STANDARDISATION OF SEED PROCESSING TECHNIQUES IN CHILLI *(Capsicum annuum* L.*)*

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THESIS

Submitted in partial fulfilment of the requirement for the degree

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1998

DECLARATION

I here by declare that this thesis entitled **"Standardization of seed processing techniques in chilli (*Capsicum annuum* L.)"** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of my degree, diploma, associateship, fellowship or other similar title of any other University or Society.

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Certified that this thesis entitled **"Standardization of seed proccessing techniques in chilli (*Capsicum annuum* L.)"** is a record of research work done independently by **Miss.P.V. Liji**, under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

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Dedicated to my beloved parents

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Introduction

INTRODUCTION

Chilli (*Capsicum annuum* L.) is native to the new world tropics and is now widely cultivated for use as spice or vegetable for its intrinsic qualities like pungency, flavour, appealing colour and nutritive value. India is the largest producer of chillies in the world, with an annual production of 7.48 lakh tonnes from an area of 8.10 lakh hectares. During 1996-`97 India earned a foreign exchange of Rs. 209.64 million by exporting 51,900 tonnes of dry chilli and as much as Rs. 4487.92 lakhs by exporting 11,930.58 kg of chilli powder (Spices Board, 1997). In India, the states of Andhra Pradesh, Maharashtra, Karnataka and Tamil Nadu are the important chilli producing areas.

Chilli is a diverse crop and has been a part of the human diet since 7500 B.C. Since the discovery by Columbus, chillies are incorporated into majority of the world's business. Annual trade of chilli in the world is 55 to 65 thousand tonnes which is 16.7% of the total spice trade in the world. Green chilli, chilli powder, cayenne pepper, tabasco, paprika, sweet or bell pepper, pimentos and serrano pepper are all derived from the berries of *Capsicum* sp. Different terms are used in different countries and even within the same country. The term chilli is not generally used in U.S.A, but is used in Britain, India, Africa and countries of the East. Chilli is valued for its pungency, spice taste and aroma, besides the appealing colour it adds to the food. The two important chemical constituents of fruits are "Capsaicinoids" imparting pungency and "carotenoid pigments"

imparting colour. The varieties which got established in India, are generally long, moderately pungent and have varying shades of red colour.

Both ripe and unripe fruits of chilli are used for culinary purpose and it forms an important source of Vitamin C. Of the five major spices, chilli ranks third next only to black pepper and cardamom. It is unique among all the spice crops, being the only source of capsaicin. The pungent principle capsaicin has significant physiological action and is used in many pharmaceutical preparations like balms, linaments and ointments for cold, sore throat and chest congestion. The oleoresin from high pungent chilli varieties is used as a counter irritant in lumbago, neuralgia, rheumatic disorders and internally for tonic and carminative action. Chilli varieties with bright red colour and moderate pungency are used for flavouring food products like hot biscuits, ginger soft drinks and for chewing tobacco.

Seeds are predominantly utilized for cultivation of chilli crop. The success of crop production commences with the use of quality seeds, which comprises of high viability and vigour. Seed viability and storability are largely dependent on maturity of seeds at the time of harvest, seed extraction and drying methods, and also the packaging materials and storage atmosphere. Kerala, having a tropical warm humid climate enhances the rate of seed senescence and reduce the viability and vigour during storage.

Hence the present study was taken up in the Department of Olericulture, College of Horticulture, Vellanikkara during 1997-98 with the following objectives.

1. To find out the physiological maturity of chilli seeds in order to fix the optimum harvest stage of fruit for seed extraction.
2. To standardize the seed extraction and drying methods for optimum seed quality in chilli.
3. To standardize the optimum storage conditions and packaging materials to extend the longevity of seeds.

Review of Literature

REVIEW OF LITERATURE

Seed in simple terms refers to a fertilized and ripened ovule. After fertilization zygote undergoes series of multiplicative changes leading to seed development. Abdul - Baki and Baker (1973) reported that seed maturation begins at the end of seed development. According to Delouche (1973) seed development and maturation refers to the morphological and functional changes that occur from the time of fertilization until the mature seeds are ready for harvest. The seed is said to be physiologically mature when it contains maximum dry matter and attains highest germination potential. This stage of physiological maturity varies with crop and also with variety (Suryavanshi and Patil, 1995). Information available on the seed maturity studies in various vegetable crops are reviewed hereunder .

2.1 Studies on physiological maturity of seeds

One of the most important factors contributing to crop production per unit of land is the use of good seeds. According to Helmer *et al.* (1962) seeds attain maximum quality at their physiological maturity. Harvesting at this optimum stage of maturity not only minimise the loss in viability and vigour of the seeds but also protect the seeds from field damages due to adverse environmental conditions as well as from insects and fungus.

According to Garris and Hoffman (1946) prolonged field exposure after the stage of maturity would cause losses in germinability, longevity and vigour of seedlings

produced. In musk melon 100 seed weight increased upto 37 d.a.a (37 days after anthesis) and beyond that there was a slight decrease in 100 seed weight. The seeds from 37, 42 and 47 d.a.a. when subjected to germination showed not much difference in germination, but a slight difference was observed four months after harvest which persisted nine months after harvest (Harrington, 1959). Chauhan and Bhandari (1971) observed differences in germination among seeds obtained at various stages of maturity in okra and the seeds collected from fruits at 27 d.a.a. recorded highest germination per cent (89.2). The seeds collected from fruits harvested at 30 d.a.a recorded 85.5 % germination. According to Nassar *et al.* (1972) mature red fruits of Capsicum provided the most viable seeds of the best quality. Sandhu *et al.* (1972) reported that, in onion cultivar Punjab Selection seed germination was high when the fruits harvested at full mature stage while harvesting two weeks earlier resulted in poor germination of seeds.

Quagliotti (1977) observed that seeds collected from the fruits of pepper cvs. Corno di bue and Di cuveo at 3 stages of ripeness (green, market ripe and physiologically ripe), germination was the best with seeds from physiologically ripened fruits. Number of seeds per fruit and weight per 100 seeds were lower with green fruits than with others. Tomato, lettuce, spinach, beans and radish seeds harvested at the slightly underripe stage germinated well as seeds harvested at full physiological maturity and it is suggested that seeds from these crops can be harvested early with out the risk of loss due to dehiscence. But seeds from fruits of capsicum, carrots, celery and

peas harvested at the slightly underripe stage gave poor germination compared with well ripened seeds (Nowosielska,1978). Lablab (*Lablab purpureus* L.) seeds attained the maximum dry weight and physiological maturity on the 27th d.a.a. (Shanmugaraj, 1978), ribbed gourd 60 d.a.a. and bitter gourd 27 d.a.a.(Varatharaj, 1979), bottlegourd at 65 d.a.a. (Chandrasekharan, 1979) and ash gourd at 80 d.a.a. (Krishnaprasad, 1980).

Lysenko and Butkevich (1980) reported that in Capsicum cultivars Podark Moldovy and Gogoshary Mestnge, reddening of fruit, which occurs about 50 days after flowering, was established as marking the beginning of fruit biological maturation and seed germination was optimal at this stage of fruit maturity. Capsicum cv. Avelar were harvested at every 5 days from 25 to 70 days after flowering and the seeds were either extracted immediately or after 3 days. Delay in extraction by 3 days improved seed vigour and germination and the germination being highest (98 %) in seeds harvested 50 and 55 days after flowering (Mantovani *et al.*, 1980)

According to Pereira *et al.* (1982) egg plant fruits should be harvested 80 d.a.a. for high quality seeds. Singh *et al.* (1985) reported that in musk melon, germination per cent was highest when the fruits were harvested at full maturity stage. Seeds of chilli variety Co-1 harvested with reduced moisture contents on the 48th day and at subsequent periodical intervals up to 120 days after anthesis could remain highly germinable and vigorous, as they posseed well matured and sound embryos and endosperms with sufficient nutrient resources, enzymes, vitamins and organells (Metha and Ramakrishnan, 1986). According to Dharmatti and Kulkarni (1987) fruits of bell

pepper cultivar California Wonder harvested 52 d.a.a. have the highest germination. Edward and Sundstrom (1987) reported that seeds extracted from red fruits had a significantly greater germination rate and final germination percentage than seeds from orange fruits in *Capsicum frutescens*. According to Lassim and Chin (1987) cowpea seeds become physiologically mature 19 days after anthesis and seeds attained maximum dry weight at this stage.

Kanwar and Saimbhi (1987) observed that okra seeds were fully mature 21 days after anthesis to give above 90 % germination. Doijode (1988a) studied about the seed viability and seedling vigour in relation to five stages (immature green, mature green, breaker, ripe and over ripe) of fruit maturity in chilli cultivar Pant C-1 and Byadagi Local. Seeds harvested at the ripe (fourth) fruit stage showed high germination capacity and seedling vigour. Nerson and Paris (1988) observed that one cultivar of each of four cucurbit crops, cucumber, melon, watermelon and squash, germinability of seeds was best from fruits which were 49-54 days past anthesis (dpa), the most mature fruits studied. Storage for up to 48 months generally did not affect seeds from the most mature fruits. But it adversely affected germination of seeds from immature (26-28 dpa) fruits of the cucumber, melon and squash, and favourably affected germination of seeds from immature (26 dpa) fruits of the watermelon.

Jayabarathi *et al.* (1990) reported that in brinjal cv.PKM-1 seeds obtained from the fruits harvested at completely yellow colour stage recorded the highest fruit and seed yield per hectare, seed recovery percentage, germination and vigour index. Harvesting

the fruits prior to this stage was found to record low yield and quality of seeds. According to Demir and Ellis (1992a), in *Capsicum annuum* cv. California Wonder, mass maturity (defined as the end of seed filling phase) occured 49-53 days after anthesis when seed moisture content was 51-53 % . The onset of both germinability and desiccation tolerance occured either just before or at mass maturity and the potential longevity was achieved 63-65 d.a.a. Demir and Ellis (1992b) suggested that tomato seeds be harvested one mouth after mass maturity (35-41 day after anthesis) and it is about 7-10 days after the full red fruit colour is attained. At this stage tomato seeds maintained near-maximum normal germination, minimal mean time to germination and high potential longevity for 40 days between 55 and 95 days after anthesis.

Barbedo *et al.*(1993) observed that in cucumber (cv. Nazare) physiological maturity of the seeds was reached 40-45 days after anthesis. Fruits were completely yellow and the highest values for dry matter content, germination per cent, vigour, fruit weight and fruit size were observed at this stage. Basavaraja and Dutta (1992) reported that fresh weight of seeds and dry weight of seeds were maximum on 49th day after anthesis in brinjal and the seeds were mature and ready for extraction by this time. Earlier formed fruits (i.e., on primary and secondary branches) had more number and better developed seeds per fruit. Hosmani (1993) reported that maximum percentage of viable seed are obtained from the chillies which are harvested when the reddening of the fruit begins. According to Sanchez *et al.* (1993) seeds from red (50 d.a.a.) and (60 d.a.a.) over-mature red fruits of capsicum cultivars Early Calwonder, Resistant Giant

No.4, VR2 and Yolo wonder generally had greater dry weight and higher germination percentage than seeds from less mature fruits. Seeds extracted from mature green fruits did not germinate regardless of storage time. According to Barbedo *et al.* (1994) seed germination and vigour increased as fruit picking was delayed from 15-40 days, in cucumber cultivar. There was no added advantage with further delay. According to Demir (1994) maximum seed quality, assessed as germination and emergence percentage was record in okra pods harvested 52 d.a.a and delaying harvest to 59 d.a.a. resulted in marked seed loss from shattering.

Rodriguez *et al.* (1994) harvested the fruits of capsicum cultivar Jarocho at 40-45 days (green) 55-60 days (green -red) or 80-85 days (red) after flowering and the seeds were extracted in each case 1,10 or 20 days after harvest. The green-red and the red fruits gave the highest percentage of good quality seeds (93-96%) on the 3 extraction dates. The best germination was obtained in seeds from green-red fruits extracted 10 and 20 days after harvest (92 and 94% respectively). Cavero *et al.* (1995) studied the influence of fruit ripeness at the time of seed extraction on seed germination at 25^0C or 13^0C in 2 Spanish pepper cultivars for canning. Germination of seeds from half-ripe fruits improved with room ripening or overripening, but remained poorer than that of seeds extracted from fully ripe fruits that were allowed to over ripen. Overripening of fruits picked when fully ripe slightly improved germination.

Suryavanshi and Patil(1995) studied the physiological maturity in four mungbean cultivars at Rahuri during summer and results showed that maximum dry weight and

vigour index were attained 25 d.a.a. in cultivar K-851, while in others (PM2, S-8 and J-781) at 30 d.a.a. The fruits of tomato cv. Moneymaker and pepper (capsicum) cv.California Wonder were harvested serially from 25 to 75 days after anthesis and their physical characteristics, germination and emergence determined. The results indicated that optimum seed quality was attained some 20-30 days after anthesis and maximum dry weight and seed quality did not decline after that point (Demir *et al.*, 1995). Kannath (1996) studied the seed quality parameters in ash gourd cv. BH-21 and it was observed that seeds attained maximum dry weight, seed germination and vigour at 70 d.a.a. Pandita *et al.* (1996) reported that highest germination per cent, vigour index and field emergence was attained in seeds extracted from pink stage of tomato. Studies on seed quality parameters in okra cv. Arka Anamika showed that seeds attained physiological maturity at 36 d.a.a. and the germination per cent, vigour index, speed of germination, root length and shoot length were maximum at this stage (Anitha, 1977).

2.2 Method of seed extraction and drying

Seed moisture has a major role in determining the longevity of seeds in several vegetable species. Most of the seeds withstand drying and extend their storage life with decrease in moisture content. The traditional methods of sun drying are inadequate and slow. So, mechanical drying has to be adopted for quicker and safe drying of seeds. Not all kinds of drying retain the seed viability and vigour equally well under any given set of environmental conditions. Drying too rapidly or unequally or with high temperature is injurious to seeds (Doijode, 1990a). Seed extraction

employing manual labour is a time consuming process which involves more labour force and the recovery of seeds obtained is very low. By employing machine extraction there was increased percentage of seed recovery, time taken was quicker and the operational cost was the lowest (Karivaratharaju and Palanisamy, 1984). Informations available on the seed extraction and drying methods of various vegetable crops are reviewed hereunder.

Sandhu *et al.* (1972) observed that sundrying of onion seeds for two days significantly lowered germination compared to seeds dried in shade. The conventional method of drying-sun drying is time consuming and depend on atmospheric conditions. To overcome these mechanical drying can be followed. According to Vanraj and Kulkarni (1977) in mechanical drying, air temperature and initial moisture content of the fruits are most important as they affect seed quality. They reported thermal injury to the seeds when dried at high temperature with high initial moisture content. 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 extraction. Araujo *et al.* (1984) observed that okra seeds dried naturally or artificially in hot air oven at 50^0C or 60^0C decreased seed quality, especially in seeds with high initial moisture content, but 40^0C had no adverse effect. After 12 months storage, germination was the highest in naturally dried control seeds (96.8%) and next highest (95.5%) in those harvested at 45 % moisture content and dried at 40^0C.

In capsicum cv. Dluga Z Mor, highest yield of seeds of good quality was obtained with the earlier transplanting and by picking the fruits as they ripened on the plant, the fruits were held in boxes for a further three weeks before the seeds were extracted. Once over harvest and immediate seed extraction gave the poor results (Duczmal and Kaczmarkiewicz, 1984). Karivaratharaju and Palanisamy (1984) opined that mechanical extraction was quicker, cheaper and had no adverse effects on seed quality compared to manual extraction in chilli cultivar Co.1. The germination of seeds was maximum in the machine extraction. According to Baldo *et al.* (1985) tomato seeds from pulp fermented at room temperature for 2,4 or 6 days and control seeds gave 94,62,23 and 98 % germination respectively and a similar trend was observed with regard to seedling vigour. Nerson *et al.* (1985) studied the effect of washing and drying the seeds of cucumber, *Cucurbita pepo* , musk melon, and watermelon from fruits ranging in the age from 21-54 d.a.a. Seeds were handled with or without 15 minuts of washing and with or without air drying before subjected to germination. Germination of seeds harvested from ripe fruits (45-54 d.a.a.) was not affected either by washing or drying. The rate of germination of these seeds was accelerated in musk melon and inhibited in *Cucurbita pepo* by drying. Singh *et al.* (1985) opined that seed germination was decreased with duration of fermentation in mature green, turning red and ripe fruits of two cultivars (Punjab Chhuhara and Punjab Kesari) of tomato. The best fermentation time was 24 and 48 h for the cultivars Punjab Chhuhara and Punjab Kesari, respectively.

Rachidian and Deunff (1986) observed that accelerated drying of pea seeds at 15, 20 or 35^{0}C of different maturity stages and moisture contents indicated that high drying temperature markedly reduced germination in seeds of high moisture contents (62.7-75%). Drying at 15 or 20^{0}C increased germination in seeds of high moisture content compared with freshly harvested seed. Studies conducted by Singh and Verma (1986) showed that there is little difference in seed germination between manually and mechanically extracted seeds of tomato, brinjal and chilli. Tucker and Gray (1986) observed that carrot seeds dried within the temperature range of 15-35^{0}C gave the highest germination per cent, seedling emergence, most rapid germination than the seeds dried at 45 or 55^{0}C. According to Rudolph (1987) onion seeds extracted with the E512 machine with a drum revolution of more than thousand per minute impaired seed quality and reduced germination capacity, conductivity and emergence rate compared with hand harvested seed. Doijode (1988b) reported that in general, okra seeds are dried in shade or with silica gel. Rapid drying at higher temperature reduces germination and seed germinability was affected by drying seeds at 60^{0}C initially. Pandian (1988) observed that mechanical drying of okra seeds with hot air at 53 ± 0.5^0C in a fluidised bed drier improved the germination and vigour when compared to sun drying. According to Selvaraj (1988) shade dried seeds in brinjal have higher germination per cent and better storage potential than sun dried seeds.

Neelamathi(1989) opined that natural drying of seeds over screen bottom tray, cowdung floor and gunny proved to be superior over the control(shade drying) in terms of germination, root length, seedling vigour and dry matter production of tomato. In onion cv. Nasik Red, after comparing different methods of drying, like silica gel, shade, sun, oven, forced hot air, infra red and vacuum Doijode (1990a) opined that, drying with silica gel and infra red were found to be the best for maintaining high seed viability for longer period. According to Gowda *et al.*(1990) sun and shade drying followed by mechanical drying with the air temperature of 40^{0}C were found to be optimal in terms of safe drying for better seed quality in tomato. Moreira *et al.*(1990) reported that average germination per cent after drying was higher for seeds of *Phaseolus vulgaris* dried in static drier. Sun drying of chilli fruits followed by drying at 40^{0}C air temperature recorded the highest germination and field emergence in chilli. (Hosmani, 1993). Dhanelappagol *et al.* (1994) reported that germination, field emergence, seedling growth and vigour index of the seeds obtained from capsicum fruits at three different maturity stages and dried by five different methods decreased with increase in drying air temperature. Germination was highest (92%) in seeds from sun-dried fully ripe red coloured fruits, followed by seeds obtained from fully ripe red coloured fruits dried at an air temperature of 40^{0}C. Kannath (1996) observed that seed quality was found to be influenced by the methods of seed extraction in ash gourd whereas different drying methods had no significant effect on various seed quality parameters. A combination of fruit drying in mechanical drier at 35^{0}C for six hours and seed drying initially under shade for one day followed by direct sunlight avoiding

peak hours of radiation till moisture content reaches 8 per cent was the best for getting maximum germination and vigour index in okra (Anitha, 1997).

2.3 Standardisation of seed storage

Like any other form of life seeds also can not retain their viability for a longer period. Eventually they deteriorate and die. Seed longevity is generally determined by pre-harvest factors, storage environment and pest and diseases. High seed moisture at higher temperature hasten the process of seed deterioration resulting loss of viability. By controlling various factors in storage, we can reduce the rate of deterioration. In Kerala, where we have a tropical humid climate, seed storage and maintenance of quality requires special attention. Packaging of seed results in exclusion of moisture, insects and micro organisms by creating barrier to these factors. Period of seed storage and its environment determine the choice of storage condition. Roos and Davidson (1992) estimated the longevity of vegetable seeds following long term storage (43-60 years) based on changes in germination percentage between 1963 & 1991. On an average, seedlots of most species stored in the National Seed Storage Laboratory lost 30 % viability. Onion, pepper (Capsicum) and watermelon showed the greatest loss of germination (50, 58 and 51% respectively), and peas the least (7%). Further the loss of seed viability is associated with changes in cell structure which permits leaching of electrolytes and sugars and also biochemical changes in seed. The information available in various vegetable crops on these aspects is briefly reviewed hereunder.

Murthy and Murthy (1961) reported that it is better to store fruits for seed purpose than the extracted seeds in chilli. Seeds of watermelon recorded maximum germination (88%) after 18 months of storage in cloth bag at 20^0C and 45 per cent RH, while the seeds stored in air tight container maintained well only for 12 months (Zink and Demendonea, 1964). Miyagi (1966) observed that cucumber seeds maintained the viability when stored in metal foil bags upto 22 months. Nassar *et al.* (1972) reported that when seeds of capsicum were stored in paper bags at room temperature under normal conditions they soon lost their ability to germinate. According to Villaneal *et al.* (1972) seeds of squash and bottlegourd stored in cellophane and aluminium foil packets maintained germinability longer than those in polyethylene or paper packets. In a trial conducted in okra (Silva *et al.*, 1976) it was seen that the best storage method is packing the seeds with a moisture content of 4.5% in glass containers at room temperature and cold storage. The seeds retained viability for 29 months. Thulasidas *et al.* (1977) opined that brinjal seeds stored in aluminium foil pouches along with silica gel retained germination (50%) after 29 months of storage. Capsicum and tomato seeds produced in Macedonia were stored in cloth, glass, polythylene, nylon or tin containers for 8 years and the viability of seeds decreased gradually but not uniformily, depending on the storage container. After three years seeds showed a germination range of 68.4 to 87.3% and after seven years, seeds stored in cloth bags gave zero germination where as those stored in glass showed 78.3% germination. Tomato seeds stored well in all containers and gave over 85% germination (Popovska *et al.* 1981).

According to Quagliotti *et al.* (1981) market ripe sweet pepper fruits of cultivar Corno di Bue and Yolo Wonder, should have at least 20 days post harvest ripening for getting more number of viable seeds per fruit. But prolonging the post harvest ripening to 30 days increased the percentage of fruits containing viable seeds, number of viable seeds per plant and germination per cent. He also reported that, storage of fruits at 20^0C, rather than 10^0C before seed removal also increased the percentage of germination. Sandhan (1982) suggested that storage of field bean seeds in 700 gauge polythene was effective in preserving good germination. According to Doijode (1986) the seeds of cluster bean cv. Pusa Navbahar, remained viable for 12 months when stored in paper containers, where as it was for 36 months when stored in polyethylene, laminates or glass containers. The seeds of *Capsicum annuum* when stored in different controlled environments like room temperature, 25^0C and 35^0C, at four levels of relative humidity (20,35 55 and 76%) it was seen that the aging of seeds reduced in low levels of RH (Quagliotti, 1986).

Agrawal *et al.* (1988) reported that seeds of onion cultivar Pusa Red, with moisture contents of 4 to 40% were stored in aerobic and anaerobic (sealed) conditions at 35 and 45^0C for 8 days. Seed viability reduced at high temperature irrespective of moisture and oxygen avaibility. Seeds with high moisture (40%) at 35^0C under aerobic conditions showed least decline in germination, while seeds stored in sealed conditions showed rapid loss of viability, which hastened with higher seed moisture. Doijode (1988c) opined that when the seeds of brinjal cv. Arka Shirish were subjected to

accelerated aging (40^{0}C and 90% RH) for 20 days, seed viability and vigour were reduced rapidly with increase in aging period. Doijode (1988d) also reported that in onion and bell pepper, seed viability was high when the seeds packed in laminated bags were stored in vacuum, when compared to the seeds packed in paper bags. In another study french bean seeds stored in glass jars, laminated bags and polyethylene bags gave higher percentage of germination than those stored in butter paper or kraft paper (Doijode, 1988e).

According to Jayaraj *et al.* (1988) retention of viability was greater in tomato seeds stored in aluminium laminated bags. Thakur *et al.* (1988) has reported that, when the seeds of three cultivars of *Capsicum annuum* was stored for 1-5 years in brownpaper envelops at 2-26^{0}C, the older seeds took 22 days for germination while the seeds stored for 1-3 years germinated in 16-18 days. In cultivars Russian Yellow and California Wonder the germination percentage is also declined from 88.5% and 92% to 42.5% and 29% respectively after 5 years. Doijode (1989) opined that seeds of cluster bean cv. Pusa Navbahar stored in different storage conditions such as sub zero temperature(-18^{0}C, RH 40%), low temperature(5^{0}C, RH 40 %) and ambient conditions (16-35^{0}C, RH 25-90%) for five years in polyethylene bags (300gauge), the germination was high (more than 97%) in seeds stored in cold storage and it was maximum in sub-zero temperature (-18^{0}C). There was no germination of seeds stored under ambient conditions suggesting the process of deterioration increases under high temperature.

Doijode(1990b) reported that occurrence of rains during seed maturity lowers the seed quality and reduce the germination in okra. Seed longevity can be enhanced by storing the laminated bags at 5^0C or $^-18^0$C. Storage of onion seeds under sub zero temperature ($^-18^0$C and 85% Rh) was most effective, when compared to low temperature (5^0C and 40% RH) or ambient conditions (16 - 35^0C and 25 - 90% RH) storage. (Doijode 1990c). Karivaratharaju *et al.* (1990) reported that germination of lablab seeds of variety Co-1 stored in 700 gauge polythene bag and mud pot were on par and reported high germination per cent compared to the seeds stored in unused gada cloth bag. Oladiran and Mumford (1990) observed that seeds of *Amaranthus gangeticus* and *Amaranthus hybridus* retained better viability at lower moisture content and storage temperatures. The time required for germination increased with seed age. Palanisamy and Karivaratharaju (1990) opined that storing tomato seeds at low RH levels of 35% was optimum for long term storage with minimum loss in vigour and viability.

Usha *et al.* (1990) reported that cowpea seeds treated with malathion and stored in polythene bags retained seed viability over a period of 8 months. According to Doijode (1991) radish seed quality can be retained for six years when packed in polyethlene or laminated (paper - foil - poly) bags stored at 5^0C or $^-18^0$C. Nakagawa *et al.* (1991) opined that seed quality was better after storage under ambient conditions compared with dry storage in okra seeds. Palanisamy and Karivaratharaju (1991) reported that at high relative humidity, deterioration of tomato seeds occured rapidly,

which was accompanied by loss in germination, vigour and membrane integrity. Cauliflower (cv. Pant Shubhara) and tomato (cv. HS 101) seeds stored in moisture proof container (laminated bags) showed significantly low reduction in vigour as compared to seeds stored in moisture pervious containers (unsealed polyethylene and bamboo paper bags). All the container stored seeds showed more decline in vigour as compared to loss in viability (Verma *et al.* 1991).

