish spots seen on the surface, concentrated towards stylar end. About one third of fruit whitish in colour; pedicel green. Ashy coating which is powdery in nature develops towards pedicel end; fruits pubescent. Seeds in developing stage, seed coat and cotyledons are distinctly separate - watery cotyledons. Seed coat whitish in colour.
15	Greenish fruits with white colour moving towards pedicel end and portion touching the ground turns whitish. Ashy coating progresses and covers half of the fruit; pedicel green. Pubescence decreases. Seed coat in developing stage. Seeds difficult to separate out.
20	Fruits with ashy coating almost complete over the entire surface of fruit; pedicel green, fruit less pubescent. Seeds structurally complete, seed coat fully developed, light cream in colour. Seeds embedded in white pithy placenta. Appearance of small grooves on margin of seed. Seeds can be removed from placenta on touching with hand. Development of cotyledons complete. Minute embryo can be seen on dissection.
25	Ashy coating over the entire fruit surface; becoming thicker and more sticky; pedicel green. Fruit less pubescent. Seed coat becoming more creamy in colour and becoming more harder. Grooves on the margin of fruit becoming more prominent. Seeds becoming more easy to separate from placenta.

Contd.....

Table 1 contd.....

30	Ashy coating becoming more sticky - cannot be easily removed by rubbing with hand; pedicel green. Pubescence decreases. Rind of fruit getting harder. Seeds seems to be fully developed. Seed coat light creamy, becoming harder. Seeds easily separated out from placenta.
35	Ashy coating becoming more sticky. Fruit pedicel turns from dark green to light green colour. Pubescence of fruit decreases. Fruitrind becomes harder and not easily pearsibile with nails. Prominent longitudinal grooves develop on surface of fruits. Constrictions on the stalk end of fruit becoming prominent. Air spaces are seen in placental region. Seeds easy to separate from placenta. Seed coat becoming deep (strong cream) in colour. Seed coat becoming more harder and seeds seems to be well developed.
40	Ashy coating becoming more sticky and thicker. Pubescence on fruit about to disappear, pedicel of the fruit turning slightly yellowish green. Depressions seen on pedicel end. Longitudinal grooves on fruits becoming prominent. Seeds strong cream in colour and seems to be fully developed.
45	Ashy coating on the fruits removed only by forceful rubbing and sticks to hand. Withering of pedicels started and pedicel becoming yellowish green. Prominent longitudinal grooves seen on surface of fruit. Prominent depression seen at pedicel end; fruit rind very hard, cannot be pierced by nails. Pubescence of fruit disappears. Pericarp becomes pithy. Seed coat fully developed; seeds hard and deep cream in colour.
50 to 60	No visible changes in the fruits. Rind became more thicker.
65 to 75	Withering of vines; thickness of ashy coating getting reduced and become dried into a white powder which could be removed by rubbing.

Plate 2. Pattern of fruit development in ash gourd (five to 20 d.a.a.)

Plate 3. Cross section of fruits at different maturity stages (five to 20 d.a.a.)


S1
5 dpa
S2
10 dpa
S3
15 dpa
S4
20 dpa


S1
5 dpa
S2
10 dpa
S3
15 dpa
S4
20 dpa

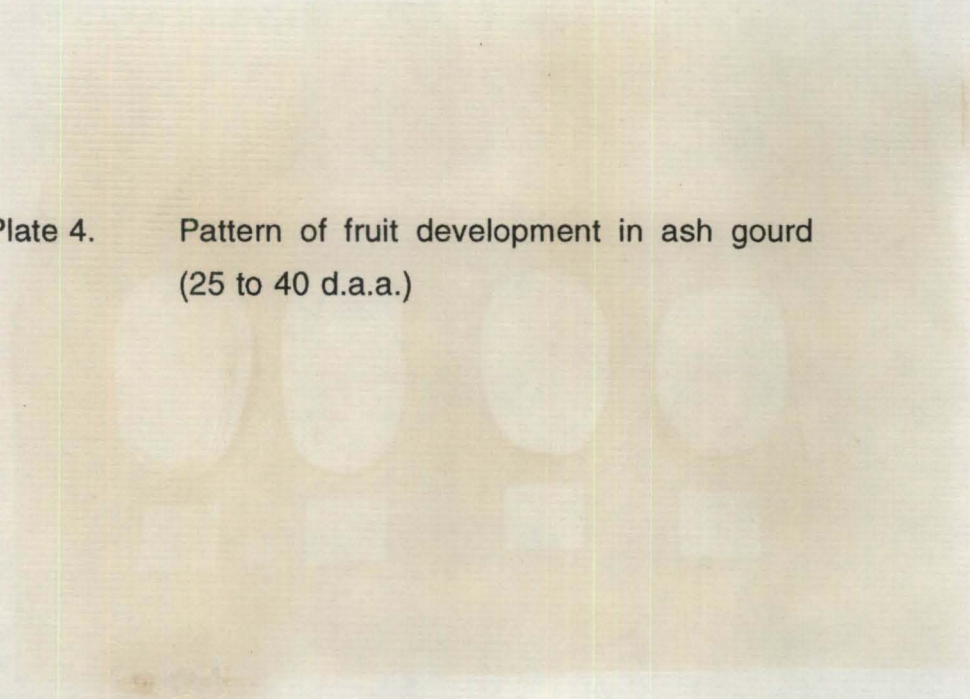


Plate 4. Pattern of fruit development in ash gourd (25 to 40 d.a.a.)

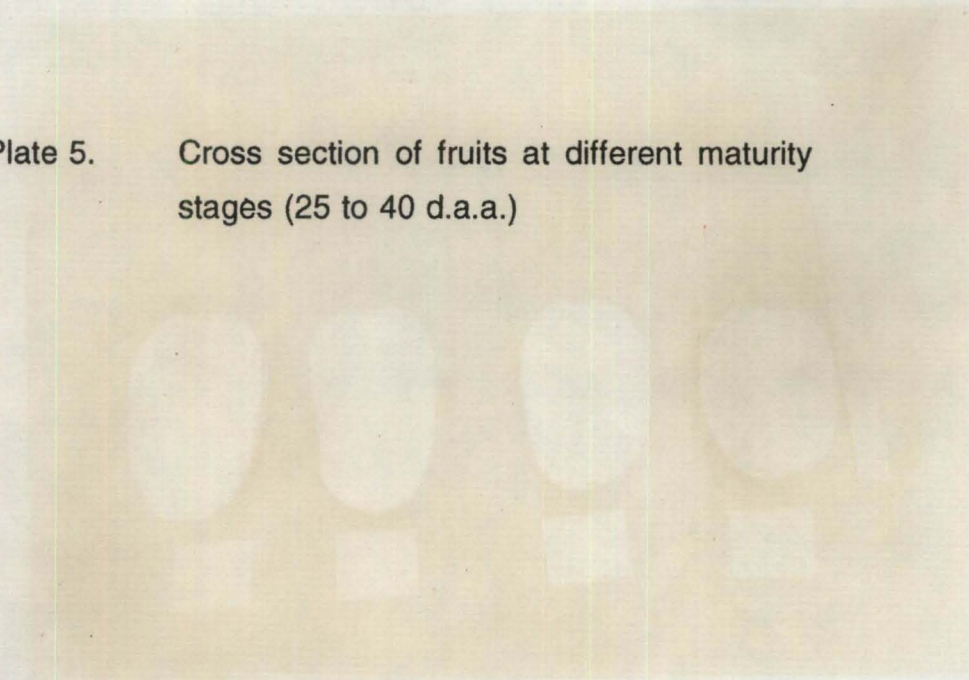
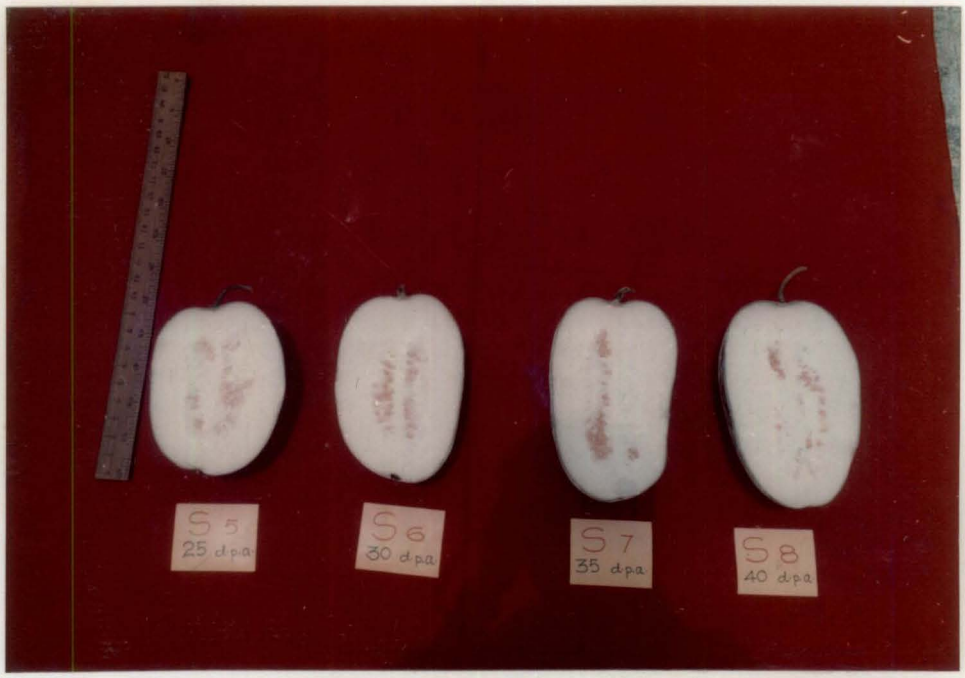


Plate 5. Cross section of fruits at different maturity stages (25 to 40 d.a.a.)


S 5
25 d.p.a.
S 6
30 d.p.a.
S 7
35 d.p.a.
S 8
40 d.p.a.


S 5
25 d.p.a.
S 6
30 d.p.a.
S 7
35 d.p.a.
S 8
40 d.p.a.

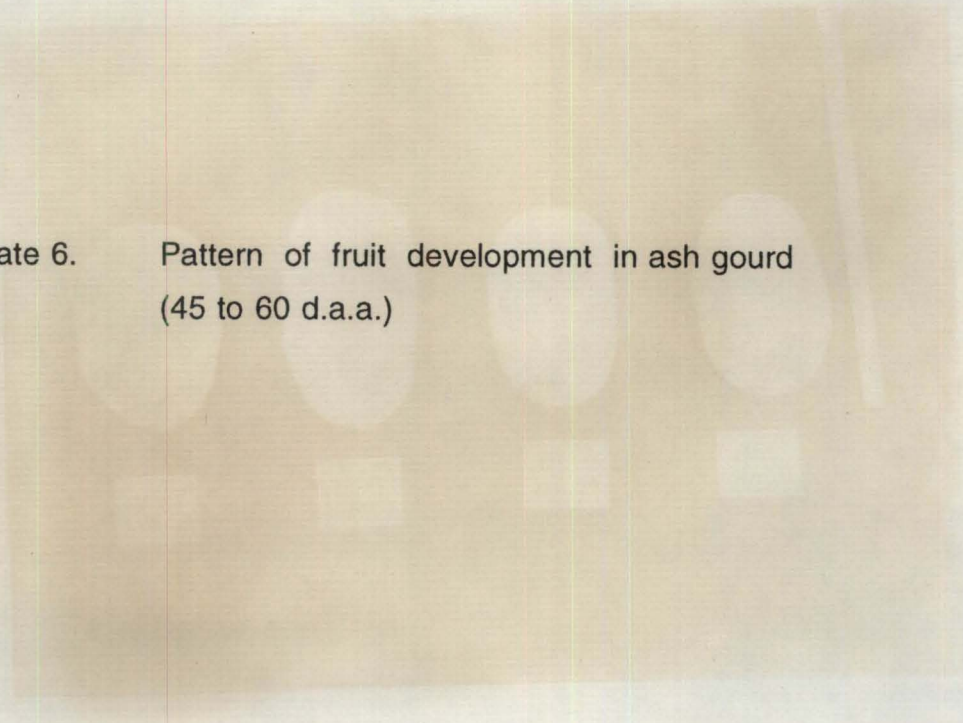


Plate 6. Pattern of fruit development in ash gourd (45 to 60 d.a.a.)

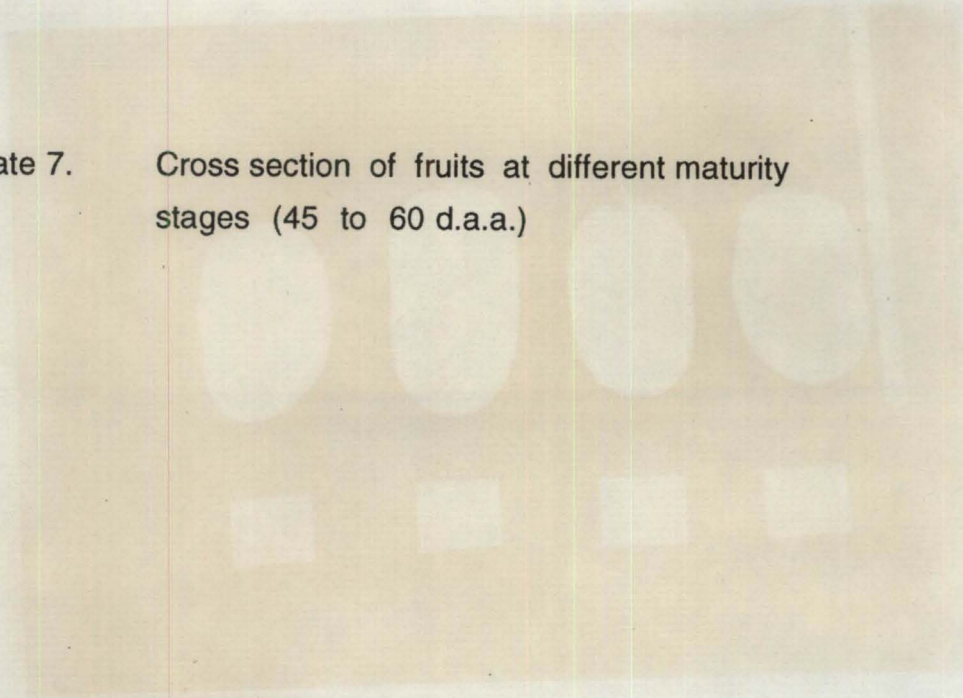
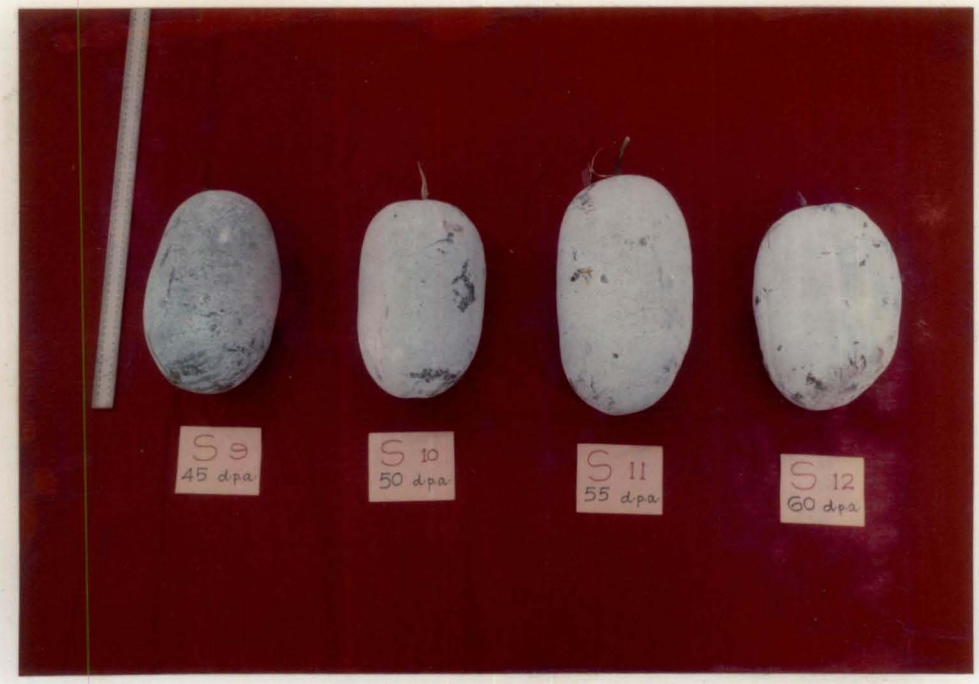


Plate 7. Cross section of fruits at different maturity stages (45 to 60 d.a.a.)


S 9
45 d.p.a
S 10
50 d.p.a
S 11
55 d.p.a
S 12
60 d.p.a

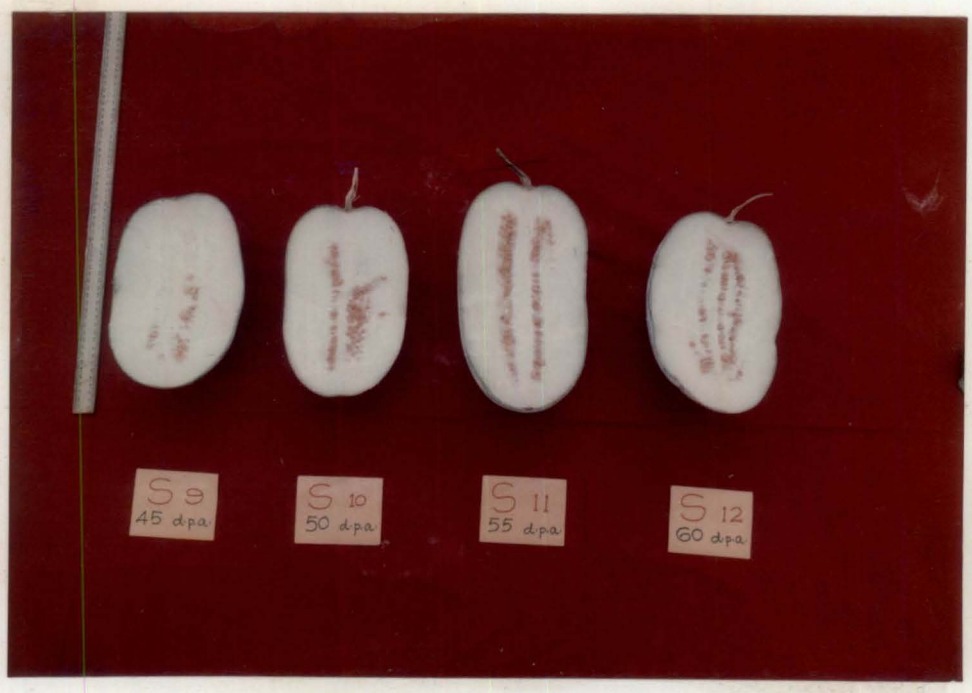

S 9
45 d.p.a
S 10
50 d.p.a
S 11
55 d.p.a
S 12
60 d.p.a

Plate 8. Pattern of fruit development in ash gourd (65 to 75 d.a.a.)

Plate 9. Cross section of fruits at different maturity stages (65 to 75 d.a.a.)


S 13
65 dpa
S 14
70 dpa
S 15
75 dpa


S 13
65 dpa
S 14
70 dpa
S 15
75 dpa

Table 2 Mean fruit and seed characteristics of ash gourd at different stages of maturity (Season I)

Stage	d.a.a.	Fruit weight (g)	Volume (cc)	Length (cm)	Diameter (cm)	Number of seeds	Fresh weight of filled seeds (g)	Dry weight of filled seeds (g)
S_1	5	184.17	185.28	11.27	5.18	-	-	-
S_2	10	1106.63	1120.66	17.83	10.24	-	-	-
S_3	15	2002.22	2094.44	21.97	12.59	-	-	-
S_4	20	2880.00	3071.11	22.28	14.24	426.00	72.11	9.43
S_5	25	4367.78	4704.72	28.42	16.58	627.00	93.56	17.69
S_6	30	5011.11	5422.22	30.55	16.72	711.00	90.83	22.06
S_7	35	4355.55	4755.83	27.94	17.04	741.00	119.86	33.23
S_8	40	4655.00	5002.09	28.77	16.23	777.00	127.25	38.23
S_9	45	3995.56	4191.11	28.95	16.21	677.00	117.49	34.27
S_{10}	50	4424.67	4740.33	28.28	17.28	863.00	132.52	44.20
S_{10}	55	4420.00	4738.00	28.87	17.43	724.00	120.47	40.20
S_{12}	60	4905.00	5262.37	28.90	17.67	592.00	138.07	32.80
S_{13}	65	4755.55	5071.11	30.01	16.00	682.00	113.56	35.33
S_{14}	70	4591.11	4922.33	28.67	14.44	774.00	119.33	40.95
C.D.		** 650.96	** 721.04	** 2.40	** 1.80	NS	NS	** 10.88

Contd....

Table 2 contd....

Stage	d.a.a.	100 seed weight (g)	Germination (%)	Speed of germination	Root length of seedling (cm)	Shoot length of seedling (cm)	Vigour index of seedings	Seedling dry weight (mg)
S_1	5	-	-	-	-	-	-	-
S_2	10	-	-	-	-	-	-	-
S_3	15	-	-	-	-	-	-	-
S_4	20	2.50	0	0	0	0	0	0
S_5	25	3.27	1.33 (0.13)	0.15	1.73	1.80	14	5.33
S_6	30	3.90	5.33 (0.22)	0.15	3.17	4.20	59	13.83
S_7	35	4.60	20.00 (0.42)	1.70	4.25	8.73	287	15.03
S_8	40	4.97	1.33 (0.13)	0.13	1.67	1.67	13	6.33
S_9	45	5.07	33.33 (0.61)	3.50	5.66	9.69	515	24.93
S_{10}	50	5.17	41.33 (0.70)	4.60	5.95	10.92	668	24.73
S_{10}	55	5.57	81.33 (1.13)	9.25	6.53	12.90	1580	26.13
S_{12}	60	5.60	86.67 (1.23)	11.17	6.05	13.25	1663	27.47
S_{13}	65	5.13	98.67 (1.44)	13.89	8.08	13.96	2174	29.87
S_{14}	70	5.30	100.00 (1.47)	14.42	9.15	13.90	2305	30.27
C.D.		0.41**	0.24**	1.80**	2.80**	3.54**	257**	11.47**

** Significant at 1% level

NS - Non significant

0 Not included in the analysis

Figures in brackets are arc-sine transformed values

Table 3 Mean fruit and seed characteristics of ash gourd at different stages of maturity (Season II)

Stage	d.a.a.	Fruit weight (g)	Volume (cc)	Length (cm)	Diameter (cm)	Number of seeds	Fresh weight of filled seeds (g)	Dry weight of filled seeds (g)	Fresh weight of unfilled seeds
S_1	5	193.33	196.22	11.83	5.25	-	-	-	-
S_2	10	1013.34	1037.78	16.47	10.18	-	-	-	-
S_3	15	2005.55	2085.11	21.53	13.02	-	-	-	-
S_4	20	2644.44	2797.22	22.62	14.04	372	34.56	9.14	20.28
S_5	25	3324.17	3866.78	24.32	15.51	572	67.23	18.54	19.59
S_6	30	3766.67	3990.14	23.25	16.92	443	49.50	16.21	14.66
S_7	35	3502.22	3666.89	23.64	16.25	549	71.78	24.41	12.11
S_8	40	4302.78	5034.22	26.12	17.00	626	65.58	27.28	14.78
S_9	45	3465.56	3688.22	25.11	15.62	609	64.78	27.31	13.66
S_{10}	50	3568.89	3798.22	25.11	15.41	597	75.67	29.04	5.89
S_{10}	55	3577.78	3799.78	26.00	16.00	744	79.67	36.01	6.78
S_{12}	60	3362.22	3590.22	25.63	16.30	613	51.00	29.38	4.61
S_{13}	65	3455.55	3688.78	25.98	15.14	571	51.41	27.00	5.44
S_{14}	70	3835.44	4090.33	26.22	16.05	844	72.67	41.45	4.78
S_{15}	75	3534.56	3651.44	24.94	15.23	643	56.11	31.69	4.56
CD		545.14**	671.03**	2.02**	1.100**	NS	21.74**	12.14**	8.14**

contd.....

Table 3 contd....

Stage	d.a.a.	100 seed weight (g)	Germination (%)	Speed of germination	Root length of seedling (cm)	Shoot length of seedling (cm)	Vigour index of seedings	Seedling dry weight (mg)
S_1	5	-	-	-	-	-	-	-
S_2	10	-	-	-	-	-	-	-
S_3	15	-	-	-	-	-	-	-
S_4	20	2.48	0*	0*	0*	0*	0*	0*
S_5	25	3.26	0*	0*	0*	0*	0*	0*
S_6	30	3.64	1.33 (0.13)	0.15	1.67	2.50	17	7.00
S_7	35	4.45	0*	0*	0*	0*	0*	0*
S_8	40	4.37	0*	0*	0*	0*	0*	0*
S_9	45	4.47	4.00 (0.20)	0.52	3.48	5.37	54	14.67
S_{10}	50	4.78	42.67 (0.71)	5.70	5.72	9.04	625	24.20
S_{10}	55	4.83	69.33 (0.99)	10.10	6.34	10.99	1200	26.20
S_{12}	60	4.79	82.67 (1.15)	12.00	6.47	11.19	1461	27.67
S_{13}	65	4.78	88.00 (1.22)	12.88	7.02	10.69	1561	26.67
S_{14}	70	4.94	86.67 (1.20)	13.11	7.19	11.44	1558	28.80
S_{15}	75	4.94	84.00 (1.16)	12.73	7.03	11.17	1527	28.13
C.D.		0.38**	0.12**	1.41**	2.64**	4.05**	176**	10.94**

** Significant at 1% level

NS - Non significant

* Not included in the analysis

Figures in brackets are arc-sine transformed values

weight was observed in both seasons. The rate of increase in fruit weight was very high between five and 10 d.a.a. in both seasons. The differences in weight of fruit at different stages of development were highly significant between five to 25 d.a.a. in both seasons.

4.1.3 Volume

The volume of developing fruits increased significantly from 185.28 cc (five d.a.a) and reached a maximum of 5422.22 cc on 30 d.a.a. in season I, whereas in season II, it increased to a maximum of 5034.22 cc on 40 d.a.a. After attaining a maximum volume, a slight decrease in volume of fruits was observed in both seasons. The rate of increase in fruit volume was maximum between five d.a.a. and 10 d.a.a. The differences in volume of fruit at different stages of development were highly significant between five d.a.a. to 25 d.a.a. in both seasons.

4.1.4 Length

The length of developing fruits, increased significantly from 11.27 cm on five d.a.a. to 30.55 cm at 30 d.a.a. in season I. In season II, length of developing fruits increased from 11.83 cm on five d.a.a.

to 26.12 cm on 40 d.a.a. Thereafter a slight decrease in length of fruits was observed in both seasons. The rate of increase in fruit length was the highest between five d.a.a and 10 d.a.a. in both seasons. The differences in fruit length at different stages of development were highly significant between five d.a.a. to 25 d.a.a. in both seasons.

4.1.5 Diameter

In season I, the diameter of fruits increased significantly from 5.18 cm, on five d.a.a. to 16.58 cm on 25 d.a.a. The maximum diameter was recorded of 60 d.a.a. (17.67 cm). Fruit diameter during various stages of development ie. from 25 d.a.a. to 65 d.a.a. were not statistically significant and were on par. A slight decrease in diameter of fruit was observed after 60 d.a.a. In season II, diameter of the fruits increased significantly from 5.25 cm (five d.a.a.) to 16.92 cm, (30 d.a.a.) and the maximum diameter was recorded on 40 d.a.a. (17 cm). A slight decrease in diameter of fruit was observed after 40 d.a.a. The rate of increase in diameter of developing fruits was maximum between five d.a.a. and 10 d.a.a. in both seasons. The differences in weight of fruit at different stages of development were

highly significant between five d.a.a. to 25 d.a.a. in season I , whereas it was highly significant between five d.a.a. to 30 d.a.a. in season II.