According to Gupta *et al.* (1992) seeds of chilli cv. Pusa Jwala stored in tin containers deteriorated less rapidly than in the cloth bag. Between 5 and 10 months after harvest, seeds lost 6-15% viability in tins and 26-32% in the cloth bags. Doijode (1993) reported that, the seeds of chilli cv. Sel 1 can be successfully preserved for three years under partial vacuum and for four years with carbondioxide atmosphere. Currah and Msika (1994) opined that onion seeds stored in air tight jars under ambient condition retained their viability and vigour while those packed in paper packets showed reduction in seed quality. According to Dourado and Carson (1994) all the low temperature storage of onion seeds resulted in good viability retention, whereas viability fell most rapidly in high moisture content seed stored at 30^0C in aluminium foil packets or muslin bags. According to Fischer (1994) the seed quality of *capsicum annuum* cv. Javitott could be maintained in long term storage in glass jars and plastic flasks sealed hermetically. The seeds stored in this way at 5-10^0C maintained 84 -94 % of their germination ability even after 20-22 years and seed vigour was only

4 % inferior to it on average. The germination ability of seeds stored in cheese cloth bags fell markedly after 3 years stored at room temperature and after 7 years at 5-10^{0}C.

Hernandez *et al.* (1994) reported that common bean seeds stored in glass flasks for 24 months obtained the highest germination (67%) compared to polythene bags and jute bags. Storage of seeds at 3-10^{0}C resulted in a mean germination percentage of 58% regardless of container type. Thiagarajan (1994) reported that chilli seeds dried to a moisture content of 8% and with an initial germination of 85% recorded 73% germination after 30 months. Seeds harvested at different times exhibited difference in storability and seed germination decreased as storage was prolonged where as the electrical conductivity of the seed leachate increased. Doijode (1995a) reported that storage of onion seeds with silica gel in aluminium foil laminated pouches, glass or polyethylene bags is effective in retaining high seed germinability up to 7 years without loss of seedling vigour. When the seeds of pumpkin cv.Arka Chandan preserved in polyethylene bags at ambient, 5^{0}C and -20^{0}C for five years, seeds remained viable for four years, but high germination was maintained for 2 years only under ambient conditions, seed storability was enhanced to 5 years at 5^{0}C and -20^{0}C storage. The reduction in germinability was associated with increased leaching of electrolytes, soluble sugars, free amino acids and decrease in dehydrogenase activity in seeds (Doijode 1995 b).

Palanisamy *et al.* (1995) reported that moringa seeds stored in 700 gauge polyethylene bag recorded higher seed germination than the seeds stored in gada cloth bag after 12 months storage. Kannath (1996) observed that packing the seeds of

ashgourd cv.BH-21 in moisture impervious 700 gauge polythene bag was the best in maintaining high germination, vigour, dehydrogenase activity during storage. Brown paper bag and gada cloth bag were not seen suitable to maintain the seed viability. According to Anitha (1997) irrespective of the storage atmosphere, packing the seeds in 700 gauge polythene bags is ideal for maintaining viability and vigour of okra seeds. Seeds of sweet pepper cultivars E-84066 and Yolo Wonder stored at 25^{0}C showed reduced germination when storage time was extended to 56 months and 68 months respectively and those stored at 5^{0}C still germinated to over 80% (Passam *et al.*,1997).

From the informations given above it is well known that for getting good quality vegetable seeds the seed crop should be harvested at its optimum stage of maturity. This physiological maturity stages for different vegetables such as okra, chilli, onion, brinjal, cucurbits etc. were described here. Apart from the maturity of seeds, seed quality was influenced by the methods of seed extraction and fruit drying. In general seed germination was decreased with increase in drying air temperature. Among the different seed extraction methods hand extraction of seeds was good for better quality seeds. But in some crops, there is little difference between seed germination between manually and mechanically extracted seeds. High seed moisture at higher temperature hasten the process of seed deterioration resulting loss of viability. Seed storage studies conducted at different parts of the world were described here. From these studies it can be concluded that deterioration of seeds during prolonged storage differs between the vegetable crops and is influenced by storage methods and cultivation conditions. In this investigation about two chilli varieties Jwalasakhi and

Ujwala, we can find the optimum maturity stages, effective seed extraction and fruit drying methods and best storage methods for mainitaining the seed quality in our condition having a tropical humid climate.

Materials and methods

MATERIALS AND METHODS

The present investigation "Standardization of seed processing techniques in chilli" was carried out in the Vegetable Research Farm of the Department of Olericulture, College of Horticulture, Kerala Agricultural University, Vellanikkara during 1997 to 1998. The site is located at an altitude of 22.5 m above MSL and 10^0 32^1 N latitude and $76°16^1$ E longitude. The soil is sandy loam and the area enjoys a tropical warm humid climate. The study consisted of three experiments.

1. Studies on physiological maturity of seeds.
2. Standardization of seed extraction and drying methods.
3. Standardization of packaging materials and storage conditions.

3.1 Studies on physiological maturity of seeds

Two varieties of chilli, Ujwala and Jwalasakhi were grown in the vegetable research farm. Nursery preparation and sowing were done on twenty first April 1997. Seedlings were transplanted during the last week of May 1997. During the period of crop growth, the recommended cultural operations and plant protection measures (KAU, 1993) were carried out.

Flowering started by the end of July. Flowers were tagged by noting the date of anthesis on the label. The tagged flowers were observed for various parameters of fruit and seed development at periodic intervals as detailed below. Fruits were harvested at five days interval from the date of flower opening and continued upto seventy days, till the drying and shrinkage of fruits. The fruits thus collected at

1. Field view of the experimental plot of chilli, var. Jwalasakhi

2. Field view of the experimental plot of chilli, var. Ujwala

different intervals were designated serially from S_1 to S_{14} to represent five days to seventy days old fruits. A total of eighty fruits were examined in each stage of development (ten fruits per replication). The following fruit and seed characters were recorded.

(i) Fruit length (cm)

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

(ii) Fruit weight (g)

The weight of eighty fruits was taken at each stage of development and the mean value was expressed in grams.

(iii) Total number of seeds per fruit.

At each stage of development seeds from eighty fruits were separated and the mean number of seeds per fruit was recorded.

(iv) Number of well filled seeds per fruit.

From the total number of seeds obtained per fruit, well filled seed were seperated and counted.

(v) Percentage of well filled seeds per fruit

$$\text{percentage of well filled seeds} = \frac{\text{No. of well filled seeds}}{\text{Total No. of seeds}} \times 100$$

(vi) 1000 seed weight (dry seed)

Dried seeds were weighed to determine the 1000 seed weight and expressed in grams.

The seeds obtained in each treatment were packed in polythene bags and stored in ambient conditions. The observations on germination and seedling characters were recorded at monthly intervals and the following observations were recorded

(vii) Germination per cent

A total number of 50 seeds from each treatment were placed in sterilised sand medium in two replication and allowed to germinate under ambient conditions. Seedlings were watered daily and observed upto the tenth day of emergence of first seedling and the total number of normal seedlings were recorded. The mean number of seedlings produced was expressed as germination per cent.

(viii) Speed of germination

From the sample sown for recording germination, number of seedlings emerged was recorded daily until the tenth day of the emergence of first seedling. Cotyledon slipping out of the seed coat was taken as the criterion 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).

$$\text{Speed of germination} = \frac{X1}{Y1} + \frac{X2-X1}{Y2} + \text{-----} + \frac{Xn-(Xn-1)}{Yn}$$

Where, Xn = Per cent germination on n^{th} day

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

(ix) Root length of seedling

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

(x) Shoot length of seedling

After measuring the root length of seedlings the length between collar and tip of the terminal leaf was measured in cm and the mean value was recorded as shoot length.

(xi) Vigour index of seedlings

Vigour index was computed adopting 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

(xii) Sedling dry weight

After measuring the length five normal seedlings were air dried for six hours and then in hot air oven maintained at 85°c for 24 hours, cooled in a desiccator for 45 minutes, then the dry weight of the seedlings was recorded in milligrams (mg).

(xiii) Seed colour

According to the IPGRI descriptors for capsicum, colour of fresh and dried seeds were observed in the different stages (S_1 to S_{14}) of harvest of cultivars Ujwala

and Jwalasakhi. Change in seed colour was recorded during the storage period at monthly intervals.

3.2 Standardization of seed extraction and drying methods

Red ripe fruits of Ujwala and Jwalasakhi were harvested during the last fortnight of October 1997. The fruits harvested were subjected to the following extraction and drying methods.

3.2.1. Fruit drying in sunlight avoiding peak hours and hand extraction of seeds (E_1)

Fruits were dried in sunlight avoiding peak hours (12 noon to 3 p.m.) until the pericarp became completely dried and seeds were removed manually.

3.2.2. Fruit drying in sunlight avoiding peak hours and machine extraction of seeds (E_2)

Well ripe fruits were dried in sunlight avoiding peak hours (12 noon to 3 p.m.) until the pericarp became completely dried. These dried fruits were passed through an axial flow vegetable seed extracting machine. Then the seeds were cleaned manually by winnowing.

3.2.3. Drying in direct sunlight and threshing (E_3)

Fruits were dried in sunlight until the pericarp became completely dried and the seeds were extracted by threshing. The pericarp was seperated from the extracted seeds by winnowing.

3.2.4. Drying in direct sunlight and machine extraction (E_4)

Fruits were dried in sunlight and extracted in the machine. Extracted seeds were cleared by winnowing.

3.2.5. Drying in seed drier and threshing (E_5)

Well ripe fruits were dried in a seed drier at a temperature of 50°C until the pericarp became completely dried. Seeds were extracted by threshing and cleaned by winnowing.

3.2.6. Drying in seed drier and machine extraction (E_6)

Well ripe fruits were dried in the seed drier until the pericarp became completely dried. Dried fruits were extracted by machine and cleaned manually.

Dried and cleaned seeds of the six treatments were packed in polythene bags of 150 guage thickness and stored in ambient conditions. The seeds were taken out and tested for various quality parameters at monthly intervals. The following observations such as germination per cent, speed of germination, root length of seedling, shoot length of seedling, vigour index, seedling dry weight, electrical conductivity of the seed leachate and seed colour were recorded.

Electrical conductivity was recorded at monthly intervals using the procedure given by Presley (1958). Three replicates of 25 seeds were taken and washed in distilled water to remove all dirt, soil or chemicals. The seeds were then soaked in 20 ml 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 the 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 dsm^{-1}.

3.3 Standardization of packaging materials and storage conditions

Red ripe fruits of Ujwala and Jwalasakhi were harvested from the seed crop raised during April 1997. Seed were extracted manually cleaned thoroughly and dried to bring the moisture content to eight per cent. Seed samples were stored in different conditions in different packaging materials.

Different packaging materials used in this experiment were

P_1 Brown paper cover

P_2 Butter paper

P_3 Cloth bag

P_4 Polythene bag of 150 gauge thickness

P_5 Polythene bag of 700 gauge thickness

P_6 Control (open storage of dried fruits)

Seeds packed in the above packing materials were stored under the following conditions.

C_1 Room temperature / Ambient conditions

C_2 Air conditioned storage (25-27^{0}C)

C_3 Storage at 5°C temperature (B.O.D.)

There were 18 treatment combinations of six packaging materials and three storage conditions. Seed samples were drawn at monthly intervals and tested for various seed quality parameters such as germination per cent, speed of germination, root length of seedling, shoot length of seedling, vigour index, seedling dry weight, electrical conductivity of the seed leachate and seed colour

3.4. Statistical analysis

Statistical analysis of the data was done in computer using SPSS package in factorial completely randomised design (CRD) for experiment 3 and CRD for experiment 1 and 2.

Results

RESULTS

Results of the investigation on "Standardization of seed processing techniques in chilli" are presented under the following heads.

4.1. Studies on physiological maturity of seeds in chilli

4.2. Effect of seed extraction and fruit drying methods in chilli

4.3. Standardisation of packaging materials and storage conditions in chilli

4.1 Studies on physiological maturity of seeds in chilli

Means of fruit and seed characteristics during various developmental stages of fruits are furnished in Tables 1a, and 1b. Analysis of variance showed that there was significant difference among the treatments for the characters like length of fruits, weight of fruits, total number of seeds per fruit, number of well filled seeds per fruit, percentage of well filled seeds per fruit and 1000 seed weight after drying (Appendix I and II).

4.1.1. Fruit and seed characteristics of chilli at various stages of fruit maturity

4.1.1.1. Length of the fruit (cm)

a. Jwalasakhi

The length of the developing fruits increased significantly from 1.51 cm (5d.a.a.) to a maximum of 8.94 cm at 30 d.a.a. Thereafter a decrease in fruit length was observed from 40 d.a.a. The rate of increase in fruit length was the highest between 10 d.a.a and 15 d.a.a.(Table 1a)

b. Ujwala

Fruit length increased significantly from 1.77 cm (5 d.a.a.) to a maximum of 5.90 cm (40 d.a.a.). Thereafter slight decrease in fruit length was observed from 45 d.a.a. The rate of increase in fruit length was the highest between 5 d.a.a and 10 d.a.a.(Table 1b).

4.1.1.2. Fruit weight (g)

a. Jwalasakhi

The weight of developing fruits increased gradually from the day of anthesis. Mean weight of developing fruits increased significantly from 0.20 g (5 d.a.a.) to a maximum of 6.81 g (35 d.a.a.). Then it remained almost stable. From 45 d.a.a. a decrease in fruit weight was observed (Table 1a).

b. Ujwala

Fruit weight differed significantly in various stages of development. Mean weight of developing fruits increased gradually from 0.225 g (5 d.a.a.) to a maximum 2.288 g (40 d.a.a.). Decrease in fruit weight was observed from 45 d.a.a. (Table 1b).

4.1.1.3 Total number of seeds per fruit

a. Jwalasakhi

Total number of seeds was high (79.61) at 30 d.a.a.(Table 1a)

Table 1a. Mean fruit and seed characteristics of chilli var. Jwalasakhi at various stages of fruit maturity

Days after anthesis (d.a.a)	Length of the fruit (cm)	Fruit weight (g)	Total number of seeds per fruit	Number of well filled seeds per fruit	Percentage of well filled seeds per fruit	1000 seed weight (g)
5	1.51 ^{H}	0.204 ^{I}	53.68 ^{EFG}	-	-	0.281 ^{N}
10	2.91 ^{G}	0.473 ^{HI}	48.87 ^{FG}	-	-	0.480 ^{M}
15	6.58 ^{DE}	2.642 ^{F}	49.79 ^{FG}	-	-	1.439 ^{I}
20	7.44 ^{C}	3.679 ^{E}	60.59 ^{CDE}	-	-	2.049 ^{A}
25	6.98 ^{D}	5.127 ^{C}	48.69 ^{FG}	2.38 ^{G}	4.92 ^{C}	2.208 ^{J}
30	8.94 ^{A}	6.531 ^{A}	79.61 ^{A}	75.98 ^{A}	95.33 ^{AB}	2.269 ^{I}
35	8.85 ^{A}	6.811 ^{A}	72.07 ^{AB}	66.48 ^{B}	92.27 ^{AB}	3.635 ^{H}
40	7.84 ^{B}	6.523 ^{A}	68.89 ^{BC}	65.72 ^{BC}	95.47 ^{A}	4.242 ^{F}
45	7.95 ^{B}	6.077 ^{B}	57.31 ^{DEF}	52.94 ^{DE}	91.06 ^{B}	4.930 ^{A}
50	7.98 ^{B}	5.792 ^{B}	63.45 ^{BCDE}	59.20 ^{CD}	93.30 ^{AB}	4.766 ^{B}
55	6.69 ^{DE}	4.536 ^{D}	45.20 ^{G}	40.90 ^{F}	91.34 ^{B}	4.448 ^{D}
60	6.43 ^{E}	1.851 ^{G}	66.40 ^{BCD}	62.06 ^{BC}	93.62 ^{AB}	3.933 ^{G}
65	6.50 ^{E}	0.705 ^{H}	64.70 ^{BCD}	61.47 ^{BC}	94.96 ^{AB}	4.513 ^{C}
70	5.59 ^{F}	0.535 ^{HI}	54.86 ^{EFG}	49.81 ^{E}	91.38 ^{B}	4.356 ^{E}

Table 1b. Mean fruit and seed characteristics of chilli var. Ujwala at various stages of fruit maturity

Days after anthesis (d.a.a)	Length of the fruit (cm)	Fruit weight (g)	Total number of seeds per fruit	Number of well filled seeds per fruit	Percentage of well filled seeds per fruit	1000 seed weight (g)
5	1.77 ^{G}	0.225 ^{I}	42.50 ^{D}	-	-	0.272 ^{M}
10	4.06 ^{F}	0.648 ^{H}	46.03 ^{CD}	-	-	0.473 ^{L}
15	4.64 ^{E}	1.082 ^{G}	52.43 ^{ABC}		-	1.244 ^{K}
20	5.26 ^{BC}	1.186 ^{FG}	50.51 ^{BC}	-	-	2.063 ^{J}
25	5.11 ^{CD}	1.668 ^{D}	42.38 ^{D}	-	-	2.170 ^{I}
30	5.32 ^{BC}	1.699 ^{CD}	54.23 ^{ABC}	14.49 ^{E}	19.45 ^{D}	2.297 ^{H}
35	5.13 ^{BCD}	1.972 ^{B}	57.57 ^{AB}	24.85 ^{D}	43.89 ^{C}	2.852 ^{G}
40	5.90 ^{A}	2.288 ^{A}	52.21 ^{ABC}	39.30 ^{C}	70.17 ^{B}	3.726 ^{A}
45	5.19 ^{BCD}	1.832 ^{BCD}	54.11 ^{ABC}	47.96 ^{AB}	89.53 ^{A}	3.579 ^{B}
50	5.73 ^{A}	1.851 ^{BC}	53.81 ^{ABC}	48.94 ^{AB}	90.91 ^{A}	3.522 ^{B}
55	5.13 ^{BC}	1.426 ^{E}	53.98 ^{ABC}	49.40 ^{AB}	91.50 ^{A}	3.359 ^{C}
60	5.36 ^{B}	1.283 ^{EF}	55.95 ^{AB}	50.69 ^{AB}	90.58 ^{A}	3.175 ^{D}
65	5.03 ^{CD}	0.751 ^{H}	57.26 ^{AB}	52.48 ^{AB}	91.50 ^{A}	2.971 ^{F}
70	4.91 ^{DE}	0.710 ^{H}	59.59 ^{A}	53.47 ^{A}	91.50 ^{A}	3.072 ^{E}

Treatment means with the same alphabet as superscript do not differ significantly

b. Ujwala

Total number of seeds per fruit was maximum at 70 d.a.a.(59.59). There was no significant difference between the treatments from 30 d.a.a. to 70 d.a.a. and were on par with each other (Table1b)

4.1.1.4 Percentage of well filled seeds per fruit

a. Jwalasakhi

Percentage of well filled seeds was the highest at 40 d.a.a. (95.47 %). There was not much difference between the treatments from 40 d.a.a. (Table 1a).

b. Ujwala

Fruits harvested from 45 days to 70 days maturity recorded the highest percentage of well filled seeds per fruit and it was minimum for fruits harvested at 30 d.a.a. (Table 1a).

4.1.1.5 1000 seed weight (g)

a. Jwalasakhi

The mean 1000 seed weight (dry) at different stages of fruit development was highly significant. Seeds from fruits of 45 d.a.a. recorded the highest 1000 seed weight (4.930g) and it was the lowest (0.281 g) at 5 d.a.a. (Table 1a)

b. Ujwala

There was significant difference between the stages of fruit development for the mean 1000 seed weight. Seeds from fruits harvested at 40 d.a.a. recorded the

Table 2a. Effect of various stages of fruit maturity on germination percentage in chilli var. Jwalasakhi.

Days after anthesis (d.a.a.)	Months after storage 0	1	2	3	4	5	6	Mean
S_7(35)	15.00 (21.45)	12.50 (20.60)	12.50 (20.60)	20.00 (26.38)	10.00 (17.85)	0.00 (6.42)	10.00 (17.85	11.43 ^{F} (18.74)
S_8(40)	50.00 (44.98)	47.50 (43.55)	42.50 (40.62)	32.50 (34.73)	17.50 (24.21)	30.00 (32.89)	35.00 (36.21)	36.43 ^{DE} (36.74)
S_9(45)	82.50 (65.30)	72.50 (58.56)	82.50 (68.64)	62.50 (52.23)	57.50 (49.34)	67.50 (55.36)	47.50 (43.55)	67.50 ^{A} (56.18)
S_{10}(50)	70.00 (56.84)	55.00 (47.86)	75.00 (61.14)	72.50 (58.37	62.50 (52.76)	82.50 (66.91)	65.00 (53.76)	68.93 ^{A} (56.81)
S_{11}(55)	52.50 (46.43)	47.50 (43.50)	62.50 (52.48)	30.00 (32.89)	30.00 (33.12)	27.50 (30.27)	40.00 (39.19)	41.43 ^{D} (39.70)
S_{12}(60)	65.00 (53.76)	50.00 (44.98)	50.00 (44.98)	25.00 (29.99)	32.50 (34.60)	60.00 (50.78)	60.00 (50.78)	48.93 ^{BC} (44.27)
S_{13}(65)	67.50 (55.36)	47.50 (43.55)	40.00 (39.19)	35.00 (36.21)	22.50 (28.27)	52.50 (46.42)	40.00 (39.19)	43.57 ^{CD} (41.17)
S_{14}(70)	75.00 (60.09)	52.50 (46.42)	57.50 (49.44)	47.50 (43.53	45.00 (42.05)	37.50 (37.66)	55.00 (47.86)	52.86 ^{B} (46.72)
Mean	59.69 (50.53)^{A}	48.13 (43.63)^{BC}	52.81 (47.14)^{AB}	40.63 (39.29)^{CD}	34.69 (35.28)^{D}	44.69 (40.84)^{CD}	44.06 (40.47)^{CD}	46.39 ^{C} (42.45)

Table 2b. Effect of various stages of fruiti maturity on germination percentage in chilli var. Ujwala.

Days after anthesis (d.a.a.)	Months after storage 0	1	2	3	4	5	6	Mean
S_7(35)	38.00 (38.04)	18.00 (21.30)	22.00 (27.94)	26.00 (30.63)	27.50 (31.00)	18.00 (25.06)	2.00 (8.64)	21.64 ^{E} (26.08)
S_8(40)	40.00 (39.14)	54.00 (47.28)	44.00 (41.49)	38.00 (37.49)	27.50 (31.41)	20.00 (26.45)	18.00 (25.06)	34.50 ^{CD} (35.47)
S_9(45)	82.00 (64.90)	60.00 (50.77)	52.00 (46.13)	58.00 (49.68)	72.50 (58.56)	36.00 (36.34)	40.00 ((39.14)	57.21 ^{A} (49.36)
S_{10}(50)	68.00 (55.57)	42.00 (40.38)	34.00 (34.34)	58.00 (49.62)	57.50 (49.34)	80.00 (63.41)	54.00 (47.28)	56.21 ^{A} (48.56)
S_{11}(55)	54.00 (47.28)	18.00 (24.79)	42.00 (40.28)	48.00 (43.80)	85.00 (67.19)	64.00 (53.14)	56.00 (48.53)	52.43 ^{AB} (46.43)
S_{12}(60)	60.00 (50.93)	38.00 (37.72)	16.00 (21.73)	32.00 (33.19)	57.50 (49.34)	46.00 (42.67)	40.00 (38.87)	41.36 ^{CD} (39.21)
S_{13}(65)	62.00 (51.93)	24.00 (28.56)	18.00 (24.18)	58.00 (49.93)	62.50 (52.31)	48.00 (43.82)	44.00 (41.43)	45.21 ^{BC} (41.74)
S_{14}(70)	80.00 (63.52)	16.00 (23.57)	24.00 (29.24)	20.00 (26.45)	25.00 (29.99)	26.00 (30.21)	22.00 (27.94)	30.43 ^{D} (32.99)
Mean	60.50 (51.41)^{A}	33.75 (34.30)^{CD}	31.50 (33.17)^{D}	42.25 (40.10)^{BC}	51.83 (46.14)^{AB}	42.25 (40.14)^{BC}	34.50 (34.61)^{CD}	

Treatment means with the same alphabet as subscript do not differ significantly

b. Ujwala

Seed germination differed significantly at different fruit maturity stages. Here also the process of seed germination started at a fruit maturity of 35 d.a.a. (S_7). Seeds of 45 days maturity (S_9) recorded the maximum germination of 82 %.

After a storage period of six months seeds of 45-50 days maturity retained the maximum mean germination per cent of 57.21 and 56.21 respectively. Seeds recorded the highest mean germination per cent (60.50 %) before storage and it decreased significantly after six months (Table 2b).

4.1.2.2. Speed of germination

a. Jwalasakhi

Speed of germination differed significantly for seeds from fruits of different stages of maturity and also for different periods of storage. Immediately after harvest speed of germination was the lowest (1.74) for seeds of 35 days maturity (S_7) and the highest was recorded for 45 days maturity (S_9). These seeds recorded the highest mean speed of germination after six months storage (Table 3a)

b. Ujwala

Seeds from fruits of 35 days maturity (S_7) recorded the lowest speed of germination of 4.06. Seeds of 45 days maturity (S_9) recorded the highest speed germination of 9.48 and it declined to 6.01 after six months of storage. After storage the mean speed of germination was maximum for seeds of 50 days maturity (S_{10}) and it declined from 8.45 to 6.29 after six months (Table 3b).

Table 3a. Effect of various stages of fruit maturity on speed of germination in chilli, var. Jwalasakhi.

Days after anthesis (d.a.a.)	Months after storage							
	0	1	2	3	4	5	6	Mean
S_7(35)	1.74	1.33	1.48	2.74	1.02	0	0.95	1.32^{E}
S_8(40)	6.07	5.09	5.06	4.44	1.7	3.82	3.15	4.19^{D}
S_9(45)	10.25	8.09	9.90	7.60	6.11	9.5	5.17	8.09^{A}
S_{10}(50)	8.18	6.17	8.46	8.72	6.82	11.65	5.98	7.99^{A}
S_{11}(55)	7.00	4.89	7.72	4.08	3.52	3.34	3.72	4.90^{CD}
S_{12}(60)	8.35	5.26	6.05	3.08	3.79	9.67	6.23	6.06^{B}
S_{13}(65)	8.31	5.32	4.66	4.28	2.54	7.10	8.21	5.77^{BC}
S_{14}(70)	8.92	5.45	6.59	5.86	4.71	4.73	6.26	6.07^{B}
Mean	7.35^{A}	5.20^{B}	6.24^{AB}	5.10^{B}	3.78^{C}	6.23^{AB}	4.96^{BC}	

Table 3b. Effect of various stages of fruiti maturity on speed of germination in chilli, var. Ujwala.

Days after anthesis (d.a.a.)	Months after storage							
	0	1	2	3	4	5	6	Mean
S_7(35)	4.06	1.72	2.33	2.68	2.31	2.04	0.20	2.19^{E}
S_8(40)	4.46	5.56	5.17	4.14	2.31	2.62	1.53	3.68^{CD}
S_9(45)	9.48	5.85	5.64	7.09	6.18	4.23	3.58	6.01^{AB}
S_{10}(50)	8.45	4.92	3.77	6.14	5.20	10.54	5.00	6.29^{A}
S_{11}(55)	6.02	1.90	5.16	5.94	7.75	8.59	5.31	5.81^{AB}
S_{12}(60)	7.83	3.93	1.76	4.26	4.74	6.24	3.32	4.58^{C}
S_{13}(65)	7.04	2.21	2.00	7.46	5.48	6.25	3.75	4.88^{BC}
S_{14}(70)	9.43	1.59	3.15	2.03	1.74	2.63	1.79	3.19^{DE}
Mean	7.10^{A}	3.46^{CD}	3.62^{CD}	4.97^{B}	4.46^{BC}	5.39^{B}	3.06^{D}	

Treatment means with the same alphabet as superscript do not differ significantly

4.1.2.3. Shoot length (cm)

a. Jwalasakhi

Lowest shoot length (1.62 cm) was recorded for the seeds of 35 days maturity (S_7) and the highest (2.19 cm) was recorded for the seeds of 40 d.a.a. Seeds of 45 and 50 days maturity recorded the maximum mean shoot length of (2.19 and 2.13 cm respectively) after six months. storage. (Table 4a)

b. Ujwala

Seeds from fruits harvested at 50 d.a.a. (S_{10}) recorded the maximum shoot length of 1.86 cm and it declined to 1.72 cm (mean shoot length) after storage. Seeds of 45, 50, 55 and 65 days maturity recorded maximum shoot length (1.74, 1.72, 1.84, 1.81) cm respectively after six months storage and were on par with each other (Table 4b).

4.1.2.4 Root length (cm)

a. Jwalasakhi

Maximum root length was recorded for the seeds of 40 days maturity (S_8). It declined to 1.05 cm and recorded the maximum mean root length even after six months storage and was on par with seeds of 45 days maturity (S_9, 1.14 cm) (Table 5a).

b. Ujwala

Seeds of 40 d.a.a. (S_8) recorded the maximum root length of 1.61 cm and it declined to 1.08 cm mean root length after six months storage. The maximum mean

Table 4a. Effect of various stages of fruit maturity on Shoot length (cm) in chilli, var. Jwalasakhi seedlings

Days after anthesis (d.a.a.)	Months after storage							
	0	1	2	3	4	5	6	Mean
S_7(35)	1.62	1.36	2.19	1.90	1.48	0.00	2.01	1.51^{A}
S_8(40)	2.19	2.18	2.47	1.96	1.53	1.78	1.81	1.99^{BC}
S_9(45)	1.74	1.99	2.54	2.33	2.43	2.26	2.06	2.19^{A}
S_{10}(50)	1.97	1.98	2.15	2.26	1.94	2.16	2.425	2.13^{A}
S_{11}(55)	1.75	1.56	2.00	2.48	2.23	1.91	1.975	1.99^{BC}
S_{12}(60)	1.76	1.79	2.26	1.81	2.16	2.05	1.78	1.94^{C}
S_{13}(65)	1.87	1.45	1.76	2.19	2.09	1.76	2.26	1.91^{CD}
S_{14}(70)	1.67	1.55	1.80	2.37	1.55	1.79	2.22	1.85^{D}
Mean	1.82^{BC}	1.73^{C}	2.14^{A}	2.16^{A}	1.93^{BC}	1.71^{C}	2.07^{B}	

Table 4b. Effect of various stages of fruit maturity on Shoot length (cm) in chilli, var. Ujwala.

Days after anthesis (d.a.a.)	Months after storage							
	0	1	2	3	4	5	6	Mean
S_7(35)	1.69	1.73	1.48	1.62	1.49	1.41	1.03	1.49^{B}
S_8(40)	1.68	1.65	1.88	1.72	2.02	1.46	1.43	1.69^{AB}
S_9(45)	1.71	1.9	1.68	1.94	1.61	1.46	1.85	1.74^{A}
S_{10}(50)	1.86	2.01	1.47	1.8	1.75	1.51	1.69	1.72^{A}
S_{11}(55)	1.68	1.61	2.21	1.9	1.65	1.85	2.01	1.84^{A}
S_{12}(60)	1.66	1.8	1.14	1.55	1.74	1.73	1.90	1.64^{AB}
S_{13}(65)	1.79	1.74	1.35	1.75	1.69	2.05	2.32	1.81^{A}
S_{14}(70)	1.54	1.42	1.98	1.65	1.47	1.6	1.81	1.64^{AB}
Mean	1.70^{A}	1.73^{A}	1.65^{A}	1.74^{A}	1.68^{A}	1.64^{A}	1.75^{A}	

Treatment means with the same alphabet as superscript do not differ significantly

Table 5a. Effect of various stages of fruit maturity on root length (cm) in chilli, var. Jwalasakhi seedlings

Days after anthesis (d.a.a.)	Months after storage							Mean
	0	1	2	3	4	5	6	
S_7(35)	0.74	1.02	1.02	1.60	0.78	0.00	0.71	0.84^{D}
S_8(40)	1.30	1.13	0.65	1.76	0.90	0.82	0.815	1.05^{A}
S_9(45)	0.96	1.16	1.06	2.02	1.12	0.87	0.775	1.14^{A}
S_{10}(50)	0.80	0.83	0.92	1.50	0.83	0.89	0.98	0.96^{BC}
S_{11}(55)	0.72	1.05	1.02	1.83	0.86	1.12	0.57	1.02^{AB}
S_{12}(60)	0.72	1.05	1.06	1.39	1.01	0.83	0.675	0.96^{BC}
S_{13}(65)	1.04	1.33	1.08	1.68	0.94	1.17	0.475	1.10^{A}
S_{14}(70)	0.77	1.03	1.06	1.58	0.81	1.30	0.675	1.03^{AB}
Mean	0.88^{C}	1.07^{B}	0.98^{BC}	1.67^{A}	0.90^{C}	0.88^{C}	0.709^{D}	

Table 5b. Effect of various stages of fruit maturity on root length (cm) in chilli, var. Ujwala seedlings

Days after anthesis (d.a.a.)	Months after storage							Mean
	0	1	2	3	4	5	6	
S_7(35)	1.17	1.50	0.89	1.33	0.71	0.82	0.26	0.96^{B}
S_8(40)	1.61	1.33	1.18	1.50	0.86	0.56	0.53	1.08^{AB}
S_9(45)	1.02	1.26	0.96	1.59	1.00	1.24	0.72	1.11^{AB}
S_{10}(50)	0.92	1.00	1.15	1.31	0.75	1.08	0.58	0.97^{B}
S_{11}(55)	0.90	1.30	1.19	1.71	0.95	0.86	0.68	1.08^{AB}
S_{12}(60)	1.48	1.27	0.98	1.64	0.82	1.32	0.56	1.15^{A}
S_{13}(65)	1.16	1.50	1.07	1.08	0.73	0.80	0.74	1.01^{AB}
S_{14}(70)	0.77	1.36	0.82	1.35	1.00	0.76	0.64	0.96^{B}
Mean	1.13^{B}	1.31^{A}	1.03^{BC}	1.44^{A}	0.85^{D}	0.93^{CD}	0.59^{E}	

Treatment means with the same alphabet as superscript do not differ significantly

root length (1.15) was recorded for seeds of 60 days maturity after storage (Table 5b).

4.1.2.5 Vigour index of seedling

a. Jwalasakhi

Seeds from fruits of different stages of maturity showed significant difference in vigour index. Seeds from fruits harvested at 50 d.a.a (S_{10}) and 65 d.a.a. (S_{13}) recorded the maximum vigour index of 195.58 and 195.90 respectively. Even after six months storage seeds of 50 days maturity retained the maximum (209.42) mean vigour index and it declined to 140.19 in seeds of 65 days maturity (Table 6a). Minimum vigour index was recorded for seeds of 35 days maturity (S_7, 33.76) and it declined to 31.61 after six months of storage (Table 6a).

b. Ujwala

Maximum vigour index (218.08) was record for seeds of 45 days maturity (S_9) and it retained the maximum (162.00) after six months storage. Vigour index was the lowest for seeds of 35 days maturity (S_7, 109.98) and it declined to 62.19 and recorded the minimum mean vigour index after six months storage (Table 6b)

4.1.2.6 Seedling dry weight (mg/seedling)

a. Jwalasakhi

The dry matter production by seedlings was maximum (3.12 mg/seedling) for seeds of 45 days maturity and it declined to 2.61 mg/seedling and recorded the maximum mean seedling dry weight even after six months storage. Minimum

Table 6a. Effect of various stages of fruit maturity on vigour index in chilli, var. Jwalasakhi seedlings

Days after anthesis (d.a.a.)	Months after storage							
	0	1	2	3	4	5	6	Mean
S_7(35)	33.76	30.58	40.62	69.47	22.59	0.00	24.25	31.61^{C}
S_8(40)	167.40	157.13	132.09	120.65	42.82	78.04	92.05	112.88^{B}
S_9(45)	179.92	235.09	299.30	271.48	204.20	212.05	134.375	219.49^{A}
S_{10}(50)	195.58	152.00	225.00	272.50	172.48	252.51	195.90	209.42^{A}
S_{11}(55)	130.05	121.35	186.75	127.90	92.26	83.07	103.425	120.69^{B}
S_{12}(60)	158.90	141.88	183.70	79.75	101.85	171.95	146.50	140.65^{B}
S_{13}(65)	195.90	131.40	138.00	135.50	68.10	153.34	159.10	140.19^{B}
S_{14}(70)	181.20	139.21	162.98	186.55	107.22	115.57	153.35	149.44^{B}
Mean	155.34^{AB}	138.58^{B}	171.05^{A}	157.98^{AB}	101.44^{C}	133.32^{B}	126.10^{BC}	

Table 6b. Effect of various stages of fruit maturity on vigour index in chilli, var. Ujwala seedlings

Days after anthesis (d.a.a.)	Months after storage							
	0	1	2	3	4	5	6	Mean
S_7(35)	109.98	86.76	54.68	76.14	59.97	42.63	5.14	62.19^{F}
S_8(40)	144.46	157.53	129.04	77.48	80.06	39.21	35.58	94.77^{DE}
S_9(45)	218.08	183.28	142.20	204.30	189.81	93.18	103.12	162.00^{A}
S_{10}(50)	183.00	123.10	58.60	179.76	145.02	206.65	122.50	145.52^{AB}
S_{11}(55)	140.32	61.14	159.68	176.94	220.15	173.8	148.50	154.36^{A}
S_{12}(60)	207.84	95.64	20.46	101.62	147.20	141.94	97.40	116.01^{CD}
S_{13}(65)	179.58	96.84	56.42	160.34	150.02	134.74	134.12	130.30^{BC}
S_{14}(70)	180.16	44.40	61.34	60.08	61.91	58.98	53.76	74.38^{EF}
Mean	170.43^{A}	106.09^{CD}	85.30^{D}	129.58^{B}	131.77^{B}	111.39^{BC}	87.52^{D}	

Treatment means with the same alphabet as superscript do not differ significantly

Table 7a. Effect of various stages of fruit maturity on seedling dry weight (mg/seedling) of chilli, var. Jwalasakhi seedlings.

Days after anthesis (d.a.a.)	Months after storage							
	0	1	2	3	4	5	6	Mean
S_7(35)	1.75	2.13	1.38	1.63	1.00	0.00	1.61	1.36^{E}
S_8(40)	2.90	2.58	1.53	2.00	1.05	1.4	1.89	1.91^{D}
S_9(45)	3.12	2.85	2.17	2.49	2.57	2.43	2.62	2.61^{A}
S_{10}(50)	2.72	2.71	2.15	1.95	1.95	2.33	2.57	2.34^{B}
S_{11}(55)	2.55	2.56	2.13	2.06	1.89	1.62	2.17	2.14^{C}
S_{12}(60)	2.25	2.52	1.93	1.46	1.37	1.91	2.15	1.94^{D}
S_{13}(65)	2.66	2.28	1.68	2.03	1.44	2.16	1.98	2.03^{CD}
S_{14}(70)	2.32	2.49	1.89	2.20	1.58	1.95	1.80	2.03^{CD}
Mean	2.53^{A}	$.2.51^{A}$	1.86^{C}	1.98^{BC}	1.61^{DE}	1.73^{CD}	2.10^{B}	

Table7b. Effect of various stages of fruit maturity on seedling dry weight (mg/seedling) in chilli, var. Ujwala seedlings

Days after anthesis (d.a.a.)	Months after storage							
	0	1	2	3	4	5	6	Mean
S_7(35)	1.59	1.30	1.40	1.32	1.06	1.21	0.72	1.23^{D}
S_8(40)	2.16	1.57	1.48	1.68	1.76	1.88	1.57	1.73^{A}
S_9(45)	1.86	1.80	1.41	1.45	1.59	1.76	1.61	1.64^{AB}
S_{10}(50)	1.92	2.01	1.52	1.53	1.39	1.58	1.68	1.66^{AB}
S_{11}(55)	1.81	1.33	1.53	1.56	0.98	1.71	1.75	1.52^{BC}
S_{12}(60)	1.54	1.45	1.22	1.31	1.20	1.56	1.84	1.45^{C}
S_{13}(65)	2.61	1.49	1.39	1.52	1.26	1.92	2.07	1.75^{A}
S_{14}(70)	1.82	1.22	1.40	1.41	1.03	1.19	1.95	1.43^{C}
Mean	1.91^{A}	1.52^{BCD}	1.42^{D}	1.47^{CD}	1.28^{E}	1.60^{BC}	1.65^{B}	

Treatment means with the same alphabet as superscript do not differ significantly

seedling dry weight was recorded for seeds of 35 days maturity and it declined from 1.75 to 1.36 mg per seedling after six months storage (Table 7a).

b. Ujwala

Seedling dry weight was maximum for seeds of 65 days maturity (S_{13}, 2.61 mg/seedling) and declined to 1.75 mg/seedling after six months storage. It recorded the maximum mean dry matter production per seedling after storage and was on par with seeds of 40 days maturity (S_8, 1.73 mg/Seedling) (Table 7b)

4.1.2.7 Seed colour

a. Jwalasakhi

Seeds were tender, watery and Whitish in colour upto 20 d.a.a. (S_4). Greenish tinch was more to the seeds of 5 and 10 days maturity and it gradually changed to creamish white by 35 d.a.a. (S_7). Seed filling was completed by 40 d.a.a. (S_8) and they became cream in colour. Seeds of 5 and 10 days maturity completely blackened on drying. There was a mixture of brownish and whitish seeds upto 25 d.a.a. (S_5). Unfilled whitish seeds were obtained from 30 and 35 d.a.a. Seed were well filled and yellowish cream in colour from 40 d.a.a. (S_8).

b. Ujwala

Similar to Jwalasakhi seeds were tender, watery and greenish white upto 10 d.a.a. (S_2). From 15 to 30 d.a.a. (S_3 to S_6) white colour changed to cream coloured seeds. From 35 d.a.a. (S_7) there was yellowish tinch to the seeds. Seeds were well filled and (deep yellow cream in colour) from 40 d.a.a. (S_8). On drying tender seeds

of (5 and 10 d.a.a.) become completely blackened. There was a mixture of brownish and whitish seeds from 15 to 25 d.a.a. (S_3 to S_5). Seeds were cream in colour at 30 and 35 days maturity. On drying deep yellow coloured well filled seeds were obtained from 40 d.a.a. (S_8).

4.2. Effect of seed extraction and fruit drying methods in chilli

Studies were conducted using chilli cultivars Jwalasakhi and Ujwala with a view to standardise the fruit drying and seed extraction methods in chilli. For this six combination of fruit drying and seed extraction were tried and seeds were tested for six months. Analysis of variance is given in Appendix IV and V.

4.2.1 Germination per cent

a. Jwalasakhi

There was significant difference in the overall mean for different combination fruity drying seed extraction methods. Among the different treatments hand extraction of seeds and fruit drying in sunlight avoiding the peak hours (E_1) recorded the highest overall germination (48.76 %) and the lowest (14.67 %) was recorded for fruits dried in seed drier extracted by machine (E_6).

Overall mean for different months differed significantly. Highest germination (57.11 %) was recorded for the seeds immediately after extraction, which gradually decreased to 24.22 per cent after six months of storage (Table 8a).

Table 8a. Effect of various methods of seed extraction and fruit drying on germination per cent in chilli, var. Jwalasakhi seeds

Treatments	Months after storage							Mean
	0	1	2	3	4	5	6	
E_1	80.00	62.67	74.67	44.00	26.67	24.00	29.33	48.76^{A}
	(63.68)	(52.35)	(59.98)	(41.41)	(28.27)	(28.88)	(32.7)	(43.92)
E_2	72.00	45.33	(54.67)	44.00	18.67	14.67	34.67	40.57^{B}
	(58.66)	(42.27)	(47.69)	(41.49)	(23.28)	(21.47)	(35.52)	(38.63)
E_3	57.33	42.67	49.33	34.67	38.67	20.00	38.67	40.19^{AB}
	(49.33)	(40.73)	(44.62)	(35.86)	(38.31)	(26.09)	(38.31)	(39.04)
E_4	76.00	41.33	53.33	22.67	33.33	10.67	24.00	37.33^{B}
	(60.78)	(39.87)	(47.03)	(26.77)	(34.98)	(18.45)	(28.40)	(36.61)
E_5	30.67	25.33	25.33	9.33	10.67	6.67	10.67	16.95^{C}
	(33.60)	(29.98)	(29.98)	(17.17)	(17.85)	(14.37)	(18.45)	(23.06)
E_6	26.67	26.67	22.67	9.33	4.00	5.33	8.00	14.67^{C}
	(30.79)	(31.06)	(28.04)	(17.35)	(11.46)	(12.74)	(16.07)	(21.07)
Mean	57.11^{A}	40.67^{B}	46.67^{B}	27.33^{C}	22.00^{C}	13.56^{D}	24.22^{C}	
	(49.51)	(39.38)	(42.89)	(30.01)	(25.69)	(20.33)	(28.24)	

Table 8b. Effect of various methods of seed extraction and fruit drying on germination per cent in chilli var. Ujwala seeds

Treatments	Months after storage							Mean
	0	1	2	3	4	5	6	
E_1	68.00	48.00	30.67	25.33	18.67	17.33	30.67	34.10^{A}
	(55.70)	(43.80)	(33.54)	(29.92)	(24.97)	(23.18)	(33.42)	(34.93)
E_2	61.33	41.33	30.67	16.00	18.67	10.67	16.00	27.81^{B}
	(51.63)	(39.95)	(33.60)	(23.46)	(25.25)	(18.81)	(22.87)	(30.80)
E_3	54.67	26.67	33.333	18.67	10.67	8.00	14.67	23.81^{B}
	(47.67)	(30.55)	(35.13)	(25.25)	(18.45)	(16.07)	(22.14)	(27.94)
E_4	48.00	41.33	33.33	18.00	10.67	6.67	13.33	24.48^{B}
	(43.80)	(39.94)	(35.10)	(24.40)	(18.81)	(14.44)	(20.55)	(28.15)
E_5	30.67	22.67	21.33	14.67	8.00	2.67	8.00	15.43^{C}
	(33.49)	(27.89)	(27.48)	(22.18)	(16.67)	(9.60)	(16.07)	(21.83)
E_6	18.67	16.00	22.67	10.67	5.33	2.67	6.67	11.81^{C}
	(24.51)	(22.35)	(28.35)	(18.45)	(13.16)	(9.60)	(14.79)	(18.75)
Mean	46.89^{A}	32.67^{B}	28.67^{B}	17.22^{C}	12.00^{D}	8.00^{E}	14.89^{CD}	
	(42.80)	(34.67)	(32.20)	(23.94)	(19.45)	(15.28)	(21.70)	

Treatment means with the same alphabet as superscript do not differ significantly

E_1 : Hand extraction and fruit drying under sunlight avaiding the peak hours (12 noon to 3 pm)
E_2 : Machine extraction and fruit drying under sunlight avoiding the peak hours (12 noon to 3 pm)
E_3 : Drying in direct sunlight and threshing
E_4 : Drying in direct sunlight and machine extraction
E_5 : Drying in seed drier and threshing
E_6 : Drying in seed drier and machine extraction

b. Ujwala

Under different methods of fruit drying and seed extraction, hand extracted seeds of fruits dried in sunlight avoiding the peak hours (E_1) recorded the highest overall germination percentage (34.10 %). Mean germination percentage was lowest for the seeds of fruits dried in seed drier extracted by machine (E_6, 11.81%).

The overall mean for months differed significantly. The highest mean germination (46.89 %) was recorded for the seeds immediately after extraction and it gradually decreased to 14.89 per cent after six months storage(Table 8b).

4.2.2. Speed of germination

a. Jwalasakhi

It was observed that, different combinations of fruit drying and seed extraction had significant effect on speed of germination. Highest mean speed of germination (6.09) was recorded for hand extracted seeds of fruits dried in sunlight avoiding the peak hours (E_1). Mean speed of germination was the lowest (1.63) for the seed dried in seed drier extracted by machine (E_6).

The overall mean for different months differed significantly. The highest (7.71) was recorded immediately after extraction and it was reduced to 2.30 after six months storage. (Table 9a)

b. Ujwala

The mean speed of germination differed significantly under different combinations of fruit drying and seed extraction. It was the highest (3.45) for fruits

Table 9a. Effect of various methods of seed extraction and fruit drying on speed of germination in chilli, var. Jwalasakhi

Treatments	Months after storage							
	0	1	2	3	4	5	6	Mean
E_1	11.19	7.67	9.79	5.21	2.85	3.20	2.73	6.09^{A}
E_2	9.93	5.73	6.95	5.18	1.98	1.95	3.28	5.00^{B}
E_3	7.67	5.66	5.03	4.06	4.32	2.47	3.72	4.70^{B}
E_4	10.73	5.83	6.40	2.72	3.64	1.30	2.34	4.71^{B}
E_5	3.42	2.81	2.78	1.03	1.20	0.86	0.94	1.86^{C}
E_6	3.31	2.83	2.41	1.03	0.45	0.61	0.78	1.63^{C}
Mean	7.71^{A}	5.09^{B}	5.56^{B}	3.21^{C}	2.41^{CD}	1.73^{D}	2.30^{CD}	

Table 9b. Effect of various methods of seed extraction and fruit drying on speed of germination in chilli, var. Ujwala

Treatments	Months after storage							
	0	1	2	3	4	5	6	Mean
E_1	7.05	5.20	2.62	2.70	2.39	1.90	2.03	3.45^{A}
E_2	7.06	4.18	2.40	1.85	2.15	1.07	1.32	2.86^{B}
E_3	6.76	2.83	2.65	2.09	1.32	0.84	1.08	2.51^{B}
E_4	5.47	4.46	2.76	1.74	1.35	0.80	0.89	2.49^{B}
E_5	3.17	2.33	1.67	1.73	1.02	0.33	0.78	1.58^{C}
E_6	2.13	1.58	1.77	1.19	0.71	0.31	0.62	1.19^{D}
Mean	5.27^{A}	3.43^{B}	2.31^{C}	1.88^{CD}	1.49^{DE}	0.88^{E}	1.16^{E}	

Treatment means with the same alphabet as superscript do not differ significantly

E_1 : Hand extraction and fruit drying under sunlight avoiding the peak hours (12 noon to 3 pm)
E_2 : Machine extraction and fruit drying under sunlight avoiding the peak hours (12 noon to 3 pm)
E_3 : Drying in direct sunlight and threshing
E_4 : Drying in direct sunlight and machine extraction
E_5 : Drying in seed drier and threshing
E_6 : Drying in seed drier and machine extraction

dried in sunlight avoiding the peak hours and seeds extracted by hand (E_1). Machine extracted seeds of fruits dried in seed drier recorded the lowest mean speed of germination (E_6, 1.19).

There was significant difference in overall mean speed of germination for months. It was highest (5.27) for seeds immediately after extraction and gradually decreased to 1.16 after six months storage. (Table 9b)

4.2.3. Shoot length (cm)

a. Jwalasakhi

Different combinations of fruit drying and seed extraction had significant effect on shoot length. The overall mean shoot length was highest (2.16 cm) for fruits dried in direct sunlight extracted by machine (E_4). Lowest mean shoot length (1.74 cm) was recorded for fruits dried in seed drier and seeds extracted by threshing (E_5).

The overall mean for different months had significant effect on shoot length. Shoot length was maximum for seeds after one month storage (2.63 cm) and lowest shoot length (1.49 cm) was recorded for seeds after five months of storage (Table 10a).

b. Ujwala

Overall mean for shoot length differed significantly under different combinations of fruit drying and seed extraction. The mean shoot length was highest (1.77 cm) for machine extracted seeds of fruits dried in sunlight avoiding the peak

Table 10a. Effect of various methods of seed extraction and fruit drying on shoot length (cm) in chilli, var. Jwalasakhi seedlings

Treatments	Months after storage							
	0	1	2	3	4	5	6	Mean
E_1	2.40	1.71	2.44	2.23	1.58	1.57	1.62	1.94 ^{ABC}
E_2	2.35	2.84	2.38	2.02	1.27	1.60	1.77	2.03 ^{ABC}
E_3	2.55	2.89	2.45	1.60	1.74	1.61	2.05	2.13 ^{AB}
E_4	2.31	2.73	2.64	2.05	2.25	1.91	1.22	2.16 ^{A}
E_5	2.15	2.54	2.39	1.91	1.08	1.16	0.96	1.74 ^{C}
E_6	2.08	3.08	1.99	1.90	1.31	1.06	1.45	1.84 ^{BC}
Mean	2.31 ^{B}	2.63 ^{A}	2.38^{AB}	1.95 ^{C}	1.54 ^{D}	1.49 ^{D}	1.51 ^{D}	

Table 10b. Effect of various methods of seed extraction and fruit drying on shoot length (cm) in chilli, var. Ujwala seedlings

Treatments	Months after storage							
	0	1	2	3	4	5	6	Mean
E_1	1.78	2.01	1.76	1.49	1.63	1.52	1.66	1.69 ^{AB}
E_2	1.93	1.99	1.95	1.61	1.48	2.16	1.30	1.77 ^{A}
E_3	2.06	1.57	1.71	1.55	1.58	1.44	1.65	1.65 ^{ABC}
E_4	1.69	2.03	1.84	1.44	1.43	1.41	1.42	1.61 ^{BCD}
E_5	1.78	1.73	1.77	1.64	1.4	0.88	1.69	1.56 ^{CD}
E_6	1.69	1.59	1.73	1.43	1.41	0.90	1.71	1.49 ^{D}
Mean	1.82 ^{A}	1.82 ^{A}	1.79 ^{A}	1.53 ^{BC}	1.49^{C}	1.38 ^{C}	1.57 ^{B}	

Treatment means with the same alphabet as superscript do not differ significantly

E_1 : Hand extraction and fruit drying under sunlight avoiding the peak hours (12 noon to 3 pm)
E_2 : Machine extraction and fruit drying under sunlight avoiding the peak hours (12 noon to 3 pm)
E_3 : Drying in direct sunlight and threshing
E_4 : Drying in direct sunlight and machine extraction
E_5 : Drying in seed drier and threshing
E_6 : Drying in seed drier and machine extraction

hours (E_2). The lowest mean shoot length (1.49 cm) was recorded for fruits dried in seed drier and seeds extracted by machine (E_6)

It was observed that, there was significant difference in overall mean shoot length for months. Seeds immediately after extraction and after one month of storage recorded the maximum mean shoot length of 1.82 cm and it was lowest (1.38 cm) for seeds after five months storage (Table 10b)

4.2.4 Root length (cm)

a. Jwalasakhi

Different combinations of fruit drying and seed extraction had significant effect on root length. Hand extracted seeds of fruits dried in sunlight avoiding the peak hours (E_1) recorded the maximum mean root length (1.15 cm). Lowest mean root length was recorded for fruits dried in seed drier and seeds extracted by machine (E_6,0.81 cm).