4.1.6 Total Number of seeds

Total number of seeds during different stages of fruit development was found to be non significant in both the seasons.

4.1.7 Fresh weight of filled seeds

The extractable and filled seeds were obtained from fruits of 20 d.a.a. in both the seasons. Fresh weight of filled seeds/fruit was found to be non significant in season I. The fresh weight of filled seeds varied significantly in season II and the maximum fresh weight (79.67 g) was recorded 55 d.a.a. Thereafter a slight decrease in fresh weight was observed. The fruits of 70 d.a.a. also recorded a high fresh seed weight 72.67 g per fruit.

4.1.8 Dry weight of filled seeds

The dry weight of seeds per fruit which was 9.43 g per fruit on 20 d.a.a increased significantly and

recorded a maximum 44.2 g per fruit in 55 d.a.a. in season I. Thereafter a slight decrease in dry weight of seeds was observed. The dry weight of seeds during the stages 40, 45, 50, 55, 65 and 70 d.a.a. were on par with each other in season I. The dry weight of seeds which was 9.14 g per fruit on 20 d.a.a. increased significantly and reached a maximum 41.45 g per fruit on 70 d.a.a. in season II. The seeds obtained from fruits of 55 d.a.a., 60 d.a.a. and 75 d.a.a. recorded high dry weight and were on par with seeds of 70 d.a.a. in season II. The rate of increase in dry weight of seeds was maximum between 20 d.a.a. and 25 d.a.a. in both the seasons.

4.1.9 Fresh weight of unfilled seeds

The weight of unfilled seeds was recorded only in season II. The weight of unfilled seeds was maximum (20.28 g per fruit) at 20 d.a.a. and recorded a minimum (4.56 g per fruit) at 75 d.a.a. The weight of unfilled seeds showed slight reduction until 45 d.a.a. and differences in their weight during these periods of developments were on par. There was a significant reduction in weight of unfilled seeds from 13.66 g on 45 d.a.a. to 5.89 g on 50 d.a.a.; fruits from 50 d.a.a.

showed negligible differences during subsequent periods of development. The weights of unfilled seeds were on par from 50 d.a.a. to 75 d.a.a.

4.1.10 100 seed weight

The mean 100 seed weight at different stages of fruit development was highly significant in both the seasons. In season I, it was the lowest (2.5 g) on 20 d.a.a. and reached the highest (5.6 g) on 60 d.a.a. From 60 d.a.a. to 70 d.a.a. a slight decrease in 100 seed weight was observed. The seeds from fruits of 70 d.a.a. recorded a 100 seed weight of 5.3 g in the first season; 100 seed weight of fruits of 55 d.a.a., 60 d.a.a and 70 d.a.a. were on par with each other.

In season II, 100 seed weight was the lowest (2.48 g) in fruits of 20 d.a.a. and reached the highest (4.94 g) on 70 and 75 d.a.a. The seeds from fruits of stages 50 d.a.a. to 75 d.a.a. recorded high 100 seed weight and were on par with each other.

4.1.11 Germination percentage

The germination percentage at different maturity stages of seeds were highly significant in both the

seasons. Seeds from fruits of 20 d.a.a. recorded no (zero per cent) germination in both the seasons. In season I, seeds became germinable to low extent of 1.33 per cent at 25 d.a.a. and thereafter showed remarkable increase ie. on 55 d.a.a. with 81.33 per cent and reached a maximum of 100 per cent germination on 70 d.a.a. The seeds from of 60 d.a.a., 65 d.a.a. and 70 d.a.a. were on par with each other for germination (86.67, 98.67 and 100 per cent respectively).

In season II, the seeds became germinable to a low extent of 1.33 per cent at 30 d.a.a. and showed a remarkable increase at 50 d.a.a. with 42.67 per cent. The maximum germination (68 per cent) was recorded in seeds at 65 d.a.a. Thereafter a slight decrease in germination was observed in second season. The seeds from stages 60 d.a.a. to 75 d.a.a. recorded high germination and were on par with each other.

4.1.12 Speed of germination

The differences in speed of germination at different stages of seed development were highly significant in both the seasons. Speed of germination recorded a continuous increase upto 70 d.a.a. in both seasons. In season I, least speed of germination was recorded

on 25 d.a.a. and 30 d.a.a.(0.15) and the highest (14.42) on 70 d.a.a.; whereas in season II, it was least (0.15) on 30 d.a.a. and the highest (13.11) on 70 d.a.a. Speed of germination of seeds from fruits of 65 and 70 d.a.a. were on par with each other (13.89 and 14.42) in season I, whereas in season II the stages 60 d.a.a. to 75 d.a.a. were on par with each other.

Seedling characters

4.1.13 Root length of seedling

The root length of seedlings from seeds of different stages of development and maturity was highly significant in both the seasons. In season I, it was the least (1.73 cm) from seeds of 25 d.a.a. and maximum (9.15 cm) from 70 d.a.a. Seeds of 65 d.a.a. also recorded high mean root length of 8.08 cm. Seeds on 65 and 70 d.a.a. recorded high root length (8.08 and 9.15 cm respectively) and were on par with each other in season I.

In season II, root length was least (1.67 cm) in seedlings from seeds of 30 d.a.a. and maximum (7.19 cm) in seedlings from seeds of 70 d.a.a. The root length of seedlings from stages 50 d.a.a. to 75 d.a.a. recorded high value and was on par with each other in season II.

4.1.14 Shoot length of seedlings

The shoot length of seedlings at different stages of seed development and maturity was highly significant in both seasons. In season I, it was the least (1.8 cm) at 25 d.a.a. and maximum (13.96 cm) at 65 d.a.a. In season II, the least shoot length of 2.5 cm was recorded in seeds of 30 d.a.a. and the highest shoot length of 11.44 cm was recorded from seeds of 70 d.a.a. The shoot length of seedling from 50 d.a.a. to full maturity recorded high value in both seasons and were on par with each other.

4.1.15 Vigour index of seedling

Mean Vigour index recorded at different stages of seed development were highly significant in both the seasons. In season I, it was least (14.13) from seeds of 25 d.a.a. and thereafter recorded a continuous increase up to 70 d.a.a. (2305). The seedlings from seeds of 65 and 70 d.a.a. recorded high vigour index and were on par with each other (Plate 10).

In season II, lowest vigour index (16.67) was recorded by seeds of 30 d.a.a. and thereafter recorded a continuous increase up to 65 d.a.a. (1561).

Plate 10. Seedling vigour at different fruit maturity of ash gourd


S10
S11
S12
S13
S14
S6
S7
S8
S9

Thereafter a slight decrease in vigour index was noticed. The seedlings from seeds of 60 d.a.a. to 75 d.a.a. recorded high vigour index and were on par with each other.

4.1.16 Seedling dry weight

The dry matter production by seedlings from seeds at different stages of development and maturity differed significantly in both the seasons. In season I, seedling from seeds of 25 d.a.a. had the minimum quantity of dry matter (5.33 mg per seedling) and the seeds from 70 d.a.a. recorded the maximum (30.27 mg). The seedlings from seeds of 45 to 70 d.a.a. recorded high dry matter production and were on par with each other.

In season II, the seedlings from seeds of 30 d.a.a. produced the minimum dry matter of 7 mg per seedling and those from 70 d.a.a. recorded the maximum (28.8 mg per seedling). The seedling from seeds of 50 d.a.a. to 75 d.a.a. recorded high dry matter and were on par with each other.

4.2 Standardisation of seed extraction and drying methods

Studies were initiated in ash gourd with a view to standardise the seed extraction and drying methods for optimum seed quality during storage. For this, seven extraction methods with a combination of four drying methods were tried and seeds were tested for six months at monthly interval. Analysis of variance (ANOVA) of the data is furnished in Appendix III. Results obtained are given below.

4.2.1 Germination percentage

Results of statistical analysis of the germination percentage of seeds are furnished in Tables 4a and 4b.

The overall mean for different drying methods indicated that different drying methods had no significant effect on germination of seeds up to six months.

The overall mean of the different extraction methods differed significantly. Seeds extracted by machine extraction + acid treatment @ 1% HCl of the pulp for 30 minutes (E_5) recorded the highest overall germination (89%) which was on par with machine

Table 4a Overall mean effect of various extraction and drying methods and storage on germination (%) of ash gourd seeds

		Months after storage						Mean
		1	2	3	4	5	6	
Drying methods	D_1	71.86 (1.04)	88.00 (1.25)	71.42 (1.02)	79.71 (1.14)	76.86 (1.10)	81.14 (1.16)	78.17 (1.12)
	D_2	81.86 (1.17)	84.86 (1.22)	72.29 (1.03)	87.14 (1.26)	84.86 (1.20)	78.86 (1.13)	81.65 (1.17)
	D_3	76.86 (1.12)	80.57 (1.14)	77.71 (1.10)	79.71 (1.12)	86.86 (1.25)	77.43 (1.11)	79.86 (1.14)
	D_4	78.00 (1.11)	88.29 (1.26)	69.71 (1.00)	80.57 (1.14)	88.29 (1.26)	84.26 (1.20)	81.52 (1.16)
Extraction methods	E_1	56.50 (0.86)	90.50 (1.28)	76.00 (1.07)	91.00 (1.28)	85.00 (1.21)	83.50 (1.17)	80.42 (1.14)
	E_2	80.00 (1.14)	91.00 (1.29)	76.50 (1.07)	90.50 (1.27)	96.00 (1.38)	88.00 (1.25)	87.00 (1.23)
	E_3	62.75 (0.92)	76.00 (1.07)	69.50 (0.99)	85.50 (1.19)	91.00 (1.28)	79.50 (1.11)	77.38 (1.09)
	E_4	79.25 (1.13)	92.00 (1.31)	71.50 (1.01)	85.50 (1.20)	89.50 (1.26)	83.00 (1.16)	83.46 (1.18)
	E_5	93.00 (1.32)	96.00 (1.37)	75.50 (1.07)	87.50 (1.24)	90.50 (1.27)	91.50 (1.29)	89.00 (1.26)
	E_6	85.50 (1.22)	84.00 (1.20)	86.50 (1.22)	89.50 (1.27)	85.00 (1.21)	96.50 (1.39)	87.83 (1.25)
	E_7	83.00 (1.16)	68.50 (0.99)	54.00 (0.83)	43.00 (0.71)	52.50 (0.81)	41.00 (0.69)	57.00 (0.86)
Mean		77.14 (1.11)	85.43 (1.21)	72.78 (1.04)	81.78 (1.17)	84.21 (1.20)	80.42 (1.15)	

C.D. for comparing means:

Drying methods - NS
Extraction methods - 0.05**
Monthly mean - 0.05**

D_1 - Drying under shade
D_2 - Drying under direct sunlight
D_3 - Drying using hot air in a mechanical seed drier
D_4 - Initial drying in shade for one day then in sun avoiding peak hours

E_1 - Manual extraction - no fermentation
E_2 - Manual extrtaction + with 48 hrs of fermentation
E_3 - Machine extraction - no fermentation
E_4 - Machine extraction + with 48 hrs of fermentation
E_5 - Machine extraction + acid treatment @ 1% HCl
E_6 - Machine extraction + acid treatment @ 2% HCl
E_7 - Machine extraction + alkali treatment @ 1% NaOH

** Significant at 1% level
NS - Non significant
Figures in brackets are arc-sine transformed values

Table 4b Mean effect of various seed extraction, drying and storage period on germination (%) of ash gourd seeds

Treatment combination	Months after storage						Mean
	1	2	3	4	5	6	
E_1D_1	50	94	70	96	64	70	74.00
	(0.79)	(1.33)	(0.99)	(1.38)	(0.93)	(0.99)	(1.07)
E_1D_2	70	94	66	96	94	86	84.33
	(0.99)	(1.33)	(0.95)	(1.38)	(1.33)	(1.20)	(1.20)
E_1D_3	38	80	84	86	86	94	78.00
	(0.66)	(1.13)	(1.19)	(1.19)	(1.20)	(1.33)	(1.12)
E_1D_4	68	94	84	86	96	84	85.33
	(0.98)	(1.33)	(1.16)	(1.19)	(1.37)	(1.16)	(1.20)
E_2D_1	76	96	78	84	94	96	87.33
	(1.06)	(1.38)	(1.08)	(1.16)	(1.33)	(1.38)	(1.23)
E_2D_2	88	90	86	88	98	88	89.67
	(1.22)	(1.26)	(1.19)	(1.22)	(1.42)	(1.24)	(1.26)
E_2D_3	96	86	70	94	98	82	87.67
	(1.38)	(1.21)	(0.99)	(1.33)	(1.42)	(1.17)	(1.25)
E_2D_4	60	92	72	96	94	86	83.33
	(0.89)	(1.32)	(1.02)	(1.38)	(1.34)	(1.21)	(1.19)
E_3D_1	53	82	66	84	90	76	75.17
	(0.82)	(1.13)	(1.96)	(1.16)	(1.26)	(1.06)	(1.06)
E_3D_2	54	66	72	92	90	88	77.00
	(0.83)	(0.95)	(1.01)	(1.29)	(1.26)	(1.24)	(1.10)
E_3D_3	84	72	72	82	88	72	78.33
	(1.16)	(1.01)	(1.01)	(1.13)	(1.24)	(1.01)	(1.10)
E_3D_4	60	84	68	84	96	82	79.00
	(0.89)	(1.16)	(0.97)	(1.16)	(1.38)	(1.13)	(1.12)
E_4D_1	68	96	72	86	90	84	82.67
	(0.97)	(1.37)	(1.01)	(1.24)	(1.29)	(1.16)	(1.17)
E_4D_2	89	96	70	92	88	76	85.17
	(1.28)	(1.37)	(0.99)	(1.28)	(1.22)	(1.06)	(1.20)
E_4D_3	70	80	82	84	96	76	81.33
	(1.01)	(1.11)	(1.13)	(1.17)	(1.37)	(1.06)	(1.14)
E_4D_4	90	96	62	80	84	96	84.67
	(1.26)	(1.38)	(0.91)	(1.11)	(1.16)	(1.37)	(1.20)

Contd. ...

Table 4b contd....

E_5D_1	84	96	66	94	88	96	87.33
	(1.17)	(1.38)	(0.95)	(1.33)	(1.22)	(1.37)	(1.24)
E_5D_2	94	96	76	98	84	88	89.33
	(1.33)	(1.37)	(1.06)	(1.42)	(1.16)	(1.24)	(1.26)
E_5D_3	100	98	88	76	96	88	91.00
	(1.47)	(1.42)	(1.24)	(1.06)	(1.38)	(1.24)	(1.30)
E_5D_4	94	94	72	82	94	94	88.33
	(1.33)	(1.33)	(1.01)	(1.13)	(1.33)	(1.33)	(1.24)
E_6D_1	98	66	88	80	64	94	81.67
	(1.42)	(0.95)	(1.24)	(1.11)	(0.93)	(1.33)	(1.16)
E_6D_2	96	96	92	100	86	98	94.67
	(1.38)	(1.38)	(1.28)	(1.47)	(1.19)	(1.42)	(1.35)
E_6D_3	64	78	86	84	96	96	84.00
	(0.94)	(1.09)	(1.21)	(1.16)	(1.38)	(1.38)	(1.19)
E_6D_4	84	96	80	94	94	98	91.00
	(1.16)	(1.38)	(1.13)	(1.33)	(1.33)	(1.42)	(1.29)
E_7D_1	74	86	60	34	48	52	59.00
	(1.04)	(1.20)	(0.89)	(0.62)	(0.76)	(0.81)	(0.88)
E_7D_2	82	56	44	44	54	28	51.33
	(1.13)	(0.85)	(0.73)	(0.73)	(0.83)	(0.54)	(0.80)
E_7D_3	86	70	62	52	48	34	58.67
	(1.21)	(0.99)	(0.91)	(0.81)	(0.77)	(0.62)	(0.88)
E_7D_4	90	62	50	42	60	50	59.00
	(1.25)	(0.91)	(0.79)	(0.70)	(0.89)	(0.79)	(0.89)
Mean for the month	77.14	85.43	72.79	81.79	84.21	80.42	
	(1.11)	(1.21)	(1.04)	(1.17)	(1.20)	(1.15)	

CD for comparing extraction x drying interaction - NS

CD for comparing extraction x drying x month interaction - 0.25**

** Significant at 1% level NS - Non significant

Figures in brackets are arc-sine transformed values

extraction + acid treatment @ 2% HCl of pulp for 30 minutes (E_6, 87.83%) and manual extraction with 48 hours of fermentation (E_2, 87%). Seeds extracted by machine extraction + alkali treatment @ 1% NaOH solution for one night (E_7) recorded the lowest overall germination (57%) and was found significantly inferior to other methods of seed extraction.

The overall means of germination for different months differed significantly. The highest mean germination was recorded after second month of seed extraction and drying (85.43%). Germination of seeds reduced gradually from fourth month. The lowest germination was recorded after three months of seed extraction (72.79%).

The overall mean for different extraction x drying methods interaction was found to be non significant upto six months whereas, extraction x drying x month interaction was found to be statistically significant. The highest germination of 100 per cent was recorded in seeds of machine extraction + 1% HCl of pulp for 30 minutes and dried in hot air with mechanical seed drier (E_5D_3) after four months of storage. The lowest germination (28%), was recorded in seeds obtained by

machine extraction + alkali treatment @ 1% NaOH for one night and dried under direct sunlight (E_7D_2) after six months of seed extraction and drying.

4.2.2 Speed of germination

Results of the statistical analysis of speed of germination are furnished in the Tables 5a and 5b.

The overall means for different drying methods did not vary significantly with respect to speed of germination up to six months, whereas that for different extraction methods differed significantly. Seeds extracted by manual extraction + 48 hours of fermentation (E_2) recorded the highest overall speed of germination (12.46), which was on par with the following extraction methods, viz., machine extraction + 48 hours of fermentation (E_4, 12.1), machine extraction + acid treatment @ 1% HCl of the pulp for 30 minutes (E_5, 11.99) and machine extraction + acid treatment @ 2% HCl of pulp for 30 minutes (E_6, 11.97). Seeds extracted by machine extraction + alkali treatment @ 1% NaOH solution for one night (E_7) recorded the lowest overall speed of germination (8.05) and was found to be significantly inferior to all other methods of seed extraction.

Table 5a Overall mean effect of various extraction and drying methods and storage on speed of germination of ash gourd seeds

		Months after storage						Mean
		1	2	3	4	5	6	
Drying methods	D_1	10.62	13.90	11.44	12.31	9.87	8.79	11.16
	D_2	11.88	13.14	11.26	13.06	10.68	8.28	11.39
	D_3	11.06	12.88	12.48	12.16	11.33	8.49	11.40
	D_4	11.26	13.66	11.17	12.58	11.19	8.84	11.45
Extraction methods	E_1	8.82	14.56	12.27	14.20	11.45	9.07	11.73
	E_2	11.91	14.54	12.37	14.00	12.34	9.60	12.46
	E_3	9.27	12.57	11.09	13.42	11.97	8.65	11.16
	E_4	11.94	14.59	11.57	13.35	11.91	9.10	12.10
	E_5	12.28	14.59	11.60	13.23	10.92	9.32	11.99
	E_6	12.24	12.81	13.57	13.05	10.10	10.03	11.97
	E_7	11.97	10.12	8.63	6.45	6.70	4.42	8.05
Mean		11.20	13.40	11.59	12.53	10.77	8.60	

C.D. for comparing means:

Drying methods	-	NS
Extraction methods	-	0.58**
Monthly mean	-	0.53**

D_1 - Drying under shade
D_2 - Drying under direct sunlight
D_3 - Drying using hot air in a mechanical seed drier
D_4 - Initial drying in shade for one day then in sun avoiding peak hours

** Significant at 1% level

E_1 - Manual extraction - no fermentation
E_2 - Manual extrtaction + with 48 hrs of fermentation
E_3 - Machine extraction - no fermentation
E_4 - Machine extraction + with 48 hrs of fermentation
E_5 - Machine extraction + acid treatment @ 1% HCl
E_6 - Machine extraction + acid treatment @ 2% HCl
E_7 - Machine extraction + alkali treatment @ 1% NaOH
NS - Non significant

Table 5b Mean effect of various seed extraction, drying and storage period on speed of germination of ash gourd seeds

Treatment combination	Months after storage						Mean
	1	2	3	4	5	6	
E_1D_1	7.88	15.34	11.21	15.43	8.62	7.68	11.02
E_1D_2	11.10	15.10	10.59	14.71	12.68	9.42	12.26
E_1D_3	5.91	12.93	13.56	13.21	11.64	10.10	11.22
E_1D_4	10.39	14.89	13.75	13.44	12.89	9.10	12.41
E_2D_1	11.41	15.35	12.22	13.01	12.15	10.32	12.41
E_2D_2	13.22	14.43	14.11	13.44	12.67	9.72	12.93
E_2D_3	13.83	13.75	11.52	14.70	12.75	9.17	12.62
E_2D_4	9.18	14.63	11.66	14.86	11.80	9.20	11.89
E_3D_1	7.79	13.06	10.87	13.10	11.58	8.43	10.80
E_3D_2	8.45	10.43	11.05	14.43	11.85	9.55	10.96
E_3D_3	12.11	13.11	11.41	12.73	11.68	7.89	1.49
E_3D_4	8.76	13.67	11.05	13.43	12.77	8.73	1.40
E_4D_1	10.29	15.38	11.80	13.29	11.92	9.25	1.99
E_4D_2	13.46	15.26	11.27	14.38	11.75	8.34	12.41
E_4D_3	10.61	12.69	13.12	13.21	13.18	8.46	11.88
E_4D_4	13.40	15.02	10.07	12.52	10.79	10.36	12.02
E_5D_1	11.36	14.88	10.32	14.10	10.64	9.96	11.87
E_5D_2	12.10	14.39	11.16	13.90	9.44	8.41	11.56
E_5D_3	13.11	15.10	13.80	11.30	12.34	9.69	12.55
E_5D_4	12.57	14.03	11.14	13.64	11.25	9.21	11.97
E_6D_1	14.72	10.63	14.31	12.11	7.93	10.24	11.66
E_6D_2	13.12	14.14	13.44	13.98	9.43	9.59	12.28
E_6D_3	9.45	12.43	14.15	12.34	11.71	10.32	11.73
E_6D_4	11.67	14.04	12.40	13.78	11.33	9.96	12.20
E_7D_1	10.93	12.70	9.34	5.14	6.30	5.63	8.34
E_7D_2	11.73	8.25	7.24	6.61	6.98	2.95	7.29
E_7D_3	12.39	10.19	9.80	7.65	6.03	3.81	8.31
E_7D_4	12.84	9.34	8.16	6.40	7.49	5.32	8.26
Mean for the month	11.20	13.40	11.59	12.53	10.77	8.60	

CD for comparing extraction x drying interaction - NS

CD for comparing extraction x drying x month interaction - 2.83**

** Significant at 1% level NS - Non significant

The overall mean speed of germination for different months differed significantly. The highest speed of germination was recorded after second month of seed extraction and drying (13.4). The speed of germination reduced gradually from fourth month and the lowest (8.6) was recorded after six months of storage.

The overall mean speed of germination for extraction x drying interactions was found to be non-significant up to six months whereas, the extraction x drying x month interaction was found to be statistically significant. The highest speed of germination (15.43) was recorded in seeds obtained by manual extraction with out fermentation and drying in shade (E_1D_1) after four months of storage. The lowest speed of germination (2.95) was recorded in machine extraction + alkali treatment @ 1% NaOH for one night and dried under direct sun light (E_7D_2) after five months.

4.2.3 Root length of seedling

Results of statistical analysis on root length of seedlings are furnished in Tables 6a and 6b.

Table 6a Overall mean effect of various extraction and drying methods and storage on root length of seedlings (cm)of ash gourd seeds

		Months after storage						Mean
		1	2	3	4	5	6	
Drying methods	D_1	5.75	6.67	7.76	6.58	7.26	6.53	6.76
	D_2	5.93	6.94	8.30	6.55	6.82	6.51	6.84
	D_3	5.98	6.90	8.13	6.01	6.95	6.62	6.76
		5.86	6.49	8.13	6.18	6.81	6.24	6.62
Extraction methods		5.66	6.37	7.51	7.03	7.21	6.77	6.76
		6.22	6.57	8.44	6.36	7.01	6.21	6.80
	E_3	6.05	6.47	7.30	6.13	7.10	6.50	6.59
	E_4	5.95	6.84	8.32	6.15	7.10	6.73	6.85
	E_5	5.57	7.29	8.31	5.92	6.54	6.32	6.66
	E_6	5.58	6.73	8.12	6.08	6.85	6.05	6.57
	E_7	6.15	6.99	8.59	6.64	6.93	6.75	7.01
Mean		5.88	6.75	8.08	6.33	6.96	6.48	

C.D. for comparing means:

Drying methods	-	NS
Extraction methods	-	0.23**
Monthly mean	-	0.21**

D_1 - Drying under shade
D_2 - Drying under direct sunlight
D_3 - Drying using hot air in a mechanical seed drier
D_4 - Initial drying in shade for one day then in sun avoiding peak hours

** Significant at 1% level

E_1 - Manual extraction - no fermentation
E_2 - Manual extrtaction + with 48 hrs of fermentation
E_3 - Machine extraction - no fermentation
E_4 - Machine extraction + with 48 hrs of fermentation
E_5 - Machine extraction + acid treatment @ 1% HCl
E_6 - Machine extraction + acid treatment @ 2% HCl
E_7 - Machine extraction + alkali treatment @ 1% NaOH
NS - Non significant

Table 6b Mean effect of various seed extraction, drying and storage period on root length of seedlings (cm) of ash gourd seeds

Treatment combination	Months after storage						Mean
	1	2	3	4	5	6	
E_1D_1	6.15	6.70	7.21	7.48	7.26	6.99	6.97
E_1D_2	5.99	6.39	8.38	6.49	7.00	6.67	6.82
E_1D_3	5.11	6.74	7.40	7.26	7.29	6.89	6.78
E_1D_4	5.40	5.65	7.03	6.89	7.30	6.53	6.47
E_2D_1	5.57	6.24	8.00	7.41	7.34	6.38	6.82
E_2D_2	6.31	6.73	9.12	6.60	6.92	6.24	6.99
E_2D_3	6.98	7.06	8.34	5.54	6.88	6.29	6.85
E_2D_4	6.01	6.25	8.28	5.87	6.88	5.94	6.54
E_3D_1	5.73	6.46	7.38	5.99	7.71	6.02	6.55
E_3D_2	5.14	6.14	6.76	7.10	7.20	6.81	6.53
E_3D_3	6.13	6.40	7.22	5.63	6.50	6.52	6.40
E_3D_4	7.19	6.88	7.82	5.78	6.99	6.66	6.89
E_4D_1	6.64	7.14	7.75	6.04	7.15	6.39	6.85
E_4D_2	5.56	6.87	7.97	5.95	6.65	7.32	6.72
E_4D_3	5.75	6.87	9.06	6.32	7.34	7.13	7.08
E_4D_4	5.83	6.48	8.48	6.30	7.24	6.07	6.73
E_5D_1	5.11	7.00	8.70	6.69	6.51	6.38	6.57
E_5D_2	5.92	7.69	7.82	6.26	6.86	5.96	6.75
E_5D_3	5.66	7.62	8.86	6.05	6.62	7.08	6.98
E_5D_4	5.57	6.86	7.85	5.68	6.18	5.85	6.33
E_6D_1	5.49	6.65	7.44	6.31	7.70	6.41	6.67
E_6D_2	6.29	7.50	8.90	6.99	6.15	6.05	6.98
E_6D_3	5.36	6.50	8.46	5.35	6.76	5.71	6.36
E_6D_4	5.19	6.25	7.66	5.65	6.77	6.01	6.26
E_7D_1	5.58	6.50	7.82	7.14	7.17	7.17	6.90
E_7D_2	6.27	7.27	9.18	6.45	6.94	6.50	7.10
E_7D_3	6.87	7.12	7.54	5.89	7.28	6.69	6.90
E_7D_4	5.86	7.08	9.80	7.08	6.34	6.64	7.10
Mean for the month	5.88	6.75	8.08	6.33	6.96	6.48	

CD for comparing extraction x drying interaction - 0.46*

CD for comparing extraction x drying x month interaction - 1.13*

* Significant at 5% level

The overall mean for different drying methods indicated that different drying methods had no significant effect on root length of seedlings upto six months.

The overall mean of root length for different extraction methods differed significantly. Seeds extracted by machine extraction + alkali treatment @ 1% NaOH solution for one night (E_7) recorded the highest overall mean root length (7.01 cm) and it was on par with the following extraction methods - manual extraction + with 48 hours of fermentation (E_2, 6.8 cm) and machine extraction + 48 hours of fermentation (E_4, 6.85 cm). Seeds extracted by machine extraction + acid treatment @ 2% HCl of pulp for 30 minutes (E_6) recorded the lowest mean root length (6.57 cm).

The overall mean root length of seedlings for different months differed significantly. The highest mean root length was recorded after third month (8.08 cm) and the lowest mean root length was recorded during first month (5.88 cm) of seed extraction and drying . The overall mean root length for different extraction x drying interaction was found to be statistically significant. The highest mean root length (7.1 cm) was recorded in machine extraction + alkali treatment

@ 1% NaOH solution for one night and drying under direct sunlight (E_7D_2, 7.1 cm) and machine extraction + alkali treatment @ 1% NaOH solution for one night drying initially in shade for one day and then in sun avoiding peak hours (E_7D_4, 7.1 cm). The lowest mean root length (6.26 cm) was recorded in machine extraction + acid treatment @ 2% HCl of pulp for 30 minutes and drying initially in shade for one day and then in sun avoiding peak hours (E_6D_4, 6.26 cm).

Influence of extraction x drying x month interaction on root length was found to be statistically significant. The highest root length (9.8 cm) was recorded for seeds obtained from machine extraction + alkali treatment @ 1% NaOH solution for one night and drying initially in shade for one day and then in sun avoiding peak hours (E_7D_4) after three months of seed extraction and drying . The lowest root length (5.11 cm) was recorded in seeds from machine extraction + acid treatment @ 1% HCl of pulp for 30 minutes and drying under shade during first month after seed extraction and drying.

4.2.4 Shoot length of seedling

Results of statistical analysis on shoot length of seedlings are furnished in the Tables 7a and 7b.

The overall mean shoot length of seedlings for different methods of drying differed significantly. Seeds dried under shade (D_1) recorded the highest overall shoot length (12.33 cm) and it was on par with the following drying methods - drying using hot air in a mechanical seed drier (D_3, 12.23 cm) and initial drying in shade for one day and then in sun avoiding peak hours (D_4,12.19 cm). Seeds dried under direct sunlight (D_2) recorded the lowest overall shoot length (11.98 cm).

The overall mean shoot length of seedlings for different seed extraction methods differed significantly. Seeds extracted by machine extraction + 48 hours of fermentation (E_4) recorded the highest overall mean shoot length (12.91 cm). Seeds extracted by machine extraction + acid treatment @ 2% HCl of the pulp for 30 minutes (E_6) recorded the lowest mean shoot length (11.36 cm).

Table 7a Overall mean effect of various extraction and drying methods and storage on shoot length of seedlings (cm) of ash gourd seeds

		Months after storage						Mean
		1	2	3	4	5	6	
Drying methods	D_1	17.05	14.75	10.02	11.77	10.34	10.06	12.33
	D_2	16.65	14.26	9.95	11.67	10.17	9.14	11.98
	D_3	16.80	14.12	10.17	11.58	10.71	9.99	12.23
	D_4	16.66	13.79	10.43	11.73	10.65	9.88	12.19
Extraction methods	E_1	18.29	15.70	9.67	11.79	10.06	10.19	12.62
	E_2	17.77	15.25	9.71	11.67	10.43	9.84	12.44
	E_3	16.65	14.69	10.10	11.75	10.67	9.85	12.29
	E_4	17.52	14.79	10.84	12.42	11.45	10.43	12.91
	E_5	16.31	13.01	10.14	11.51	10.38	9.27	11.77
	E_6	15.05	12.81	10.24	11.37	9.84	8.84	11.36
	E_7	15.94	13.38	10.31	11.31	10.46	9.95	11.89
Mean		16.79	14.23	10.14	11.69	10.47	9.77	

C.D. for comparing means:

Drying methods	-	0.2**
Extraction methods	-	0.26**
Monthly mean	-	0.24**

D_1 - Drying under shade
D_2 - Drying under direct sunlight
D_3 - Drying using hot air in a mechanical seed drier
D_4 - Initial drying in shade for one day then in sun avoiding peak hours

** Significant at 1% level

E_1 - Manual extraction - no fermentation
E_2 - Manual extrtaction + with 48 hrs of fermentation
E_3 - Machine extraction - no fermentation
E_4 - Machine extraction + with 48 hrs of fermentation
E_5 - Machine extraction + acid treatment @ 1% HCl
E_6 - Machine extraction + acid treatment @ 2% HCl
E_7 - Machine extraction + alkali treatment @ 1% NaOH
NS - Non significant

Table 7b Mean effect of various seed extraction, drying and storage period on shoot length of seedlings (cm) of ash gourd seeds

Treatment combination	Months after storage						Mean
	1	2	3	4	5	6	
E_1D_1	18.05	16.35	9.55	11.70	9.77	8.97	12.40
E_1D_2	17.78	15.08	8.65	11.60	10.04	10.08	12.21
E_1D_3	18.66	16.40	10.17	12.11	10.36	10.37	13.01
E_1D_4	18.68	14.95	10.30	11.73	10.08	11.33	12.85
E_2D_1	18.31	15.48	9.15	11.35	9.95	9.46	12.28
E_2D_2	17.32	15.32	10.25	12.16	10.78	9.26	12.52
E_2D_3	17.73	15.36	9.72	11.60	10.58	9.93	12.49
E_2D_4	17.72	14.85	9.70	11.55	10.41	10.71	12.49
E_3D_1	17.50	14.59	9.80	11.49	10.82	9.79	12.33
E_3D_2	17.25	15.67	10.18	11.76	10.67	10.08	12.60
E_3D_3	15.92	14.24	10.01	11.73	10.56	9.64	12.02
E_3D_4	15.91	14.25	10.42	12.02	10.64	9.89	12.19
E_4D_1	16.95	15.40	10.49	12.72	11.35	10.42	12.89
E_4D_2	17.20	14.69	10.79	12.94	11.36	10.12	12.85
E_4D_3	18.74	15.37	11.04	11.41	11.61	11.47	13.27
E_4D_4	17.20	13.70	11.04	12.60	11.48	9.72	12.62
E_5D_1	16.41	14.20	11.56	12.61	10.73	11.48	12.83
E_5D_2	16.29	12.73	9.30	11.17	10.09	7.41	11.17
E_5D_3	15.55	12.30	9.78	11.00	10.53	9.62	11.46
E_5D_4	16.97	12.79	9.91	11.26	10.17	8.58	11.61
E_6D_1	15.07	13.23	9.45	11.37	9.14	9.70	11.33
E_6D_2	14.21	12.12	10.01	10.74	8.22	7.41	10.45
E_6D_3	15.06	12.50	9.95	11.54	10.75	8.65	11.41
E_6D_4	15.86	13.40	11.54	11.82	11.26	9.60	12.25
E_7D_1	17.09	14.00	10.12	11.13	10.65	10.61	12.27
E_7D_2	16.51	14.24	10.49	11.32	10.06	9.62	12.04
E_7D_3	15.91	12.68	10.54	11.66	10.61	10.22	11.94
E_7D_4	14.26	12.59	10.07	11.13	10.52	9.33	11.32
Mean for the month	16.79	14.23	10.14	11.69	10.47	9.77	

CD for comparing extraction x drying interaction - 0.46*

CD for comparing extraction x drying x month interaction - 1.13*

* Significant at 5% level

The overall mean shoot length for different months also differed significantly. The highest mean shoot length (16.79 cm) was recorded during first month. Shoot length of seedlings reduced gradually from second month. The lowest mean shoot length (9.77 cm) was recorded during sixth month.

The overall mean shoot length for different extraction x drying interaction was found to be statistically significant. The highest mean shoot length (13.27 cm) was recorded in machine extraction + 48 hours of fermentation and drying using hot air in a mechanical seed drier (E_4D_3). The lowest mean shoot length (10.45 cm) was recorded in machine extraction + acid treatment @ 2% HCl of the pulp for 30 minutes and drying under direct sunlight (E_6D_2).

Extraction x drying x month interaction was found to be statistically significant. The highest shoot length (18.74 cm) was recorded in machine extraction + 48 hours of fermentation and drying using hot air in a mechanical seed drier (E_4D_3) during first month. The lowest shoot length (7.41 cm) was recorded in machine extraction + acid treatment @ 2% HCl of pulp for 30 minutes and drying under direct sunlight (E_6D_2) after six months.

4.2.5 Vigour index of seedling

Results of statistical analysis on vigour index of seedlings are furnished in the Tables 8a and 8b.

The overall mean for different drying methods indicated that different drying methods had no significant effect on vigour index of seedlings up to six months.

The overall mean for different extraction methods differed significantly. Seeds extracted by manual extraction + 48 hours of fermentation (E_2) recorded the highest overall mean vigour index (1668). It was on par with following extraction methods - machine extraction + 48 hours of fermentation (E_4 1646) and machine extraction + acid treatment @ 1 % HCl of the pulp for 30 minutes (E_5 1643). Seeds extracted by machine extraction + alkali treatment @ 1% NaOH solution for one night recorded the lowest overall vigour index (1100).

The overall mean vigour index for different months differed significantly. The highest vigour index (1793) was recorded during second month after seed extraction and drying. It was on par with first month (1739). The

Table 8a Overall mean effect of various extraction and drying methods and storage on vigour index of seedlings of ash gourd seeds

		Months after storage						Mean
		1	2	3	4	5	6	
Drying methods	D_1	1627	1893	1266	1466	1360	1344	1493
	D_2	1840	1794	1318	1589	1445	1222	1535
	D_3	1744	1696	1422	1402	1533	1280	1513
	D_4	1745	1791	1291	1441	1544	1366	1530
Extraction methods	E_1	1348	1993	1311	1711	1470	1432	1544
	E_2	1920	1985	1392	1628	1673	1413	1668
	E_3	1429	1606	1209	1532	1619	1308	1450
	E_4	1851	1987	1373	1587	1663	1417	1646
	E_5	2032	1949	1385	1528	1534	1430	1643
	E_6	1762	1642	1589	1563	1422	1435	1569
	E_7	1830	1392	1011	771	912	687	1100
Mean		1739	1793	1324	1474	1471	1303	

C.D. for comparing means:

Drying methods	-	NS
Extraction methods	-	81.56**
Monthly mean	-	75.49**

D_1 - Drying under shade
D_2 - Drying under direct sunlight
D_3 - Drying using hot air in a mechanical seed drier
D_4 - Initial drying in shade for one day then in sun avoiding peak hours

** Significant at 1% level

E_1 - Manual extraction - no fermentation
E_2 - Manual extrtaction + with 48 hrs of fermentation
E_3 - Machine extraction - no fermentation
E_4 - Machine extraction + with 48 hrs of fermentation
E_5 - Machine extraction + acid treatment @ 1% HCl
E_6 - Machine extraction + acid treatment @ 2% HCl
E_7 - Machine extraction + alkali treatment @ 1% NaOH
NS - Non significant

Table 8b Mean effect of various seed extraction, drying and storage period on vigour index of seedling of ash gourd seeds

Treatment combination	Months after storage						Mean
	1	2	3	4	5	6	
E_1D_1	1208	2168	1180	1845	1094	1121	1436
E_1D_2	1644	2017	1126	1734	1602	1444	1595
E_1D_3	903	1852	1483	1666	1516	1622	1507
E_1D_4	1636	1936	1456	1601	1668	1542	1640
E_2D_1	1811	2081	1340	1579	1624	1521	1659
E_2D_2	2077	1984	1665	1651	1736	1366	1746
E_2D_3	2369	1935	1265	1610	1711	1330	1703
E_2D_4	1424	1940	1298	1671	1623	1434	1565
E_3D_1	1276	1726	1132	1468	1669	1204	1413
E_3D_2	1206	1438	1222	1738	1608	1487	1450
E_3D_3	1852	1486	1241	1424	1501	1164	1445
E_3D_4	1382	1773	1240	1498	1697	1376	1494
E_4D_1	1602	2164	1320	1615	1679	1412	1632
E_4D_2	2027	2070	1311	1738	1583	1325	1676
E_4D_3	1704	1778	1644	1483	1819	1414	1640
E_4D_4	2072	1936	1217	1512	1573	1516	1638
E_5D_1	1801	2034	1337	1721	1517	1715	1687
E_5D_2	2087	1960	1296	1707	1432	1171	1609
E_5D_3	2121	1952	1629	1297	1649	1478	1688
E_5D_4	2120	1849	1280	1388	1537	1355	1588
E_6D_1	2016	1311	1477	1416	1077	1513	1468
E_6D_2	1968	1884	1740	1773	1237	1318	1653
E_6D_3	1297	1486	1584	1419	1680	1379	1474
E_6D_4	1768	1885	1553	1643	1695	1529	1679
E_7D_1	1676	1764	1076	617	861	924	1153
E_7D_2	1869	1203	865	782	918	442	1013
E_7D_3	1962	1383	1110	913	856	575	1133
E_7D_4	1812	1218	994	772	1013	806	1102
Mean for the month	1739	1793	1324	1474	1471	1303	

CD for comparing extraction x drying interaction - 163**

CD for comparing extraction x drying x month interaction - 400**

** Significant at 1% level

vigour index values reduced gradually from fourth month. The lowest vigour index (1303) was recorded during six months after storage.

The overall mean vigour index for different extraction x drying interaction was found to be statistically significant. The highest mean vigour index (1746) was recorded in manual extraction + 48 hours of fermentation and dried under direct sunlight (E_2D_2); the lowest mean vigour index (1102) was recorded in machine extraction + alkali treatment @ 1% NaOH solution for one night and initial drying in shade for one day and then in sun avoiding the peak hours (E_1D_4). The extraction method, machine extractions + alkali treatment @ 1% NaOH solution for one night (E_1) in combination with all drying methods recorded low vigour index and was on par with each other.

Extraction x drying x month interactions were found to be statistically significant. The highest vigour index (2369) was recorded in manual extraction + 48 hours of fermentation and drying using hot air in mechanical seed drier (E_2D_3) during first month. The lowest vigour index (442) was recorded in machine

extraction + alkali treatment @ 1% NaOH solution for one night and drying under direct sunlight (E_7D_2) after six months.

4.2.6 Seedling dry weight

Results of statistical analysis on seedling dry weight are furnished in Tables 9a and 9b.

The overall mean of seedling dry weight for different methods of drying differed significantly. Seeds dried under shade (D_1) recorded the highest overall dry weight per seedling (29.63 mg). It was on par with the following drying methods - drying under direct sun light (D_2 29.36 mg) and drying using hot air in mechanical seed drier (D_3 29.41 mg). Seeds dried initially in shade for one day and then in sun avoiding the peak hours (E_4) recorded the lowest overall seedling dry weight (28.12 mg).

The overall mean for different extraction methods differed significantly. Seeds extracted manually without fermentation (E_1) recorded the highest overall mean dry weight per seedling (33.73 mg). Seeds extracted by machine extraction + acid treatments

Table 9a Overall mean effect of various extraction and drying methods and storage on dry weight per seedling (mg) of ash gourd seeds

		Months after storage						Mean
		1	2	3	4	5	6	
Drying methods	D_1	40.61	33.72	25.25	27.74	25.65	24.79	29.63
	D_2	38.80	33.86	26.70	27.96	25.78	23.07	29.36
	D_3	38.66	33.31	26.66	26.47	25.74	25.64	29.41
	D_4	35.10	32.64	25.01	27.49	25.35	23.13	28.12
Extraction methods	E_1	46.88	39.00	29.00	31.20	28.88	27.45	33.73
	E_2	40.23	35.85	28.60	24.50	24.10	22.78	29.33
	E_3	41.03	33.23	24.60	22.45	23.38	23.55	28.04
	E_4	41.55	34.45	24.10	28.30	26.65	26.03	30.18
	E_5	31.90	31.10	26.28	28.33	23.43	21.65	27.11
	E_6	29.93	29.26	24.63	28.00	25.81	21.95	26.60
	E_7	36.50	30.83	24.18	29.13	27.23	25.70	28.93
Mean		38.29	33.28	25.91	27.41	25.63	24.16	

C.D. for comparing means:

Drying methods	-	0.9**
Extraction methods	-	1.19**
Monthly mean	-	1.1**

D_1 - Drying under shade
D_2 - Drying under direct sunlight
D_3 - Drying using hot air in a mechanical seed drier
D_4 - Initial drying in shade for one day then in sun avoiding peak hours

** Significant at 1% level

E_1 - Manual extraction - no fermentation
E_2 - Manual extrtaction + with 48 hrs of fermentation
E_3 - Machine extraction - no fermentation
E_4 - Machine extraction + with 48 hrs of fermentation
E_5 - Machine extraction + acid treatment @ 1% HCl
E_6 - Machine extraction + acid treatment @ 2% HCl
E_7 - Machine extraction + alkali treatment @ 1% NaOH

Table 9b Mean effect of various seed extraction, drying and storage period on dry weight per seeding (mg) of ash gourd seeds

Treatment combination	Months after storage						Mean
	1	2	3	4	5	6	
E_1D_1	52.00	41.10	28.80	31.90	29.45	28.90	35.36
E_1D_2	45.80	38.90	29.90	29.70	29.25	28.70	33.71
E_1D_3	48.60	38.90	28.80	32.70	28.55	26.70	34.04
E_1D_4	41.10	37.10	28.50	30.50	28.25	25.50	31.83
E_2D_1	39.00	33.40	25.40	25.70	23.50	22.30	28.23
E_2D_2	38.80	36.60	30.40	23.90	24.25	20.90	29.14
E_2D_3	45.60	39.40	32.25	23.90	24.50	24.30	31.66
E_2D_4	37.50	34.00	26.30	24.50	23.95	23.60	28.31
E_3D_1	42.70	31.50	27.00	21.90	22.30	22.20	27.93
E_3D_2	41.00	35.20	23.10	22.00	23.60	22.30	27.88
E_3D_3	40.10	33.90	26.50	22.10	23.60	24.70	28.48
E_3D_4	40.20	32.30	21.80	23.80	24.00	25.00	27.85
E_4D_1	47.00	38.10	22.20	27.90	24.10	27.40	31.12
E_4D_2	43.20	34.20	24.20	32.00	28.20	27.30	31.52
E_4D_3	41.30	32.10	24.30	25.20	27.75	28.10	29.79
E_4D_4	34.70	33.40	25.60	28.10	26.55	21.30	28.28
E_5D_1	34.70	31.00	25.10	26.40	22.70	21.90	26.97
E_5D_2	31.40	30.75	28.90	30.20	21.20	17.90	26.73
E_5D_3	31.30	30.75	25.60	31.10	28.30	28.20	29.21
E_5D_4	30.20	31.80	25.50	25.60	21.50	18.60	25.53
E_6D_1	34.60	31.75	24.10	29.70	28.25	22.20	28.43
E_6D_2	27.10	28.60	24.40	26.70	25.10	18.70	25.10
E_6D_3	29.00	28.10	26.20	26.10	24.20	22.60	26.03
E_6D_4	29.00	28.60	23.80	29.50	25.70	24.30	26.82
E_7D_1	34.30	29.20	24.10	30.70	29.25	28.60	29.36
E_7D_2	44.20	32.80	26.00	31.20	28.85	25.70	31.46
E_7D_3	34.70	30.00	23.00	24.20	23.30	24.90	26.68
E_7D_4	32.80	31.30	23.60	30.40	27.50	23.60	28.20
Mean for the month	38.29	33.38	25.91	27.41	25.63	24.16	

CD for comparing extraction x drying interaction - 2.38**

CD for comparing extraction x drying x month interaction - NS

** Significant at 1% level NS - Non significant

@ 2% HCl of the pulp for 30 minute (E_6) recorded the lowest dry weight per seedling (26.6 mg) and it was on par with seeds extracted by machine extraction + acid treatment @1% HCl of the pulp for 30 minute (E_5, 27.11 mg).

The overall mean for different months differed significantly. The highest mean dry weight per seedling (38.29 mg) was recorded during first month. Seedling dry weight decreased gradually from second month. The lowest mean seedling dry weight (24.16 mg) was recorded during sixth month.

The overall mean seedling dry weight for different extraction x drying interaction was found to be statistically significant. The highest mean seedling dry weight (35.36 mg) was recorded in seeds obtained by manual extraction with out fermentation and drying under shade (E_1D_1). It was on par with seeds obtained from following extraction x drying combinations - seeds extracted manually without fermentation and drying under direct sunlight (E_1D_2, 33.71 mg) and seeds extracted manually without fermentation and dried using hot air in mechanical seed drier (E_1D_3, 34.04 mg). Seeds extracted

by machine extraction + acid treatment @ 2% HCl of pulp for 30 minutes and dried under direct sunlight (E_2D_2) recorded the lowest dry weight per seedling (25.1 mg).

Extraction x drying x month interaction was found to be insignificant during the period of study.

4.2.7 Electrical conductivity of seed leachate

Results of statistical analysis on electrical conductivity of seed leachate are furnished in Tables 10a and 10b.

The overall mean electrical conductivity of seed leachate under different methods of drying differed significantly. Seeds dried using hot air in a mechanical seed drier (D_3) recorded the highest overall electrical conductivity (79.03). It was on par with seeds dried under shade (D_1, 77.32). Seeds dried under direct sunlight (D_2) recorded the lowest electrical conductivity (74.42).

The overall mean for different extraction methods differed significantly. Seeds extracted by machine extraction + alkali treatment @ 1% NaOH solution for one night (E_7) recorded the highest overall electrical

Table 10a Overall mean effect of various extraction and drying methods and storage on electrical conductivity of seed leachate of ash gourd seeds (μ mhos/cm)

		Months after storage						Mean
		1	2	3	4	5	6	
Drying methods	D_1	67.16	68.71	76.57	80.65	81.75	89.10	77.32
	D_2	67.88	66.26	74.15	76.93	79.01	82.29	74.42
	D_3	69.65	68.82	77.66	81.83	86.04	90.10	79.03
	D_4	67.42	69.44	73.83	80.78	80.64	88.04	76.69
Extraction methods	E_1	43.31	41.73	50.83	53.83	56.99	60.40	51.18
	E_2	38.70	43.21	45.60	48.65	44.45	50.91	45.25
	E_3	48.39	50.00	58.86	63.89	78.14	79.38	63.11
	E_4	49.26	48.81	57.89	61.54	62.99	66.60	57.85
	E_5	36.86	36.78	41.14	44.48	39.10	46.78	40.85
	E_6	40.10	41.14	43.44	48.70	48.28	56.50	46.35
	E_7	219.63	216.50	231.13	239.25	243.10	251.28	233.48
Mean		68.03	68.31	75.55	80.05	81.86	87.41	

C.D. for comparing means:

Drying methods	-	1.8**
Extraction methods	-	2.38**
Monthly mean	-	2.21**

D_1 - Drying under shade
D_2 - Drying under direct sunlight
D_3 - Drying using hot air in a mechanical seed drier
D_4 - Initial drying in shade for one day then in sun avoiding peak hours

** Significant at 1% level

E_1 - Manual extraction - no fermentation
E_2 - Manual extrtaction + with 48 hrs of fermentation
E_3 - Machine extraction - no fermentation
E_4 - Machine extraction + with 48 hrs of fermentation
E_5 - Machine extraction + acid treatment @ 1% HCl
E_6 - Machine extraction + acid treatment @ 2% HCl
E_7 - Machine extraction + alkali treatment @ 1% NaOH

Table 10b Mean effect of various seed extraction, drying and storage period on electrical conductivity of seed leachate of ash gourd seeds (μ mhos/cm)

Treatment combination	Months after storage						Mean
	1	2	3	4	5	6	
E_1D_1	42.00	39.25	48.20	53.55	53.05	64.75	50.13
E_1D_2	44.50	39.95	48.80	47.35	50.40	49.25	46.71
E_1D_3	47.25	45.25	55.30	57.00	59.35	64.60	54.79
E_1D_4	39.50	42.45	51.00	57.40	65.15	63.00	53.08
E_2D_1	37.65	45.75	42.05	48.45	41.75	51.95	44.60
E_2D_2	35.10	42.50	39.00	44.75	37.50	41.70	40.10
E_2D_3	43.55	41.05	51.00	49.95	54.35	52.30	48.70
E_2D_4	38.50	43.55	50.35	51.45	44.20	57.70	47.63
E_3D_1	49.00	52.50	72.25	65.60	89.15	89.90	69.73
E_3D_2	46.30	52.10	57.10	56.95	66.50	68.00	57.83
E_3D_3	53.00	42.70	55.60	70.85	77.25	80.70	63.35
E_3D_4	45.25	52.70	50.50	62.15	79.65	78.90	61.53
E_4D_1	50.50	49.75	55.75	60.60	71.40	63.20	58.53
E_4D_2	51.30	44.45	57.65	66.65	61.20	66.30	57.93
E_4D_3	44.20	54.60	63.35	55.25	65.70	70.60	58.95
E_4D_4	51.05	46.45	54.80	63.65	53.65	66.30	55.98
E_5D_1	35.40	35.15	42.00	46.35	36.15	42.65	39.62
E_5D_2	36.35	34.55	40.60	43.80	36.60	43.35	39.21
E_5D_3	40.30	38.60	46.35	43.10	45.10	55.20	44.77
E_5D_4	35.40	38.80	35.60	44.65	38.55	45.90	39.82
E_6D_1	39.60	37.55	40.75	46.00	45.65	54.30	43.98
E_6D_2	42.60	39.80	45.40	47.00	53.80	62.55	48.53
E_6D_3	38.25	42.55	45.10	51.65	45.95	51.10	45.75
E_6D_4	39.75	44.65	42.55	50.15	47.70	58.10	47.15
E_7D_1	216.00	221.00	235.00	244.00	235.10	256.90	234.67
E_7D_2	219.00	210.50	230.50	232.00	247.10	244.90	230.67
E_7D_3	221.00	217.00	227.00	245.00	254.60	256.90	236.92
E_7D_4	222.50	217.50	232.00	236.00	235.60	246.40	231.67
Mean for the month	68.00	68.31	75.55	80.10	81.86	87.41	

CD for comparing extraction x drying interaction - 4.79**

CD for comparing extraction x drying x month interaction - NS

** Significant at 1% level NS - Non significant

conductivity (233.48). The lowest overall electrical conductivity (40.85) was recorded in seeds extracted by machine extraction + acid treatment @ 1% HCl of pulp for 30 minutes (E_5).

The overall mean electrical conductivity of seed leachate at different storage periods also differed significantly. The lowest electrical conductivity (68.03) was recorded during first month. It was on par with overall electrical conductivity during second month (68.31). A gradual increase in overall electrical conductivity was observed from second month and the highest electrical conductivity (87.41) was recorded after sixth month.