The overall mean for root length of seedling for different months different significantly. Highest mean root length (1.34 cm) was recorded for seeds after one month of storage and it was lowest (0.61 cm) for seeds after six months of storage (Table 11a).

b. Ujwala

There was significant effect for mean shoot length under different combination of fruit drying and seed extraction. Machine extracted seeds of fruits dried in sunlight avoiding the peak hours (E_2) recorded the maximum mean shoot

Table 11a. Effect of various methods of seed extraction and fruit drying on root length (cm) in chilli, var. Jwalasakhi seedlings

Treatments	Months after storage							
	0	1	2	3	4	5	6	Mean
E_1	1.40	1.60	1.26	1.20	0.52	1.10	0.94	1.15^{A}
E_2	1.25	1.61	1.50	1.21	0.49	0.88	0.60	1.08^{A}
E_3	1.16	1.15	1.35	1.16	0.90	0.73	0.66	1.02^{A}
E_4	1.32	1.25	1.23	1.05	0.88	0.84	0.66	1.03^{A}
E_5	1.14	1.40	1.07	0.94	0.47	0.45	0.38	0.84^{B}
E_6	1.05	1.07	1.16	1.02	0.53	0.47	0.40	0.81^{B}
Mean	1.22^{AB}	1.34^{A}	1.26^{A}	1.10^{B}	0.63^{C}	0.74^{C}	0.61^{C}	

Table 11b. Effect of various methods of seed extraction and fruit drying on root length (cm) in chilli, var. Ujwala seedlings

Treatments	Months after storage							
	0	1	2	3	4	5	6	Mean
E_1	1.19	1.20	0.91	0.91	0.75	0.60	0.42	0.85^{A}
E_2	1.24	1.54	1.15	0.83	0.75	0.43	0.37	0.90^{A}
E_3	1.20	1.50	0.96	0.76	0.65	0.54	0.49	0.87^{A}
E_4	1.40	1.54	1.00	0.71	0.62	0.58	0.39	0.89^{A}
E_5	1.29	0.93	1.03	0.73	0.61	0.33	0.37	0.76^{B}
E_6	1.20	1.28	0.88	0.71	0.55	0.31	0.35	0.75^{B}
Mean	1.25^{B}	1.33^{A}	0.99^{C}	0.78^{D}	0.65^{E}	0.46^{F}	0.40^{F}	

Treatment means with the same alphabet as superscript do not differ significantly

E_1 : Hand extraction and fruit drying under sunlight avaiding the peak hours (12 noon to 3 pm)
E_2 : Machine extraction and fruit drying under sunlight avoiding the peak hours (12 noon to 3pm)
E_3 : Drying in direct sunlight and threshing
E_4 : Drying in direct sunlight and machine extraction
E_5 : Drying in seed drier and threshing
E_6 : Drying in seed drier and machine extraction

length (0.90 cm). It was the lowest (0.75 cm) for fruits dried in seed drier and seeds extracted by machine (E_6).

It was observed that , overall mean for root length differed significantly for months and it was highest (1.33 cm) for seeds after one month of storage. The lowest mean root length was recorded for seeds after six months of storage (0.40 cm) (Table 11b)

4.2.5 Vigour index of seedling

a. Jwalasakhi

The overall mean for different combination of fruit drying and seed extraction differed significantly. The highest mean vigour index (165.72) was recorded for hand extracted seeds of fruits dried in sunlight avoiding the peak hours (E_1). Fruits dried in seed drier and seed extraction by machine (E_6, 46.99) recorded the lowest vigour index.

There was significant difference in overall mean for months and mean vigour index was maximum (199.13) for seeds immediately after extraction and it slowly declined to 56.60 after six months storage (Table 12a)

b. Ujwala

Different combinations of fruit drying and seed extraction had significant effect on vigour index. Hand extracted seeds of fruits dried in sunlight avoiding the peak hours (E_1) recorded the highest mean vigour index (91.66). It was the lowest (28.12) for fruits dried in seed drier extracted by machine (E_6)

Table 12a. Effect of various methods of seed extraction and fruit drying on vigour index in chilli, var. Jwalasakhi seedling

Treatments	Months after storage							
	0	1	2	3	4	5	6	Mean
E_1	305.48	207.48	275.92	148.56	83.87	63.10	75.61	165.72 ^{A}
E_2	211.53	201.79	212.08	141.32	49.48	36.80	82.57	133.65 ^{B}
E_3	216.96	171.88	183.84	95.44	101.68	48.19	107.19	132.17 ^{B}
E_4	276.20	164.39	207.49	72.28	105.37	28.39	44.08	128.32 ^{B}
E_5	101.23	100.47	86.36	27.43	24.84	16.27	14.49	53.01 ^{C}
E_6	83.37	110.38	69.95	26.27	10.97	12.39	15.63	46.99 ^{C}
Mean	199.13 ^{A}	159.40 ^{B}	172.61 ^{B}	85.22 ^{C}	62.70 ^{CD}	34.19 ^{E}	56.60 ^{DE}	

Table 12b. Effect of various methods of seed extraction and fruit drying on vigour index in chilli, var. Ujwala seedlings

Treatments	Months after storage							
	0	1	2	3	4	5	6	Mean
E_1	203.28	152.35	81.63	60.27	44.41	36.63	63.05	91.66 ^{A}
E_2	194.83	144.56	95.04	28.89	41.39	27.58	26.93	79.89 ^{AB}
E_3	177.99	82.40	88.83	39.47	23.55	15.90	31.93	65.72 ^{C}
E_4	147.76	155.14	94.32	39.47	22.19	13.26	33.66	72.25 ^{BC}
E_5	92.35	61.01	59.63	35.07	16.12	4.81	16.41	40.77 ^{D}
E_6	40.87	45.60	58.53	22.77	10.45	4.84	13.75	28.12 ^{D}
Mean	142.85 ^{A}	106.84 ^{B}	79.66 ^{C}	37.65 ^{D}	26.35 ^{DE}	17.17 ^{E}	30.95 ^{DE}	

Treatment means with the same alphabet as superscript do not differ significantly

E_1 : Hand extraction and fruit drying under sunlight avoiding the peak hours (12 noon to 3pm)
E_2 : Machine extraction and fruit drying under sunlight avoiding the peak hours (12 noon to 3pm)
E_3 : Drying in direct sunlight and threshing
E_4 : Drying in direct sunlight and machine extraction
E_5 : Drying in seed drier and threshing
E_6 : Drying in seed drier and machine extraction

The overall mean for different months was found to be significant. Maximum Vigour index (142.85) was recorded for seeds immediately after extraction and it decreased to 30.95 after six months of storage (Table 12b).

4.2.6 Seedling dry weight (mg/seedling)

a. Jwalasakhi

It was observed that, different combinations of fruit drying and seed extraction had significant effect on seedling dry weight. Maximum dry matter production per seedling (2.48 mg/seedling) was recorded for fruits dried in sunlight avoiding the peak hours and seed extraction by hand (E_1). It was the lowest (1.48 mg/seedling) for machine extracted seeds of fruits dried in seed drier (E_6).

There was significant difference in overall mean for different months. Seeds after one month of storage recorded the highest mean dry matter production per seedling (2.51 mg/seedling) and it gradually decreased to 1.87 mg/seedling after six months of storage (Table 13a)

b. Ujwala

The overall mean for seedling dry weight differed significantly under different combinations of fruit drying and seed extraction methods. It was the highest (1.67 mg/seedling) for the hand extracted seeds from fruits dried in sunlight avoiding the peak hours (E_1). Machine extracted seeds of fruits dried in seed drier (E_6) recorded the lowest mean seedling dry weight (1.50 mg/seedling).

Table 13a. Effect of various methods of seed extraction and fruit drying on seedling dry weight (mg / seedling) in chilli, var. Jwalasakhi seedlings

Treatments	Months after storage							
	0	1	2	3	4	5	6	Mean
E_1	2.43	3.27	2.97	2.51	2.16	2.09	1.93	2.48 ^{A}
E_2	1.67	2.31	2.57	2.23	1.65	2.04	1.75	2.03 ^{B}
E_3	2.41	3.09	2.25	1.68	1.98	1.91	1.81	2.16 ^{B}
E_4	2.71	2.85	2.77	2.58	1.81	1.78	1.59	2.30^{AB}
E_5	1.25	1.73	2.17	1.69	1.06	1.05	2.27	1.60^{C}
E_6	1.13	1.79	1.78	1.75	1.01	1.05	1.86	1.48 ^{C}
Mean	1.94 ^{BC}	2.51 ^{A}	2.42 ^{A}	2.08 ^{B}	1.61 ^{D}	1.65 ^{CD}	1.87 ^{BCD}	

Table 13b. Effect of various methods of seed extraction and fruit drying on seedling dry weight (mg /seedling) in chilli, var. Ujwala seedlings

Treatments	Months after storage							
	0	1	2	3	4	5	6	Mean
E_1	1.93	1.91	1.56	1.70	1.56	1.59	1.45	1.67 ^{A}
E_2	1.78	1.98	1.65	1.69	1.46	1.39	1.31	1.61 ^{B}
E_3	1.81	1.87	1.63	1.74	1.32	1.66	1.32	1.62 ^{B}
E_4	1.85	1.85	1.60	1.47	1.19	1.53	1.45	1.56 ^{B}
E_5	1.98	1.81	1.61	1.57	1.37	1.05	1.62	1.57 ^{B}
E_6	1.75	1.96	1.41	1.39	1.20	1.15	1.64	1.50 ^{C}
Mean	1.85 ^{A}	1.90 ^{A}	1.58 ^{B}	1.59 ^{B}	1.35 ^{C}	1.40 ^{C}	1.44 ^{C}	

Treatment means with the same alphabet as superscript do not differ significantly

E_1 : Hand extraction and fruit drying under sunlight avoiding the peak hours (12 noon to 3 pm)
E_2 : Machine extraction and fruit drying under sunlight avoiding the peak hours (12 noon to 3 pm)
E_3 : Drying in direct sunlight and threshing
E_4 : Drying in direct sunlight and machine extraction
E_5 : Drying in seed drier and threshing
E_6 : Drying in seed drier and machine extraction

The overall mean for seedling dry weight differed significantly for months. Seeds after one month of storage recorded the highest mean seedling dry weight (1.90 mg/seedling) and it gradually decreased to 1.44 mg/seedling after six months of storage (Table 13b)

4.2.7 Electrical conductivity of seed leachate (dsm^{-1})

a. Jwalalsakhi

There was significant difference in mean electrical conductivity of seed leachate under different combinations of fruit drying and seed extraction methods. It was the highest (0.056 dsm^{-1}) for hand extracted seeds of fruits dried in sunlight avoiding the peak hours (E_1). The mean electrical conductivity was the lowest (0.046 dsm^{-1}) for fruits dried in direct sunlight and seed extraction by threshing (E_3).

It was observed that the mean electrical conductivity differed significantly for different periods of storage months. Seeds immediately after extraction recorded the lowest mean electrical conductivity (0.042 dsm^{-1}) and it gradually increased to 0.058 dsm^{-1} after six months of storage (Table 14a).

b. Ujwala

Different methods of fruit drying and seed extraction had significant effect on mean electrical conductivity of seed leachate. Machine extracted seeds of fruits dried in seed drier (E_6) recorded the highest mean electrical conductivity (0.049 dsm^{-1}).

Table 14a. Effect of various methods of seed extraction and fruit drying on electrical conuctivity (dsm^{-1}) in chilli, var. Jwalasakhi

Treatments	Months after storage							
	0	1	2	3	4	5	6	Mean
E_1	0.044	0.047	0.054	0.056	0.063	0.069	0.056	0.056 ^{A}
E_2	0.044	0.047	0.053	0.058	0.061	0.064	0.061	0.055 ^{A}
E_3	0.038	0.039	0.042	0.046	0.047	0.054	0.058	0.046 ^{C}
E_4	0.040	0.045	0.049	0.056	0.057	0.061	0.055	0.052 ^{B}
E_5	0.043	0.050	0.050	0.053	0.054	0.062	0.054	0.052 ^{B}
E_6	0.042	0.048	0.053	0.057	0.059	0.062	0.064	0.055 ^{A}
Mean	0.042 ^{F}	0.046 ^{E}	0.050 ^{D}	0.054 ^{C}	0.057 ^{B}	0.062 ^{A}	0.058 ^{B}	

Table 14b. Effect of various methods of seed extraction and fruit drying on electrical conductivity(dsm^{-1}) in chilli, var. Ujwala

Treatments	Months after storage							
	0	1	2	3	4	5	6	Mean
E_1	0.032	0.039	0.044	0.046	0.052	0.055	0.049	0.047 ^{A}
E_2	0.034	0.041	0.045	0.046	0.052	0.056	0.046	0.0046 ^{A}
E_3	0.034	0.039	0.042	0.042	0.050	0.052	0.051	0.044 ^{B}
E_4	0.032	0.040	0.045	0.045	0.051	0.59	0.062	0.048 ^{A}
E_5	0.035	0.039	0.044	0.044	0.049	0.055	0.054	0.046 ^{A}
E_6	0.034	0.040	0.047	0.047	0.048	0.054	0.067	0.049 ^{A}
Mean	0.034^{E}	0.040^{D}	0.045 ^{C}	0.045 ^{C}	0.050 ^{B}	0.055 ^{A}	0.055^{A}	

Treatment means with the same alphabet as superscript do not differ significantly

E_1 : Hand extraction and fruit drying under sunlight avaiding the peak hours (12 noon to 3 pm)
E_2 : Machine extraction and fruit drying under sunlight avoiding the peak hours (12 noon to 3 pm)
E_3 : Drying in direct sunlight and threshing
E_4 : Drying in direct sunlight and machine extraction
E_5 : Drying in seed drier and threshing
E_6 : Drying in seed drier and machine extraction

Overall mean for electrical conductivity differed significantly for months. Seeds immediately after extraction recorded the lowest mean electrical conductivity (0.034 dsm^{-1}) and it gradually increased to 0.055 dsm^{-1} after six months of storage (Table 14b).

4.2.8 Seed colour

a. Jwalasakhi

There was no significant difference in seed colour under different methods of fruit drying and seed extraction. Seed colour did not differ significantly after six months of storage. Seeds were cream in colour immediately after extraction and after storage.

b. Ujwala

Seeds were deep yellow in colour immediately after extraction and no significant difference under different methods of fruit drying and seed extraction. There was no change in seed colour after six months of storage.

4.3 Standardization of packaging materials and storage conditions in chilli

Studies were conducted in chilli cultivars Jwalasakhi and Ujwala with a view to find out the effect of packaging materials and storage conditions on seed quality. For this extracted seeds were packed in five different packaging materials and dried fruits as such as sixth treatment. Seeds packed were stored under three different

Table 15a. Effect of various packaging materials, storage conditions on germination per cent in chilli, var. Jwalasakhi

Treatments	Months after storage							
	0	1	2	3	4	5	6	Mean
P_1	74.00	70.00	67.33	48.00	60.67	44.00	38.67	57.52 ^{BC}
	(59.65)	(57.58)	(55.59)	(43.80)	(51.31)	(41.43)	(38.10)	(49.64)
P_2	78.00	82.67	66.00	60.67	71.33	41.33	59.33	65.62 ^{A}
	(66.42)	(66.78)	(55.04)	(51.37)	(58.14)	(39.45)	(50.43)	(54.80)
P_3	70.67	68.67	61.33	50.67	72.00	46.00	60.00	61.33 ^{ABC}
	(59.02)	(56.09)	(51.67)	(45.48)	(59.77)	(41.63)	(50.81)	(52.07)
P_4	74.67	71.33	61.33	41.33	64.00	48.67	40.67	57.43 ^{BC}
	(59.85)	(57.73)	(51.83)	(39.63)	(53.33)	(44.04)	(38.87)	(49.33)
P_5	79.33	80.00	72.00	46.67	60.00	53.50	61.33	64.69 ^{AB}
	(63.83)	(63.79)	(58.38)	(43.04)	(50.91)	(45.99)	(51.88)	(53.97)
P_6	79.33	66.00	62.00	44.67	62.00	47.67	34.00	56.52 ^{C}
	(62.98)	(54.43)	(52.12)	(41.65)	(52.77)	(43.35)	(33.88)	(48.74)
C_1	80.67	72.67	61.00	50.00	56.53	32.08	39.33	56.01 ^{B}
	(64.68)	(59.56	(51.73)	(44.88)	(48.74)	(33.37)	(37.91)	(48.74)
C_2	74.00	73.67	69.33	46.00	74.67	52.67	53.67	63.43 ^{A}
	(60.08)	(59.70)	(56.90)	(42.64)	(60.82)	(46.21)	(46.90)	(48.70)
C_3	73.33	73.00	64.67	50.00	64.00	55.83	54.00	62.12 ^{A}
	(59.12)	(58.95)	(53.68)	(44.95)	(53.56)	(48.37)	(47.17)	(52.26)
Mean	76.00 ^{A}	73.11 ^{A}	65.00 ^{B}	48.67 ^{C}	65.00 ^{B}	46.86 ^{C}	49.00 ^{A}	
	(61.29)	(59.40)	(54.10)	(44.16)	(54.37)	(42.65)	(44.00)	

Table 15b. Effect of various packaging materials, storage conditions on germination per cent in chilli, var. Ujwala

Treatments	Months after storage							
	0	1	2	3	4	5	6	Mean
P_1	86.00	80.00	69.33	74.06	63.33	70.67	79.33	74.67 ^{A}
	(68.28)	(63.48)	(56.58)	(60.78)	(53.60)	(58.28)	(63.77)	(60.68)
P_2	88.67	75.33	72.00	63.33	62.00	72.00	68.67	71.71 ^{A}
	(70.43)	(60.28)	(58.38)	(54.47)	(52.44)	(58.67)	(56.97)	(58.81)
P_3	86.67	76.00	69.33	66.67	64.00	67.33	70.67	71.52 ^{AB}
	(69.12)	(61.07)	(56.64)	(55.25)	(53.89)	(55.51)	(58.59)	(58.58)
P_4	85.33	81.33	76.00	59.33	55.33	64.67	59.33	68.76 ^{AB}
	(68.11)	(64.53)	(60.80)	(50.53)	(49.85)	(54.43)	(51.97)	(57.17)
P_5	82.67	75.33	70.00	50.00	58.67	55.33	59.33	64.48 ^{BC}
	(65.49)	(60.31)	(57.11)	(44.88)	(50.37)	(47.01)	(50.75)	(53.70)
P_6	87.33	71.33	62.00	32.00	38.67	44.67	63.33	57.05 ^{C}
	(69.70)	(57.92)	(52.39)	(32.23)	(36.63)	(41.80)	(53.21)	(49.13)
C_1	87.67	76.00	68.67	50.00	51.00	47.33	55.00	62.24 ^{B}
	(69.81)	(60.85)	(56.38)	(45.04)	(45.84)	(42.63)	(47.90)	(52.63)
C_2	84.33	75.00	66.00	66.33	63.33	68.67	78.00	71.67 ^{A}
	(66.87)	(60.16)	(54.52)	(55.03)	(53.42)	(56.52)	(64.07)	(58.65)
C_3	86.33	78.67	74.67	56.33	56.67	71.33	67.33	70.19 ^{A}
	(68.89)	(62.79)	(60.05)	(49.01)	(49.14)	(58.70)	(55.67)	(57.75)
Mean	86.11 ^{A}	76.56 ^{B}	69.78 ^{BC}	57.56 ^{D}	57.00 ^{D}	62.44 ^{CD}	66.78 ^{C}	
	(68.52)	(61.27)	(56.98)	(49.69)	(49.46)	(52.62)	(55.88)	

Treatment means with the same alphabet as superscript do not differ significantly

P_1 : Brown paper cover P_4 : Polythene bag of 150 gauge thickness C_1: Room temperature

P_2 : Butter paper P_5 : Polythene bag of 700 gauge thickness C_2 : Air conditioned storage

P_3 : Cloth bag P_6 : Control (open storage of dried fruits) C_3 : Storage at 5^{0}C temperature

storage conditions. Analysis of variance of the data is given in Appendix VI, VII and VIII.

4.3.1 Germination per cent

a. Jwalasakhi

Different packaging materials had significant effect on germination percentage of Jwalasakhi seeds. Overall mean for various packaging materials showed that seeds packed in butter paper cover (P_2) had the maximum overall germination per cent (65.62 %). Seeds from dried fruits stored as such (P_6) recorded the lowest overall mean germination percentage (56.52 %). There was significant difference in the overall mean for different storage conditions. Seeds stored under air conditioned storage (C_2) recorded the highest overall mean germination percentage (63.43 %) and it was the lowest (56.01 %) for the seeds stored under ambient conditions (C_1) (Table 15a).

Different packaging materials x storage conditions x month interaction had significant effect on germination per cent. Among the various treatment combinations seeds packed in 700 gauge polythene bag stored at 5°c temperature (P_5C_3) recorded the highest overall mean germination per cent (72.00 %). It was the lowest (48.86 %) for the seeds from open storage of dried fruits under ambient condition (P_6C_1) (Table16a).

Table 16a. Effect of various combination of packaging materials and storage conditions on germination per cent in chilli, var. Jwalasakhi

Treatments	Months after storage							
	0	1	2	3	4	5	6	Mean
P_1C_1	82	70	72	52	62	38	36	58.857^{ABC}
P_2C_1	80	96	66	60	58	26	62	64.000^{ABC}
P_3C_1	94	70	60	50	60	48	50	61.714^{ABC}
P_4C_1	70	64	52	46	54	48	24	51.143^{C}
P_5C_1	80	74	66	44	42	6.5	48	51.500^{C}
P_6C_1	78	62	50	48	62	26	16	48.857^{C}
P_1C_2	74	72	66	46	62	54	36	55.143^{BC}
P_2C_2	68	70	60	66	78	34	60	70.571^{AB}
P_3C_2	62	72	62	52	64	64	66	59.143^{ABC}
P_4C_2	78	74	62	44	62	42	42	63.429^{ABC}
P_5C_2	76	80	70	60	72	72	74	70.571^{AB}
P_6C_2	82	70	68	32	46	69	46	61.714^{ABC}
P_1C_3	66	68	64	46	58	40	44	58.571^{ABC}
P_2C_3	86	82	72	56	78	64	56	62.286^{ABC}
P_3C_3	56	64	62	50	92	26	64	63.143^{ABC}
P_4C_3	76	76	70	34	76	56	56	57.714^{ABC}
P_5C_3	82	86	80	36	66	82	62	72.000^{A}
P_6C_3	78	66	68	54	78	48	40	59.000^{ABC}
Mean	76^{A}	73.11^{AB}	65^{C}	48.667^{D}	65^{BC}	46.861^{D}	49^{D}	

Table 16b. Effect of various combination of packaging materials and storage conditions on germination per cent in chilli, var. Ujwala

Treatments	Months after storage							
	0	1	2	3	4	5	6	Mean
P_1C_1	90	82	72	70	70	58	70	73.143^{ABCDE}
P_2C_1	80	78	76	74	72	70	62	74.00^{ABCDE}
P_3C_1	92	70	79	68	46	50	46	63.143^{CDEF}
P_4C_1	86	78	78	54	66	54	22	62.571^{DEF}
P_5C_1	80	80	66	30	42	16	56	52.857^{FG}
P_6C_1	92	68	50	40	10	36	74	47.714^{G}
P_1C_2	82	82	70	86	58	72	88	76.857^{AB}
P_2C_2	90	78	74	78	60	86	78	77.714^{A}
P_3C_2	86	72	60	56	82	80	90	75.143^{ABCD}
P_4C_2	86	80	74	68	52	76	84	74.286^{ABCDE}
P_5C_2	82	72	64	56	56	66	52	64.00^{BCDEF}
P_6C_2	80	66	54	54	72	32	76	62.00^{DEF}
P_1C_3	86	76	66	66	62	82	80	74.00^{ABCDE}
P_2C_3	90	70	66	38	54	60	66	63.429^{BCDEF}
P_3C_3	82	86	78	76	64	72	76	76.286^{ABC}
P_4C_3	84	86	76	56	48	64	72	69.429^{ABCDE}
P_5C_3	86	74	80	64	78	84	70	76.571^{ABC}
P_6C_3	90	80	82	38	34	66	40	61.429^{EF}
Mean	86.111^{A}	76.556^{B}	69.778^{BC}	57.556^{D}	57.00^{D}	62.444^{CD}	66.778^{C}	

Treatment means with the same alphabet as superscript do not differ significantly

P_1 : Brown paper cover P_4 : Polythene bag of 150 gauge thickness C_1: Room temperature

P_2 : Butter paper P_5 : Polythene bag of 700 gauge thickness C_2 : Air conditioned storage

P_3 : Cloth bag P_6 : Control (open storage of dried fruits) C_3 : Storage at 5^0C temperature

The overall mean for different months differed significantly. The mean germination percentage decreased from 76 % to 49 % after six months of storage (Table 15a).

b. Ujwala

There was significant difference in the overall mean for different packaging materials. Seeds packed in brown paper cover recorded the highest overall mean germination percentage (P_1, 60.68). Lowest overall mean germination percentage (57.05) was recorded for the dried fruits stored as such. Overall mean germination percentage for different storage conditions differed significantly. Mean germination percentage was highest (71.67 %) for the seeds stored under air conditioned storage (C_2) and it was lowest (62.24 %) for the seeds stored under room temperature (C_1, Table 15b).

It was observed that, the interaction between different packaging materials x storage conditions x month was found significant. Seeds packed in butter paper cover stored under air conditioned storage (P_2 C_2) recorded the highest overall mean germination percentage (77.71 %) It was lowest (47.71 %) for the seeds from dried fruits stored under room temperature (Table 16b, 47.71 %).

Overall mean germination percentage for different months differed significantly. It was highest for the seeds immediately after extraction (86.11 %) and gradually decreased to 66.78 % after six months of storage (Table15b).

Table 17a. Effect of various packaging materials , storage conditions on speed of germination in chilli, var. Jwalasakhi

Treatments	Months after storage							
	0	1	2	3	4	5	6	Mean
P_1	9.64	8.51	8.6	6.12	7.35	5.41	4.57	7.16^{B}
P_2	10.70	10.97	8.04	8.01	9.18	4.95	7.48	8.48^{A}
P_3	11.07	8.99	7.87	6.54	10.10	5.55	7.39	8.22^{AB}
P_4	10.62	9.01	7.96	5.15	7.99	6.16	4.73	7.38^{AB}
P_5	11.56	9.49	9.38	5.97	8.05	7.24	7.39	8.44^{A}
P_6	11.84	8.13	8.33	5.73	8.33	6.48	4.19	7.58^{AB}
C_1	11.05	9.34	7.65	6.00	6.93	3.53	4.37	6.98^{B}
C_2	11.12	9.50	8.84	5.83	9.81	7.01	6.53	8.38^{A}
C_3	10.54	8.70	8.58	6.93	8.76	7.34	6.98	8.26^{A}
Mean	10.91^{A}	9.18^{B}	8.36^{B}	6.25^{C}	8.50^{B}	5.96^{C}	5.96^{C}	

Table 17b. Effect of various packaging materials, storage conditions speed of germination in chilli, var. Ujwala

Treatments	Months after storage							
	0	1	2	3	4	5	6	Mean
P_1	11.70	9.31	8.31	9.47	6.45	8.08	8.78	8.87^{A}
P_2	11.04	8.84	8.11	7.87	6.17	8.36	7.32	8.24^{AB}
P_3	11.09	8.76	7.66	7.90	6.48	7.77	7.01	8.10^{AB}
P_4	11.27	9.85	9.92	6.99	5.64	7.50	5.98	8.02^{AB}
P_5	10.06	9.09	7.99	6.78	5.93	6.70	6.33	7.56^{B}
P_6	11.07	8.57	7.08	3.79	4.08	5.21	6.30	6.59^{C}
C_1	11.83	11.15	7.52	6.53	5.17	4.80	5.56	7.22^{B}
C_2	10.34	8.92	8.11	8.20	6.61	8.46	8.09	8.39^{A}
C_3	10.94	9.14	8.42	6.67	5.59	8.54	7.21	8.07^{A}
Mean	11.04^{A}	9.07^{B}	8.01^{C}	7.13^{CD}	5.79^{E}	7.27^{CD}	6.95^{D}	

Treatment means with the same alphabet as superscript do not differ significantly

P_1 : Brown paper cover
P_2 : Butter paper
P_3 : Cloth bag
P_4 : Polythene bag of 150 gauge thickness
P_5 : Polythene bag of 700 gauge thickness
P_6 : Control (open storage of dried fruits)
C_1: Room temperature
C_2 : Air conditioned storage
C_3 : Storage at 5^0C temperature

4.3.2. Speed of germination

a. Jwalasakhi

There was significant difference in the overall mean of speed of germination for different packaging materials. The mean speed of germination was highest (8.48) for the seeds packed in butter paper cover (P_2) and it was lowest (7.16) for the seeds packed in brown paper cover (P_1).

The overall mean speed of germination for different storage conditions differed significantly and the seeds stored under air conditioned storage (C_2) recorded the highest mean speed of germination (8.38) and it was the lowest (6.98) for the seeds stored under room temperature (C_1, Table 17a).

The overall mean for speed of germination for different packaging materials x storage condition x month interaction was found to be significant. Seeds packed in polythene bag of 700 gauge thickness stored at 5°c temperature ($P_5 C_3$) recorded the highest overall mean speed of germination (9.59). It was the lowest (6.22) for the seeds packed in polythene bag of 150 gauge thickness stored under room temperature (P_4C_1) (Table 18a).

There was significant difference in the overall mean of speed of germination for different months. It was the highest for the seeds before storage (10.906) and it gradually decreased to 5.96 after six months of storage (Table 17a).

Table 18a. Effect of various combination of packaging materials and storage conditions on speed of germination in chilli, var. Jwalasakhi

Treatments	Months after storage							
	0	1	2	3	4	5	6	Mean
P_1C_1	10.249	8.11	8.567	5.814	7.155	4.245	3.875	6.859^{B}
P_2C_1	10.993	13.043	8.303	7.93	6.935	2.625	6.995	8.118^{AB}
P_3C_1	14.428	8.957	7.434	5.942	8.202	5.143	5.745	7.978^{AB}
P_4C_1	8.642	9.037	6.199	5.625	5.973	5.468	2.570	6.216^{B}
P_5C_1	11.560	9.052	8.756	4.879	4.844	0.764	5.520	6.482^{B}
P_6C_1	10.422	7.825	6.657	5.794	8.486	2.956	1.515	6.236^{B}
P_1C_2	8.425	8.645	7.626	5.613	6.970	4.879	5.385	6.792^{B}
P_2C_2	12.239	10.989	8.716	6.914	10.521	7.823	7.175	9.196^{A}
P_3C_2	9.876	9.538	7.943	6.389	12.715	3.648	7.935	8.298^{AB}
P_4C_2	12.285	9.425	8.955	4.284	10.049	7.250	6.265	8.359^{AB}
P_5C_2	11.625	10.298	10.193	4.842	8.633	11.671	7.425	9.241^{A}
P_6C_2	12.297	8.089	9.608	6.955	9.958	6.810	4.997	8.388^{AB}
P_1C_3	10.233	8.766	9.476	6.931	7.926	7.096	4.465	7.842^{AB}
P_2C_3	8.882	8.871	7.117	9.170	10.086	4.395	8.280	8.114^{AB}
P_3C_3	8.918	8.438	8.228	7.297	9.379	7.847	8.477	8.369^{AB}
P_4C_3	10.936	8.571	8.723	5.551	7.96	5.766	5.355	7.552^{AB}
P_5C_3	11.488	9.118	9.183	8.188	10.683	9.281	9.215	9.593^{A}
P_6C_3	12.802	8.465	8.740	4.446	6.544	9.683	6.070	8.107^{AB}
Mean	10.906^{A}	9.182^{B}	8.356^{D}	6.254^{E}	8.501^{C}	5.964^{F}	5.959^{G}	

Table 18b. Effect of various combination of packaging materials and storage conditionson speed germiantion in chilli, var. Ujwala

Treatments	Months after storage							
	0	1	2	3	4	5	6	Mean
P_1C_1	13.571	9.451	8.321	8.608	7.196	6.089	7.605	8.692^{ABC}
P_2C_1	11.52	9.293	8.696	9.694	7.423	7.022	6.533	8.597^{ABC}
P_3C_1	11.008	8.115	7.233	8.008	4.504	5.050	3.826	6.821^{DEF}
P_4C_1	12.707	10.037	9.059	6.553	6.858	5.549	2.235	7.571^{BCDE}
P_5C_1	10.079	9.824	6.770	5.892	3.965	1.385	5.940	6.265^{EF}
P_6C_1	12.092	8.20	5.035	0.422	1.094	3.727	7.220	5.399^{F}
P_1C_2	10.041	10.046	9.407	12.44	6.151	8.453	10.355	9.557^{A}
P_2C_2	10.937	8.95	8.372	9.270	5.742	11.018	8.28	8.938^{AB}
P_3C_2	10.662	8.414	7.115	6.602	8.705	10.149	9.325	8.710^{ABC}
P_4C_2	10.263	9.621	9.258	7.308	5.592	9.584	7.620	8.464^{ABC}
P_5C_2	9.528	8.448	7.806	7.176	5.844	7.811	5.705	7.474^{BCDE}
P_6C_2	10.634	8.045	6.678	6.401	7.635	3.768	7.28	7.206^{CDE}
P_1C_3	11.48	8.44	7.194	7.367	5.991	9.683	8.380	8.362^{ABCD}
P_2C_3	10.678	8.271	7.269	4.638	5.359	7.026	7.140	7.197^{CDE}
P_3C_3	11.59	9.763	8.648	9.09	6.242	8.122	7.88	8.762^{ABC}
P_4C_3	10.838	9.893	8.457	7.102	4.458	7.371	8.09	8.030^{ABCD}
P_5C_3	10.565	9.010	9.396	7.272	7.993	10.914	7.35	8.928^{AB}
P_6C_3	10.478	9.476	9.54	4.542	3.501	8.125	4.395	7.151^{CDE}
Mean	11.037^{A}	9.072^{B}	8.014^{C}	7.133^{CD}	5.792^{E}	7.269^{CD}	6.953^{D}	

Treatment means with the same alphabet as superscript do not differ significantly

P_1 : Brown paper cover P_4 : Polythene bag of 150 gauge thickness C_1: Room temperature

P_2 : Butter paper P_5: Polythene bag of 700 gauge thickness C_2: Air conditioned storage

P_3 : Cloth bag P_6: Control (open storage of dried fruits) C_3 : Storage at 5^0C temperature

b. Ujwala

The overall mean of speed of germination for different packaging materials differed significantly. Seeds stored in brown paper cover (P_1) recorded the highest overall mean speed of germination (8.87). The mean speed of germination was the lowest (6.59) for the open storage of dried fruit. It was observed that, overall mean of speed of germination for different storage conditions differed significantly. It was the highest (8.39) for the seeds stored under air conditioned storage (C_2) and it was the lowest (7.22) for the seeds stored under room temperature (C_1, Table 17b).

There was significant difference in the overall mean speed of germination for different packaging materials x storage condition x month interaction. Seeds packed in brown paper cover stored under air conditioned storage (P_1C_2) recorded the highest overall mean speed of germination (9.56). It was the lowest (5.40) for the seeds from dried fruits as such stored under room temperature (P_6C_1, Table. 18b).

The overall mean speed of germination for different months was found to be significant. It was the highest (11.037) before storage and decreased to 6.953 after six months of storage (Table17b).

4.3.3. Shoot length (cm)

a. Jwalasakhi

There was no significant effect in the overall mean for different packaging material and storage conditions. The overall mean for different packaging materials

Table 19a. Effect of various packaging materials, storage conditions on shoot length(cm) in chilli, var. Jwalasakhi seedlings

Treatments	Months after storage							
	0	1	2	3	4	5	6	Mean
P_1	2.95	2.55	2.31	1.98	2.19	2.18	2.06	2.32^{A}
P_2	2.63	3.07	2.04	2.07	2.28	1.79	1.83	2.25^{A}
P_3	3.46	2.53	2.41	2.06	2.20	1.58	1.93	2.31^{A}
P_4	3.15	2.66	2.37	2.00	1.97	2.39	1.60	2.31^{A}
P_5	3.59	2.69	2.23	1.83	2.27	1.91	1.92	2.35^{A}
P_6	3.42	2.60	2.10	1.97	2.25	1.91	1.40	2.24^{A}
C_1	3.27	2.96	2.46	1.95	2.18	1.72	1.72	2.32^{A}
C_2	3.08	2.54	2.09	2.07	2.11	2.12	1.73	2.25^{A}
C_3	3.25	2.55	2.19	1.94	2.29	2.04	1.92	2.31^{A}
Mean	3.20^{A}	2.68^{B}	2.24^{C}	1.99^{D}	2.19^{C}	1.96^{D}	1.79^{E}	

Table 19b. Effect of various packaging materials, storage conditions on shoot length(cm) in chilli, var. Jwalasakhi seedlings

Treatments	Months after storage							
	0	1	2	3	4	5	6	Mean
P_1	1.70	1.64	1.88	1.86	1.63	1.62	2.15	1.78^{A}
P_2	2.10	1.76	1.65	2.00	1.58	1.55	1.82	1.78^{A}
P_3	2.02	1.57	1.74	1.92	1.74	1.54	1.67	1.74^{A}
P_4	2.16	1.66	1.70	1.71	1.57	1.67	1.99	1.78^{A}
P_5	2.17	1.55	1.64	1.76	1.46	1.41	2.16	1.73^{A}
P_6	2.08	1.76	1.62	1.45	1.22	1.55	1.97	1.66^{A}
C_1	1.96	1.70	1.60	1.68	1.48	1.39	1.86	1.67^{B}
C_2	1.93	1.61	1.63	1.82	1.63	1.69	1.98	1.76^{A}
C_3	2.23	1.66	1.88	1.84	1.50	1.59	2.04	1.82^{A}
Mean	2.04^{A}	1.66^{CD}	$1.70B^{C}$	1.78^{B}	1.54^{D}	1.56^{D}	1.96^{A}	

Treatment means with the same alphabet as superscript do not differ significantly

P_1 : Brown paper cover
P_2 : Butter paper
P_3 : Cloth bag
P_4 : Polythene bag of 150 gauge thickness
P_5 : Polythene bag of 700 gauge thickness
P_6 : Control (open storage of dried fruits)
C_1: Room temperature
C_2 : Air conditioned storage
C_3 : Storage at 5^0C temperature

Table 20a. Effect of various combination of packaging materials and storage conditions on shoot length (cm) in chilli, var. Jwalasakhi

Treatments	Months after storage							
	0	1	2	3	4	5	6	Mean
P_1C_1	3.06	2.775	2.315	1.75	2.165	1.495	1.86	2.203^{E}
P_2C_1	2.598	3.510	2.00	2.21	2.013	1.64	1.85	2.26^{CD}
P_3C_1	3.385	2.795	2.998	1.95	2.03	1.555	2.18	2.413^{AB}
P_4C_1	3.235	3.16	2.535	1.935	2.204	2.184	1.85	2.443^{A}
P_5C_1	3.52	2.495	2.418	1.820	2.203	1.555	1.675	2.241^{DE}
P_6C_1	3.82	3.045	2.495	2.015	2.435	1.909	0.905	2.375^{ABCD}
P_1C_2	2.995	2.69	2.265	2.025	2.24	2.229	1.785	2.318^{ABCDE}
P_2C_2	2.635	2.82	2.185	2.13	2.45	2.105	1.715	2.291^{BCDE}
P_3C_2	3.565	2.395	2.175	2.035	2.305	1.75	1.815	2.291^{BCDE}
P_4C_2	2.955	2.37	2.285	2.275	1.690	2.493	1.585	2.236^{DE}
P_5C_2	3.47	2.61	2.20	1.935	2.055	2.545	2.14	2.422^{AB}
P_6C_2	2.865	2.36	1.405	2.03	1.94	1.60	1.325	1.932^{F}
P_1C_3	2.79	2.195	2.355	2.16	2.17	2.81	2.525	2.429^{AB}
P_2C_3	2.665	2.885	1.945	1.880	2.39	1.629	1.925	2.188^{E}
P_3C_3	3.43	2.405	2.065	2.205	2.25	1.44	1.80	2.228^{DE}
P_4C_3	3.255	2.46	2.30	1.795	2.007	2.491	1.355	2.238^{DE}
P_5C_3	3.765	2.955	2.06	1.74	2.565	1.615	1.935	2.376^{ABCD}
P_6C_3	3.585	2.385	2.41	1.86	2.38	2.234	1.97	2.403^{ABC}
Mean	3.20^{A}	2.684^{B}	2.245^{C}	1.986^{D}	2.194^{C}	1.960^{D}	1.789^{E}	

Table 20b. Effect of various combination of packaging materials and storage conditions on shoot length (cm) in chilli, var. Ujwala

Treatments	Months after storage							
	0	1	2	3	4	5	6	Mean
P_1C_1	1.765	1.532	1.565	1.800	1.585	1.480	2.050	1.682^{CDE}
P_2C_1	1.605	1.915	1.595	2.100	1.584	1.438	1.620	1.694^{CDE}
P_3C_1	1.790	1.590	1.755	1.710	1.920	1.725	1.500	1.713^{CDE}
P_4C_1	1.815	1.925	1.630	1.620	1.715	1.425	1.780	1.701^{CDE}
P_5C_1	2.675	1.285	1.525	1.645	1.415	0.690	2.115	1.621^{DE}
P_6C_1	2.105	1.965	1.500	1.200	0.660	1.575	2.085	1.584^{E}
P_1C_2	1.535	1.353	1.985	1.695	1.743	1.440	2.120	1.724^{CDE}
P_2C_2	2.110	1.785	1.390	2.095	1.655	1.800	2.015	1.836^{ABC}
P_3C_2	1.780	1.505	1.595	2.010	1.773	1.750	1.840	1.750^{BCD}
P_4C_2	2.190	1.685	1.595	1.645	1.740	1.850	2.025	1.819^{ABC}
P_5C_2	1.770	1.526	1.590	1.795	1.284	1.788	2.060	1.687^{CDE}
P_6C_2	2.175	1.585	1.642	1.675	1.590	1.515	1.840	1.718^{CDE}
P_1C_3	1.810	1.850	2.075	2.075	1.576	1.933	2.295	1.945^{A}
P_2C_3	2.575	1.580	1.975	1.800	1.515	1.425	1.820	1.813^{ABC}
P_3C_3	2.485	1.625	1.875	2.045	1.540	1.146	1.680	1.771^{BCD}
P_4C_3	2.485	1.380	1.870	1.850	1.245	1.738	2.175	1.820^{ABC}
P_5C_3	2.060	1.825	1.800	1.825	1.677	1.745	2.295	1.889^{AB}
P_6C_3	1.955	1.715	1.710	1.410	1.425	1.545	1.995	1.688^{CDE}
Mean	2.038^{A}	1.657^{C}	1.704^{BC}	1.781^{B}	1.536^{D}	1.556^{D}	1.962^{A}	

Treatment means with the same alphabet as superscript do not differ significantly

P_1 : Brown paper cover P_4 : Polythene bag of 150 gauge thickness C_1: Room temperature

P_2 : Butter paper P_5: Polythene bag of 700 gauge thickness C_2 : Air conditioned storage

P_3 : Cloth bag P_6: Control (open storage of dried fruits) C_3 : Storage at 5^0C temperature

x storage condition x month was found to be significant. Seeds packed in polythene bag of 150 gauge thickness stored under room temperature (P_4C_1) recorded the highest mean shoot length (2.44 cm). The mean shoot length was lowest (1.9 cm) for the dried fruits stored under air conditioned storage (P_6C_2, Table 22a).

It was observed that, there was significant difference in the overall mean for different months. Seeds before storage recorded the highest mean shoot length (3.2 cm) and it was lowest (1.79 cm) for seeds after six months of storage (Table 19a).

b.Ujwala

Different packaging materials had no significant effect on the mean shoot length of Ujwala seedlings. The overall mean for different storage conditions differed significantly. The highest mean shoot length (1.82 cm) was recorded for the seeds stored at 5°C temperature (C_3). The overall mean shoot length was lowest (1.67 cm) for the seeds stored under ambient condition(C_1, Table 19b).

Different packaging materials x storage condition x month interaction was found to be significant. The highest mean shoot length (1.95 cm) was recorded for the seeds packed in brown paper cover stored at 5°C temperature (P_1C_3). It was the lowest (1.58 cm) for the seeds from open storage of dried fruits under room temperature (P_6C_1, Table 20b).

There was significant difference in the overall mean for months. The highest mean shoot length (2.047 cm) was recorded before storage and it was lowest (1.54 cm) after four months of storage (Table 19b).

Table 21a. Effect of various packaging materials, storage conditions on root length(cm) in chilli, var. Jwalasakhi seedlings

Treatments	Months after storage							
	0	1	2	3	4	5	6	Mean
P_1	1.74	1.66	1.49	1.54	0.95	0.78	0.75	1.27^{A}
P_2	1.75	1.52	1.04	1.58	1.09	0.65	0.54	1.17^{B}
P_3	1.90	1.68	1.39	1.56	0.88	0.93	0.49	1.26^{A}
P_4	2.34	1.59	1.30	1.51	1.04	0.64	0.53	1.28^{A}
P_5	2.21	1.82	1.44	1.63	1.04	0.61	0.47	1.32^{A}
P_6	2.00	1.78	1.40	1.47	0.94	0.60	0.41	1.23^{AB}
C_1	1.87	1.83	1.43	1.62	1.01	0.67	0.43	1.27^{A}
C_2	2.00	1.50	1.40	1.50	1.02	0.77	0.52	1.24^{A}
C_3	2.10	1.70	1.20	1.52	0.93	0.67	0.65	1.25^{A}
Mean	1.99^{A}	1.68^{B}	1.34^{A}	1.55^{C}	0.99^{E}	0.70^{F}	0.53^{G}	

Table 21b. Effect of various packaging materials, storage conditions on root length(cm) in chilli, var. Ujwala seedlings

Treatments	Months after storage							
	0	1	2	3	4	5	6	Mean
P_1	1.17	1.40	0.91	1.43	0.91	0.84	0.65	1.04^{A}
P_2	1.19	1.43	1.12	1.56	0.78	0.97	0.66	1.10^{A}
P_3	1.50	1.13	1.08	1.62	0.88	0.79	0.67	1.09^{A}
P_4	1.39	1.54	1.12	1.27	0.93	0.78	0.54	1.08^{A}
P_5	1.35	0.99	0.94	1.45	1.09	0.74	0.55	1.02^{A}
P_6	1.33	1.39	1.07	1.20	0.75	0.85	0.61	1.03^{A}
C_1	1.14	1.30	1.15	1.34	0.87	0.79	0.69	1.04^{A}
C_2	1.46	1.51	0.93	1.50	0.87	0.81	0.60	1.10^{A}
C_3	1.37	1.14	1.04	1.42	0.92	0.89	0.54	1.05^{A}
Mean	1.32^{B}	1.32^{B}	1.04^{C}	1.42^{A}	0.89^{D}	0.83^{D}	0.61^{E}	

Treatment means with the same alphabet as superscript do not differ significantly

P_1 : Brown paper cover
P_2 : Butter paper
P_3 : Cloth bag
P_4 : Polythene bag of 150 gauge thickness
P_5 : Polythene bag of 700 gauge thickness
P_6 : Control (open storage of dried fruits)
C_1: Room temperature
C_2 : Air conditioned storage
C_3 : Storage at 5^0C temperature

4.3.4. Root length (cm)

a. Jwalasakhi

The overall mean for root length differed significantly for different packaging materials. The mean root length was highest (1.32 cm) for the seeds packed in polythene bag of 700 gauge thickness and it was the lowest (1.17 cm) for the seeds packed in butter paper cover. There was no significant difference in mean root length for different storage conditions (Table 21a).

Different packaging materials x storage condition month interaction was found to be significant. Seeds packed in polythene bag of 700 and 150 gauge thickness stored under air-conditioned storage recorded the highest mean root length (1.385 and 1.387 cm respectively) and were on par with each other. Lowest mean root length was recorded for the seeds packed in butter paper cover stored under air conditioned storage (Table 22a).

b. Ujwala

The overall mean for different packaging materials, storage conditions had no significant effect on mean root length (Table 21b)

Different packaging materials x storage conditions x month interaction had significant effect on mean root length. It was highest (1.21 cm) for the seeds packed in butter paper cover stored under ambient conditions (P_2C_1). The lowest mean root length (0.86 cm) was recorded for the seeds packed in polythene bag of 700 gauge thickness stored under room temperature (P_5C_1, Table 22b).

Table 22a. Effect of various combination of packaging materials and storage conditions on root length (cm) in chilli, var. Jwalasakhi

Treatments	Months after storage							
	0	1	2	3	4	5	6	Mean
P_1C_1	1.675	1.76	1.885	1.73	0.93	0.655	0.64	1.325^{AB}
P_2C_1	2.00	1.775	0.955	1.885	1.055	0.596	0.535	1.257^{BCD}
P_3C_1	1.51	1.50	1.19	1.45	0.915	0.903	0.365	1.119^{E}
P_4C_1	1.935	1.725	1.010	1.500	1.143	0.754	0.400	1.210^{D}
P_5C_1	2.15	2.06	1.92	1.59	0.986	0.515	0.425	1.379^{A}
P_6C_1	1.955	2.175	1.605	1.585	1.05	0.583	0.23	1.312^{ABC}
P_1C_2	2.008	1.42	1.375	1.315	0.985	0.854	0.415	1.196^{DE}
P_2C_2	1.36	1.015	1.020	1.33	1.03	0.797	0.545	1.014^{F}
P_3C_2	1.970	1.665	1.870	1.545	0.843	1.045	0.525	1.352^{A}
P_4C_2	2.64	1.685	1.495	1.69	1.00	0.657	0.540	1.387^{A}
P_5C_2	2.41	1.705	1.410	1.685	1.205	0.70	0.58	1.385^{A}
P_6C_2	1.605	1.505	1.210	1.435	1.04	0.566	0.495	1.122^{E}
P_1C_3	1.535	1.815	1.195	1.58	0.94	0.843	1.19	1.300^{ABC}
P_2C_3	1.888	1.775	1.155	1.535	1.173	0.571	0.535	1.233^{CD}
P_3C_3	2.23	1.89	1.10	1.69	0.867	0.843	0.59	1.316^{ABC}
P_4C_3	2.43	1.37	1.39	1.345	0.987	0.504	0.665	1.242^{BCD}
P_5C_3	2.08	1.685	0.985	1.60	0.92	0.623	0.415	1.187^{DE}
P_6C_3	2.45	1.65	1.39	1.395	0.72	0.645	0.49	1.249^{BCD}
Mean	1.991^{A}	1.676^{B}	1.342^{B}	1.549^{B}	0.988^{C}	0.703^{C}	0.532^{C}	

Table 22b. Effect of various combination of packaging materials and storage conditions on root length (cm) in chilli, var. Ujwala

Treatments	Months after storage							
	0	1	2	3	4	5	6	Mean
P_1C_1	1.205	1.303	0.960	1.525	0.780	1.006	0.475	1.036^{CDEFG}
P_2C_1	0.885	1.435	1.515	1.840	0.945	0.955	0.890	1.209^{A}
P_3C_1	1.40	1.195	1.360	1.465	0.787	0.771	0.765	1.106^{BCD}
P_4C_1	1.205	1.470	1.210	0.875	1.210	0.724	0.615	1.044^{CDEF}
P_5C_1	1.085	0.870	0.795	1.235	1.014	0.420	0.620	0.863^{H}
P_6C_1	1.065	1.500	1.085	1.100	0.495	0.863	0.770	0.983^{FG}
P_1C_2	0.910	1.098	1.080	1.285	1.010	0.640	0.680	0.958^{G}
P_2C_2	1.290	1.495	0.945	1.580	0.670	1.123	0.575	1.097^{BCDE}
P_3C_2	1.420	0.955	0.965	1.485	0.917	0.817	0.570	1.018^{DEFG}
P_4C_2	1.540	1.405	1.070	1.405	0.944	0.842	0.530	1.105^{BCD}
P_5C_2	1.580	0.720	0.985	1.650	1.113	1.135	0.316	1.071^{BCDEF}
P_6C_2	1.505	1.170	1.173	1.105	0.890	0.775	0.570	1.027^{DEFG}
P_1C_3	1.395	1.810	0.695	1.475	0.933	0.873	0.780	1.137^{ABC}
P_2C_3	1.410	1.365	0.890	1.260	0.715	0.833	0.500	0.996^{EFG}
P_3C_3	1.690	1.235	0.905	1.895	0.925	0.771	0.675	1.157^{AB}
P_4C_3	1.435	1.755	1.075	1.540	0.635	0.787	0.465	1.099^{BCDE}
P_5C_3	1.390	1.390	1.040	1.450	1.145	0.677	0.710	1.114^{ABCD}
P_6C_3	1.420	1.505	0.950	1.390	0.855	0.900	0.490	1.073^{BCDEF}
Mean	1.324^{B}	1.315^{B}	1.039^{C}	1.420^{A}	0.888^{D}	0.828^{E}	0.611^{F}	

Treatment means with the same alphabet as superscript do not differ significantly

P_1 : Brown paper cover
P_2 : Butter paper
P_3 : Cloth bag
P_4 : Polythene bag of 150 gauge thickness
P_5 : Polythene bag of 700 gauge thickness
P_6 : Control (open storage of dried fruits)
C_1 : Room temperature
C_2 : Air conditioned storage
C_3 : Storage at 5^0C temperature

Table 23a. Effect of various packaging materials, storage conditions on vigour index in chilli, var. Jwalasakhi seedlings

Treatments	Months after storage							
	0	1	2	3	4	5	6	Mean
P_1	346.42	295.69	256.75	168.91	188.70	133.53	110.23	214.32^{B}
P_2	322.08	382.35	204.61	221.36	242.82	106.07	141.73	231.57^{AB}
P_3	373.66	290.28	232.79	185.83	223.17	128.22	144.83	225.54^{AB}
P_4	410.06	307.74	226.76	121.11	190.98	147.45	84.80	212.70^{B}
P_5	458.17	360.17	263.33	159.77	199.83	146.66	148.03	248.00^{A}
P_6	431.27	279.93	197.02	154.23	197.59	124.11	66.33	207.21^{AB}
C_1	413.43	350.06	238.20	179.34	178.91	79.56	91.51	218.71^{A}
C_2	363.73	298.25	32.65	151.93	233.89	156.37	122.44	222.75^{A}
C_3	393.67	309.78	219.78	174.34	208.74	157.09	134.03	228.20^{A}
Mean	390.28^{A}	319.36^{B}	230.21^{C}	168.54^{D}	207.18^{C}	131.01^{E}	115.99^{E}	

Table 23b. Effect of various packaging materials, storage conditions on vigour index in chilli, var. Ujwala seedlings

Treatments	Months after storage							
	0	1	2	3	4	5	6	Mean
P_1	247.84	242.57	193.37	240.30	158.24	167.28	231.69	211.61^{A}
P_2	292.93	236.80	180.55	232.27	147.12	169.68	168.32	203.95^{A}
P_3	303.59	205.77	196.32	202.19	143.81	155.87	163.25	195.83^{A}
P_4	303.26	260.45	213.95	117.23	142.94	158.70	151.99	192.66^{A}
P_5	290.69	202.31	181.74	165.03	152.84	144.40	167.75	186.40^{A}
P_6	300.01	225.46	164.77	52.72	88.62	107.52	168.38	158.21^{B}
C_1	271.07	232.39	189.97	152.20	132.14	112.58	148.68	177.00^{B}
C_2	278.52	205.05	166.83	178.24	148.69	168.04	198.94	192.04^{AB}
C_3	319.58	249.24	208.56	174.42	135.96	171.15	178.07	205.28^{A}
Mean	289.72^{A}	228.89^{B}	188.45^{C}	168.29^{CD}	138.93^{E}	150.59^{DE}	175.23^{CD}	

Treatment means with the same alphabet as superscript do not differ significantly

P_1 : Brown paper cover
P_2 : Butter paper
P_3 : Cloth bag
P_4 : Polythene bag of 150 gauge thickness
P_5 : Polythene bag of 700 gauge thickness
P_6 : Control (open storage of dried fruits)
C_1: Room temperature
C_2 : Air conditioned storage
C_3 : Storage at 5^0C temperature

Overall mean for different months differed significantly. The highest mean root length (1.32 cm) was recorded before storage and it was reduced to 0.61 cm after six months of storage (Table 21b).