The overall mean electrical conductivity values of seed leachate for different extraction x drying interaction was found to be statistically significant. The highest mean electrical conductivity (236.92) was recorded in machine extraction + alkali treatment @1% NaOH solution for one night and dried using hot air in a mechanical seed drier (E_1D_3). It was on par with seeds extracted by machine + alkali treatment @ 1% NaOH for one night and dried under shade (E_1D_1, 234.67). The lowest electrical conductivity (39.21) was recorded in machine extraction + acid treatment @ 1% HCl of pulp for

30 minutes and dried under direct sunlight (E_5D_2) and it was on par with following combinations - machine extraction + acid treatment @ 1% HCl of the pulp for 30 minutes and dried under shade (E_5D_1, 39.62), machine extraction + acid treatment @ 1% HCl of pulp for 30 minutes and dried initially in shade for one day and then in sun avoiding peak hours (E_5D_4, 39.82) and machine extraction + acid treatment @ 2% HCl of the pulp for 30 minutes and dried under shade (E_6D_1, 43.98).

Extraction x drying x month interaction was found to be insignificant for electrical conductivity of seed leachate during the period of study.

4.2.8 Time and man hour required for seed extraction

Among the different extraction methods, machine extraction recorded three to 4.5 per cent of seed damage, whereas in manual extraction no seed damage was noticed (Table 11). When comparing the time required for seed extraction, machine extraction + alkali treatment @ 1% NaOH equal to the weight of pulp for one night (E_4) took the minimum time (20 minutes). Machine extraction + acid treatment @2% HCl of the pulp (E_3) and manual extraction + 48 hours of fermentation (E_2) also recorded less time for seed extraction (30 minutes).

Table 11 Comparative effect of various seed extraction methods in ash gourd

Method of seed extraction	Time taken for seed extraction of five fruits (20 kg) minutes	Seed damage (%)	Overall mean percentage of germination	Remarks
Manual extraction with no fermentation (E_1)	45	0	80.42	Fruit pulp adhers to the seeds and it makes the washing and cleaning of seeds difficult
Manual extraction + with 48 hours of fermentation (E_2)	30	0	87.00	As a result of fermentation of fruit pulp, seed extraction becomes more easy. Pulp was easily removed from seed while washing and cleaning
Machine extraction with no fermentation (E_3)	75	3	77.38	Due to high ratio of fruit pulp and adherance to seeds it took more time when compared to manual extraction with out fermentation for washing and cleaning of seeds
Machine extraction + with 48 hours of fermentation (E_4)	45	3.5	83.46	As a result of fermentation of fruit pulp, seed extraction become more easy. Pulp was easily removed from seed while washing
Machine extraction + acid treatment @ 1% HCl of weight of pulp for 30 minutes (E_5)	70	3.8	89.00	1% HCl of weight of pulp was not very effective in removing the pulp. Here also fruit pulp adhers to the seeds and it makes seed extraction difficult
Machine extraction + acid treatment @ 2% HCl of weight of pulp for 30 minutes (E_6)	30	3.2	87.83	2% HCl of weight of pulp was very effective in removing the adhering pulp. Pulp was easily removed from the seeds while washing
Machine extraction + alkali treatment @ 1% NaOH equal to weight of pulp for one night (E_7)	20	4.5	57.00	Most easiest method of seed extraction. It took minimum time for seed extraction. Fruit pulp was easily removed from seeds while washing. Colour of the seed deepens with use of NaOH

When comparing the overall mean for germination of different extraction methods, the highest overall germination (89%) was recorded in machine extraction + acid treatment @ 1% HCl of the weight of pulp (E_5) which was on par with machine extraction + acid treatment @ 2% HCl of the pulp (E_6, 87.83%) and with manual extraction and 48 hours of fermentation (E_2, 87%). Seed extracted by machine extraction + alkali treatment @ 1% NaOH equal to the weight of pulp for one night (E_7) recorded the lowest overall mean germination (57%) and was significantly inferior to other methods of seed extraction.

4.3 Storage of intact fruits after harvest

Details of statistical analysis are furnished in Appendix IV. Meansof fruit and seed characteristics as influenced by the storage period are given in Table 12.

Fruit characters

4.3.1 Fresh weight of the fruits at the time of harvest

Fresh weight of the fruit was found to be not significant at the time of harvest and it varied from 3.47 kg to 4.77 kg.

Table 12 Mean fruit and seed characters as influenced by storage of fruits

Months of storage	Fruit weight at the time of harvest (kg)	Fruit weight at the time of extraction (kg)	Percentage weight loss of fruits	Fresh weight of seeds per fruit (g)	Dry weight of seeds per fruit (g)	Germination percentage of seeds
0	4.06	4.06	0.00	45.43	26.00	33 (0.61)
1	3.57	3.45	3.37	4.87	3.29	8 (0.29)
2	4.77	4.35	8.82	14.12	9.59	44 (0.73)
3	3.47	3.05	12.37	24.50	17.00	92 (1.28)
4	3.66	2.92	19.82	33.00	18.56	90 (1.25)
5	3.81	3.01	21.12	25.50	15.80	86 (1.19)
6	3.83	3.05	20.66	29.00	17.90	98 (1.42)
7	3.89	2.58	33.04	22.50	13.80	82 (1.13)
8	4.12	2.79	32.40	26.25	16.40	86 (1.20)
9	3.60	2.13	41.05	25.50	17.55	90 (1.25)
10	4.00	2.26	44.07	22.75	14.75	88 (1.22)
11	3.94	1.99	50.29	35.30	22.25	82 (1.13)
C.D.	NS	0.92**	10.38**	NS	NS	0.12**

Contd.....

Table 12 contd.....

Month of storage	Speed of germination	Root length of seedling (cm)	Shoot length of seedling (cm)	Vigour index of seedling	Seedling dry weight (mg)	Percentage of viviparous seeds
0	3.23	6.60	13.60	668	24.00	5.31
1	0.73	7.13	14.63	174	26.25	2.07
2	4.92	6.60	11.25	484	26.50	7.82
3	14.10	4.50	14.80	1776	26.50	1.39
4	10.93	8.20	12.40	1851	27.50	2.39
5	12.37	5.55	16.85	1928	27.70	2.77
6	13.95	5.62	15.22	2039	27.70	1.37
7	11.43	5.45	15.60	1727	28.90	6.09
8	12.19	5.53	15.57	1812	28.50	2.22
9	12.80	6.57	13.80	1830	29.30	0.24
10	10.95	6.00	12.95	1669	32.99	7.11
11	8.76	5.48	11.71	1410	29.30	16.50
C.D.	1.29**	NS	2.40**	417**	2.28**	NS

** Significant at 1% level NS - Non significant

Figures in brackets are arc-sine transformed values

4.3.2 Weight of the fruits at the extraction time

The weight of the fruits at the time of extraction was found to be highly significant. There was a loss in weight of the fruits throughout the period of storage. Fruits stored for eleven months recorded the lowest weight of 1.99 kg.

4.3.3 Weight loss of fruits

The weight loss (percentage) of the fruits was found to be highly significant over the period of storage. There was a steady increase in the weight loss of the fruits during the period of storage. Fruits recorded 3.37 per cent weight loss after one month of storage and 50.29 per cent after eleven months of storage. Loss of fruit weight upto two months were not significant and was on par with the weight of fresh fruits; weight loss from fourth to six months were also on par; weight loss from seventh to ninth months of storage was on par; and that in tenth and eleventh months were also on par.

Seed characters

4.3.4 Fresh weight of seeds per fruit

The fresh weight of the seeds from the fruits stored was found to be non-significant during the period of storage.

4.3.5 Dry weight of the seed per fruits

The dry weight of the seeds from the fruits stored was also found to be non-significant during the period of storage.

4.3.6 Germination percentage

Germination percentage of seeds was found to be significant during the period of storage. Seeds extracted from fresh fruits, with out storage recorded 33 per cent germination. The seeds from the fruits extracted during first two months recorded low germination percentage with eight and 44 per cent respectively. There was a considerable increase in germination of seeds, when fruits were stored for three months. The seeds from fruits extracted after three months of storage recorded 92 per cent germination. The seeds from the fruits extracted after six months of

storage recorded the highest (98%) germination. A slight decrease in germination percentage was observed after six months of storage. The seeds from the fruits stored after eleven months recorded 82 per cent germination.

4.3.7 Speed of germination

Speed of germination of the seeds was found statistically significant during the period of storage. Seeds from the fresh fruits and during first two months of storage recorded low speed of germination with 3.23, 0.73 and 4.92 respectively. Seeds from the fruits stored after three months recorded the highest speed of germination with 14.1. Thereafter speed of germination decreased. Seeds extracted after eleven months of fruit storage recorded a speed of germination of 8.76.

Seedling characters

4.3.8 Root length of seedling

The root length of seedling from the seeds obtained from the fruits stored over the period were found to be non-significant.

4.3.9 Shoot length of seedling

Shoot length of seedling of seeds obtained from fruits during period of storage was highly significant. Shoot length from seeds of fruits stored for five months recorded the highest value of 16.85 cm and it was on par upto eight months. A gradual decrease in shoot length was observed from nine months of fruit storage. Shoot length from seeds obtained from fruits stored after eleven months recorded 11.71 cm. The lowest shoot length was recorded from seeds obtained from fruits stored after two months with 11.25 cm.

4.3.10 Vigour index of seedling

The difference in vigour index of seedling was highly significant during period of fruit storage. The seedling from the seeds obtained from fresh fruits and during first two months of storage recorded low vigour index values with 668, 174 and 484 respectively. High vigour index was recorded for seeds obtained after six months of fruit storage with value of 2039. In general, vigour index was high from third to tenth month of fruit storage and were on par with each other.

4.3.11 Seedling dry weight

The difference in seedling dry weight was significant during period of fruit storage. The highest seedling dry weight was recorded from the seeds obtained after ten months of fruit storage (32.99 mg per seedling). The lowest seedling dry weight was recorded from the fresh seeds with 24.00 mg per seedling.

4.3.12 Percentage of viviparous seeds

The percentage of viviparous seeds during the period of fruit storage was found to be non-significant over the period of storage.

4.4 Storage of extracted seeds

Studies were carried out in ash gourd BH 21 with a view to determine the viability potential of seeds treated with selected seed protectants and stored in three different kinds of packing materials. Analysis of variance of the data are furnished in Appendix V and VI.

4.4.1 Germination percentage

Results of statistical analysis on germination percentage is furnished in Tables 13a and 13b.

Statistical analysis of the data indicated that the effect of packing material on germination was significant from fourth month after storage. Among the different packing materials, packing in polythene bags of 700 gauge (P_2) was found to be the best and gave significantly highest overall mean germination percentage (61.42). It was followed by brown paper bag (P_1, 44.55 per cent) and gada cloth bag (P_3, 42.22 per cent) and the latter two were significantly inferior to polythene package.

Effect of seed treatment also had a significant effect on germination except in two months. Among the different seed treatments, captan (T_1) was found to be superior and recorded the highest overall mean germination percentage (61.76 per cent). It was followed by thiram (T_2, 52.36 per cent). Germination of seeds treated with captan and thiram were on par with each other upto four months after storage. In general, effects of bavistin (T_3), cowdung + ash slurry and

Table 13a Overall mean effects of packing, seed treatments and storage on germination (%) of ash gourd seeds

Months	Packing			Treatments					Mean
	P_1	P_2	P_3	T_1	T_2	T_3	T_4	T_5	
1	76.00 (1.11)	69.00 (1.03)	76.80 (1.12)	96.67 (1.39)	96.67 (1.39)	57.33 (0.87)	56.00 (0.85)	63.33 (0.93)	74.00 (1.08)
2	89.20 (1.28)	90.40 (1.28)	88.40 (1.24)	96.00 (1.38)	95.33 (1.36)	82.67 (1.16)	87.33 (1.23)	85.33 (1.19)	89.33 (1.26)
3	83.20 (1.18)	77.60 (1.11)	81.20 (1.15)	96.00 (1.38)	94.00 (1.33)	67.33 (0.97)	78.00 (1.08)	68.00 (0.98)	80.67 (1.15)
4	62.40 (0.92)	81.60 (1.17)	68.40 (0.98)	86.00 (1.23)	79.33 (1.13)	61.33 (0.90)	68.67 (0.98)	58.67 (0.88)	70.80 (1.03)
5	50.00 (0.79)	73.60 (1.06)	47.60 (0.76)	71.33 (1.03)	52.67 (0.86)	56.67 (0.88)	55.33 (0.84)	45.33 (0.74)	57.10 (0.87)
6	40.00 (0.68)	63.60 (0.93)	37.20 (0.65)	54.67 (0.83)	50.00 (0.79)	46.67 (0.75)	42.00 (0.70)	41.33 (0.69)	46.93 (0.75)
7	31.60 (0.59)	63.60 (0.93)	28.00 (0.55)	53.33 (0.82)	44.67 (0.73)	36.00 (0.63)	32.00 (0.60)	39.33 (0.67)	41.10 (0.69)
8	15.60 (0.38)	58.00 (0.88)	17.60 (0.42)	33.33 (0.60)	23.33 (0.48)	29.33 (0.54)	28.67 (0.56)	37.33 (0.63)	30.40 (0.56)
9	18.00 (0.41)	43.60 (0.71)	8.00 (0.28)	38.00 (0.65)	25.33 (0.47)	18.00 (0.48)	24.00 (0.48)	10.67 (0.31)	23.20 (0.47)
10	13.60 (0.35)	22.80 (0.46)	8.00 (0.26)	25.33 (0.52)	3.33 (0.18)	5.33 (0.23)	14.00 (0.37)	26.00 (0.47)	14.80 (0.35)
11	10.40 (0.29)	31.60 (0.57)	3.20 (0.18)	28.67 (0.54)	11.30 (0.32)	16.00 (0.36)	5.33 (0.23)	14.00 (0.30)	15.10 (0.35)
Mean	44.55 (0.73)	61.42 (0.92)	42.22 (0.69)	61.76 (0.94)	52.36 (0.82)	43.33 (0.70)	44.67 (0.72)	44.48 (0.71)	

CD for comparing means of packing materials - 0.03**
CD for comparing means of treatments - 0.03**
CD for comparing means of months - 0.05**
CD for comparing means of packing x months - 0.09**
CD for comparing means of treatment x months - 0.11**

P_1 - Brown paper bag
P_2 - Polythene bag (700 gauge)
P_3 - Gada cloth bag

** Significant at 1% level

T_1 Captan - 2.5 g/kg seed
T_2 Thiram - 2.5 g/kg seed
T_3 Bavistin - 2.5 g/kg seed
T_4 (Cowdung-ash slurry) and drying in smoke
T_5 Control - untreated seeds

Figures in brackets are arc-sine transformed values

Table 13b Mean effect of packing, treatment and storage period on germination (%) of ash gourd seeds

Treatments	Months after storage											Mean
	1	2	3	4	5	6	7	8	9	10	11	
P_1T_1	96 (1.38)	94 (1.33)	94 (1.34)	86 (1.21)	58 (0.87)	48 (0.77)	42 (0.71)	14 (0.38)	22 (0.49)	32 (0.60)	32 (0.60)	56.18 (0.88)
P_1T_2	98 (1.42)	100 (1.47)	98 (1.42)	64 (0.93)	48 (0.77)	44 (0.72)	32 (0.60)	10 (0.31)	6 (0.24)	4 (0.19)	8 (0.28)	46.55 (0.76)
P_1T_3	58 (0.87)	72 (1.05)	64 (0.93)	60 (0.89)	42 (0.71)	46 (0.75)	34 (0.62)	12 (0.35)	30 (0.58)	8 (0.28)	4 (0.20)	39.09 (0.66)
P_1T_4	54 (0.83)	92 (1.32)	74 (1.04)	58 (0.87)	68 (0.97)	48 (0.77)	38 (0.66)	36 (0.64)	30 (0.58)	20 (0.46)	8 (0.29)	47.83 (0.77)
P_1T_5	74 (1.04)	88 (1.22)	84 (1.19)	44 (0.72)	34 (0.62)	14 (0.38)	12 (0.35)	6 (0.23)	2 (0.15)	4 (0.19)	0 (0.10)	33.1 (0.56)
P_2T_1	96 (1.38)	100 (1.47)	96 (1.38)	100 (1.47)	92 (1.28)	66 (0.95)	76 (1.06)	68 (0.98)	84 (1.16)	26 (0.53)	48 (0.77)	77.45 (1.13)
P_2T_2	96 (1.37)	92 (1.29)	94 (1.33)	94 (1.34)	78 (1.08)	72 (1.01)	72 (1.01)	42 (0.70)	64 (0.93)	6 (0.24)	22 (0.47)	66.55 (0.98)
P_2T_3	50 (0.79)	86 (1.18)	58 (0.87)	54 (0.83)	90 (1.26)	68 (0.97)	60 (0.89)	64 (0.93)	12 (0.35)	4 (0.20)	40 (0.69)	53.27 (0.81)
P_2T_4	40 (0.68)	84 (1.17)	82 (1.13)	80 (1.11)	56 (0.85)	26 (0.54)	22 (0.49)	24 (0.51)	38 (0.66)	12 (0.35)	6 (0.24)	42.72 (0.70)

Contd....

Table 13b contd...

P_2T_5	64 (0.93)	90 (1.26)	58 (0.87)	80 (1.11)	52 (0.81)	86 (1.19)	88 (1.22)	92 (1.29)	20 (0.46)	66 (0.95)	42 (0.71)	67.1 (0.98)
P_3T_1	98 (1.42)	94 (1.34)	98 (1.42)	72 (1.02)	64 (0.93)	50 (0.79)	42 (0.70)	18 (0.43)	8 (0.29)	18 (0.42)	6 (0.24)	51.64 (0.82)
P_3T_2	96 (1.37)	94 (1.33)	90 (1.25)	80 (1.11)	44 (0.73)	34 (0.62)	30 (0.58)	18 (0.44)	6 (0.24)	0 (0.10)	4 (0.20)	45.09 (0.72)
P_3T_3	64 (0.95)	90 (1.25)	80 (1.11)	70 (0.99)	38 (0.66)	26 (0.54)	14 (0.38)	12 (0.33)	12 (0.35)	4 (0.20)	4 (0.20)	37.63 (0.63)
P_3T_4	74 (1.04)	86 (1.20)	78 (1.08)	68 (0.97)	42 (0.70)	52 (0.81)	36 (0.64)	26 (0.54)	4 (0.20)	10 (0.31)	2 (0.15)	43.45 (0.69)
P_3T_5	52 (0.81)	78 (1.08)	60 (0.89)	52 (0.81)	50 (0.79)	24 (0.51)	18 (0.44)	14 (0.38)	10 (0.32)	8 (0.26)	0 (0.10)	33.27 (0.58)
CD packing	NS	NS	NS	0.11**	0.09**	0.08**	0.05**	0.11**	0.07**	0.12**	0.08**	
CD Treatment	0.14*	0.17*	0.11**	0.14**	0.11**	NS	0.06**	NS	0.10**	0.15**	0.10**	
CD Interaction	NS	NS	0.19*	0.24*	0.19**	0.18**	0.10**	0.24**	0.17**	0.26**	0.17**	

CD for comparing overall mean of packing material x treatment interaction = 0.06**
CD for comparing means of packing material x treatment x months interaction = 0.19**
Figures in brackets are arc-sine transformed values

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

drying in smoke (T_4) and control (T_5) were on par with each other and inferior to captan and thiram treated seeds.

The overall mean of germination of seeds reduced gradually from three months after storage and it differed statistically in each month except in tenth and eleventh months. The lowest germination (14.8 per cent) was recorded in the tenth month after storage and the highest germination was observed in second month after storage (89.33 per cent).

Packing material x seed treatment interaction was found to be statistically significant from third month onwards. The seeds treated with captan and stored in polythene (P_2T_1) recorded the highest mean germination (77.45 per cent); followed by untreated seeds stored in polythene bags (P_2T_5, 67.1 per cent) and seeds treated with thiram and stored in polythene (P_2T_2, 66.55 per cent), and the latter two were on par with each other. Though overall germination percentage of untreated seeds was low (T_5, 44.48), when packed in polythene bags (P_2), it gave the highest germination from sixth month after storage indicating significant interaction effect. Among the different packing material and seed treatment combinations tried, the lowest germination was recorded

in untreated control seeds packed in brown paper cover (P_1T_5, 33.1 percent) which was on par with untreated seeds packed in gada cloth bag (P_3T_5, 33.27 per cent).

Packing material x month interaction and seed treatment x month interaction were also statistically significant. Seeds stored in polythene bags (P_2) gave maximum germination (90.4 per cent) two months after storage. The seeds treated with captan and thiram gave maximum germination (96.67 per cent) one month after storage.

Considering the packing material x seed treatment x month interaction, the maximum germination (100 per cent) was obtained in the following treatments. Seeds treated with captan and packed in polythene (P_2T_1) two and four months after storage, and seeds treated with thiram and stored in brown paper bag (P_1T_2) two months after storage.

4.4.2 Speed of germination

Results of the statistical analysis on speed of germination are furnished in the Tables 14a and 14b.

Table 14a Overall mean effects of packing, seed treatments and storage on speed of germination of ash gourd seeds

Months	Packing			Treatments					Mean
	P_1	P_2	P_3	T_1	T_2	T_3	T_4	T_5	
1	12.62	11.43	12.14	15.79	16.18	9.73	8.50	10.11	12.06
2	12.16	13.21	12.59	14.14	13.79	11.08	11.54	12.70	12.65
3	12.76	12.71	12.55	15.03	15.12	10.55	11.88	10.78	12.67
4	7.79	11.59	8.44	11.38	10.89	7.94	8.41	7.74	9.27
5	5.92	9.69	5.68	9.43	7.13	7.23	6.41	5.30	7.10
6	4.26	7.93	4.00	6.12	5.76	5.41	4.53	5.19	5.40
7	3.42	7.86	3.12	6.15	5.48	4.17	3.31	4.87	4.80
8	1.48	6.51	1.69	3.59	2.49	3.16	2.49	4.42	3.23
9	2.13	4.79	0.77	4.07	2.79	1.60	3.12	1.19	2.55
10	1.20	2.63	0.77	2.38	0.32	0.55	1.30	3.10	1.53
11	1.05	3.51	0.32	3.17	1.20	1.83	0.48	1.47	1.63
Mean	5.88	8.35	5.64	8.30	7.38	5.75	5.63	6.08	

CD for comparing means of packing materials - 0.28**
CD for comparing means of treatments - 0.37**
CD for comparing means of months - 0.54**
CD for comparing means of packing x months - 0.94**
CD for comparing means of treatment x months - 1.22**

P_1 - Brown paper bag
P_2 - Polythene bag (700 gauge)
P_3 - Gada cloth bag

** Significant at 1% level

T_1 Captan - 2.5 g/kg seed
T_2 Thiram - 2.5 g/kg seed
T_3 Bavistin - 2.5 g/kg seed
T_4 (Cowdung-ash slurry) and drying in smoke
T_5 Control - untreated seeds

Table 14b Mean effect of packing, treatment and storage period on speed of germination of ash gourd seeds

Treatments	Months after storage											Mean
	1	2	3	4	5	6	7	8	9	10	11	
P_1T_1	16.15	13.52	14.09	10.85	7.13	5.18	4.67	1.44	1.95	2.58	3.22	7.34
P_1T_2	16.45	13.67	15.11	7.89	5.55	4.61	3.89	0.95	0.55	0.40	0.92	6.36
P_1T_3	10.08	8.55	9.49	7.73	5.22	4.77	3.55	1.06	2.70	0.82	0.40	4.94
P_1T_4	8.43	12.12	11.19	6.88	7.88	5.22	3.61	3.35	2.79	1.79	0.71	6.04
P_1T_5	11.99	12.93	13.91	5.59	3.82	1.55	1.38	0.60	0.16	0.40	0.00	4.76
P_2T_1	15.94	14.93	15.72	14.52	13.11	7.99	9.29	7.51	9.50	2.76	5.62	10.62
P_2T_2	16.13	13.94	16.42	14.72	10.66	9.10	9.05	4.79	7.28	0.56	2.31	9.54
P_2T_3	8.62	12.21	9.57	7.21	11.85	8.49	7.24	7.15	1.16	0.44	4.66	7.14
P_2T_4	6.16	11.34	12.46	10.55	6.68	2.63	1.96	1.76	3.63	1.21	0.57	5.40
P_2T_5	10.31	13.67	9.36	10.95	6.18	11.45	11.26	11.34	2.34	8.20	4.42	9.05

Contd.....

Table 14b contd.....

P_3T_1	15.29	13.96	15.28	8.79	8.06	5.19	4.51	1.81	0.76	1.80	0.64	6.92
P_3T_2	15.95	13.76	13.83	10.04	5.17	3.56	3.51	1.73	0.56	0.00	0.37	6.22
P_3T_3	10.49	12.49	12.59	8.89	4.62	2.96	1.74	1.27	0.95	0.40	0.42	5.16
P_3T_4	9.43	11.23	11.99	7.82	4.67	5.73	3.87	2.36	0.44	0.91	0.16	5.46
P_3T_5	8.04	11.50	9.07	6.69	5.89	2.59	1.96	1.31	1.02	0.72	0.00	4.34
CD Packing	NS	NS	NS	1.11**	0.99**	0.94**	0.33**	0.82**	0.53**	0.83**	0.62**	
CD Treatment	2.34**	1.29**	1.62**	1.43**	1.27**	NS	0.70**	1.06**	0.68**	1.08**	0.80**	
CD Interaction	NS	NS	2.57**	2.48**	2.22**	2.11**	1.22**	1.83**	1.18**	1.87*	1.39**	

CD for comparing overall mean of packing material x treatment interaction = 0.64**
CD for comparing means of packing material x treatment x months interaction = 2.11**

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

Statistical analysis of the data indicated that the effect of packing material on speed of germination was significant from fourth month after storage. Among the different packing material, packing in polythene bags of 700 gauge (P_2) was found to be the best and significantly superior to brown paper bag and gada cloth packages. The packing in polythene (P_2) gave the highest overall mean speed of germination value of 8.35, followed by brown paper bag (P_1, 5.88) and gada cloth bag (P_3, 5.64) and the latter two were on par with each other.

Effect of seed treatment also had a significant effect on speed of germination value. Among the different treatments, seeds treated with captan (T_1) was found to be superior and recorded the highest overall mean speed of germination value of 8.30; it was followed by thiram treated seeds (T_2,7.38). Speed of germination of seeds treated with captan and thiram were on par with each other up to fourth month of storage. In general, the effects of bavistin (T_3), cowdung + ash slurry and drying in smoke (T_4) and control (T_5) were on par with each other and inferior to captan and thiram treated seeds.

The overall mean speed of germination reduced gradually from fourth month onwards. The highest speed

of germination was recorded on third (12.67) and second months (12.65) after storage and the lowest in tenth (1.53) and eleventh (1.63) months after storage.

Influence of packing material x seed treatment interaction on speed of germination was found to be statistically significant from third month after storage. Seeds treated with captan and stored in polythene bags of 700 gauge (P_2T_1) recorded the highest overall mean speed of germination value (10.62); followed by seeds treated with thiram and stored in polythene bags (P_2T_2, 9.54) and untreated control seeds stored in polythene bags (P_2T_5, 9.05); and the latter two were on par with each other. Though the overall speed of germination of untreated control seeds was low (T_5, 6.08), when packed in polythene bag (P_2), they gave the highest value from sixth month after storage indicating significant interaction effect. Among the different packing material and seed treatment combinations tried, the lowest speed of germination was recorded in untreated control seeds packed in gada cloth bag (P_3T_5, 4.34), which was on par with the untreated control seeds packed in brown paper bag ($P_1 T_5$, 4.76).

Packing material x month interactions and seed treatment x month interactions were also statistically

significant. Seeds stored in polythene bags (P_2) gave the maximum speed of germination (13.21), two months after storage. The seeds treated with thiram (T_2) gave maximum speed of germination (16.18), one month after storage, closely followed by seeds treated with captan (T_1, 15.79), one month after storage.