4.3.5. vigour index

a. Jwalasakhi

There was significant difference in the overall mean for vigour index for different packaging materials. The highest mean vigor index (248.00) was recorded for the seeds packed in polythene bag of 700 gauge thickness (P_5) and it was lowest (207.21) for the seeds from open storage of dried fruits (P_6).

Different packaging materials x storage conditions x month interactions had significant effect on mean vigour index. Seeds packed in polythene bag of 700 gauge thickness stored under air conditioned storage (P_5 C_2) recorded the highest overall mean vigour index (274.67, Table 24a). The overall mean for different storage conditions had no significant effect on vigour index (Table 23a).

b.Ujwala

It was observed that, different packaging materials had no significant effect on the overall mean for vigour index. But, the overall mean for vigour index differed significantly for different storage conditions. The highest mean vigour index (205.28) was recorded for the seeds stored at 5°C temperature (C_3) and it was lowest (177.00) for the seeds stored under room temperature (C_1, Table 23b).

Table 24a. Effect of various combination of packaging materials and storage conditions on vigour index in chilli, var. Jwalasakhi

Treatments	Months after storage							
	0	1	2	3	4	5	6	Mean
P_1C_1	388.72	317.38	302.08	180.24	187.42	80.44	96.00	221.754^{BCD}
P_2C_1	368.245	507.18	195.80	246.08	178.13	57.914	148.30	243.093^{ABC}
P_3C_1	459.92	300.68	251.3	171.40	178.36	117.76	127.28	229.529^{ABC}
P_4C_1	362.32	312.98	186.16	157.86	180.855	140.965	54.00	199.306^{CD}
P_5C_1	451.08	337.52	287.78	148.84	133.615	13.38	100.80	210.431^{BCD}
P_6C_1	450.30	324.60	206.08	171.60	215.08	66.879	22.66	208.171^{BCD}
P_1C_2	330.16	281.08	232.96	153.64	186.96	123.156	99.04	200.999^{CD}
P_2C_2	287.70	312.82	230.58	194.08	272.04	185.49	129.28	230.284^{ABC}
P_3C_2	310.46	260.48	250.62	179.24	289.865	78.28	149.64	216.40^{BCD}
P_4C_2	424.46	330.96	265.44	68.92	204.44	177.40	119.76	227.34^{ABCD}
P_5C_2	481.12	371.20	289.22	130.32	214.96	266.18	169.72	274.674^{A}
P_6C_2	348.5	232.94	127.06	185.4	235.1	107.72	67.2	186.274^{D}
P_1C_3	320.38	288.60	235.20	172.84	191.72	196.99	135.64	220.196^{BCD}
P_2C_3	310.30	327.04	187.44	223.92	278.29	74.80	147.60	221.341^{BCD}
P_3C_3	350.60	309.68	196.44	206.86	201.29	188.625	157.58	230.154^{ABC}
P_4C_3	443.40	279.28	228.68	136.56	187.645	123.978	80.64	211.455^{BCD}
P_5C_3	442.32	371.795	213.00	200.16	250.92	160.41	173.56	258.881^{AB}
P_6C_3	495.00	282.26	257.92	105.68	142.6	197.74	109.14	227.191^{ABC}
Mean	390.277^{A}	319.360^{B}	230.209^{C}	168.536^{D}	207.183^{C}	131.006^{E}	115.991^{E}	

Table 24b. Effect of various combination of packaging materials and storage conditions on vigour index in chilli, var. Ujwala

Treatments	Months after storage							
	0	1	2	3	4	5	6	Mean
P_1C_1	289.722	228.893	88.45	168.289	138.928	150.589	175.229	203.643^{ABC}
P_2C_1	214.00	261.40	236.00	299.36	181.675	167.81	155.26	216.501^{AB}
P_3C_1	292.28	194.30	218.60	214.98	123.14	124.524	106.24	182.109^{BCD}
P_4C_1	259.52	264.36	221.88	69.80	198.66	115.121	51.98	168.76^{CDE}
P_5C_1	300.96	207.34	153.24	87.20	101.86	35.52	152.96	148.44^{E}
P_6C_1	291.44	234.40	128.24	9.20	23.10	88.14	223.44	142.566^{E}
P_1C_2	200.28	217.00	216.00	256.28	156.752	126.832	246.56	202.815^{ABC}
P_2C_2	306.12	242.68	117.54	287.76	139.80	204.25	193.94	213.156^{AB}
P_3C_2	275.10	177.04	153.60	195.66	150.80	205.092	216.54	196.262^{ABC}
P_4C_2	320.74	247.24	196.58	92.160	139.92	204.554	213.58	202.111^{ABC}
P_5C_2	274.50	161.80	165.10	198.52	136.23	194.52	140.32	181.57^{BCDE}
P_6C_2	294.40	184.54	152.14	39.08	168.64	73.00	182.68	156.354^{DE}
P_1C_3	275.74	278.16	182.28	231.96	153.60	230.64	246.30	228.383^{A}
P_2C_3	358.68	206.32	188.10	109.68	119.88	136.97	155.76	182.199^{BCD}
P_3C_3	342.70	245.98	216.76	195.92	157.48	137.988	166.96	209.113^{ABC}
P_4C_3	329.52	269.74	223.40	189.72	90.24	156.70	190.40	207.103^{ABC}
P_5C_3	296.62	237.80	226.88	209.38	220.43	203.172	209.96	229.177^{A}
P_6C_3	314.20	257.44	213.92	109.88	74.12	161.41	99.02	175.713^{BCD}
Mean	289.722^{A}	228.893^{B}	188.45^{C}	168.289^{C} D	138.928^{E}	150.589^{DE}	175.229 C	

Treatment means with the same alphabet as superscript do not differ significantly

P_1 : Brown paper cover P_4 : Polythene bag of 150 gauge thickness C_1: Room temperature

P_2 : Butter paper P_5 : Polythene bag of 700 gauge thickness C_2 : Air conditioned storage

P_3 : Cloth bag P_6 : Control (open storage of dried fruits) C_3 : Storage at 5^0C temperature

The overall mean for different packaging materials x storage conditions x month interaction had significant effect on vigour index. The highest mean vigour index (229.18) was recorded for the seeds packed in polythene bag of 700 gauge thickness stored at 5°C temperature (P_5C_3). It was lowest (142.57) for the seeds from dried fruits as such stored under room temperature (P_6C_1, Table 24b).

There was significant difference in overall mean for different months. The mean vigour index was highest for the seeds before storage (289.72) and it was lowest (138.93) for the seeds after four months of storage (Table 23b).

4.3.6 Seedling dry weight (mg/seedling)

a. Jwalasakhi

The overall mean for different packaging materials differed significantly for the dry matter production per seedling. Seeds packed in brown paper cover (P_1) and polythene bag of 150 gauge (P_4) thickness recorded the highest mean seedling dry weight (2.36 mg/seedling) and were on par with each other. It was lowest (2.07 mg/seedling) for the seeds from open storage of dried fruits (P_6). Different storage conditions had no significant effect on the overall mean for seedling dry weight (Table 25a).

Different packaging materials x storage conditions x month interaction had significant effect on the seedling dry weight. The highest overall mean seedling dry weight (2.5 mg/seedling) was recorded for the seeds packed in polythene bag of 150

Table 25a. Effect of various packaging materials, storage conditions on seedling dry weight (mg /seedling) in chilli, var. Jwalasakhi

Treatments	Months after storage							
	0	1	2	3	4	5	6	Mean
P_1	2.99	2.26	2.28	2.08	2.50	2.24	2.16	2.36^{A}
P_2	2.64	2.47	1.97	2.29	2.36	2.07	2.20	2.28^{AB}
P_3	2.16	2.42	2.21	2.11	2.37	2.17	1.92	2.19^{B}
P_4	2.79	2.51	2.40	2.00	2.33	2.57	1.90	2.36^{A}
P_5	2.90	2.38	2.12	2.09	2.03	2.04	1.93	2.21^{B}
P_6	2.55	2.25	1.86	1.80	2.26	1.97	1.76	2.07^{C}
C_1	2.61	2.43	2.15	2.21	2.39	2.07	2.02	2.27^{A}
C_2	2.56	2.31	2.25	1.97	2.21	2.25	1.83	2.20^{A}
C_3	2.85	2.41	2.01	2.01	2.32	2.21	2.07	2.27^{A}
Mean	2.67^{A}	2.38^{B}	2.14^{D}	2.06^{DE}	2.31^{BC}	2.18^{CD}	1.98^{E}	

Table 25b. Effect of various packaging materials, storage conditions on seedling dry weight (mg/seedling) in chilli, var. Ujwala

Treatments	Months after storage							
	0	1	2	3	4	5	6	Mean
P_1	1.70	1.70	1.67	1.48	1.63	1.58	1.75	1.65^{AB}
P_2	1.91	1.66	1.79	1.57	1.60	1.60	1.67	1.68^{AB}
P_3	1.86	1.70	1.73	1.48	1.63	1.58	1.84	1.69^{A}
P_4	1.68	1.69	1.54	1.47	1.38	1.58	1.84	1.60^{B}
P_5	1.72	1.54	1.43	1.50	1.72	1.57	1.72	1.60^{B}
P_6	1.79	1.64	1.55	1.47	1.11	1.50	1.50	1.51^{C}
C_1	1.75	1.64	1.62	1.55	1.47	1.58	1.63	1.61^{B}
C_2	1.84	1.71	1.73	1.50	1.56	1.61	1.83	1.68^{A}
C_3	1.74	1.62	1.50	1.44	1.50	1.52	1.71	1.57^{B}
Mean	1.78^{A}	1.66^{BC}	1.62^{C}	1.50^{D}	1.51^{D}	1.57^{CD}	1.72^{AB}	

Treatment means with the same alphabet as superscript do not differ significantly

P_1 : Brown paper cover
P_2 : Butter paper
P_3 : Cloth bag
P_4 : Polythene bag of 150 gauge thickness
P_5 : Polythene bag of 700 gauge thickness
P_6 : Control (open storage of dried fruits)
C_1 : Room temperature
C_2 : Air conditioned storage
C_3 : Storage at 5^0C temperature

Table 26a. Effect of various combination of packaging materials and storage conditions on seedling dry weight(mg/seedling) in chilli, var. Jwalasakhi seedlings

Treatments	Months after storage							
	0	1	2	3	4	5	6	Mean
P_1C_1	3.15	2.00	2.62	2.3	2.53	1.79	2.23	2.374^{ABC}
P_2C_1	3.06	2.11	2.01	2.4	2.25	2.29	2.54	2.38^{ABC}
P_3C_1	2.09	2.54	2.08	2.41	2.35	2.02	2.26	2.25^{CDE}
P_4C_1	2.8	2.28	2.46	2.05	2.55	2.47	1.61	2.317^{BCD}
P_5C_1	2.3	2.87	2.07	2.19	2.27	2.03	1.89	2.231^{DE}
P_6C_1	2.24	2.75	1.69	1.92	2.37	1.82	1.61	2.057^{FG}
P_1C_2	2.72	2.27	2.17	1.89	2.58	2.14	1.81	2.264^{CDE}
P_2C_2	2.21	2.73	1.84	2.14	2.51	1.99	2.005	2.204^{DE}
P_3C_2	2.28	1.81	2.52	1.81	2.14	2.11	1.48	2.021^{G}
P_4C_2	2.76	3.21	2.85	1.99	2.16	2.66	1.86	2.499^{A}
P_5C_2	2.76	1.99	2.43	2.17	1.9	2.21	2.14	2.229^{DE}
P_6C_2	2.63	1.87	1.69	1.79	1.98	2.14	1.71	1.973^{G}
P_1C_3	3.10	2.51	2.05	2.04	2.38	2.53	2.43	2.434^{AB}
P_2C_3	2.64	2.57	2.05	2.33	2.31	1.94	2.06	$2..271^{CDE}$
P_3C_3	2.10	2.90	2.02	2.10	2.62	2.37	2.01	2.303^{BCDE}
P_4C_3	2.82	2.05	1.88	1.96	2.27	2.59	2.22	2.256^{CDE}
P_5C_3	3.63	2.27	1.86	1.92	1.93	1.87	1.76	2.177^{DEF}
P_6C_3	2.79	2.14	2.20	1.70	2.43	1.94	1.965	2.166^{EF}
Mean	2.671^{A}	2.382^{B}	2.138^{D}	2.062^{E}	2.307^{C}	2.177^{D}	1.977^{F}	

Table 26b. Effect of various combination of packaging materials and storage conditions on seedling dry weight(mg/seedling) in chilli, var. Jwalasakhi seedlings

Treatments	Months after storage							
	0	1	2	3	4	5	6	Mean
P_1C_1	1.92	1.85	1.53	1.61	1.55	1.59	1.69	1.667^{CD}
P_2C_1	1.89	1.52	1.56	1.87	1.61	1.41	1.77	1.661^{CDE}
P_3C_1	1.76	1.82	2.00	1.50	1.98	1.67	1.72	1.779^{AB}
P_4C_1	1.65	1.53	1.62	1.61	1.24	1.47	1.70	1.546^{FGH}
P_5C_1	1.66	1.57	1.33	1.32	1.85	1.46	1.53	1.531^{GHI}
P_6C_1	1.61	1.54	1.7	1.4	0.61	1.87	1.36	1.441^{I}
P_1C_2	1.60	1.89	1.710	1.36	1.64	1.32	1.78	1.614^{CDEFG}
P_2C_2	2.05	1.84	2.09	1.61	1.6	1.82	1.65	1.809^{A}
P_3C_2	1.90	1.50	1.60	1.51	1.46	1.58	2.09	1.663^{CDE}
P_4C_2	1.80	1.63	1.59	1.44	1.60	1.75	2.02	1.640^{BC}
P_5C_2	1.82	1.61	1.62	1.56	1.68	1.78	1.86	1.709^{BC}
P_6C_2	1.83	1.80	1.79	1.51	1.37	1.40	1.56	1.609^{CDEFG}
P_1C_3	1.57	1.37	1.78	1.48	1.69	1.84	1.79	1.646^{CDEF}
P_2C_3	1.78	1.61	1.72	1.22	1.60	1.56	1.58	1.581^{DEFG}
P_3C_3	1.92	1.79	1.60	1.42	1.45	1.50	1.72	1.629^{CDEFG}
P_4C_3	1.59	1.92	1.41	1.37	1.3	1.52	1.79	1.557^{EFGH}
P_5C_3	1.64	1.43	1.33	1.63	1.63	1.47	1.78	1.559^{EFGH}
P_6C_3	1.93	1.58	1.15	1.51	1.34	1.23	1.57	1.473^{HJ}
Mean	1.775^{A}	1.656^{B}	1.618^{B} c	1.496^{D}	1.511^{D}	1.569^{C}	1.720^{A}	

Treatment means with the same alphabet as superscript do not differ significantly

P_1 : Brown paper cover P_4 : Polythene bag of 150 gauge thickness C_1: Room temperature

P_2 : Butter paper P_5: Polythene bag of 700 gauge thickness C_2: Air conditioned storage

P_3 : Cloth bag P_6: Control (open storage of dried fruits) C_3 : Storage at 5^0C temperature

gauge thickness stored under air conditioned storage (P_4C_2). It was lowest for the open storage of dried fruits under air conditioned storage (P_6C_2, Table 26a).

It was found that overall mean for different months differed significantly for mean seedling dry weight. The highest mean seedling dry weight (2.67 mg/seedling) recorded before storage decreased to 1.98 mg/seedling after six months of storage (Table 25a).

b. Ujwala

There was significant difference in the overall mean for different packaging materials. The highest mean seedling dry weight (1.69 mg/seedling) was recorded for the seeds packed in cloth bag (P_3,1.69 mg/seedling) and it was lowest (1.51 mg/seedling)for the open storage of dried fruits (P_6, Table 25b).

Overall mean for different storage conditions differed significantly. Seeds stored under air-conditioned storage recorded the highest overall mean seedling dry weight (C_2, 1.68 mg/seedling). It was lowest (1.57 mg/seedling.) for the seeds stored at 5°C temperature (C_3, Table 25b).

There was significant effect of different packaging materials x storage conditions x month interaction on dry matter production per seedling. It was the highest (1.81 mg/seedling) for the seeds packed in butter paper cover stored under air conditioned storage (P_2 C_2). It was lowest (1.44 mg/seedling) for the seeds from dried fruits as such stored under room temperature (P_6C_1, Table 26b).

Overall mean for different months differed significantly. The highest mean seedling dry weight (1.78 mg/seedling) was recorded before storage and it was lowest for the seeds after three months of storage (1.5 mg/seedling, Table25b).

4.3.7. Electrical conductivity of seed leachate (dsm^{-1})

a. Jwalasakhi

Different packaging materials had significant effect on the overall mean electrical conductivity of the seed leachate. The highest mean electrical conductivity (0.043 dsm^{-1}) was recorded for the seeds from open storage of dried fruits (P_6). The lowest mean electrical conductivity(0.034 dsm^{-1}) was recorded for the seeds packed in butter paper cover (Table 27a).

There was significant difference in overall mean for different storage conditions. Seeds stored under ambient condition(C_1) recorded the highest overall mean electrical conductivity (0.039 dsm^{-1}) and it was the lowest (0.036 dsm^{-1}) for the seeds stored under air conditioned storage (C_2, Table 27a).

It was observed that different packaging materials x storage conditions x month interaction had significant effect on the mean electrical conductivity of the seed leachate. Open storage of dried fruits under ambient condition (P_6C_1) recorded the highest overall mean electrical conductivity (0.044 dsm^{-1}). It was the lowest (0.031 dsm^{-1}) for the seeds packed in butter paper cover stored under air conditioned storage and at 5°C temperature and were on par with each other. (P_2C_2 and P_2C_3 respectively)(Table 28a).

Table 27a. Effect of various packaging materials, storage conditions on electrical conductivity (dsm^{-1}) in chilli, var. Jwalasakhi

Treatments	Months after storage							
	0	1	2	3	4	5	6	Mean
P_1	0.025	0.03	0.035	0.037	0.043	0.045	.045	0.037^{B}
P_2	0.025	0.026	0.028	0.032	0.039	0.042	0.046	0.034^{D}
P_3	0.026	0.028	0.031	0.036	0.038	0.044	0.044	0.035^{C}
P_4	0.027	0.031	0.033	0.038	0.043	0.048	0.045	0.038^{B}
P_5	0.026	0.03	0.032	0.034	0.04	0.044	0.052	0.037^{B}
P_6	0.027	0.03	0.036	0.038	0.049	0.06	0.063	0.043^{A}
C_1	0.029	0.031	0.034	0.038	0.044	0.048	0.051	0.039^{A}
C_2	0.024	0.028	0.031	0.035	0.04	0.046	0.049	0.036^{B}
C_3	0.025	0.028	0.031	0.035	0.042	0.047	0.048	0.037^{B}
Mean	0.026^{G}	0.029^{F}	0.032^{E}	0.035^{D}	0.042^{C}	0.047^{B}	0.049^{A}	

Table 27b. Effect of various packaging materials, storage conditions on electrical conductivity (dsm^{-1}) in chilli, var. Ujwala

Treatments	Months after storage							
	0	1	2	3	4	5	6	Mean
P_1	0.02	0.023	0.026	0.0.32	0.038	0.046	0.058	0.035^{A}
P_2	0.02	0.026	0.03	0.034	0.035	0.038	0.044	0.032^{B}
P_3	0.02	0.025	0.027	0.032	0.038	0.041	0.035	0.031^{B}
P_4	0.018	0.024	0.027	0.03	0.033	0.038	0.0347	0.031^{B}
P_5	0.019	0.024	0.026	0.029	0.031	0.036	0.037	0.029^{C}
P_6	0.02	0.026	0.037	0.044	0.048	0.051	0.056	0.040^{A}
C_1	0.018	0.024	0.026	0.031	0.034	0.042	0.057	0.035^{B}
C_2	0.021	0.025	0.029	0.035	0.036	0.041	0.045	0.033^{B}
C_3	0.02	0.026	0.031	0.035	0.039	0.043	0.041	0.034^{B}
Mean	0.02^{G}	0.025^{F}	0.029^{E}	0.034^{D}	0.042^{C}	0.044^{B}	0.047^{A}	

Treatment means with the same alphabet as superscript do not differ significantly

P_1 : Brown paper cover
P_2 : Butter paper
P_3 : Cloth bag
P_4 : Polythene bag of 150 gauge thickness
P_5 : Polythene bag of 700 gauge thickness
P_6 : Control (open storage of dried fruits)
C_1: Room temperature
C_2 : Air conditioned storage
C_3 : Storage at 5^0C temperature

Table 28a. Effect of various combination of packaging materials and storage conditions on electrical conductivity(dsm^{-1}) in chilli, var. Jwalasakhi

Treatments	Months after storage							
	0	1	2	3	4	5	6	Mean
P_1C_1	0.031	0.034	0.036	0.037	0.038	0.041	0.052	0.038^{DEF}
P_2C_1	0.030	0.031	0.034	0.038	0.046	0.053	0.049	0.040^{CD}
P_3C_1	0.032	0.031	0.033	0.042	0.040	0.042	0.052	0.039^{DEF}
P_4C_1	0.030	0.036	0.038	0.039	0.047	0.051	0.044	0.041^{CD}
P_5C_1	0.024	0.027	0.030	0.034	0.040	0.039	0.043	0.034^{HI}
P_6C_1	0.028	0.029	0.030	0.037	0.052	0.062	0.068	0.044^{A}
P_1C_2	0.022	0.026	0.037	0.039	0.043	0.047	0.043	0.037^{EFG}
P_2C_2	0.021	0.022	0.022	0.030	0.036	0.038	0.044	0.031^{J}
P_3C_2	0.024	0.029	0.031	0.035	0.036	0.047	0.041	0.035^{GHI}
P_4C_2	0.022	0.024	0.028	0.032	0.037	0.043	0.048	0.033^{I}
P_5C_2	0.024	0.032	0.035	0.035	0.045	0.052	0.056	0.040^{CD}
P_6C_2	0.031	0.033	0.036	0.039	0.045	0.052	0.058	0.042^{BC}
P_1C_3	0.023	0.029	0.032	0.034	0.047	0.047	0.042	0.036^{FGH}
P_2C_3	0.022	0.024	0.027	0.029	0.036	0.036	0.043	0.031^{J}
P_3C_3	0.022	0.025	0.028	0.032	0.038	0.043	0.041	0.033^{IJ}
P_4C_3	0.030	0.032	0.034	0.041	0.045	0.050	0.042	0.039^{DE}
P_5C_3	0.030	0.031	0.030	0.034	0.036	0.041	0.056	0.037^{EFG}
P_6C_3	0.022	0.028	0.038	0.038	0.050	0.067	0.063	0.044^{AB}
Mean	0.026^{G}	0.029^{F}	0.032^{E}	0.036^{D}	0.042^{C}	0.047^{B}	0.049^{A}	

Table 28b. Effect of various combination of packaging materials and storage conditions on electrical conductivity(dsm^{-1}) in chilli, var. Ujwala

Treatments	Months after storage							
	0	1	2	3	4	5	6	Mean
P_1C_1	0.016	0.019	0.021	0.025	0.028	0.029	0.021	0.051^{A}
P_2C_1	0.016	0.019	0.024	0.026	0.029	0.034	0.054	0.029^{GHI}
P_3C_1	0.016	0.026	0.025	0.032	0.036	0.039	0.031	0.029^{FGHI}
P_4C_1	0.017	0.024	0.025	0.026	0.032	0.037	0.057	0.031^{DEFGH}
P_5C_1	0.019	0.025	0.026	0.029	0.031	0.036	0.045	0.030^{EFGHI}
P_6C_1	0.022	0.027	0.038	0.046	0.050	0.049	0.058	0.041^{B}
P_1C_2	0.019	0.025	0.026	0.038	0.030	0.044	0.041	0.032^{DEFG}
P_2C_2	0.022	0.024	0.030	0.036	0.032	0.032	0.049	0.032^{DE}
P_3C_2	0.024	0.026	0.027	0.032	0.038	0.044	0.039	0.033^{D}
P_4C_2	0.018	0.025	0.029	0.031	0.034	0.036	0.041	0.031^{DEFGHI}
P_5C_2	0.019	0.024	0.024	0.028	0.029	0.037	0.036	0.028^{I}
P_6C_2	0.022	0.028	0.039	0.042	0.050	0.055	0.063	0.043^{B}
P_1C_3	0.024	0.026	0.031	0.034	0.037	0.043	0.058	0.036^{C}
P_2C_3	0.021	0.022	0.029	0.032	0.039	0.039	0.034	0.031^{DEFGHI}
P_3C_3	0.019	0.024	0.029	0.033	0.033	0.041	0.044	0.032^{DEF}
P_4C_3	0.019	0.025	0.027	0.030	0.034	0.036	0.032	0.029^{III}
P_5C_3	0.019	0.025	0.027	0.030	0.034	0.036	0.032	0.029^{III}
P_6C_3	0.016	0.022	0.035	0.044	0.045	0.049	0.048	0.037^{C}
Mean	0.020^{G}	0.025^{F}	0.029^{E}	0.034^{D}	0.036^{C}	0.04^{B}	0.054^{A}	

Treatment means with the same alphabet as superscript do not differ significantly

P_1 : Brown paper cover P_4 : Polythene bag of 150 gauge thickness C_1: Room temperature

P_2 : Butter paper P_5 : Polythene bag of 700 gauge thickness C_2 : Air conditioned storage

P_3 : Cloth bag P_6 : Control (open storage of dried fruits) C_3 : Storage at 5^0C temperature

The overall mean electrical conductivity for different months differed significantly. seeds after six months of storage recorded the highest mean electrical conductivity (0.049 dsm^{-1}) and it was lowest (0.026 dsm^{-1}) for the seeds before storage (Table 27a).

b. Ujwala

Different packaging materials had significant effect on the overall mean electrical conductivity of the seed leachate and it was the highest (0.04 dsm^{-1}) for the seeds from open storage of dried fruits (P_6). The lowest mean electrical conductivity (0.029 dsm^{-1}) was recorded for the seeds packed in polythene bag of 700 gauge thickness (Table 27b).