Considering the packing material x seed treatment x month interactions, the maximum speed of germination was obtained in seeds treated with thiram and stored in brown paper bag (P_2T_1) one month after storage (16.45); closely followed by seeds treated with thiram and stored in polythene bags (P_2T_2) three months after storage (16.42).

4.4.3 Vigour index of seedlings

Results of statistical analysis on vigour index of seedling are furnished in Tables 15a and 15b.

Statistical analysis of the data indicated that the effect of packing material on vigour index of seedling was significant from fourth month after storage. Among the different packing materials tried, polythene bags of 700 gauge (P_2) was found to be the best and significantly superior to brown paper bag (P_1) and gada cloth

Table 15a Overall mean effects of packing, seed treatments and storage on vigour index of seedlings of ash gourd seeds

Months	Packing			Treatments					Mean
	P_1	P_2	P_3	T_1	T_2	T_3	T_4	T_5	
1	1439	1325	1483	1806	1823	1158	1067	1225	1416
2	1945	2020	2036	2148	2108	1779	1984	1984	2000
3	1557	1570	1539	1790	1807	1346	1464	1371	1555
4	1175	1664	1345	1693	1490	1199	1442	1147	1394
5	998	1506	952	1512	1144	1128	1074	901	1152
6	699	1254	645	976	979	787	772	816	866
7	575	1285	519	1012	880	688	625	759	793
8	205	1021	254	537	394	486	378	672	493
9	281	833	127	712	462	300	416	179	414
10	237	425	141	473	56	91	222	496	268
11	126	484	41	407	157	255	60	206	217
Mean	840	1217	826	1188	1027	838	864	887	

CD for comparing means of packing materials - 48**
CD for comparing means of treatments - 61**
CD for comparing means of months - 91**
CD for comparing means of packing x months - 158**
CD for comparing means of treatment x months - 204**

P_1 - Brown paper bag
P_2 - Polythene bag (700 gauge)
P_3 - Gada cloth bag

** Significant at 1% level

T_1 Captan - 2.5 g/kg seed
T_2 Thiram - 2.5 g/kg seed
T_3 Bavistin - 2.5 g/kg seed
T_4 (Cowdung-ash slurry) and drying in smoke
T_5 Control - untreated seeds

Table 15b Mean effect of packing, treatments and storage period on vigour index of seedlings of ash gourd seeds

Treatments	Months after storage											Mean
	1	2	3	4	5	6	7	8	9	10	11	
P_1T_1	1788	2084	1721	1702	1232	835	746	169	347	576	395	1054
P_1T_2	1888	2175	1852	1070	996	786	576	149	82	59	96	885
P_1T_3	1051	1368	1194	1168	852	745	578	162	477	134	53	707
P_1T_4	1104	2118	1354	1132	1327	914	778	454	483	356	88	919
P_1T_5	1363	1979	1664	801	583	213	197	91	14	62	0	633
P_2T_1	1864	2255	1983	2000	1928	1296	1589	1167	1653	485	747	1548
P_2T_2	1752	2031	1859	1915	1583	1510	1501	771	1232	108	321	1326
P_2T_3	1061	1801	1121	1083	1812	1292	1228	1101	207	69	665	1040
P_2T_4	724	1958	1538	1763	1101	461	421	357	703	157	18	841
P_2T_5	1226	2057	1351	1556	1056	1709	1685	1695	369	1305	617	1330

Contd.....

Table 15b contd....

P_3T_1	1767	2104	1965	1378	1329	796	700	261	136	357	78	961
P_3T_2	1829	2117	1711	1485	852	641	563	262	71	0	53	871
P_3T_3	1361	2167	1722	1346	720	423	257	195	215	71	48	766
P_3T_4	1373	1876	1499	1431	795	942	677	323	62	153	25	832
P_3T_5	1086	1915	1098	1085	1064	524	396	229	154	122	0	698
CD Packing	NS	NS	NS	218**	187**	147**	111**	133**	123**	145**	93**	
CD Treatment	258**	NS	273**	282**	241**	NS	144**	172**	159**	187**	120**	
CD Interaction	NS	NS	NS	NS	418**	329**	249**	298**	276**	324**	208**	

CD for comparing overall mean of packing material x treatment interaction = 107**
CD for comparing means of packing material x treatment x months interaction = 353**

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

packages (P_3). Seeds packed in polythene bags gave the highest overall mean vigour index (1217), followed by that in brown paper bag (P_1, 840) and gada cloth bag (P_3, 826) and the latter two were on par with each other.

Effect of seed treatments also had a significant effect on vigour index. Among the different seed treatments, captan (T_1) was found to be superior which recorded the highest overall mean vigour index (1188); it was followed by thiram treated seeds (T_2, 1027). Vigour index of seeds of the above two treatments were on par with each other upto six months of storage. In general, the effects of bavistin (T_3), cowdung + ash slurry and drying in smoke (T_4) and control (T_5) were on par with each other and were significantly inferior to captan and thiram treated seeds.

The overall vigour index of different months after storage also varied significantly. The maximum vigour index of seedling was obtained in two months after storage (2000) after which the vigour index reduced gradually and came to the lowest by eleven months after storage (217).

Packing material x seed treatment interactions were found to be statistically significant from fifth month

after storage. Seeds treated with captan and stored in polythene bags (P_2T_1) recorded the highest overall mean vigour index (1548). It was followed by untreated control seeds packed in polythene bags (P_2T_5) and seeds treated with thiram and stored in polythene bags (P_2T_2) which recorded mean values of 1330 and 1326 respectively; and these two were on par with each other. Though the overall mean of vigour index of untreated control seeds was low (T_5, 887), when packed in polythene bags (P_2) gave the highest value from six months after storage indicating significant interaction effect. Among the different packing and seed treatment combinations tried, the lowest vigour index was recorded in untreated seeds packed in brown paper bag (633), which was on par with the untreated seeds packed in gada cloth bag (698).

Effect of packing material x month interactions and seed treatment x month interactions were also statistically significant. Seeds stored in gada cloth bag (P_3) gave maximum vigour index (2036), two months after storage; closely followed by seeds stored in polythene bags (P_2, 2021)two months after storage. The seeds treated with captan (T_1) gave maximum

vigour index (2148) two months after storage; closely followed by seeds treated with thiram (T_2, 2108) two months after storage.

Considering the packing material x seed treatment x month interactions, the maximum vigour index (2255) was seen in seeds treated with captan and packed in polythene bags (P_2T_1), two months after storage.

4.4.4 Seedling dry weight

Results of statistical analysis on seedling dry weight are furnished in Tables 16a and 16b.

Statistical analysis of the data indicated that effect of packing material on seedling dry weight was significant from seven months after storage. Among the different packing materials tried, polythene bags of 700 gauge (P_2) gave the highest overall mean seedling dry weight (26.6 mg per seedling) and was significantly superior to brown paper bag (P_1, 24.24 mg) and gada cloth bag (P_3, 24.15 mg); and the latter two were on par with each other.

Table 16a Overall mean effects of packing, seed treatments and storage on dry weight per seedling (mg) of ash gourd seeds

Months	Packing			Treatments					Mean
	P_1	P_2	P_3	T_1	T_2	T_3	T_4	T_5	
1	35.23	34.86	34.55	40.52	39.30	32.78	34.97	26.83	34.88
2	30.58	30.10	32.89	37.17	31.67	30.47	32.33	24.32	31.19
3	25.82	23.65	24.55	27.00	25.58	25.42	23.83	21.53	24.67
4	24.62	25.61	23.00	28.27	24.42	23.25	22.92	23.20	24.41
5	23.63	25.43	24.83	26.00	23.08	24.00	27.80	22.27	24.63
6	23.40	25.16	23.58	25.00	23.17	22.93	26.70	22.43	24.05
7	24.03	25.66	23.91	26.33	25.13	22.78	25.77	22.65	24.53
8	19.01	23.20	21.73	23.60	22.61	18.50	22.35	19.51	21.31
9	20.27	24.52	22.30	25.48	22.85	21.84	24.20	17.44	22.36
10	18.89	27.31	17.71	24.57	11.17	25.25	28.10	17.43	21.30
11	21.18	27.09	16.65	28.12	26.10	26.43	17.75	9.80	21.64
Mean	24.24	26.60	24.15	28.37	25.01	24.88	26.07	20.67	

CD for comparing means of packing materials - 0.96**
CD for comparing means of treatments - 1.24**
CD for comparing means of months - 1.84**
CD for comparing means of packing x months - 3.19**
CD for comparing means of treatment x months - 4.11**

P_1 - Brown paper bag
P_2 - Polythene bag (700 gauge)
P_3 - Gada cloth bag

** Significant at 1% level

T_1 Captan - 2.5 g/kg seed
T_2 Thiram - 2.5 g/kg seed
T_3 Bavistin - 2.5 g/kg seed
T_4 (Cowdung-ash slurry) and drying in smoke
T_5 Control - untreated seeds

Table 16b Mean effect of packing, treatments and storage period on dry weight per seedling (mg) of ash gourd seeds

Treatments	Months after storage											Mean
	1	2	3	4	5	6	7	8	9	10	11	
P_1T_1	40.30	38.00	29.00	30.00	26.00	26.00	26.40	24.71	25.43	20.90	30.90	28.88
P_1T_2	39.95	34.50	24.50	23.75	21.65	22.00	23.90	21.88	22.00	11.75	27.50	24.85
P_1T_3	37.15	28.40	28.00	24.75	26.00	24.00	23.50	17.50	22.60	25.75	24.00	25.61
P_1T_4	32.40	30.00	25.00	22.50	25.50	25.00	25.50	22.30	24.80	24.30	23.50	25.53
P_1T_5	26.35	22.00	22.60	22.10	19.00	20.00	20.84	8.67	6.50	11.75	0.00	16.35
P_2T_1	41.95	36.00	26.00	28.55	26.50	27.00	28.70	22.70	24.00	26.00	27.20	28.60
P_2T_2	35.65	28.50	26.75	25.50	25.65	24.50	25.40	23.30	25.30	21.75	27.30	26.42
P_2T_3	32.70	29.00	21.00	23.25	22.50	22.00	22.20	20.40	22.00	25.00	30.80	24.62
P_2T_4	35.50	32.00	23.50	25.75	27.50	27.00	25.50	22.50	26.80	32.00	20.75	27.21
P_2T_5	28.00	25.00	21.00	25.00	25.00	25.30	26.50	26.10	24.58	31.80	29.40	26.14

Contd.....

Table 16b contd.....

P_3T_1	39.30	37.50	26.00	26.25	25.50	22.00	23.90	23.38	27.00	26.80	26.25	27.63
P_3T_2	42.30	32.00	25.50	24.00	21.95	23.00	26.10	21.67	21.25	0.00	23.50	23.75
P_3T_3	28.50	34.00	27.25	21.75	23.50	22.80	22.63	17.60	20.92	25.00	24.50	24.40
P_3T_4	36.50	35.00	23.00	20.50	30.40	28.10	26.30	22.25	21.00	28.00	9.00	25.46
P_3T_5	26.15	25.95	21.00	22.50	22.80	22.00	20.63	23.75	21.34	8.75	0.00	19.53
CD Packing	NS	NS	NS	NS	NS	NS	1.48*	NS	3.10*	7.35*	5.0*	
CD Treatment	2.44**	3.23**	3.51**	2.76**	2.53**	2.56**	1.91**	NS	4.0**	9.49*	6.46**	
CD Interaction	4.23**	NS	NS	NS	NS	NS	3.30*	7.67*	6.93*	NS	11.19**	

CD for comparing overall mean of packing material x treatment interaction = 2.16**
CD for comparing means of packing material x treatment x months interaction = 7.12**

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

Effect of various seed treatments also had a significant effect on seedling dry weight except in one month. Among the different seed treatments, maximum seedling dry weight was obtained with seeds treated with captan (T_1) throughout the period of study. Seeds treated with captan (T_1) recorded the highest overall mean seedling dry weight (28.37 mg per seedling). It was followed by seeds treated with cowdung + ash slurry and drying in smoke (T_4), bavistin (T_3) and thiram (T_2) (26.07,25.01 and 24.88 mg respectively); and these were on par with each other. The lowest seedling dry weight of 20.67 mg per seedling was recorded in untreated control seeds (T_5) and was significantly inferior to the treated seeds throughout the period of the study.

The overall mean seedling dry weight of seeds at different months after storage also varied significantly. The maximum seedling dry weight (34.88 mg) was obtained in one month after storage, after which seedling dry weight reduced significantly and came to the lowest by ten months after storage (21.3 mg).

Packing material x seed treatment interactions was found to be statistically significant only during five

months. When comparing the overall mean packing material x seed treatment interactions, the highest seedling dry weight was recorded in seeds treated with captan and stored in brown paper bag (P_1T_1, 28.88 mg) and this was on par with seeds treated with captan and stored in polythene bags (P_2T_1, 28.6 mg); seeds treated with cowdung + ash slurry and dried in smoke and stored in polythene bags (P_2T_4, 27.21 mg) and seeds treated with captan and stored in gada cloth bags (P_3T_1, 27.63 mg). The lowest seedling dry weight were recorded in untreated seeds stored in brown paper bags and gada cloth bags (16.35 and 19.53 mg respectively). But untreated seeds stored in polythene bags (P_2T_5) recorded a high dry weight of 26.14 mg per seedling indicating the interaction effect.

Packing material x month interactions and seed treatment x month interactions were also statistically significant. Seeds stored in brown paper bag (P_1) gave maximum seedling dry weight (35.23 mg) one month after storage; which was closely followed by seeds stored in polythene bags (P_2, 34.86 mg) one month after storage. Seeds treated with captan (T_1) gave maximum seedling dry weight (40.52 mg) one month after storage, closely followed by seeds treated with thiram (T_2, 39.3 mg) one month after storage.

Considering the various packing material x seed treatment x month interactions, the maximum dry weight of seedling was obtained in seeds treated with thiram and stored in gada cloth bag (P_3T_2), one month after storage (42.30 mg); which was closely followed by seeds treated with captan and stored in polythene bags (P_2T_1) one month after storage (41.95 mg).

4.4.5 Electrical conductivity of seed leachate

Results of the statistical analysis on electrical conductivity of seed leachate are furnished in Tables 17a and 17b.

Statistical analysis of the data indicated that effect of packing material on electrical conductivity of seed leachate was significant only during five months. Among the different packing materials, packing in brown paper bag (P_1) recorded the lowest overall mean electrical conductivity (140.02) and the highest was in seeds stored in polythene bags, 700 gauge (P_2, 154.32).

Effect of various seed treatments also had a significant effect on electrical conductivity of seed leachate. The lowest overall mean electrical conductivity (68.23) was recorded in untreated control

Table 17a Overall mean effects of packing, seed treatments and storage on electrical conductivity of seed leachate of ash gourd seeds (μ mhos/cm)

Months	Packing			Treatments					Mean
	P_1	P_2	P_3	T_1	T_2	T_3	T_4	T_5	
1	127.81	141.91	123.77	70.52	59.15	65.03	394.17	66.95	131.16
2	130.43	132.34	140.98	68.17	58.18	71.10	422.50	52.97	134.58
3	132.19	150.97	140.17	70.20	55.85	67.25	450.37	62.15	141.11
4	125.29	148.53	115.33	68.12	64.03	66.75	394.17	55.52	129.72
5	133.90	147.22	133.94	70.82	60.08	71.68	430.67	58.52	138.35
6	144.00	150.55	137.33	68.93	64.77	75.37	444.90	65.83	143.96
7	139.04	155.68	142.31	72.82	72.18	72.38	447.50	63.50	145.68
8	134.46	155.51	158.60	85.53	76.95	78.68	432.67	73.78	149.52
9	155.21	163.28	166.40	89.03	86.13	87.82	457.43	87.75	161.63
10	156.69	173.72	172.21	90.62	87.28	98.60	485.33	75.87	167.54
11	161.18	177.82	172.56	89.65	87.18	99.78	488.33	87.65	170.52
Mean	140.02	154.32	145.78	76.76	70.14	77.67	440.73	68.23	

CD for comparing means of packing materials - 4.61**
CD for comparing means of treatments - 5.95**
CD for comparing means of months - 10.31**
CD for comparing means of packing x months - NS
CD for comparing means of treatment x months - 19.74**

P_1 - Brown paper bag
P_2 - Polythene bag (700 gauge)
P_3 - Gada cloth bag

** Significant at 1% level

T_1 Captan - 2.5 g/kg seed
T_2 Thiram - 2.5 g/kg seed
T_3 Bavistin - 2.5 g/kg seed
T_4 (Cowdung-ash slurry) and drying in smoke
T_5 Control - untreated seeds

Table 17b Mean effects of packing, treatments and storage period on electrical conductivity of seed leachate of ash gourd seeds (μ mhos/cm)

Treatments	Months after storage											Mean
	1	2	3	4	5	6	7	8	9	10	11	
P_1T_1	64.10	65.05	63.60	71.25	66.95	65.50	74.55	84.20	89.75	83.70	91.95	74.60
P_1T_2	61.25	58.45	52.25	55.60	60.25	64.60	75.15	66.15	82.45	80.90	89.20	67.84
P_1T_3	66.60	72.75	66.95	65.55	72.40	72.25	70.80	79.30	82.25	95.30	95.60	76.34
P_1T_4	383.50	405.30	416.20	365.00	415.00	444.50	401.00	370.00	431.80	452.50	435.50	410.94
P_1T_5	63.60	50.60	61.95	69.05	54.90	73.15	73.70	72.65	89.80	71.05	93.65	70.37
P_2T_1	76.95	60.55	71.30	70.90	68.15	65.90	69.40	70.50	77.10	85.15	80.55	72.41
P_2T_2	57.00	64.10	61.00	73.25	58.95	59.60	63.10	73.95	76.40	81.25	79.15	67.98
P_2T_3	68.55	68.90	69.70	68.75	68.50	71.65	74.00	73.35	88.90	88.95	91.85	75.34
P_2T_4	441.50	413.10	489.20	475.50	483.00	497.70	516.00	494.50	499.50	539.50	560.50	491.82
P_2T_5	65.55	55.05	63.65	54.25	57.50	57.90	55.90	65.25	74.50	73.75	77.05	63.67

Contd.....

Table 17b contd....

P_3T_1	70.50	78.90	75.70	62.20	77.35	75.40	74.50	101.90	100.25	103.00	96.45	83.29
P_3T_2	59.20	52.00	53.50	63.25	61.05	70.10	78.30	90.75	99.55	99.70	93.20	74.60
P_3T_3	59.95	71.65	65.10	65.95	74.15	82.20	72.35	83.40	92.30	111.55	111.90	80.96
P_3T_4	357.50	449.10	445.70	342.00	394.00	392.50	425.50	433.50	441.00	464.00	469.00	419.44
P_3T_5	71.70	53.25	60.85	43.25	63.15	66.45	60.90	83.45	98.95	82.30	92.25	70.64
CD Packing	NS	NS	13.57*	18.49**	8.70**	8.25*	NS	14.59**	NS	NS	NS	
CD Treatment	28.49**	23.25**	17.52**	23.87**	11.23**	10.65**	19.12**	18.84**	22.77**	20.39**	30.68**	
CD Interaction	NS	NS	NS	41.35**	19.45**	18.45**	33.12**	32.63**	NS	35.32*	53.15*	

CD for comparing overall mean of packing material x treatment interaction = 10.31**
CD for comparing means of packing material x treatment x months interaction = NS

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

seeds (T_5), closely followed by seeds treated with thiram (T_2, 70.14) and these two were on par with each other. Seeds treated with cowdung + ash slurry and dried in smoke (T_4) recorded the highest overall mean electrical conductivity (440.73).

The overall mean electrical conductivity of seed leachate at different months after storage also varied significantly. The lowest overall mean (129.72) was recorded in four months after storage and the highest (170.52) was recorded by eleven months after storage.

Packing material x seed treatment interactions was found to be statistically significant from four months after storage. The lowest overall mean electrical conductivity of seed leachate was recorded in untreated seeds stored in polythene bags (P_2T_5, 63.67). Seeds treated with cowdung + ash slurry and dried in smoke and stored in polythene bags (P_2T_4) recorded the highest electrical conductivity of seed leachate throughout the period of study with an overall mean of 491.82 μ mhos/cm.

Influence of packing material x month interactions on electrical conductivity of seed leachate were found to be non-significant whereas seed treatment x month

interactions was found to be statistically significant. The lowest electrical conductivity (55.85) was recorded in seeds treated with thiram (T_2) three months after storage.

Influence of packing material x seed treatment x month interactions were also found to be non-significant throughout the period of storage.

4.4.6 Hydrogenase enzyme activity

Results of the statistical analysis on hydrogenase enzyme activity of seeds are furnished in the Tables 18a and 18b.

Statistical analysis of the data indicated that effect of various packing materials on hydrogenase enzyme activity of seeds was significant from five months after storage. Among the different packing materials tried, packing in polythene bags, 700 gauge (P_2) resulted in the maximum overall mean hydrogenase enzyme activity (0.147); followed by brown paper bag (P_1) and gada cloth bag (P_3) which were on par with each other and both recorded a mean value of 0.127.

Table 18a Overall mean effects of packing, seed treatments and storage on hydrogenase enzyme activity of ash gourd seeds

Months	Packing			Treatments					Mean
	P_1	P_2	P_3	T_1	T_2	T_3	T_4	T_5	
1	0.252	0.246	0.239	0.266	0.281	0.235	0.289	0.158	0.246
2	0.182	0.177	0.186	0.149	0.173	0.179	0.230	0.176	0.181
3	0.151	0.163	0.166	0.135	0.140	0.149	0.224	0.153	0.160
4	0.147	0.172	0.153	0.153	0.144	0.147	0.211	0.131	0.157
5	0.145	0.159	0.147	0.153	0.142	0.148	0.174	0.134	0.150
6	0.119	0.150	0.121	0.133	0.106	0.126	0.161	0.124	0.130
7	0.106	0.132	0.108	0.121	0.110	0.107	0.127	0.111	0.115
8	0.099	0.124	0.092	0.117	0.088	0.094	0.105	0.118	0.105
9	0.083	0.117	0.079	0.108	0.084	0.086	0.092	0.095	0.093
10	0.071	0.096	0.059	0.076	0.067	0.071	0.085	0.079	0.076
11	0.046	0.080	0.050	0.057	0.055	0.062	0.055	0.064	0.059
Mean	0.127	0.147	0.127	0.134	0.126	0.128	0.159	0.122	

CD for comparing means of packing materials - 0.005**
CD for comparing means of treatments - 0.006**
CD for comparing means of months - 0.009**
CD for comparing means of packing x months - 0.016**
CD for comparing means of treatment x months - 0.021**

P_1 - Brown paper bag
P_2 - Polythene bag (700 gauge)
P_3 - Gada cloth bag

** Significant at 1% level

T_1 Captan - 2.5 g/kg seed
T_2 Thiram - 2.5 g/kg seed
T_3 Bavistin - 2.5 g/kg seed
T_4 (Cowdung-ash slurry) and drying in smoke
T_5 Control - untreated seeds

Table 18b Mean effect of packing, treatments and storage period on hydrogenase enzyme activity of ash gourd seeds

Treatments	Months after storage											Mean
	1	2	3	4	5	6	7	8	9	10	11	
P_1T_1	0.299	0.135	0.132	0.159	0.148	0.126	0.110	0.106	0.100	0.084	0.057	0.132
P_1T_2	0.302	0.135	0.119	0.113	0.125	0.095	0.096	0.076	0.058	0.057	0.045	0.111
P_1T_3	0.257	0.228	0.144	0.138	0.145	0.122	0.100	0.093	0.088	0.071	0.042	0.130
P_1T_4	0.267	0.218	0.212	0.207	0.187	0.149	0.128	0.114	0.096	0.094	0.053	0.157
P_1T_5	0.135	0.194	0.146	0.117	0.120	0.102	0.096	0.105	0.075	0.050	0.035	0.107
P_2T_1	0.261	0.168	0.132	0.166	0.174	0.148	0.146	0.158	0.146	0.099	0.079	0.152
P_2T_2	0.254	0.153	0.156	0.169	0.152	0.128	0.130	0.104	0.109	0.092	0.070	0.138
P_2T_3	0.254	0.156	0.150	0.161	0.153	0.151	0.132	0.109	0.100	0.084	0.073	0.139
P_2T_4	0.301	0.259	0.229	0.214	0.164	0.171	0.115	0.100	0.102	0.087	0.066	0.164
P_2T_5	0.163	0.146	0.149	0.150	0.152	0.153	0.135	0.148	0.128	0.118	0.113	0.141

Contd.....

Table 18b contd...

P_3T_1	0.239	0.143	0.141	0.133	0.138	0.125	0.107	0.088	0.078	0.046	0.035	0.116
P_3T_2	0.287	0.231	0.144	0.152	0.150	0.095	0.104	0.084	0.085	0.053	0.051	0.131
P_3T_3	0.194	0.154	0.152	0.142	0.145	0.106	0.089	0.081	0.070	0.056	0.071	0.115
P_3T_4	0.297	0.215	0.231	0.214	0.171	0.163	0.139	0.103	0.076	0.074	0.047	0.157
P_3T_5	0.177	0.187	0.163	0.126	0.131	0.117	0.103	0.103	0.083	0.069	0.046	0.119
CD Packing	NS	NS	NS	NS	0.01*	0.012**	0.011**	0.008**	0.009**	0.009**	0.011**	
CD Treatment	0.046**	0.029**	0.34**	0.016**	0.013**	0.015**	0.014*	0.010**	0.011**	0.012**	NS	
CD Interaction	NS	0.05**	NS	NS	0.022*	NS	0.024*	0.017**	0.019**	0.021**	0.024**	

CD for comparing overall mean of packing material x treatment interaction = 0.011**

CD for comparing means of packing material x treatment x months interaction = 0.04**

* Significant at 5% level

** Significant at 1% level

NS Non-significant

Effect of seed treatment also had a significant effect on hydrogenase enzyme activity except in the last month of storage. Among the different seed treatments, cowdung + ash slurry and drying in smoke (T_4) recorded the highest overall mean value of 0.159, followed by seed treated with captan (T_1, 0.134). Untreated control seeds recorded the lowest value (T_5, 0.122). Among the different treatments, seeds treated with cowdung + ash slurry and dried in smoke (T_4) recorded the highest enzyme activity during first seven months of storage. During the next three months seeds treated with captan (T_1) recorded the highest enzyme activity.

The overall mean hydrogenase enzyme activity of seeds at different months after storage also varied significantly. The enzyme activity decreased gradually from first month to eleven months after storage. The overall mean was maximum (0.246) in the first month and the lowest (0.059) in the eleventh month.

Packing material x seed treatment interactions were found to be statistically significant as storage period advanced. Among the different combinations, seeds treated with cowdung + ash slurry and dried in smoke and stored in polythene bags gave the highest overall mean enzyme activity (0.164). It was followed by seeds

treated with cowdung + ash slurry and dried in smoke and stored is brown paper bag and gada cloth bag (P_1T_4 and P_3T_4); both recorded an overall mean value of 0.157. Seeds treated with captan and stored in polythene bags (P_2T_1) also recorded consistently high enzyme activity with an overall mean value of 0.152 showing significant interaction effect.

Packing material x month interactions and seed treatment x month interactions were also statistically significant. Seeds stored in brown paper bag (P_1) gave maximum hydrogenase enzyme activity (0.252) one month after storage. The seeds treated with cowdung + ash slurry and dried in smoke (T_4) gave maximum hydrogenase enzyme activity (0.289) one month after storage, closely followed by seeds treated with thiram (T_2, 0.281) one month after storage.

Considering the packing material x seed treatment x month interactions, the maximum hydrogenase enzyme activity (0.302) was obtained in seeds treated with thiram and stored in brown paper bag (P_1T_2) one month after storage, which was closely followed seeds treated with cowdung + ash slurry and dried in smoke and stored in polythene bags of 700 gauge (0.301) one month after storage.