Different storage conditions had no significant effect on the mean electrical conductivity of the seed leachate (Table 27b).

The overall mean for different packaging materials x storage condition x month interaction had significant effect on the mean electrical conductivity of the seed leachate. The highest mean electrical conductivity (0.05 dsm^{-1}) was recorded for the seeds packed in brown paper cover stored under room temperature (P_1C_1). Seeds packed in polythene bag of 700 gauge thickness stored under air conditioned storage (P_5C_2) recorded the lowest mean electrical conductivity (0.028 dsm^{-1}, Table 28b).

It was observed that, there was significant difference in the overall mean electrical conductivity for different months. The highest mean electrical

electrical conductivity(0.054 dsm^{-1}) was recorded for the seeds after six months of storage and it was lowest (0.020 dsm^{-1}) for the seeds before storage .

4.3.8. seed colour

a. Jwalasakhi

Seeds was yellowish cream in colour before storage. There was no significant difference in seed colour for seeds packed in different packaging materials after six months of storage.

b. Ujwala

Seeds were deep yellow in colour before storage. There was no colour change for the seeds packed in different packaging materials after six months of storage.

Discussion

DISCUSSION

Much of the success of modern agriculture depends on the availability of high-quality seeds with good genetic potential and proven performance in germination, emergence and vigorous vegetative growth. Farmers and horticulturists are interested in the factors related to seed germination because a large part of conventional agriculture is engaged in growing plants for their seed. Production of quality seeds and their storage depends on many factors like fruit maturity at the time of harvest, post harvest handling and processing of seeds, packaging, storage environment etc. In order to standardize the various seed production aspects in chilli, three experiments were conducted during 1997-'98 at the college of Horticulture, Vellanikkara in two varieties viz. Jwalasakhi and Ujwala.

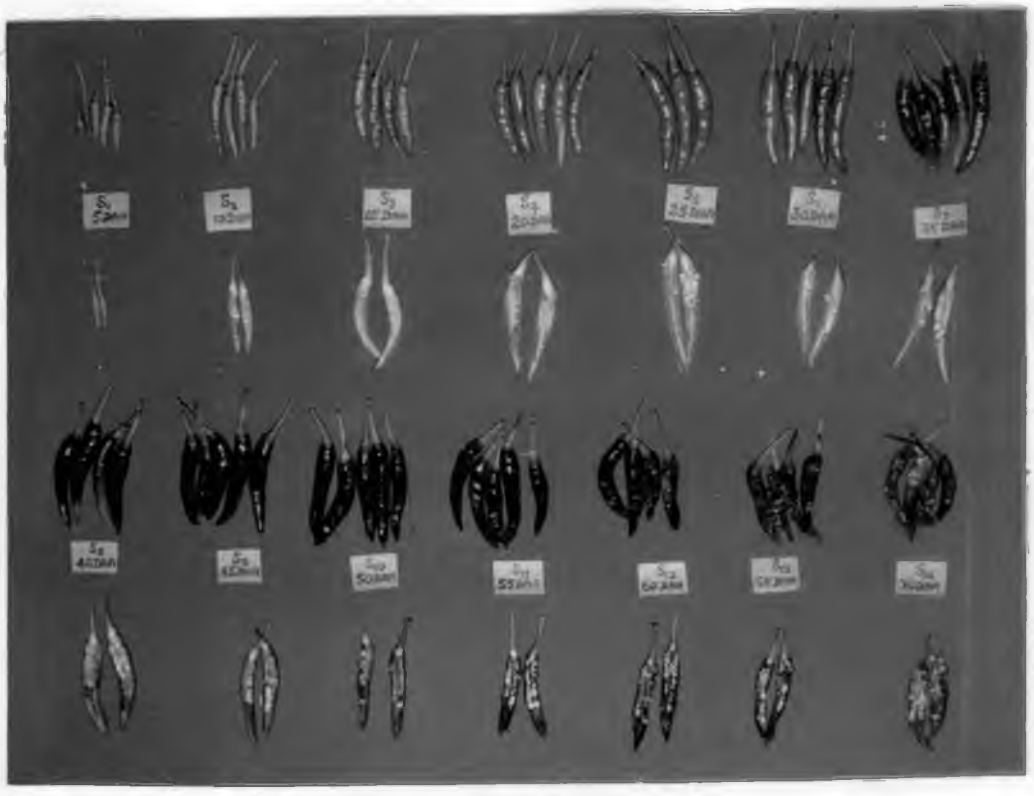
5.1 Studies on physiological maturity of seeds.

Growth pattern of chilli varieties Jwalasakhi and Ujwala was studied at five days interval to find out the stage of physiological maturity of seeds. The study showed that length of the fruit, fruit weight, total number of seeds per fruit, percentage of well filled seeds per fruit and 1000 seed weight increased from the day of anthesis in both varieties.

Maximum fruit length in variety Jwalasakhi was recorded at 30 d.a.a. (S_6, 8.94 cm) and it was at 40 d.a.a.(S_8, 5.90 cm) for variety Ujwala. This stage was characterized by a steep increase in fruit size. The fertilized ovule serves as a potential source of auxin, gibberellin and cytokinin which triggers the mechanism of creating a strong sink for assimilates and nutrients towards the developing fruit by

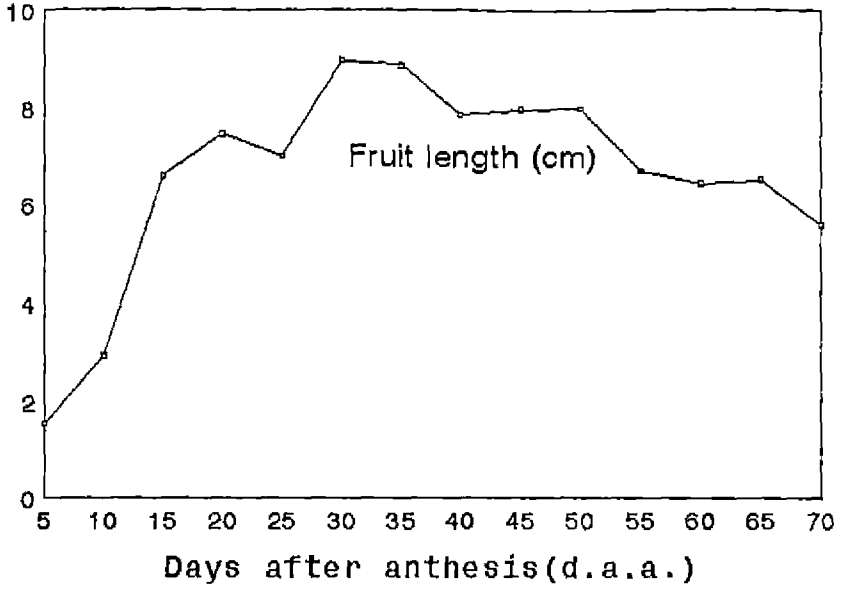
3.Pattern of fruit development in chilli, var. Jwalasakhi

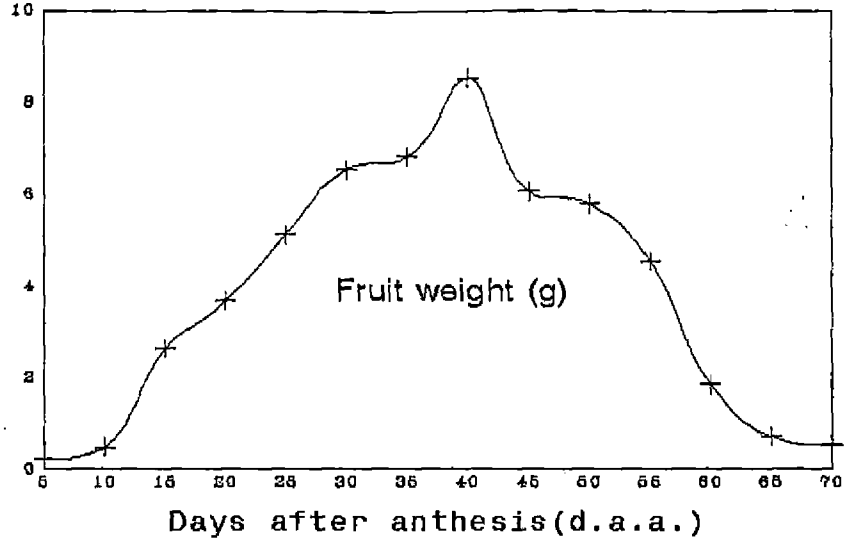
4.Pattern of fruit development in chilli, var. Ujwala

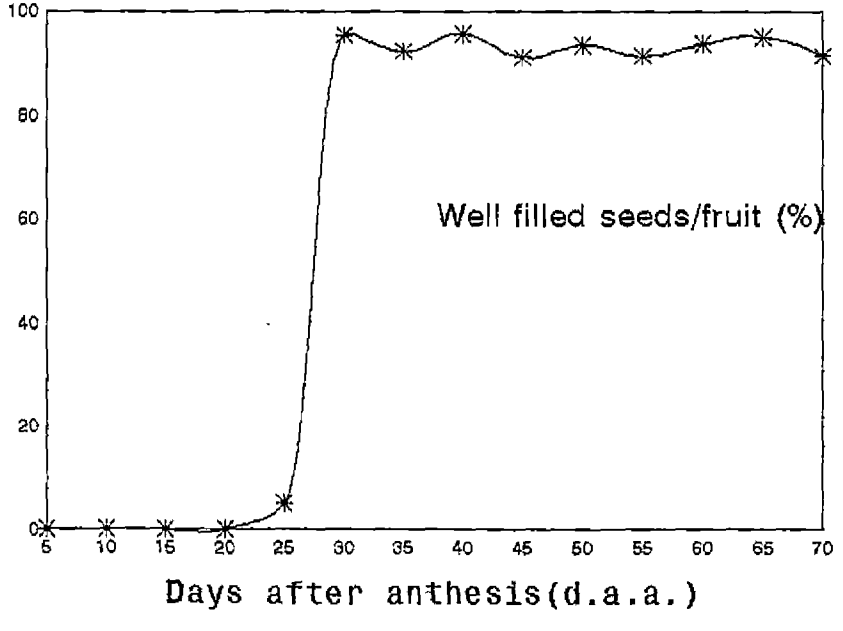


encouraging the fruit tissues also to synthesise auxins and cytokinins. The growing fruit is an active sink for the various metabolites and it draws various solutes and water from other parts of the plant. The fresh weight of fruits reached maximum at 35 d.a.a. (6.81 g)in variety Jwalasakhi. It was on par with the fresh weight of fruits at 30 and 40 d.a.a., whereas, in the variety, Ujwala, the maximum fresh weight was attained at 40 d.a.a. (2.29 g). The early stage of fruit growth is characterized by the formation of new cells, tissues and organs rich in proteins, nucleic acids, carbohydrates and fats (Noggle and Fritz, 1989). This period can be designated as phase-I (Fig. 1a and 1b) of fruit growth and after this cell division ceases. Even though the end of this phase can be designated as the optimum time for the vegetable harvest with highest fruit weight because of the change in fruit colour chilli fruits can be harvested for green vegetable purpose at 30-35 d.a.a. in both the varieties. During this phase intense cell division and differentiation occurs. There is increased metabolic activity with a high demand for low molecular weight precursors and bulk of these materials is supplied by the parent plant through direct vascular connections. At this stage of maximum fruit development, colour of the pericarp colour changed from yellowish green to sulphery yellow colour in variety Jwalasakhi and light green to dark green in variety Ujwala.

After attaining a maximum growth in the initial stages, fruit length and weight decreased towards the later stages. It shows the beginning of phase II. This reduction in length and weight was due to loss of moisture and it continued up to 70 d.a.a. (Fig. 1a and 1b). Similar results has been reported in bottlegourd







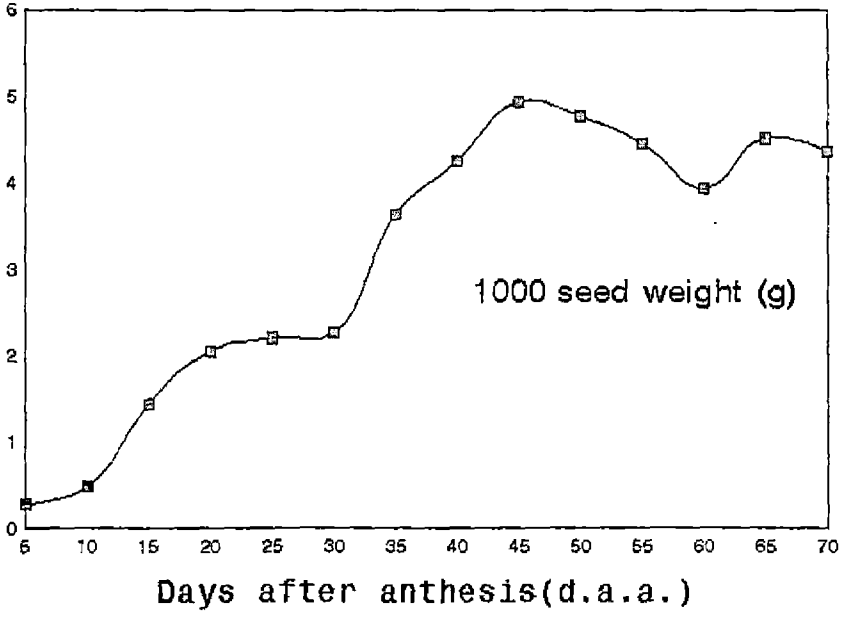
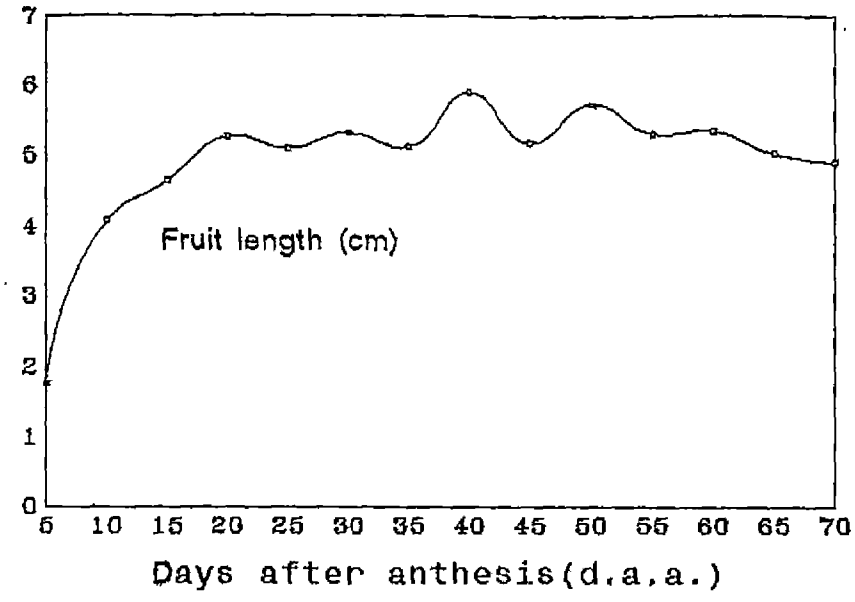
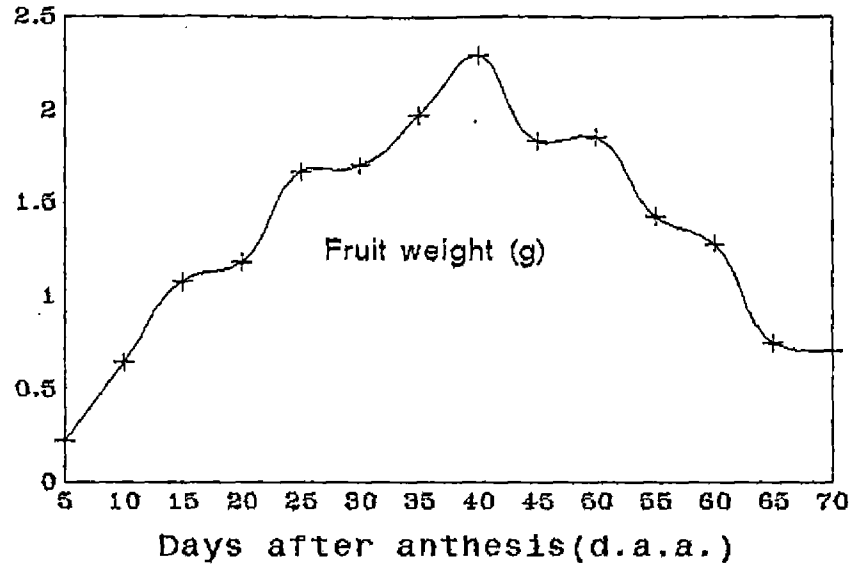


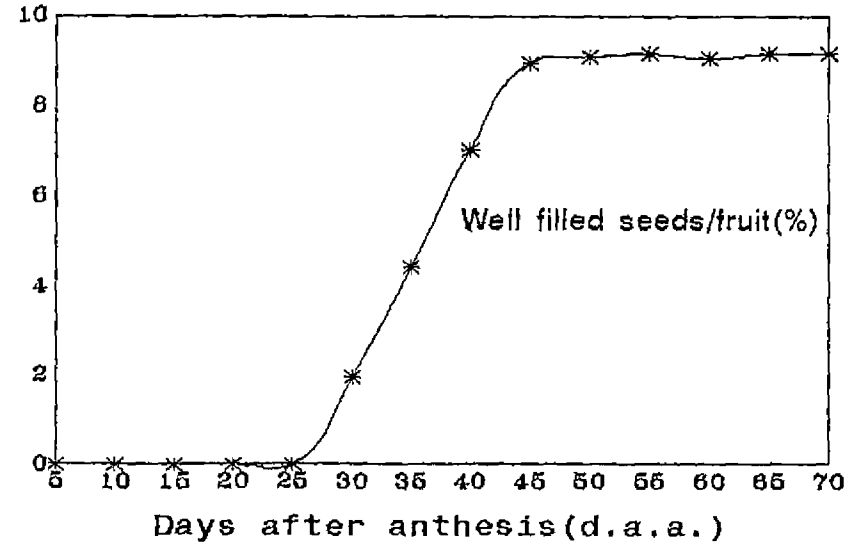
Fig.1a Pattern of fruit and seed development in chilli, var. Jwalasakhi

(Chandrasekharan, 19790 and in bittergourd (Varatharaj, 1979). Kannath (1996) and Anitha (1997) also reported that loss in fruit weight was associated with changes in moisture content in maturing fruits of ash gourd and okra respectively.

The seed characters showed that, the dry weight of seeds was very low upto 30 d.a.a. in both the varieties (Fig.1a and 1b) and it is the phase I of seed development. The 1000 seed weight increased from 0.28g to 2.27g (S_1-S_6) in variety Jwalasakhi and from 0.27g to 2.30g (S_1-S_6) in variety Ujwala. After this there was a rapid increase in seed dry weight in phase II. Seeds of 45 days maturity recorded the highest 1000 seed weight (S_9, 4.93g) in Jwalasakhi and it was at 40 d.a.a (S_8, 3.73g) in variety Ujwala. During phase II, the dry weight of seed increases because of the synthesis and deposition of seed storage materials - starch, protein, fats, phytin etc. in the seed. This synthesis and deposition of storage molecules in developing seeds constitute a major sink for carbohydrate and nitrogenous compounds made by the parent plant. During seed filling the demand for carbonaceous and nitrogenous molecules is high and may not be met by current CO_2, NO_3 or N_2 assimilation. In such cases, reserve materials in the parent plant may be mobilized and transported to developing seeds. To obtain maximum seed yields, it is essential that the leaves and other assimilatory organs of the parent plant be kept active as long as possible. It is observed that 30-45 d.a.a. (S_6-S_9) is a very critical stage in seed development. To get maximum quantity of well filled quality seeds, parent plant should be cared well. Hence, for







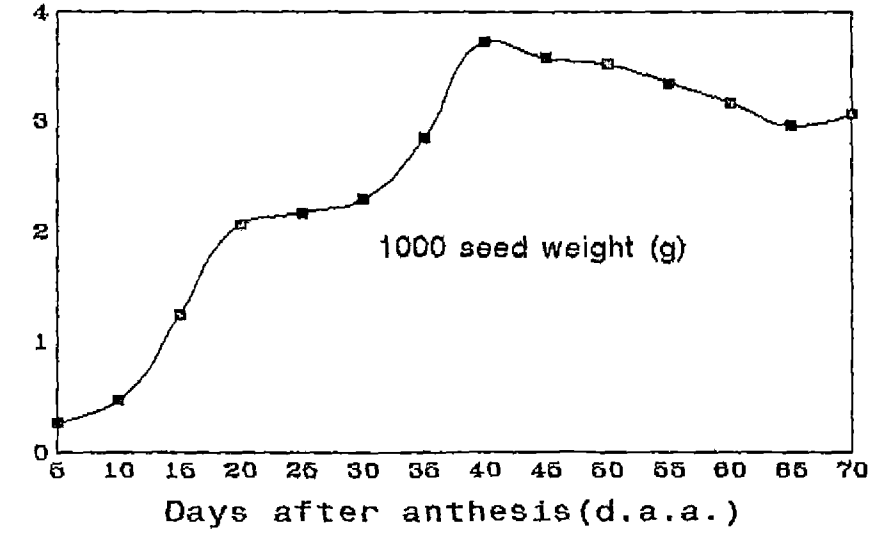


Fig.1b Pattern of fruit and seed development in chilli, var. Ujwala

good seed yield, the plants may be supplied with additional nutrients after 30 d.a.a. in chilli varieties Ujwala and Jwalasakhi.

After reaching maximum seed dry weight (4.93g) at 45 d.a.a. in variety Jwalasakhi and 40 d.a.a. in variety Ujwala (3.73g), i.e., phase II of seed development, there was a slight decline in the dry weight of seeds in both varieties (4.36g and 3.07g in Jwalasakhi and Ujwala respectively), upto 70 d.a.a.(Fig. 1a and 1b). Phase II of seed development comes to an end as the seed begins to loose water. Vascular connections between the developing seed and parent plant are broken so that no water or solutes can move into the seed. The tissue surrounding the seed that develop into seed coats undergo desiccation and sclerification, forming a hard protective structure. During phase III the desiccation process continues, attaining moisture levels between 5 and 15% (total seed). With desiccation, the subcellular organells in cotyledonary cells seems to lose their structural integrity and if seed moisture remains low, further development of the embryonic axis into a mature plant does not occur. In such a condition, seed remain in a quiescent state for considerable period of time. This dormant condition can be broken by supplying water to the dry seeds.

In chilli varieties Jwalasakhi and Ujwala germination studies were conducted in seeds from 5 d.a.a. to 70 d.a.a. (S_1 to S_{14}). Seeds in both varieties showed germination from 35 d.a.a. and seeds collected from fruits at 45 d.a.a. (67.5% and 57.21% in Jwalasakhi and Ujwala respectively) recorded the maximum

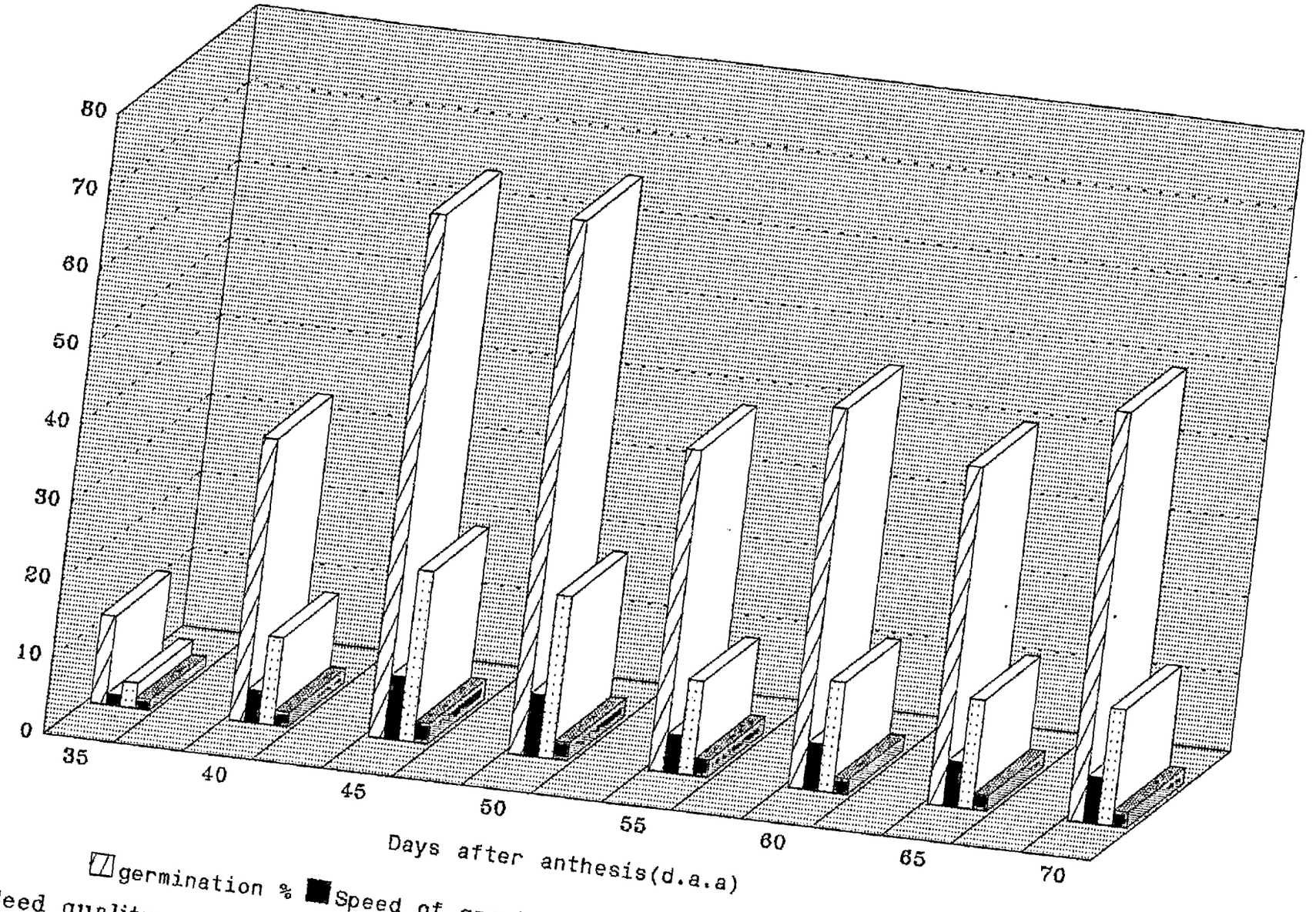


Fig. 2a Seed quality parameters during different stages of fruit maturity in var. Jwalasakhi

germination percentage (Fig.2a and 2b) confirming the most critical stage of seed development from 35- 45 d.a.a Similar trends were observed in seeds of okra and seeds from fruits at 27 d.a.a. recorded the highest germination and delay in harvest upto 30 d.a.a. showed a decline in germination percentage (Chauhan and Bhandari, 1971). According to Lysenko and Butkevich (1980) seed germination was optimal, about 50 d.a.a. in capsicum cultivars.