Discussion

DISCUSSION

Production of quality seeds and their storage depends on many factors like stage of harvest, post harvest handling and processing of seeds, seed treatment, packing, storage etc. In order to standardise these aspects in ash gourd accession BH-21, four experiments were conducted in 1994-95 at the College of Horticulture, Vellanikkara. Results obtained are discussed hereunder.

5.1 Studies on physiological maturity of seeds

One of the factors that influences quality of seed is the seed maturity at harvest. Seeds attain maximum quality at their physiological maturity (Helmer *et al.*, 1962) as indicated by maximum dry weight, germination and vigour of seeds. Growth pattern of ash gourd fruits and seeds were studied at five days interval during rainy and summer seasons to find out the stage of physiological maturity of seeds.

Fresh weight, volume, length and diameter of fruits were found to increase from anthesis and maximum fruit development was recorded by 30 d.a.a., in both seasons. Upto 15 d.a.a., the developing seeds could not be separated from placenta and seed coat was not fully

developed. Whereas by 30 d.a.a., seed coat was differentiated and the seeds could be separated from placenta. The growing fruit is an active sink that diverts and draws water and solutes from other regions of plant. Bollard (1970) stated that the central theme of fruit growth seems to be the mobilisation of substances into various tissues. Early stages of fruit growth after pollination are characterized by the formation of new cells, but this quickly changes into cell enlargement (Noggle and Fritz, 1989). During this period, embryo develops from zygote by intense cell division and differentiation and by the end of the phase I, embryonic plant is fully differentiated and cell division ceases. It was observed that in ash gourd, the maximum fruit weight was attained by 30 days in rainy season, whereas it took 40 days in summer season to attain maximum fruit weight (Fig.1a,b). During summer season, the atmospheric humidity is lower and the ambient temperature is higher than the rainy season. This low relative humidity and high atmospheric temperature during summer induces a higher rate of water loss from the fruits through transpiration and hence a reduction in fruit weight and size occurred.

FIG. 1a PATTERN OF FRUIT AND SEED DEVELOPMENT IN ASH GOURD DURING RAINY SEASON

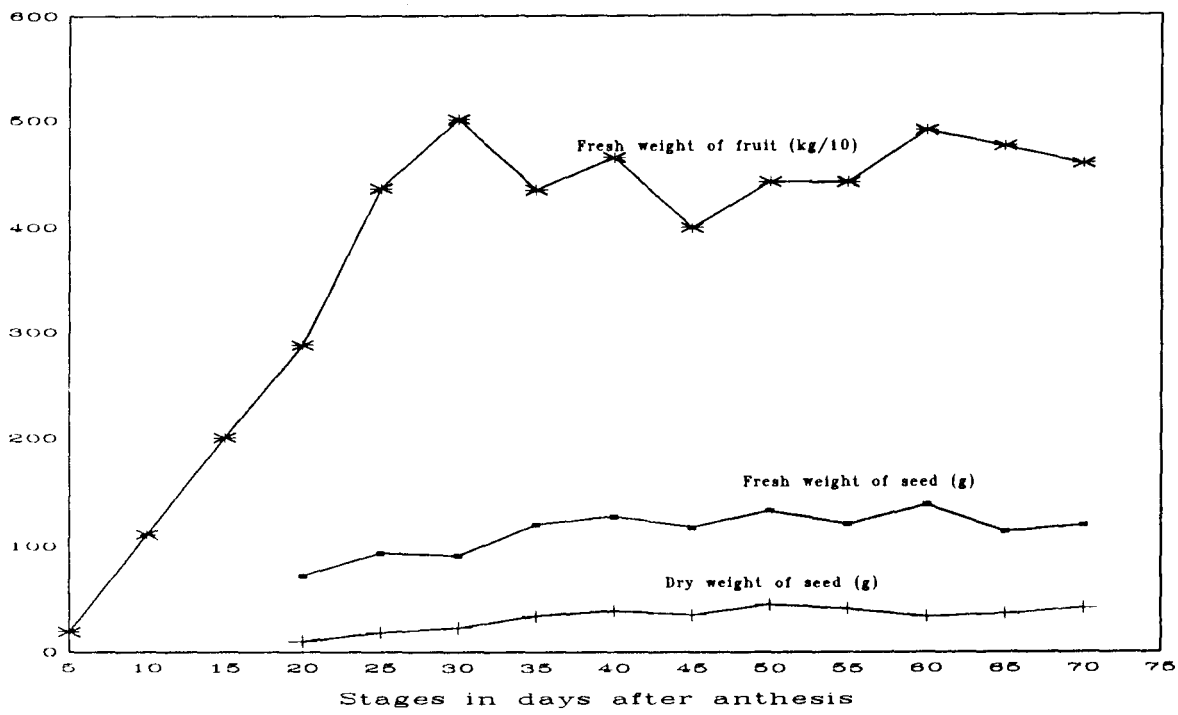
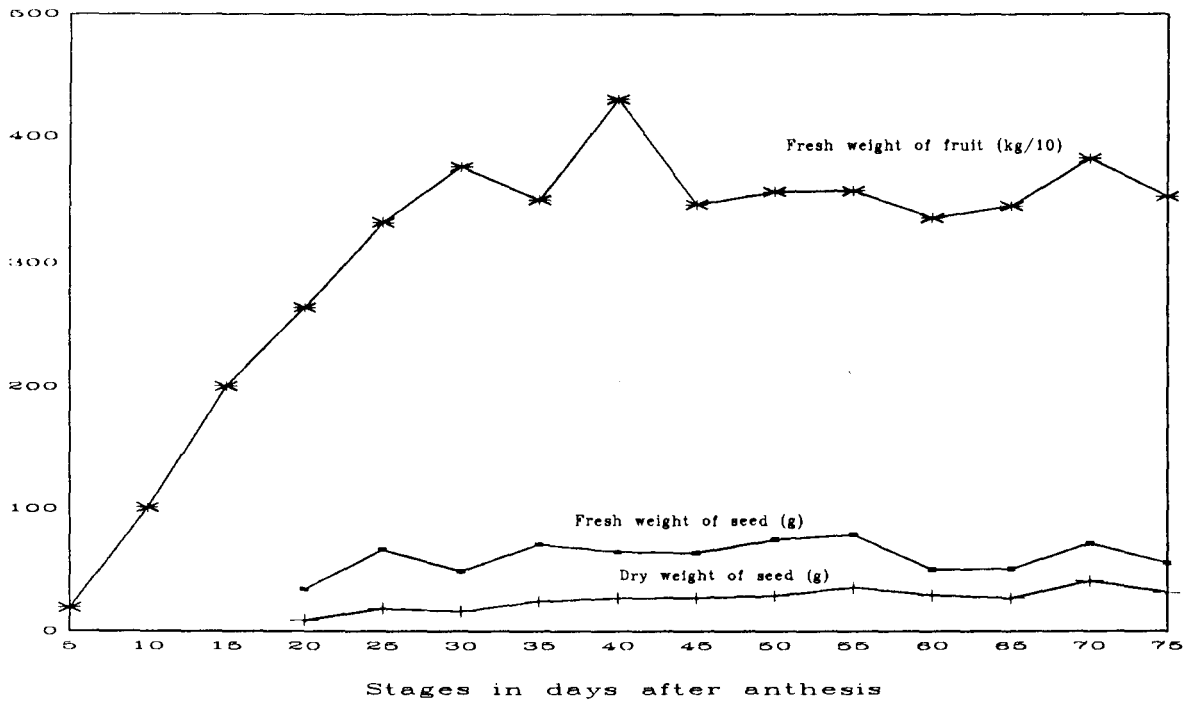


FIG 1b PATTERN OF FRUIT AND SEED DEVELOPMENT IN ASH GOURD DURING SUMMER SEASON



Fruits after attaining a maximum growth in the initial stages, its weight and volume decreased towards the later stages. Such a trend in developing fruits was reported in ash gourd (Krishnaprasad, 1980); and in other cucurbits also viz., *Cucumis melo* (Mann and Robinson, 1950 and Pratt *et al.*, 1977), bottle gourd (Chandrasekharan, 1979), bitter gourd (Varatharaj, 1979), watermelon (Hedayat, 1987). It was observed that the fruit weight showed a slight decrease after reaching maximum weight. This loss in weight of fruits was associated with changes in moisture content in maturing fruits (Martin *et al.*, 1923; Showalter, 1961; Kolhe and Chavan, 1964; Manohar and Sachan, 1974). A reduction in volume of fruit after reaching the maximum, was observed in the present study. As the fruits matured, and the resultant loss in moisture content due to drying, a reduction in volume occur. Such reduction in fruit volume at later stages of maturity was reported by Sinnott (1945) in many species of cucurbits. In both rainy and summer seasons, fruit size decreased a little by 35 days and thereafter it was almost static. When the fruit lost water and experienced a stress, it developed ashy coating on the surface of fruits and it was more thick and sticky by 30-35 days (Table 1). The rind thickness also increased and became very hard by 45 d.a.a.

There was a general resemblance in the development pattern of fruits and seeds in both seasons upto 30 days. Alternating pattern of movement of dry matter to seeds was noticed and the pattern of dry matter accumulation varied in both seasons. There was a steep rise in the fresh weight of fruits upto 30 days in both the seasons. Whereas the fresh and dry weight of seeds increased upto 40 days in rainy season. By 45 days fruit and seed weight had shown a dip in the development pattern. Seed development did not exactly follow the pattern of fruit development.

Fresh weight of the seed is an important character that determines the quality of the seed. Abdul-Baki and Baker (1973) used the fresh weight of the seed for differentiating between 'seed development' and 'seed maturation'. According to them, seed development is the period between fertilization and maximum fresh weight of the seeds and seed maturation begins at the end of the seed development and continues upto harvest. In the present investigation, in rainy season, fresh weight of seeds was found to increase as fruit development advanced and maximum fresh weight of seeds per fruit was recorded on 60 d.a.a., but the difference between the stages in fresh weight of seeds was not statistically significant. In the summer season, the fresh weight was

highly significant and maximum fresh weight of seeds per fruit was recorded on 55 d.a.a. Similar increase in fresh weight of seeds was recorded by Young (1949) in squash and by Harrington (1959) in muskmelon. In the present study, it was observed that fresh weight of seeds, after reaching the maximum, has decreased slightly and this could be attributed to the decrease in water content of seeds and steady accumulation of dry matter during l stages of seed maturation phase. Similar observations have been reported in ribbed gourd and bitter gourd (Varatharaj, 1979); in ash gourd (Krishnaprasad, 1980) and in watermelon (Hedayat, 1987). Fresh weight of fruits decreased after 30 days indicating a higher water loss through transpiration, meanwhile there was dry matter accumulation in seeds from fruits. When fruits experienced a stress of higher transpiration, they developed thick and sticky ashy coating to reduce the rate of transpiration.

The dry weight of developing seeds can be used to assess the maturity of the seeds (Delouche, 1973). In the present study, significant increase in dry weight of seeds was noticed in both the seasons. In rainy season, maximum dry weight was obtained at 50 d.a.a. whereas in summer season, maximum dry weight was recorded at 70 d.a.a.

In the present study, weight of unfilled seeds was maximum during early phase of seed development and decreased as period of seed maturation advanced and reached a minimum at 70 d.a.a. Similar observations were recorded by Krishnaprasad (1980) in ash gourd.

From 30 to 55 days stage, dry weight of seeds increased continuously in both the seasons irrespective of the variations in fresh weight of fruits and seeds indicating the mobilization and accumulation of photosynthates to the developing seeds. This mobilization may be from the plant canopy as well as from the pericarp. This is the phase of seed development. During this, especially from 40 to 55 d.a.a. germination also increased at a faster rate. Then there was a decline in the dry matter accumulation of seeds for five to 10 days. In the final stage from 60 d.a.a., when fresh weight of fruits was decreasing, dry weight of seeds kept increasing showing translocation of food reserves from fruits to seeds. This was again evident from the increasing trend of 1000 seed weight. Seed germination also increased at this stage and reached a maximum weight by 65 d.a.a. During this period,ashy coating of fruits became more thick and sticky.

The 100 seed weight increased during the seed development phase (Tables 2 and 3). In rainy season, the maximum 100 seed weight was recorded on 60 d.a.a., thereafter a slight decrease was noticed. This is due to the decrease in moisture content during the seed maturation phase. Harrington (1959) observed maximum 100 seed weight at 37 d.a.a. in muskmelon and beyond that a slight decrease is noticed. Krishnaprasad (1980) also reported similar results in which maximum 100 seed weight in ash gourd was recorded at 60 d.a.a. and thereafter a decrease was observed.

In the present investigation, the germination of seeds obtained from the two seasons differed slightly (Fig.2a,2b). In the rainy season, seeds reached the germinable maturity by 25 d.a.a. whereas in summer season, seeds became germinable by 30 d.a.a. only. Ash gourd seeds became germinable on 50th day in var. Co-1 (Krishnaprasad, 1980) under Coimbatore conditions. Varietal and climatic differences influence the stage of germinable maturity of seeds. The relationship between seed maturity and seed germination was established by many workers (Harrington, 1959; Chin, 1981; Metha, 1983 and Nerson and Paris, 1988). Seeds from 60 d.a.a. and in the later stages of development recorded high germination in both seasons and were

FIG. 2a SEED QUALITY PARAMETERS DURING DIFFERENT STAGES OF MATYURITY (RAINY SEASON)

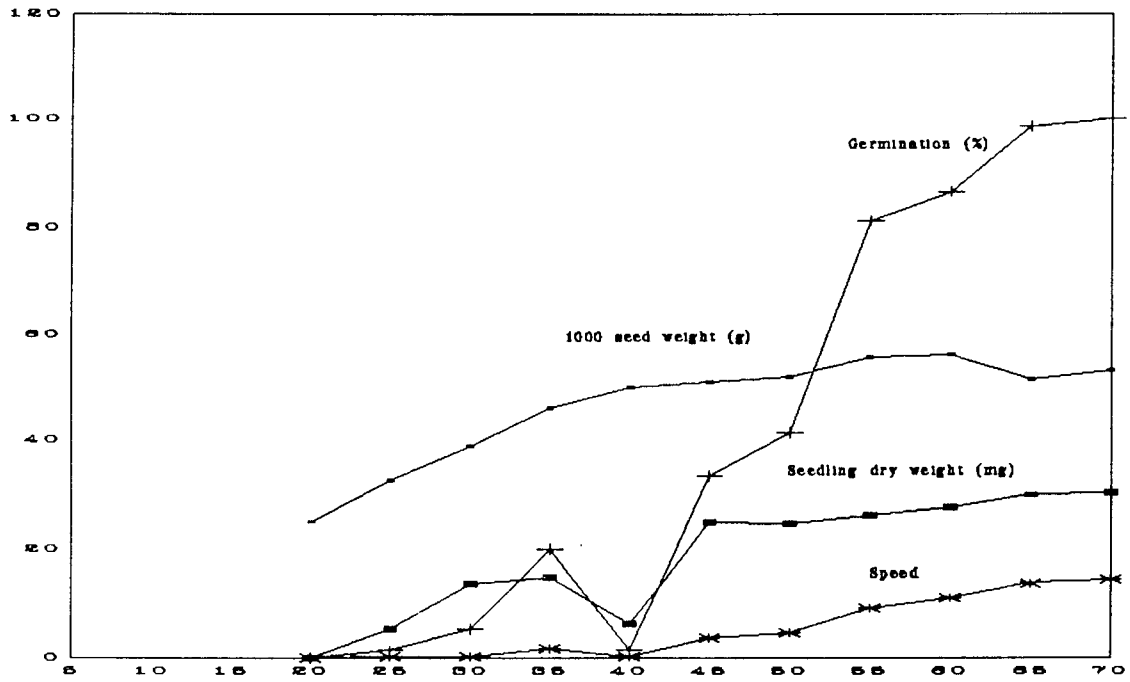
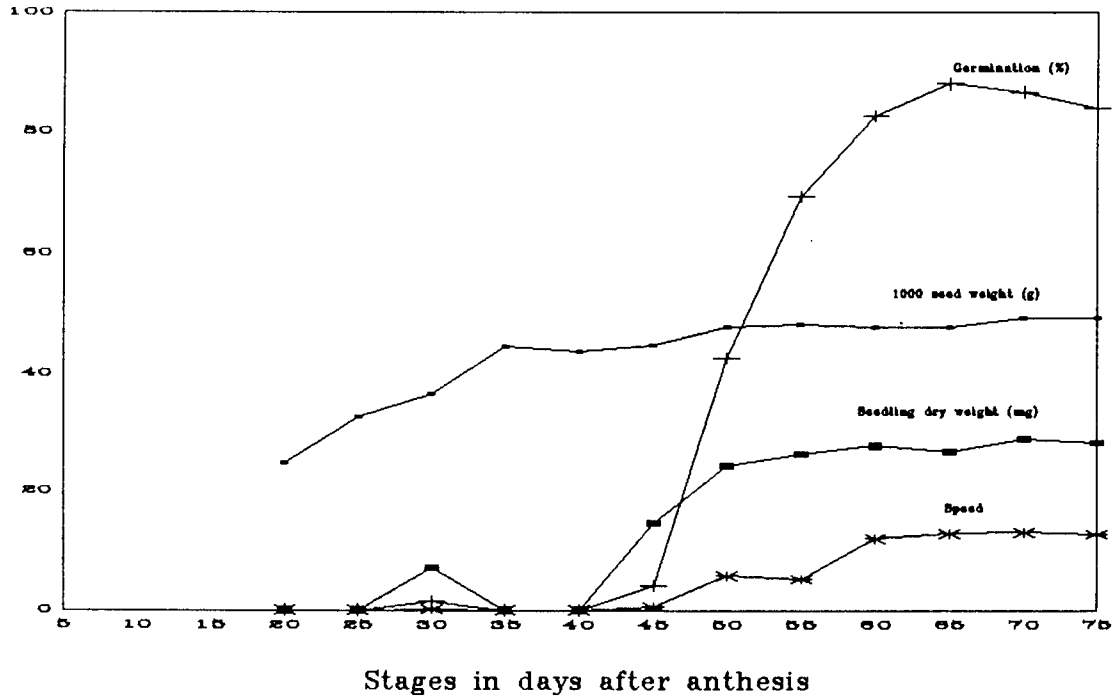


FIG.2b SEED QUALITY PARAMETERS DURING DIFFERENT STAGES OF MATURITY (SUMMER SEASON)



on par with each other. This indicates that embryo had undergone full development and attained the full viability by 60 d.a.a. (Maheswari, 1950; Manohar, 1969 and 1970). In the present study also, germination percentage increased, with increasing seed maturity. Maximum germination was obtained at 70 d.a.a. in rainy season, whereas in summer season maximum germination was obtained earlier at 65 d.a.a. It was therefore clear that upto 25-30 days seeds exhibited weak germination due to presence of immature embryos in seeds and by another 35 days embryo had undergone full ripening process. Krishnaprasad (1980) reported that in ash gourd maximum germination was obtained at 80 d.a.a. which was 10-15 days later, compared to results of the present studies. This may originate from environmental factors and cultivar differences. It is known that environmental parameters particularly temperature play an important role in developing of germination and seed quality (Gray *et al.*, 1988).

The speed of germination is an important aspect of vigour and provides a reasonably good index of vigour of any seed lot (Copeland, 1988). The relative root length (Grabe, 1965) and shoot length (Wold *et al.* 1972; Egli and Tekrony, 1973) of the seedling would predict their subsequent growth and performance and hence could be

regarded as indices of measurement of seed vigour. Seeds may germinate but may not produce vigorous seedlings (Cox and Star, 1927). Fully matured seeds have the advantage of complete physical and physiological development needed for maximum expression of vigour. In the present investigation, a positive correlation was obtained between seed maturity and speed of germination, root and shootlength of seedlings, vigour index and dry weight of seedling. Similar observations were recorded in carrot by Bothwick (1931), in ridge gourd and bitter gourd by Varatharaj (1979), in ash gourd by Krishnaprasad (1980) and in watermelon by Hedayat (1987). In the present study seeds of 70 d.a.a. recorded high speed of germination, root and shoot length of seedling, vigour index and seedling dry weight corresponding with the high germination percentage of seeds. Therefore, it could be concluded that ash gourd fruits of line BH-21 should be harvested at 70 d.a.a. for maximum seed quality attributes.

The pattern of fruit and seed development in ash gourd from this investigation showed three distinct phases; viz., structural development phase, dry matter accumulation phase and maturity phase.

a) ***Structural development phase***

This stage was characterized by a steep increase in fruit size. Fresh weight of fruit increased very rapidly due to faster accumulation of water and metabolites whereas dry matter accumulation was slow. As far as fruit development was concerned, this stage can be called as 'vegetable phase' because the fruit attains maximum size with a tender fruit rind, poor seed development and hence best suited as vegetable. This extends upto 30 d.a.a. Early stages of fruit growth were characterized by the formation of new cells, but this quickly changed to cell enlargement.

As far as seed was concerned, this is structural development phase or a phase of histo-morphological development. Whitish seed coats and watery cotyledons part were seen by 10 d.a.a. By 20 d.a.a., the seeds developed minute embryos. Seed coat became a little harder and turned light cream in colour and could be easily separated from placenta by 30 d.a.a. By the end of this first phase, seed was structurally complete. Noggle and Fritz (1989) reported that Phase I comes to an end when the embryonic plant is fully differentiated and cell division ceases.

b) *Dry matter accumulation phase*

This was actually the seed filling phase or cotyledon development phase. It was observed that fruit development is a pre-requisite for seed development. Seed development begined only after the fruit had undergone dry matter accumulation. This phase was characterized by an increase in dry matter content of fruit and seed. Fruit rind became harder and ashy coating also increased. By 40-45 days, seed coat became very hard, and deep cream in colour and became bold and plumpy. This stage extends upto 50-55 days. Phase II comes to an end as the seeds begin to lose water (Noggle and Fritz, 1989).

c) *Maturity phase*

This phase was characterized by a decline in fresh weight of fruit due to reduction in accumulation of metabolites and an increase in dry weight of seeds and its germination. Dry matter of seeds increased due to transport of metabolites from pericarp to seeds. The pericarp became more pithy in nature. There was considerable desiccation of fruit. By the end of this stage (by around 70 d.a.a.), seeds became well matured; dry weight of seeds, germination and vigour reached the

maximum; sticky and thick ashy coating became powdery - dust form with very hard fruit rind indicating the physiological maturity of seeds.

In the fruit and seed development process, the first phase is vegetable phase and the second and third phases pertain to seed maturation phase. The maximum fresh weight of fruit was attained by 40 d.a.a. and the maximum physiological maturity of seed is recorded by 70 d.a.a.

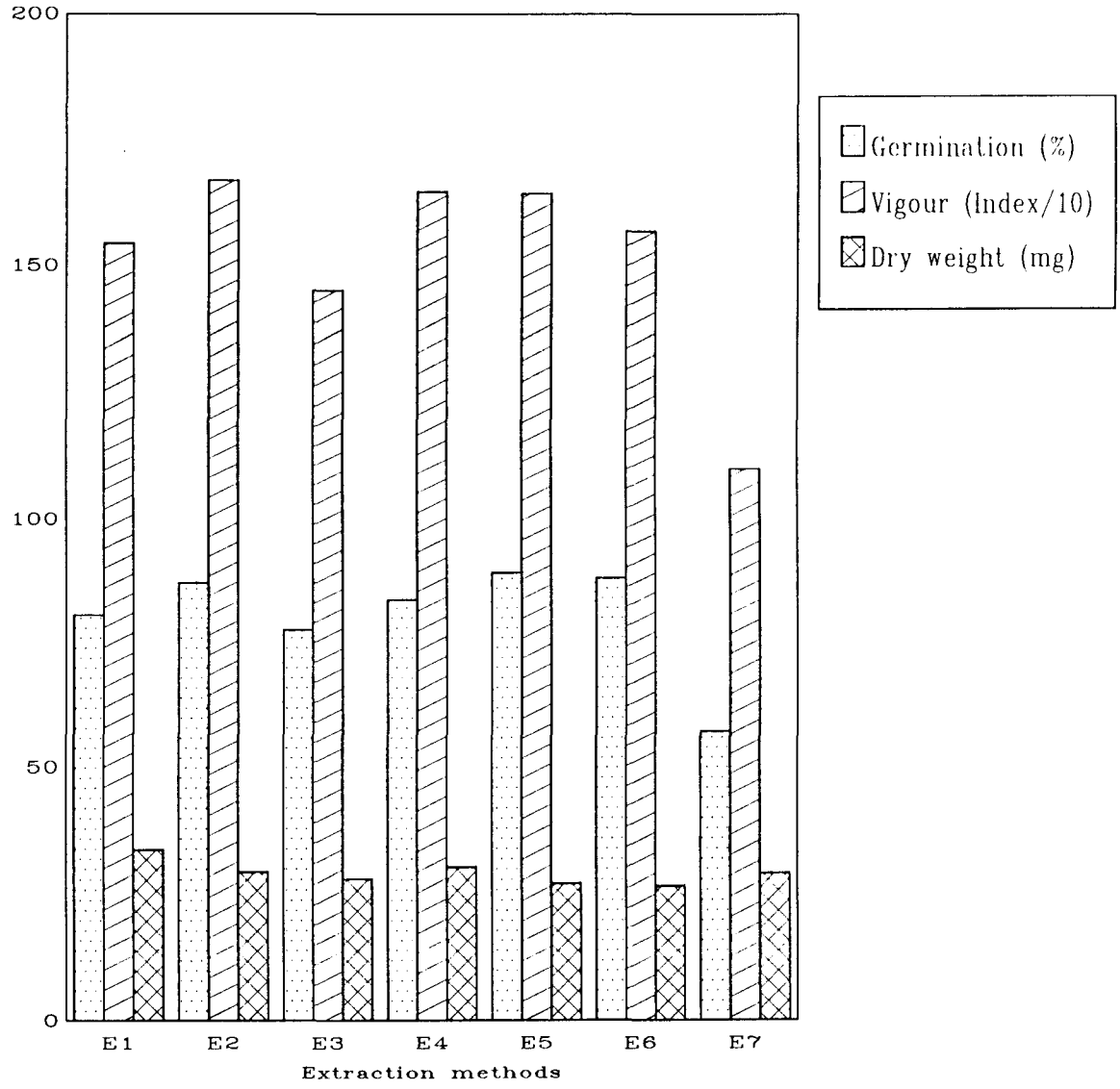
5.2 Standardisation of seed extraction and drying methods

Seed extraction from fleshy vegetables is cumbersome since seeds are embedded in the pithy placenta. In such cases, the common practice of extracting seeds is to scoop manually out the seeds along with placenta and to clean the seeds by repeated washing in water. Very little information is available on the seed extraction and drying of the fleshy fruited vegetables.

In the present study, seeds extracted by machine + acid treatment @ 1% HCl of the weight of pulp for 30 minutes (E_3) recorded the highest overall germination (89%). The seeds also recorded fairly a higher

vigour index (Fig.3). Karivaratharaju (1980) suggested HCl method for seed extraction of ash gourd. Superiority of acid method of seed extraction in improving the germination and vigour of the seeds has been reported by many workers (Ritchie, 1971; Vadivelu and Ramaswamy, 1977; Kolev and Boyadzhev, 1983; Sitoula, 1985; Gill and Singh, 1987; Hedayat, 1987). Seeds extracted by machine + acid treatment @ 2% HCl of the pulp for 30 minutes (E_6) recorded slightly lower germination (87%) than seeds extracted with 1% HCl of the pulp (E_5). A higher concentration of the acid adversely affected the seed quality but the time required was less - it took only 30 minutes for seed extraction of 20 kg fruits using 2% HCl, while it took 70 minutes using 1% HCl. Decrease in germination percentage with increase in the concentration of HCl used for seed extraction has been reported in tomato also (Harrington, 1981). Decrease in germination and vigour in seeds extracted by machine + acid treatment @ 2% HCl of the pulp (E_6) in the present study might be due to the increase in concentration of HCl. Treatment of concentrated HCl detached the seeds quickly from the adhering pulp and also ensured rapid extraction of seeds. This was confirmed by earlier reports by Hutton (1943), Vadivelu and Ramaswamy (1977) and Hedayat (1987). The higher germination percentage recorded in

FIG. 3 EFFECT OF VARIOUS SEED EXTRACTION METHODS ON GERMINATION,VIGOUR INDEX AND SEEDLING DRY WEIGHT



acid method might be due to rapidity with which seeds were extracted, or the high acidity might have destroyed or neutralised some of the germination inhibiting factors present around the seed. Seed extracted by acid method recorded the lowest overall electrical conductivity of seed leachate corresponding with the high germination observed. This indicated that the loss of membrane integrity was lower in acid extracted seeds.

Seeds extracted manually, with 48 hours of fermentation (E_2) recorded fairly high overall germination percentage (87%). Fermentation of the fruit pulp for 48 hours also helped in cleaning the seeds quickly and the seeds recorded high speed of germination and vigour also. Gill and Singh (1987) reported that in tomato optimum fermentation time for fruit pulp was 48 hours. Harrington (1959) reported that fermented seeds of muskmelon germinated better than that has been cleaned mechanically. Manual extraction if employed, no seed damage was observed, whereas in machine extracted seeds upto 4.5% seed damage was observed. This endorses the report of Bothwick (1932), who listed several types of abnormalities including damaged seed coats in seeds of machine extracted lima bean.

Seed extraction by machine + alkali treatment @ 1% NaOH equal to the weight of the pulp for one night (E_7) recorded the lowest overall germination (57%). The seeds recorded low speed of germination, vigour index and seedling dry weight also. Seeds extracted by alkali method recorded the highest electrical conductivity of seed leachate corresponding with the decrease in germination percentage of the seeds. From these observations, it is confirmed that machine extraction + alkali treatment @ 1% NaOH equal to the weight of the pulp for one night (E_7) was inferior to other methods and not suitable for seed extraction in ash gourd - either the treatment duration was very long; or the alkalinity itself was deleterious to ash gourd seeds. This was again evident from the highest electrical conductivity of seed leachate. Mechanical damage of seed coat during machine extraction might have aggravated the senescence factors along with high alkali concentration. Hedayat (1987) reported that seed extraction with NaOH 2% for 30 minutes was not suitable in watermelon. Similarly, Javaregowda *et al.* (1994) reported that alkali treatment with NaOH was not suitable for brinjal seed extraction.

Different seed drying methods tried in this experiment had no significant effect on germination and vigour of seeds. Among the different drying methods,

seeds dried under direct sunlight (D_2) recorded the lowest electrical conductivity of seed leachate. In tomato, natural (sun) drying of seed was reported to be superior in terms of germination, vigour and dry matter production of seedlings. Whereas shade dried brinjal seeds had better storage potential when compared to sun dried seeds (Selvaraj, 1988a). But no such trends were observed in the present study.

5.3 Storage of intact fruits after harvest

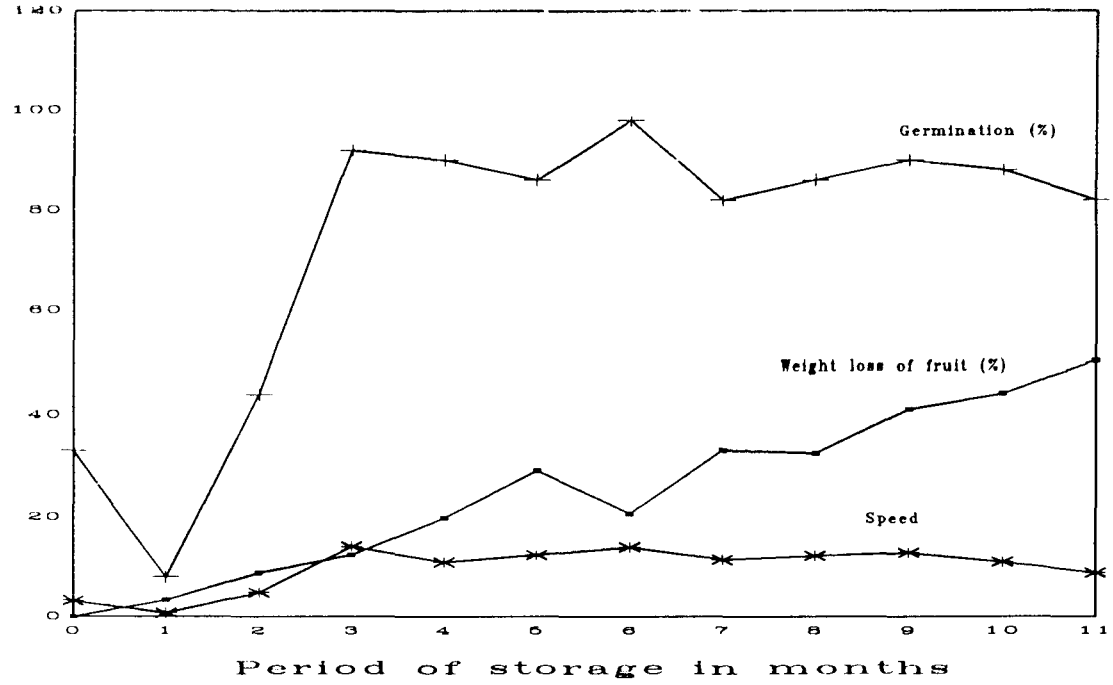
It is an age-old practice of farmers to store gourds with seed intact for several months. Seed germination of cucurbits was reported to increase with increasing period of fruit storage (Araujo *et al.*, 1982). Influence of post harvest storage of fruits on seed quality of ash gourd was studied in this context.

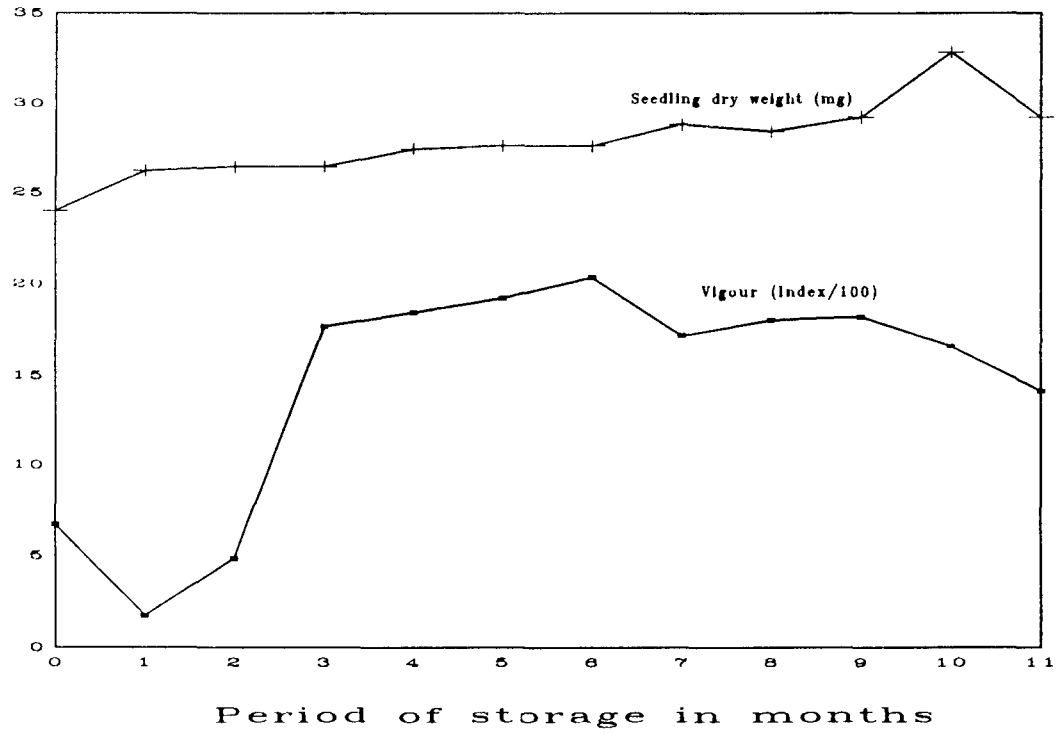
In the present study, weight of the fruits at the time of harvest before storage was non-significant indicating the uniformity of fruits selected. But the weight of stored fruit at extraction time (at monthly intervals) was highly significant and there was a continuous increase in weight loss of the fruits. It was due to loss of water by evaporation and the resultant dehydration of fruits, ie. the physiological

loss in weight in storage. Fresh weight and dry weight of seeds extracted during different months were found to be non-significant during the period of fruit storage.

Odland (1937) reported that cucurbit fruits require over-ripening for prompt germination of seeds, and if the fruits were picked at ripe stage, the germination of seeds would be delayed for several weeks. In the present study, there was an increasing trend in germination and vigour of seeds with increase in period of storage of fruits (Fig.4). Maximum germination and vigour was recorded during six months after fruit storage. Similar increase in germination of seeds stored in intact fruits was reported by Young (1949) in squash; Araujo *et al.* (1982) in cucurbits and by Krishnaprasad (1980) in ash gourd. Speed of germination and vigour index also showed similar trends as that of germination. Seeds extracted from fresh fruits and during first two months of fruit storage recorded very low germination and vigour. A sudden spurt in germination and vigour of seeds was recorded during third month of fruit storage. This may be due to the dormancy factors associated with the seeds and seeds required a period of about three months to undergo after-ripening or dormancy breaking processes, or some sort of a post harvest maturity of seeds might have taken place during the storage, as

FIG. 4 EFFECT OF FRUIT STORAGE ON LOSS OF FRUIT WEIGHT AND SEED QUALITY ATTRIBUTES





reported by Odland (1937) in cucurbits and by Holmes (1953) in squashes. Petrov and Dojkov (1970) in brinjal and Quagliotti *et al.* (1981) in chilli also reported increased seed germination due to post-harvest ripening of the fruits. Similar reports are available earlier in ash gourd (Krishnaprasad, 1980) and in cucumber (Buriev, 1987). A general decrease in germination, speed of germination and vigour was recorded after six months indicating gradual progress of seed deterioration even within the fruits. Still, seeds obtained from fruits stored for eleven months recorded fairly high germination of 82 per cent indicating superiority of the fruit storage. Advantages of fruit storage of chilli seeds in prolonging viability and vigour have been reported by Vasanthakumar and Singhal (1994).

Root length of the seedling was found to be non-significant whereas shoot length was found to be significant during the period of fruit storage. Maximum shoot length was recorded during fifth month after fruit storage. Thereafter a gradual decline in shoot length was observed concomitant with the decline in germination and vigour, suggesting the deterioration of seeds. Heydecker (1973) viewed that dry matter production by germinating seedling is the manifestation of physiological efficiency dependent on vigour. Seeds

obtained from fruits stored during the entire period recorded high seedling dry weight indicating that fruit storage helped in maintaining vigour of seeds upto eleven months. Holmes (1953) observed that germination of seeds of immature squashes that have been in store as long as seven months, possessed very high viability.

Vivipary of seeds was observed in some of the stored fruits but it was found to be non-significant during the entire storage period. Similar report of viviparous germination was observed in cucumber also (Madalageri *et al.*, 1977). Vivipary is not influenced by fruit storage.

5.4 Storage of extracted seeds

Good seed storage is a basic requirement in any seed production programme. This includes maintenance of high seed germination and vigour from harvest till planting. Seeds are practically worthless, if upon planting they fail to give adequate and uniform plant stands, in addition to healthy and vigorous plants.

Seeds reach maximum quality at physiological maturity and from that time until planting only degenerative changes occur, the rate being dependant on

the degree of deviation from optimum condition (Helmer *et al.*, 1962). Seed is a biological entity and senescence or deterioration is inevitable and irreversible during storage. A number of factors have been identified as being influential on storage behaviour of seed, which include seed moisture level, maturity status etc. In addition, environmental factors like temperature and relative humidity also play an important role in maintaining seed viability. These factors will decide on the rate of deterioration of stored seeds. The rate of seed deterioration can be reduced and the seed viability can be extended during storage by controlling these various factors responsible for seed deterioration.

Seeds are infected with various micro organisms and pests during storage. Proper seed protection using effective seed treatment is important in seed storage. It is a well established fact that materials employed for seed treatment and containers used for storage and environment in which seeds are stored exert a profound influence on the viability and vigour of seeds in storage. Seed moisture content and relative humidity of storage atmosphere are two important factors affecting the storage life of seeds. Seeds are hygroscopic and hence moisture content during storage depends on the

relative humidity of the storage atmosphere. The choice of the container, therefore assumes great importance. The superiority of moisture vapour proof containers like 700 gauge polythene bags and aluminium foil pouches has been reported in cucumber (Miyagi, 1966), watermelon and pumpkin (Kuchernko and Lebedeva, 1976), ash gourd (Krishnaprasad, 1980 and Renugadevi, 1992), watermelon (Hedayat, 1987). The maintenance of vigour potential assumes great importance in storage since vigour loss precedes viability loss. The seedling dry matter production is manifestation of physical efficiency depending on the vigour of seeds (Heydecker, 1973).

In this context, the present study was undertaken with a view to assess the storage potential of ash gourd seeds and to extend the storage life to a maximum extent possible. For this, seeds were treated with different seed protectants and stored in different types of containers under ambient conditions and tested at monthly intervals to assess viability and vigour of seeds.

In the present study, seeds stored in 700 gauge polythene bag (P_2) recorded a high overall germination, speed of germination, vigour index and seedling dry weight, during the entire storage period compared to

that in brown paper bags and gada cloth packages (Fig.5). In polythene packed seeds, humidification is less; and low interchange of oxygen as compared to paper and cloth bags. Renugadevi (1992) reported that ash gourd, seeds stored in 700 gauge polythene bags were superior to those stored in cloth bags. The ambient relative humidity has an effect on the moisture vapour of the packaging material and thereby promotes deterioration of seeds in containers which are not moisture proof (Bass and Clark, 1974).

It is a common practice to treat the seeds with fungicides and insecticides to maintain viability and vigour. Seed treatment with a suitable chemical prior to storage gives certain amount of protection during storage against infestation of fungi and insects. Seed treatment with chemicals for maintaining viability and vigour is reported by many workers - Waller *et al.*(1960) in cucumber and squash, Macias *et al.* (1969) and Buydoso (1979) in cucumber; Chandrasekaran (1979) in bottle gourd; Krishnaprasad (1980) in ash gourd and Renugadevi (1992) in ash gourd. In the present study, seed treated with captan 2.5 g per kg (T_1) seed registered a high overall germination, speed of germination, vigour index and seedling dry weight during the entire period of storage (Fig.6). Macias *et al.* (1969) reported that

FIG. 5 EFFECT OF DIFFERENT PACKING MATERIALS ON GERMINATION, VIGOUR INDEX AND SEEDLING DRY WEIGHT

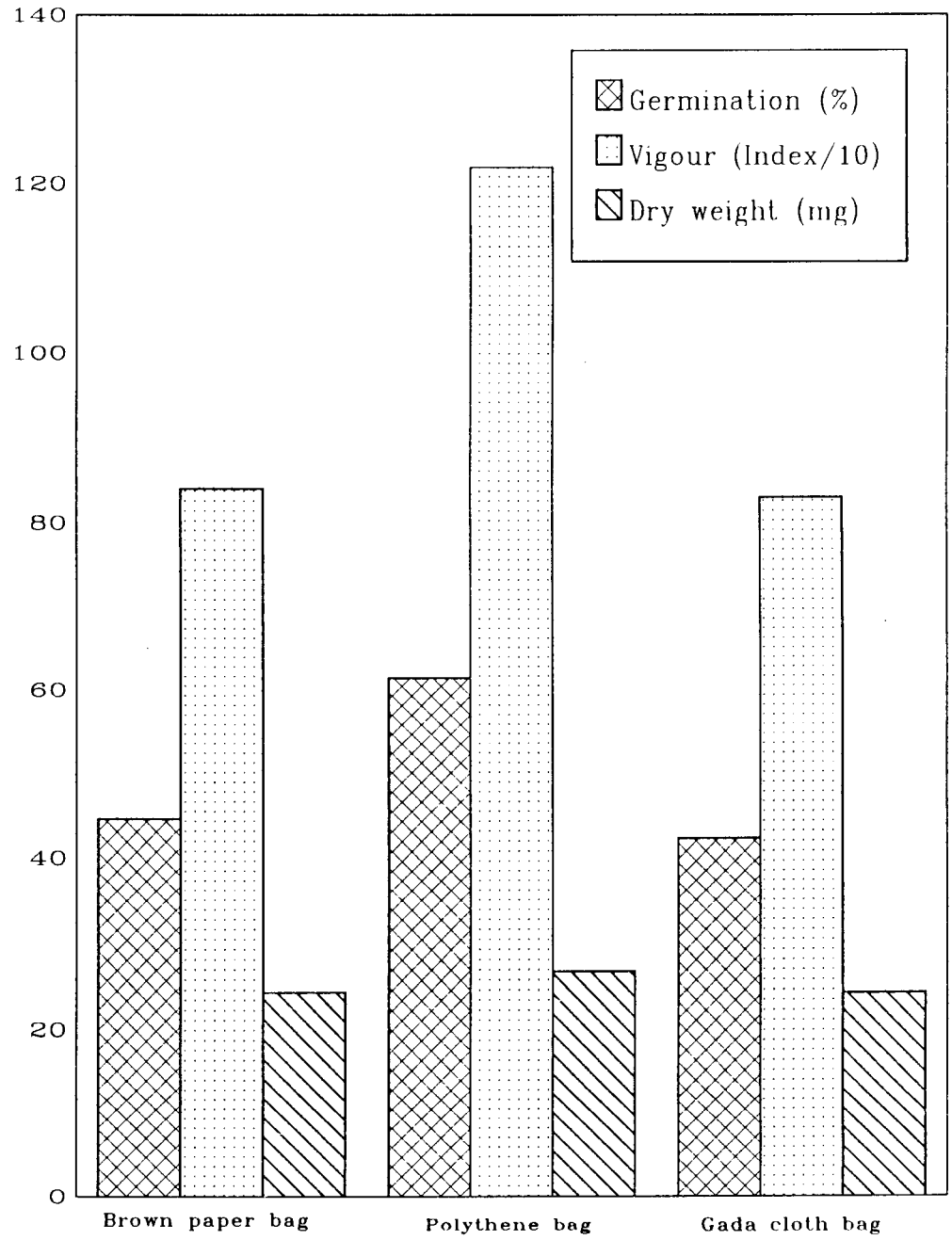
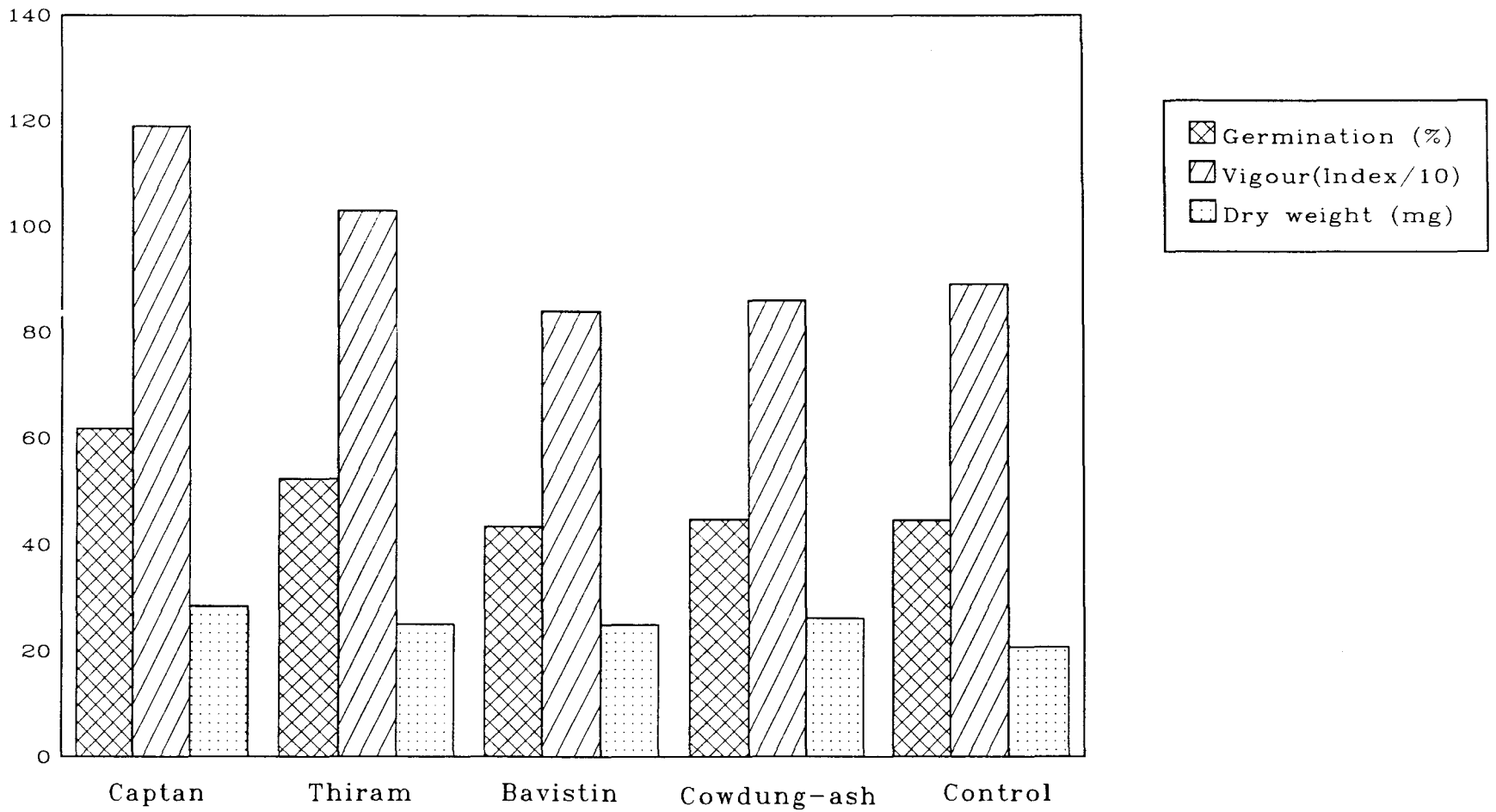


FIG. 6 EFFECT OF VARIOUS SEED TREATMENTS ON GERMINATION, VIGOUR INDEX AND SEEDLING DRY WEIGHT



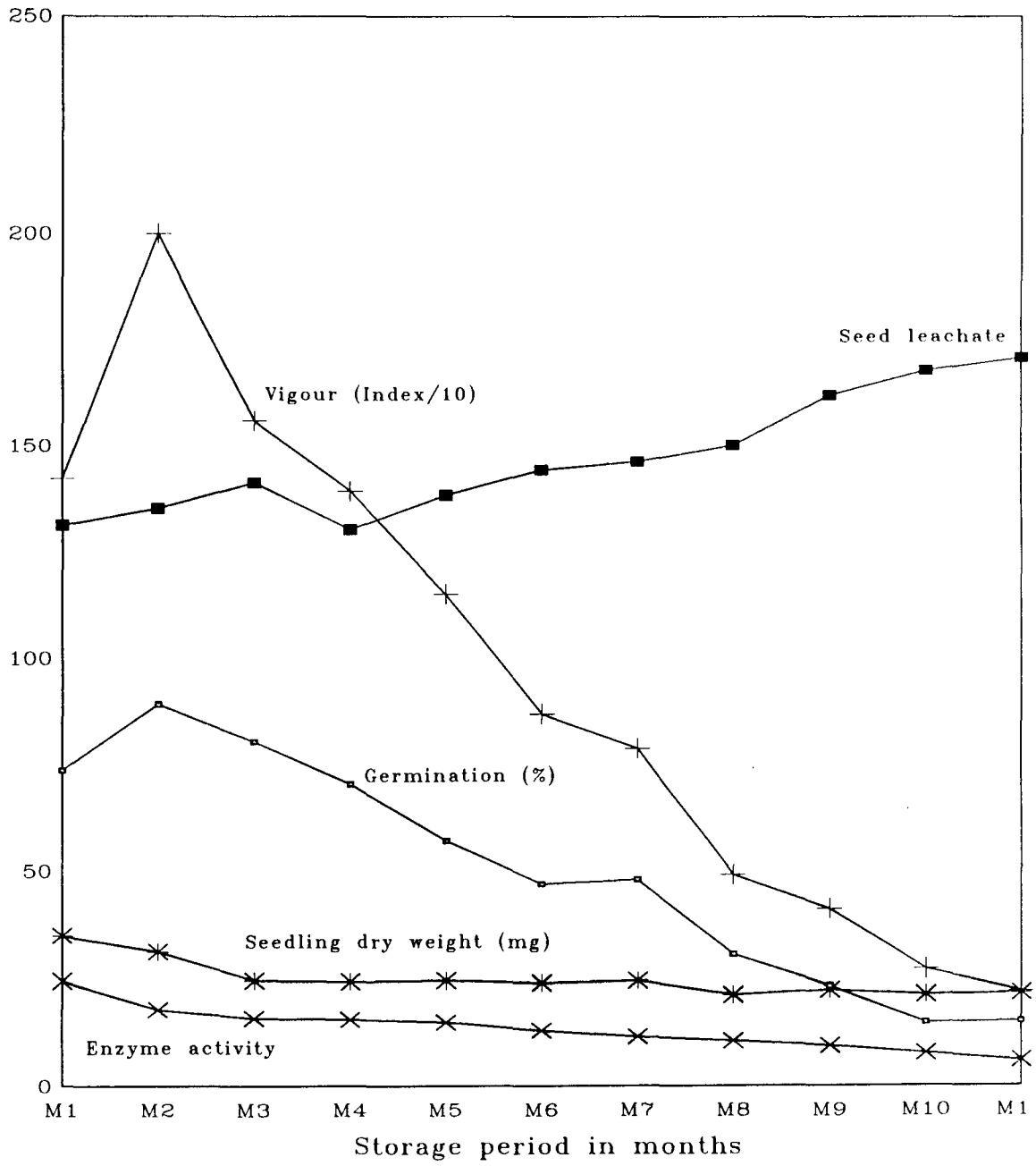
seed dressing with captan at 5-10 g per kg seed, improved seed germination besides stimulating growth and development of cucumber seedling. Renugadevi (1992) reported that seed treatment with a slurry of captan @ 2.5 g per kg seed was best in maintaining seed viability upto 10 months in ash gourd. Increase in seedling dry weight with captan treatment of seeds was reported by other workers (Bhupathi, 1978; Shanmugaraj, 1978; Renugadevi, 1992). Superiority of seed treatment with captan was reported by many workers in tomato (Vadivelu and Ramaswamy, 1983), bhendi (Jacqueline and Ramaswamy, 1983), cowpea (Vanagamudi, 1986); field bean (Vanagamudi and Karivaratharaju, 1987) and in tomato, capsicum, brinjal and okra (Jayaraj *et al.*, 1988).

In the present investigation, seed treatment with captan (T_1) was followed by thiram (T_2) in maintaining the seed quality during storage. Seed treatments with bavistin (T_3) and cowdung-ash slurry (T_4) and untreated seeds (T_5) recorded low germination, speed of germination, vigour index and seedling dry weight during the period of storage and were found to be ineffective compared to captan and thiram treated seeds. Krishnaprasad (1980) reported that thiram treated seeds maintained viability and vigour with minimum loss upto eight months in ash gourd.

Decline in seed viability and vigour are noticed during storage. There was a decline in overall germination, speed of germination, vigour index and seedling dry weight with increase in storage period of seeds (Fig.7). Highest germination, speed of germination and vigour index was noticed two months after storage. Thereafter it showed a decreasing trend. A similar trend in increasing germination of seeds by four months after storage in butternut squash has been reported by Young (1949). Gill and Delouche (1973) found rate of germination and seedling growth of corn to be the most consistent and sensitive measures of the progress of deterioration. So it should be assumed that a significant deterioration in seeds have started two months after storage. High dry matter production was also observed during first two months after storage. Thereafter a decline in dry matter production was noticed. Decrease in dry matter production with increase in storage period of seeds was reported by Setia and Singh (1973), Reddy (1980) and Renugadevi (1992).

Among the different packing material and seed treatment combinations, seeds treated with captan and stored in 700 gauge polythene bags recorded the highest overall germination, speed of germination, vigour index

FIG. 7 CHANGES OF SEED QUALITY PARAMETERS DURING STORAGE OF ASH GOURD SEEDS



and seedling dry weight when compared to other treatments. It was in confirmity with results obtained by Renugadevi (1992) in ash gourd. Seed senescence pattern influenced by various packing material (Fig.8) also indicated a higher germination and slow rate of aging of seeds stored in polythene bags of 700 gauge compared to those stored in brown paper bags and gada cloth bags. Effect of packages were not significant upto three months. Influence of seed treatments on germination of seeds indicated the superiority of captan treated seeds over others. Captan and thiram treated seeds gave high germination upto four months after storage (Fig.9).

Many physiological and biochemical changes which take place during seed deterioration have been used to assess the seed quality. Advanced stages of seed deterioration are evidenced by visible symptoms during germination and seedling growth. Reduced viability is the most widely accepted single criterion for seed deterioration. Increase in seed leachate and loss of enzyme activity are also noticed in seeds during deterioration (Delouche and Baskins, 1973).

A frequently observed symptom of deteriorated seeds is the increased leachate content when soaked in water.

FIG. 8 SEED GERMINATION AS INFLUENCED BY PACKING MATERIALS

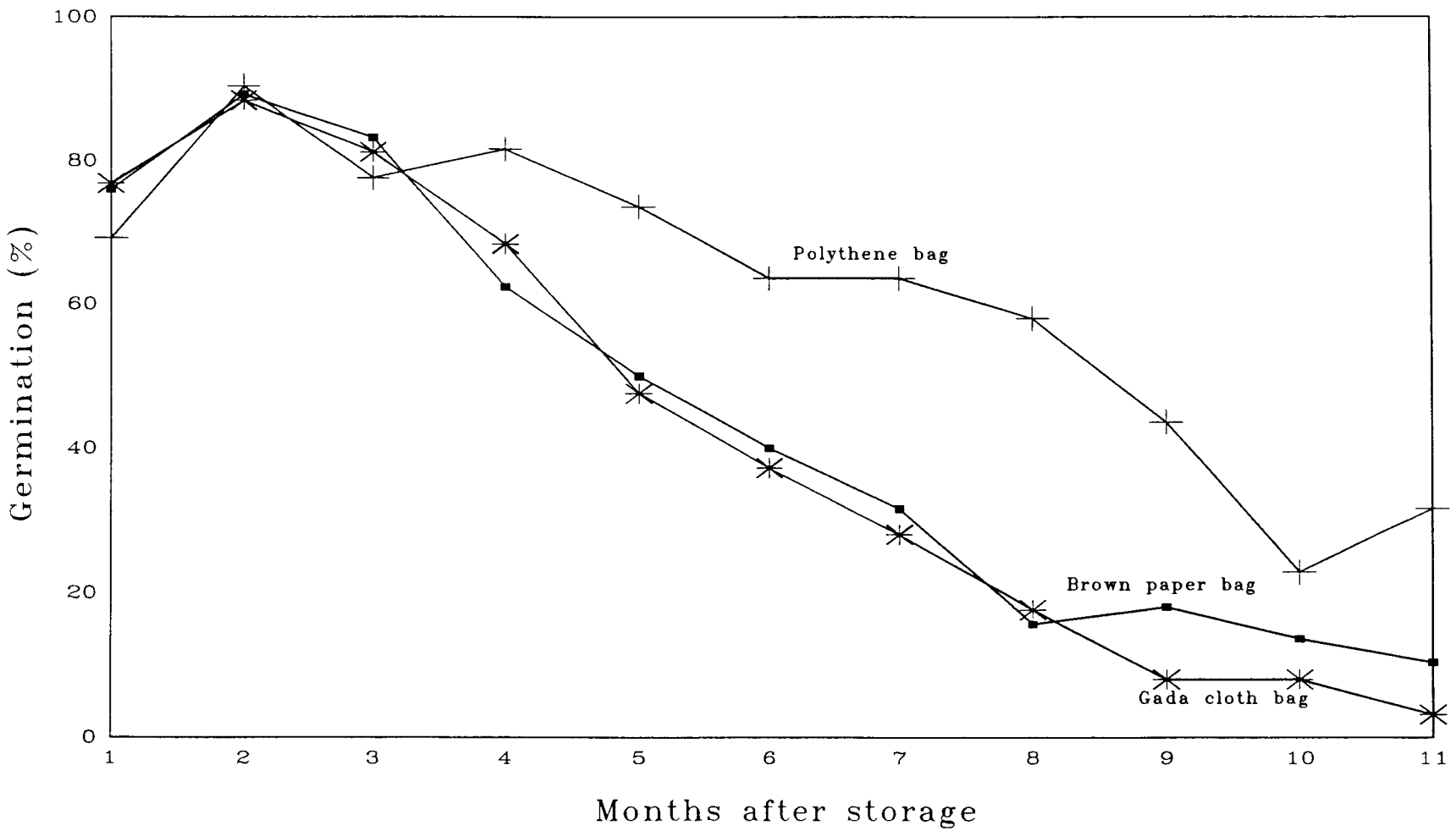
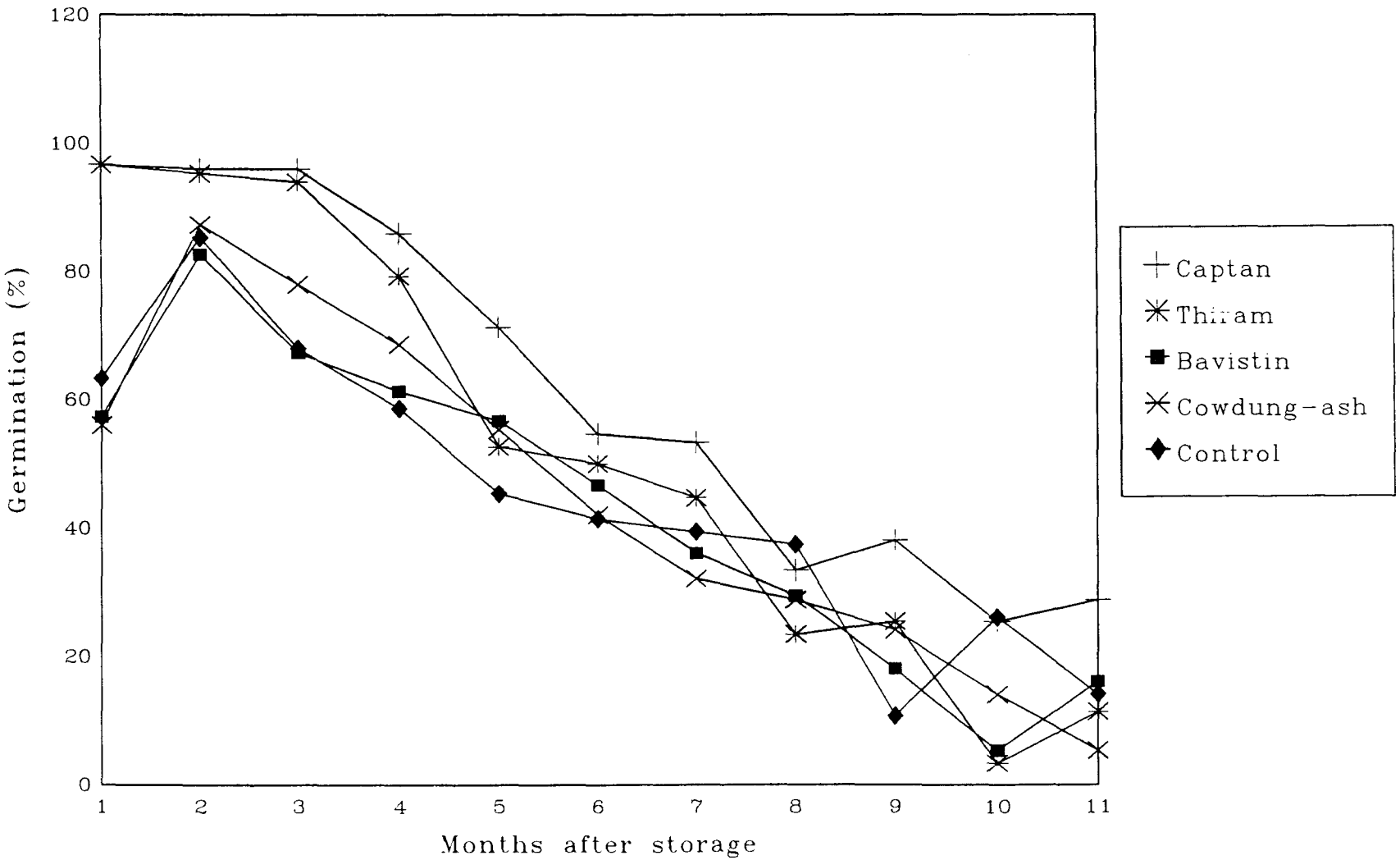


FIG. 9 SEED GERMINATION AS INFLUENCED BY TREATMENTS



The loss of germinability was positively correlated with extent of leakage in terms of conductivity (Samsherry and Banerji, 1979; Sreeramulu, 1983 and Vyas *et al.*, 1990). In the present study, there was a continuous increase in electrical conductivity of seed leachate as storage period advanced. This excessive leakage was attributed to the deterioration of cell membrane and the resultant oozing out of cell inclusions (Powell and Matthews, 1977 and Schoettle and Leopold, 1984).

In the present investigation, among the various packing materials used, the lowest electrical conductivity of seed leachate was recorded from the seeds stored in brown paper bag (P_1) and it was the highest in seeds stored in polythene bags of 700 gauge. Untreated seeds (T_5) recorded the lowest electrical conductivity of seed leachate and the highest value was recorded in seeds treated with cowdung-ash slurry. It was in contradictory to the earlier reports that electrical conductivity of seed leachate was on the increase in cloth bag, than polythene indicating quick vigour loss in cloth bag (Tatum, 1954 and Renugadevi, 1992). Electrical conductivity of seed leachate was more in untreated seeds than treated seeds (Renugadevi, 1992).

Pesis (1983) reported that in muskmelon, a significant decline in germination occurred prior to any significant increase in electrolytic leakage from seeds indicating that electrolytic leakage is not a suitable test for seed quality in muskmelon. In the present study also, no correlation could be obtained with seed leachate electrical conductivity and viability and vigour and that it cannot be taken as a suitable test for seed quality in ash gourd.

Decline in the enzyme activity is a measurable symptom of ageing of seeds, but it is only a reflection of more basic changes in enzymes itself. Decreased activity of dehydrogenase enzyme in deteriorating seeds is well documented by Copeland (1988).

In the present investigation, seeds stored in 700 gauge polythene bags recorded high overall dehydrogenase activity. It was in conformity with the high germination and vigour of the seeds stored in polythene bags. Seeds treated with captan also recorded high dehydrogenase activity. Among the different packing and seed treatment combinations, seeds treated with captan and stored in 700 gauge polythene bags also recorded high dehydrogenase activity, conforming the high germination and vigour of the seeds.

A general event in the aging seeds is the progressive loss of activity of mitochondrial dehydrogenase with seed vigour, culminating in the complete loss of activity at the stage at which embryo can no longer synthesise protein or germinate (Throneberry and Smith, 1955). In the present study also there was a steady decline in dehydrogenase activity from first month and the least enzyme activity was recorded eleven months after storage.

Summary

SUMMARY

Seed technological aspects of ash gourd culture, BH-21 were investigated (1) to find out the stage of physiological maturity of seeds in order to fix the optimum harvest stage of the fruits for seed extraction in rainy and summer seasons (2) to standardise the different seed extraction and drying methods for optimum seed quality (3) to determine the quality of seeds stored in intact fruits and (4) to standardise and determine the effects of different seed protectants and containers for prolonged storability of seeds under ambient temperature and relative humidity. The above investigations revealed the following information.

Maximum growth and size of fruits in terms of fresh weight, volume, length and diameter was attained by 30 d.a.a. in rainy season, whereas in summer season the maximum growth was attained by 40 d.a.a.

Total number of seeds during different stages of fruit development did not differ significantly in both the seasons.

Fresh weight of the seeds per fruit was found to be non-significant in rainy season whereas in summer season maximum fresh weight of the seeds was obtained at

60 d.a.a. The maximum dry weight of seeds per fruit was obtained at 50 d.a.a. in rainy season (44.2 g), whereas in summer season maximum dry weight (41.45 g) was attained at 70 d.a.a. The maximum 100 seed weight was recorded at 60 d.a.a. in rainy season (5.6 g) whereas in summer season, maximum 100 seed weight was recorded at 70 d.a.a. (4.94 g). Seasonal difference in seed weight per fruit was prominent.

The pattern of seed development followed three distinct phases. The initial phase of 'structural development' which was characterised by histo-morphological development of seed from zygote. Maximum fruit size was attained during this stage. This initial phase extended upto 30-40 days and at the end of this stage, seed was structurally complete and attained 'germinable maturity'.

This was followed by the second phase of seed development, which extended upto 50-55 days. This was characterised by a steady increase in dry weight of seeds due to accumulation of metabolites. Fruit weight was almost static.

The final phase of seed maturity was extended upto 65-70 d.a.a. during which seed dry weight, germination and vigour reached maximum. Fruit weight was reduced; ashy coating became powdery in nature and yellowing and drying of vines started. As far as fruit development is concerned, there was a vegetable phase (upto 30 days) and a maturity phase (30-70 days).

The developing seeds started germinating at 25 d.a.a. in rainy season (1.33%) and seeds recorded maximum germination at 70 d.a.a. (100%), whereas in summer season seeds started germinating at 30 d.a.a. (1.33%) and maximum germination (88%) was recorded at 65 d.a.a. However, germination percentage of seeds at 65 d.a.a. and 70 d.a.a. were on par with each other in both the seasons.

The seeds attained maximum speed of germination, root length, shoot length, vigour index and seedling dry weight by 70 d.a.a. in both rainy and summer seasons and these parameters of seeds at 65 d.a.a. and 70 d.a.a. were on par with each other.

Morphological variation of the fruits from 45 d.a.a. was negligible; withering of vines started at this stage and was complete by 70 d.a.a.

Seed quality was found to be influenced by the method of seed extraction whereas different drying methods had no significant effect. In general, seed obtained by machine extraction + acid treatment @ 1% HCl of the pulp for 30 minutes recorded high overall germination (89%), vigour (1643) and low electrical conductivity (40.85 µ mhos/cm) of seed leachate after six months of storage. The seeds obtained by machine extraction + acid treatment @ 2% HCl of the pulp for 30 minutes also recorded high overall germination (87.83%) and vigour (1569). Seeds obtained by manual extraction + with 48 hours of fermentation of pulp was also on par with above extraction methods, besides no seed damage was also observed, whereas in machine extracted seeds 3-4.5% seed damage was observed.

Seeds obtained by machine extraction + alkali treatment @ 1% NaOH equal to the weight of the pulp for one night recorded the lowest overall germination (57%), vigour (1100) and high electrical conductivity of seed leachate (233.48 µ mhos/cm) and was found to be deleterious to seeds during storage.

Storage of intact fruits was found to be an efficient method of seed storage. Stored fruits

recorded a continuous increase in weight loss with advance in storage period. The germination and speed of germination increased gradually with storage period. Maximum seed germination (98%) was recorded six months after fruit storage. The seeds from fresh fruits and during first two months of fruit storage recorded low germination, but a sudden spurt in germination was recorded during third month after storage. The seeds from fruits stored for 11 months recorded fairly high germination (82%) and vigour (1410) indicating the superiority of fruit storage in maintaining seed quality.

Seed germination and vigour parameters were significantly influenced by various seed treatments, containers and period of storage. Among the different containers, packing in 700 gauge polythene bag proved to the best and superior to brown paper bag and gada cloth packages in maintaining high overall germination (61.42%), vigour (1217) and dehydrogenase enzyme activity (0.147) of seeds. Among the different seed treatments, captan @ 2.5 g per kg seed proved to be the best in maintaining high overall germination(61.76%), vigour (1188) and dehydrogenase enzyme activity (0.134).

With advancement in storage period, there was a decrease in germination, vigour and dehydrogenase enzyme activity of seeds and an increase in electrical conductivity of seed leachate. Seed treated with captan and stored in 700 gauge polythene bag (P_2T_1) maintained high overall germination(77.45%), vigour (1548) and enzyme activity (0.152), compared to other treatment combinations.

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* Original not seen

Appendices

APPENDIX I

ANOVA table for physiological maturity of fruits - Season I

Source	d.f.	Mean sum of square			
		Fresh weight of fruits	Length of fruit	Diameter	Volume
Stages of fruit development	13	7070468**	93.62**	36.33**	8334333**
Error	28	151592	2.22	1.14	185982

Source	d.f.	Mean sum of square			
		Fresh weight of seeds	Dry weight of seeds	100 seed weight	Total No. of seeds
Stages of fruit development	10	1175.01	349.49**	3.01**	39682
Error	22	551.95	41.29	0.06	28958

Source	d.f.	Mean sum of square					
		Germination percentage	Speed of germination	Root length	Shoot length	Vigour index	Seedling dry weight
Stages of fruit development	9	0.88**	99.93**	18.91**	71.55**	2497756**	268.64**
Error	20	0.02	1.12	2.73	4.35	22764	45.36

** Significant at 1% level

APPENDIX II

ANOVA table for physiological maturity of fruits - Season II

Source	d.f.	Mean sum of square			
		Fresh weight of fruits	Length of fruit	Diameter	Volume
Stages of fruit development	14	3805328**	48.97**	28.68**	4721525**
Error	30	106932	1.48	0.43	162026

Source	d.f.	Mean sum of square				
		Fresh weight of seeds	Dry weight of filled seeds	Weight of unfilled seeds	100 seed weight	Total No. of seeds
Stages of fruit development	11	526.92**	226.86**	106.31**	1.82**	44720
Error	24	166.36	51.9	23.36	0.05	24673

Source	d.f.	Mean sum of square					
		Germination percentage	Speed of germination	Root length	Shoot length	Vigour index	Seedling dry weight
Stages of fruit development	7	0.61**	9.73**	11.93**	33.29**	1353519**	185.26**
Error	16	0.005	0.66	2.3	5.43	10395	39.94

Appendix III

ANOVA table for effect of seed extraction and drying methods on seed quality parameters

Source	d.f	Mean sum of square						
		Germination	Speed of germination	Root length	Shoot length	Vigour index	Seedling dry weight	EC of seed leachate
Extraction method	6	0.92**	108.99**	1.17**	13.84**	1895710**	272.55**	231727**
Drying method	3	0.04	1.43	0.71	1.89**	30066	39.52**	305.38**
E x D	18	0.03	2.53	0.58*	2.74**	65249	24.08**	94.63**
Month	5	0.24**	151.88**	31.62**	432.3**	2380849**	1704.98	3350**
E x M	30	0.11**	13.64**	0.89**	2.78**	264565**	55.61**	171.67**
D x M	15	0.04**	3.96*	0.58*	0.99**	97241**	16.12*	30.46
E x D x M	90	0.03**	3.25**	0.49*	0.6*	70071**	8.68	40.64
Error	168	0.02	2.08	0.33	0.43	41566	8.86	35.73

* Significant at 5% level ** Significant at 1% level

APPENDIX IV

ANOVA table on the effect fruit storage on seed quality parameters

Source	d.f	Mean sum of squares											
		Fresh weight of fruits at harvest	Weight of fruits at extraction time	Percentage weight loss	Fresh weight of seeds per fruit	Dry weight of seeds per fruit	Germination (%)	Speed of germination	Root length	Shoot length	Vigour index	Seedling dry weight	Percentage of vivipary
Treatment	11	235721	1036808**	534.72**	206.31	65.86	0.225**	38.62**	1.89	5.89**	803156**	9.69**	40.18
Error	12	207500	180458	22.68	183.12	60.29	0.004	0.36	0.92	1.22	36588	1.09	56.62

APPENDIX V

ANOVA table for effect of various packing and seed treatments on seed quality parameters at different months of storage

a) Germination percentage

Source	d.f.	Mean sum of square										
		1	2	3	4	5	6	7	8	9	10	11
Packing	2	0.024	0.005	0.012	0.169**	0.269**	0.239**	0.445**	0.772**	0.491**	0.098**	0.41**
Treatment	4	0.47**	0.061*	0.229**	0.139**	0.064**	0.021	0.048**	0.019	0.087**	0.13**	0.08**
Packing x treatment	8	0.022	0.019	0.027*	0.037*	0.048**	0.094**	0.089**	0.108**	0.111**	0.075**	0.045**
Error	15	0.012	0.019	0.008	0.013	0.008	0.007	0.002	0.013	0.006	0.015	0.006

b) Speed of germination

Source	d.f.	Mean sum of square										
		1	2	3	4	5	6	7	8	9	10	11
Packing	2	3.64	2.85	0.11	41.27**	50.65**	48.24**	67.42**	80.92**	44.98**	9.54**	28.07**
Treatment	4	84.77**	10.75**	121.69**	17.85**	13.77**	2.17	8.13**	3.97**	7.66**	8.52**	5.89**
Packing x treatment	8	3.08	2.69	52.9*	6.19**	7.4**	13.76**	11.45**	11.96**	9.95**	7.65**	2.89**
Error	15	3.62	1.09	1.73	1.35	1.07	0.98	0.33	0.74	0.30	0.77	0.43

Contd.....

c) Vigour index of seedling

Source	d.f.	Mean sum of square										
		1	2	3	4	5	6	7	8	9	10	11
Packing	2	66478	23780	4574	615719**	909910**	1091618**	1822817**	2080774**	1376395*	209094**	525796**
Treatment	4	814237**	124314	389281**	300083**	282139**	57069	143679**	84852*	239274**	258853**	106902**
Packing x treatment	8	65406	90993	111500	115207	169885**	318375**	279548**	226778**	296748**	208542**	62240**
Error	15	43855	51589	49286	52569	38533	23772	13614	19616	16720	23110	9498

d) Seedling dry weight

Source	d.f.	Mean sum of square										
		1	2	3	4	5	6	7	8	9	10	11
Packing	2	1.21	22.25	11.89	17.36	8.4	9.38	9.57*	41.54	45.62*	247.08*	274.07**
Treatment	4	180.68**	127.53**	26.04*	29.87**	30.45**	18.85*	17.62**	27.57	56.27**	285.22*	360.2**
Packing x treatment	8	18.43**	9.54	7.52	3.77	9.77	7.27	7.0*	36.65*	43.19**	81.9	117.94**
Error	15	3.92	6.89	8.17	5.03	4.23	4.34	2.4	12.96	10.59	59.55	27.57

Contd.....

e) Electrical conductivity of seed leachate

Source	d.f.	Mean sum of square										
		1	2	3	4	5	6	7	8	9	10	11
Packing	2	906.99	316	888.35*	2902.56**	589.64**	436.93*	777.23	1725.65	333.94	888.62	723.44
Treatment	4	129797**	155753**	179509**	131269**	160430**	169911**	170898**	150430**	164064**	189761**	189542**
Packing x treatment	8	739.92	262.47	485.83	1958.79**	964.58**	1350.47**	1720.29**	1763.97**	819.33	1097.1*	2071.41*
Error	15	536.28	357.31	202.89	376.6	83.3	75.02	241.63	234.53	342.61	274.74	622.14

f) Hydrogenase enzyme activity

Source	d.f.	Mean sum of square										
		1	2	3	4	5	6	7	8	9	10	11
Packing	2	0	0	0.001	0.002**	0.001*	0.003**	0.002**	0.003**	0.004**	0.004**	0.004**
Treatment	4	0.017**	0.005*	0.008**	0.006**	0.001**	0.002**	0*	0.001**	0.001**	0*	0
Packing x treatment	8	0.002	0.003**	0	0	0*	0	0*	0.001**	0*	0**	0.001**
Error	15	0.001	0.001	0.001	0	0	0	0	0	0	0	0

Appendix VI

ANOVA table for overall effect of packing materials, seed treatments and storage on seed quality parameters of ash gourd

Source	d.f	Mean sum of square					
		Germination (%)	Speed of germination	Vigour Index	Seedling dry weight	EC of seed leachate	Hydrogenase enzyme activity
Packing	2	1.71**	246.95**	542147**	211.57**	5696**	0.014**
Treatments	4	0.71**	89.11**	1417002**	514.84**	1784125**	0.015**
Packing x treatment	8	0.2**	25.51**	561534**	104.38**	9836**	0.002**
Month	10	3.16**	580.57**	10364085**	549.51**	6056**	0.085**
Packing x Month	21	0.12**	13.1**	342292**	50.7**	479	0.001**
Treatment x Month	40	0.06**	9.9**	131810**	64.71**	724**	0.003**
Packing x Treatment x Month	80	0.05**	6.1**	139521**	23.84**	340	0.001**
Error	165	0.01	1.16	32492	13.21	304	0

* Significant at 5% level ** Significant at 1% level

EFFECT OF FRUIT MATURITY, SEED PROCESSING AND STORAGE METHODS ON SEED QUALITY OF ASH GOURD (*Benincasa hispida* Thumb.)

BY

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ABSTRACT OF A THESIS

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ABSTRACT

Studies on seed quality parameters in ash gourd cv. BH-21 were undertaken in the Department of Olericulture, College of Horticulture, Vellanikkara during 1994-95 to fix the optimum fruit maturity stage and to standardise the best seed processing and storage methods for prolonging the viability and getting maximum seed quality.

Investigation on physiological maturity of seeds indicated that maximum fruit size ie., weight, volume, length and diameter of fruits was attained by 30 days in rainy season, while it took 40 days in summer season. The dry weight of seeds, seed germination and vigour were attained maximum by about 70 d.a.a. in both the seasons. Morphological variation of fruits from 45 d.a.a. was negligible. Withering of vines has started at this stage and completed by 70 d.a.a. This is the optimum stage for harvesting fruits for seed extraction.

The pattern of seed development had three distinct phases - structural development phase, upto 30-40 days; seed development phase, upto 50-55 days; and finally seed maturity phase, upto 65-70 days. Physiological maturity of seeds was achieved in the last phase.

Seed quality was found to be influenced by the methods of seed extraction whereas different drying methods had no significant effect on various seed quality parameters. Seeds extracted manually and fermenting the pulp for 48 hours was found to be the best for getting seeds without damage and in maintaining high viability and vigour of seeds during storage. In machine extraction 3-4.5% seed damage was observed. Seeds obtained from machine extraction combined with 1% or 2% HCl for 30 minutes showed a higher germination percentage. Alkali method of seed extraction using 1% NaOH equal to the weight of the pulp was deleterious to seed germination and storability.

Storage of intact fruits for seed purpose was found to be an efficient method. The fruits should be stored for a minimum of three months to get satisfactory germination. The seeds from fruits stored for 11 months after harvest maintained high seed germination (82%) and vigour (1410) indicating the effectiveness of fruit storage in maintaining seed quality.

The results of the seed storage studies indicated that packing seeds 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 bags were not suitable to maintain the seed viability. Among the different seed treatments tried, captan @ 2.5 g per kg of seeds was found to be most effective in maintaining high seed germination, vigour and dehydrogenase enzyme activity. Therefore it could be concluded that for storing seeds under ambient temperature and relative humidity conditions, seeds should be treated with captan @ 2.5 g per kg seeds and should be stored in 700 gauge polythene bags.