The term germination is used to designate those processes beginning with the imbibition of water by a dry seed and ending when a portion of the embryo penetrates the seed coat. The emergence phase of growth begins when the embryo penetrates the seed coat and ends when the shoot system is able to sustain the growth of plant by photosynthesis. The period of the plant cycle encompassing germination and emergence may be completed within a few days or may be spread out over a period of months. Regardless of the time required, environmental factors, such as temperature, light and moisture, interact with the physiological and biochemical process accompanying germination and seedling emergence. The germination percentage of the seeds harvested at different maturity stages, when stored for six months showed much variation. Seeds of 45 days maturity recorded the maximum germination percent (82.5 and 82 respectively) in both Jwalasakhi and Ujwala. After six months of storage percentage of germination declined to 67.5 in variety Jwalasakhi and 57.21 in variety Ujwala. This decline in germination

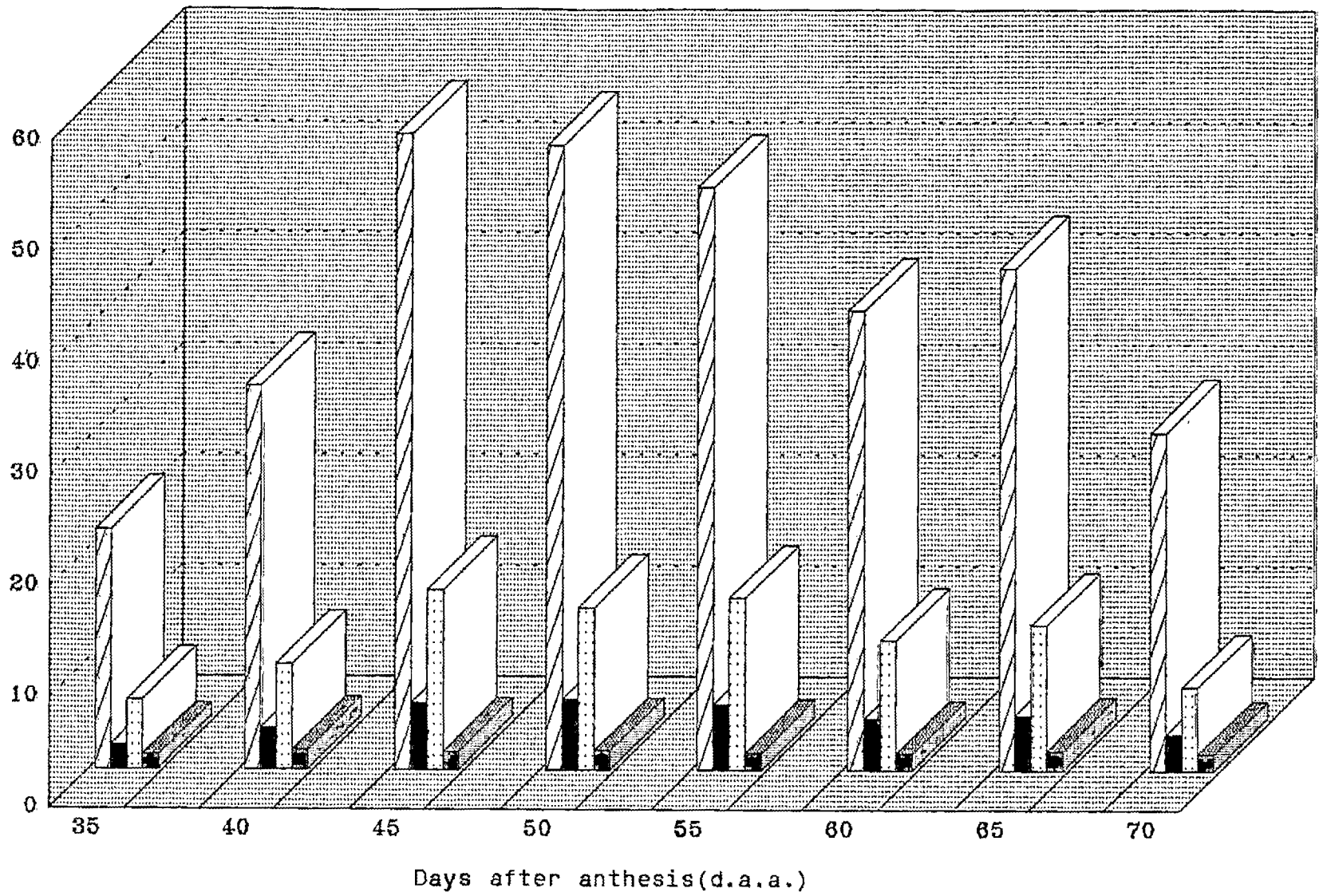


Fig.2b Seed quality parameters during different stages of fruit maturity in var. Ujwala

with increase in storage period was also reported by Metha and Ramakrishnan (1986).

Speed of germination and seedling vigour are also important parameters for determining the physiological maturity of seeds. In chilli variety Jwalasakhi, speed of germination and vigour index were maximum (8.09 and 219.49 respectively) for seeds of 45-50 days maturity (Fig.2a). In variety Ujwala maximum speed of germination (6.29) was recorded for seeds of 50 days maturity and vigour index was maximum (162) for seeds of 45-50 days maturity (Fig.2b). The highest seedling dry weight (2.61 mg / seedling) was recorded for seeds from fruits of 45 days maturity in variety Jwalasakhi and it was maximum (1.75 mg / seedling) for fruits of 65 days maturity in variety Ujwala. Similar to this, Bardedo *et al.* (1993) opined that cucumber seeds reached physiological maturity at 40-45 d.a.a. and the highest values for percentage germination and vigour were observed at this stage of seed maturity.

The present study revealed that the physiological maturity in chilli varieties Jwalasakhi and Ujwala was attained 45-50 days after anthesis. The results showed that chilli fruits for seed purposes, harvested before it attaining physiological maturity, the seeds would not store well inspite of the high germination potential possessed by the fresh seeds. However this stage of maturity can be recommended to chilli breeder for harvesting the fruits at a stage prior to physiological maturity, where the breeder need not store the seeds for longer time. Doijode (1988a) was also of the opinion that, in order to avoid damage due to natural calamities, the chilli fruits can be harvested at breaker stage.

5.2. Standardization of seed extraction and fruit drying methods

The Indian farmers depend on sunshine for drying the farm produce. In chilli, sun drying is an age old and traditional method of drying the fruits, a good amount of crop is wasted due to attack of birds and handling. Besides, it is time consuming and the drying dependent on atmospheric conditions. Seed extraction in chilli is usually done manually. Similar to sun drying, it is cumbersome and time consuming. In order to find a solution to these problems apart from the traditional methods mechanical drying and extraction methods were tried in chilli varieties Jwalasakhi and Ujwala. Seeds stored were tested upto six months at monthly interval after the different methods of seed extraction and fruit drying. Optimum method was standardized by conducting germination studies at monthly intervals and continued upto sixth month.

In this study, sun drying of fruits avoiding the peak hours and hand extraction of seeds recorded the maximum germination (48.76% and 34.10%) in Jwalasakhi and Ujwala respectively (Fig.3a and 3b). Heaney (1997) reported that when the angle of the sun is low, no effective ultra violet radiation reaches the surface of the earth. Sundrying of seeds avoiding the peak hours avoids the ultra violet rays of sun which is detrimental to seed. Speed of germination (6.09 and 3.45), vigour index (165.72 and 91.66) and seedling dry weight (2.48 and 1.67 mg/seedling) were maximum for the seeds obtained by this method in varieties Jwalasakhi and Ujwala respectively. This is in agreement with the studies

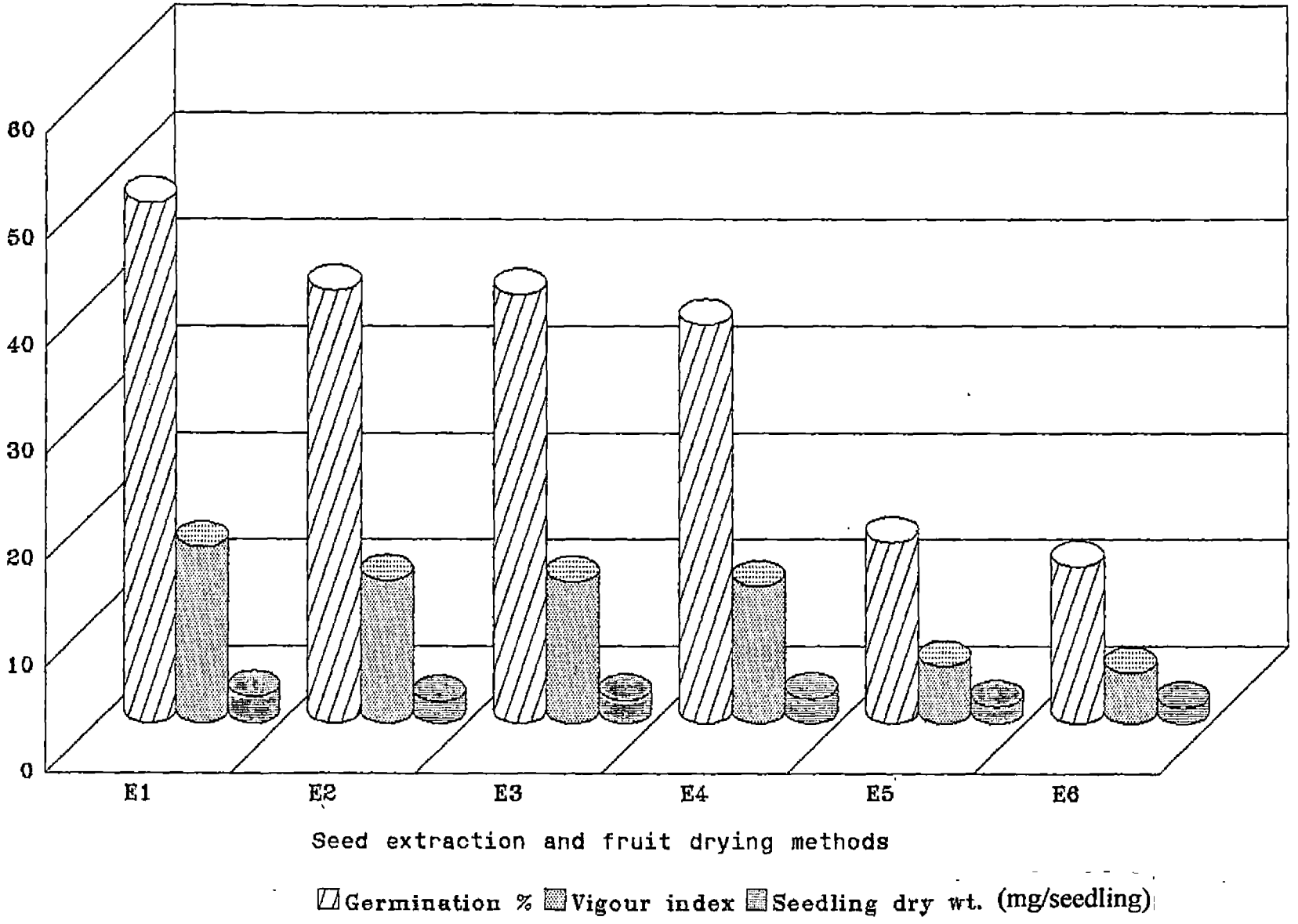


Fig.3a Effect of various seed extraction methods on germination, vigour index and seedling dry weight in chilli, var. Jwalasakhi

conducted by Dhanelappagol, *et al.* (1994) in chilli. They reported that sun drying of fruits recorded the highest germination percentage, field emergence and vigour index in chilli. According to Hosmani (1993) sun drying of chilli fruits followed by drying at 40^0Cair temperature recorded the highest germination and field emergence in chilli. According to Gowda, *et al.* (1990) sun and shade drying were found to be optimal for safe drying of tomato seeds.

Machine and hand extracted seeds of fruits dried in mechanical drier recorded the lowest mean germination per cent (14.67 and 14.89), speed of germination (1.63 and 1.19), vigour index (46.99 and 38.12) and seedling dry weight (1.48 and 1.50 mg/seedling) in varieties Jwalasakhi and Ujwala (Fig.3a and 3b). Vanraj and Kulkarni (1977) opined that in mechanical drying, air temperature and initial moisture content of the fruits are most important as they affect seed quality. In this study, the thermal injury to the seeds when dried at high temperature with high initial moisture content, might have aggravated the senscence factors. This was also supported by a high value for electrical conductivity of seed leachate (0.055 and 0.049) in seeds of fruits dried using mechanical drier in Jwalasakhi and Ujwala respectively. Significant drop in germination and field emergence and increase in electrical conductivity were noticed when the drying air temperature exceeded 40^0C in tomato (Gowda, *et al.* 1990).

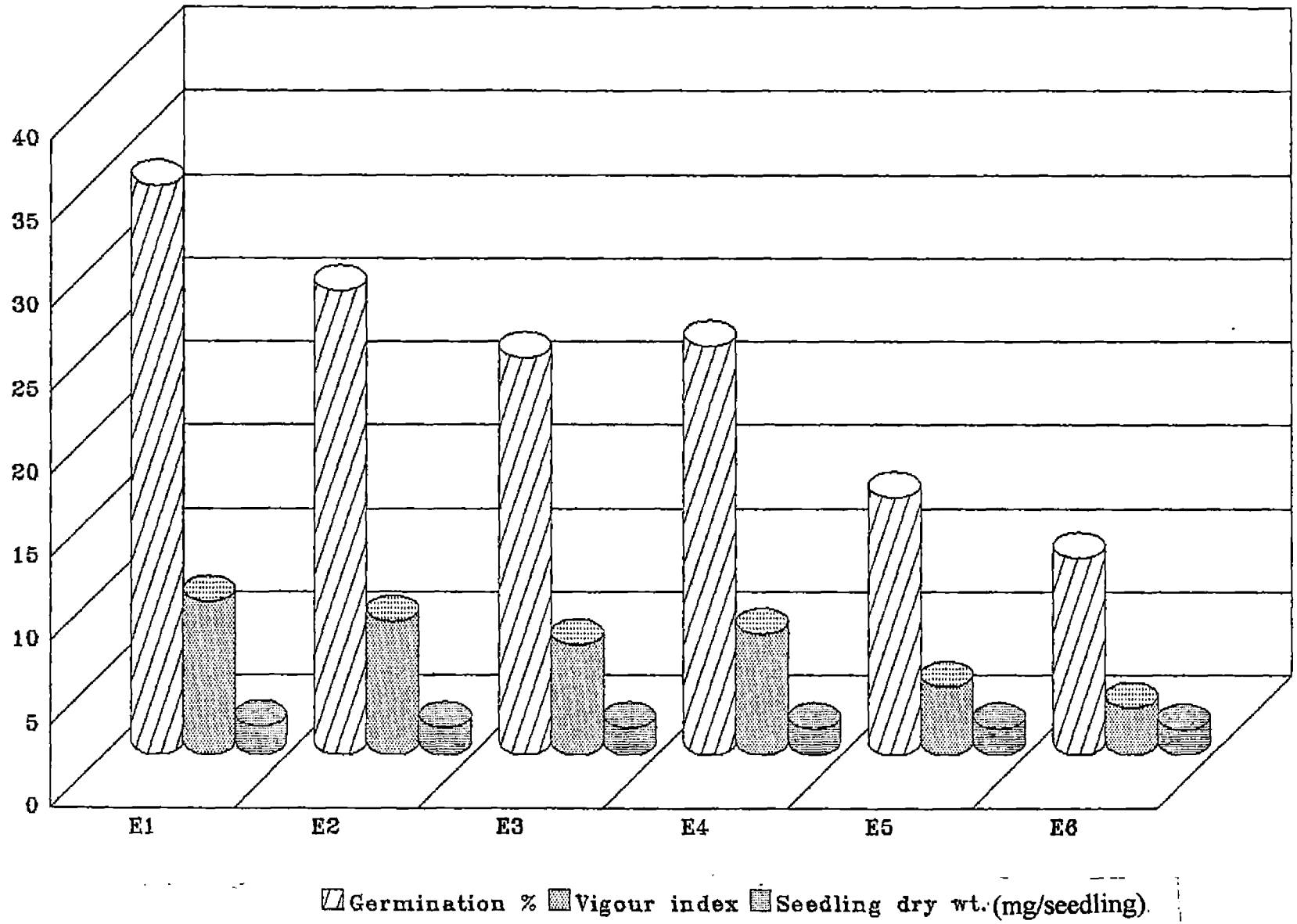


Fig. 3b Effect of various seed extraction methods on germination, vigour index and seedling dry weight in chilli, var. Ujwala

The rapid leakage of electrolytes during very early period of inhibition might be due to loss of integrity of semi permeable membrane while drying. According to Doijode (1988c) in brinjal cv.Arka Shirish, decrease in germination was associated with increase in leaching of electrolytes, soluble sugars and free amino acids.

The results of this study showed that seed quality was reduced drastically with increase in drying air temperature. This may be due to the stretching of cell membrane in rapid drying resulting in loss of integrity of seed coat causing death of cells when moistened. Among the six combinations of seed extraction and fruit drying, sun drying of chilli fruits avoiding the peak hours of sunlight and hand extraction of seeds was found to be the feasible method for chilli.

5.3. Standardization of packaging materials and storage conditions in chilli

Like any other form of life seeds can not retain their viability indefinitely and eventually they deteriorate and die. This decline in seed vigour and viability is noticed in storage and it is determined by a number of factors, of which seed moisture and storage temperature are the most important ones. In addition, environmental factors like temperature and relative humidity also play an important role in maintaining seed viability. Seed storage and maintenance of quality requires special attention in our state having a tropical humid climate. Seeds of high quality can be maintained by proper control of storage environment.

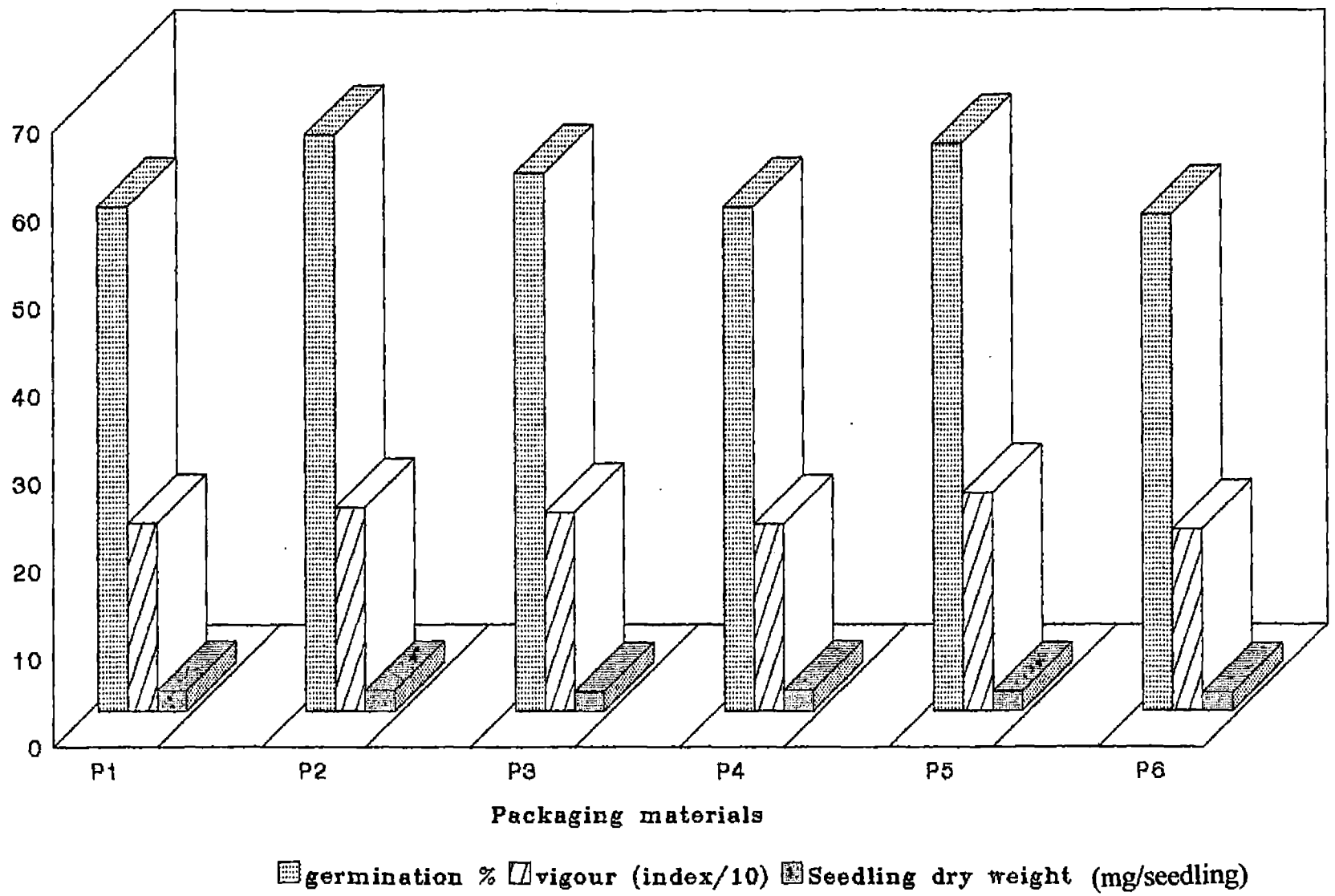


Fig.4a Effect of different packaging materials on germination percentage, vigour index and seedling dry weight in chilli, var. Jwalasakhi

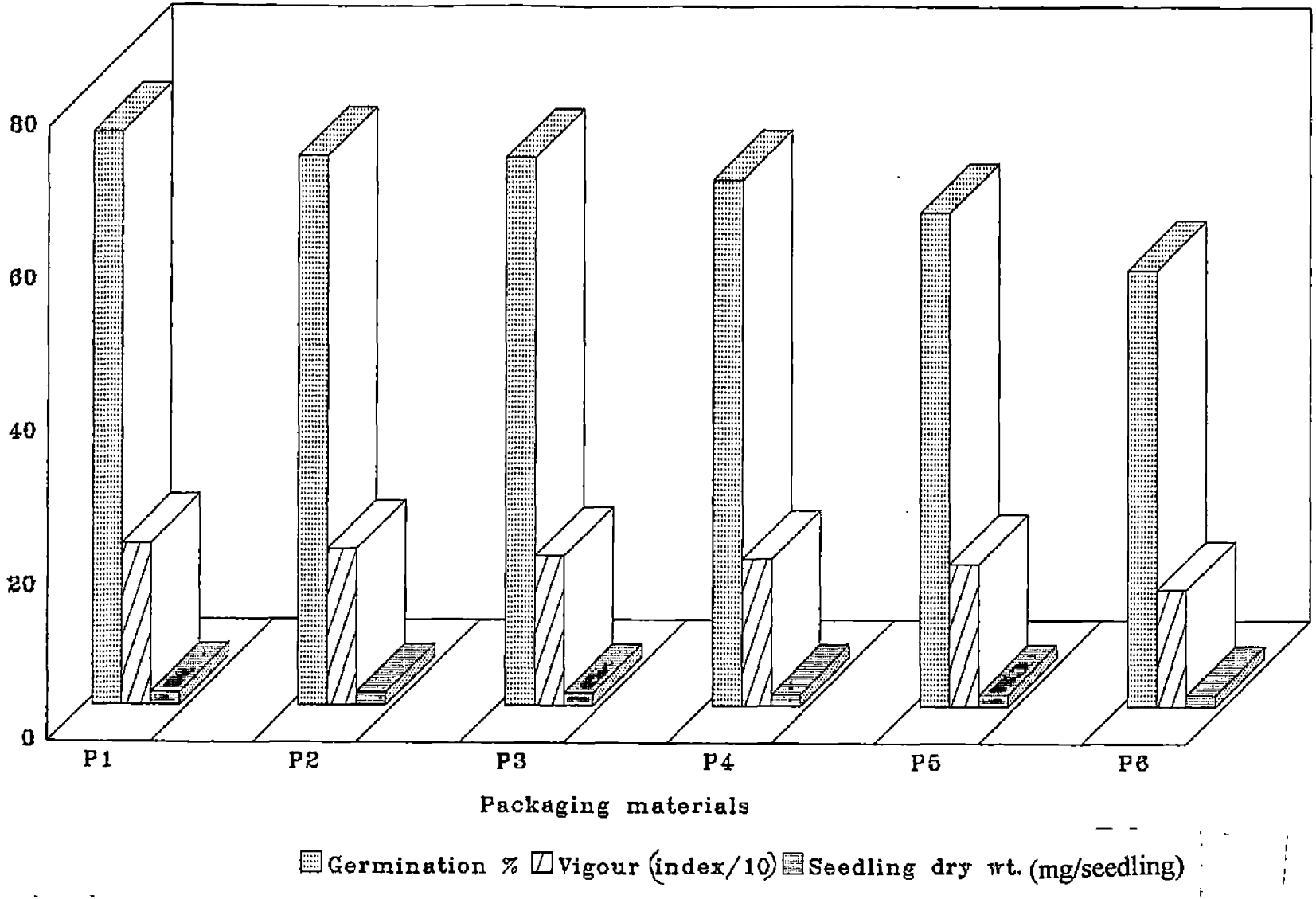
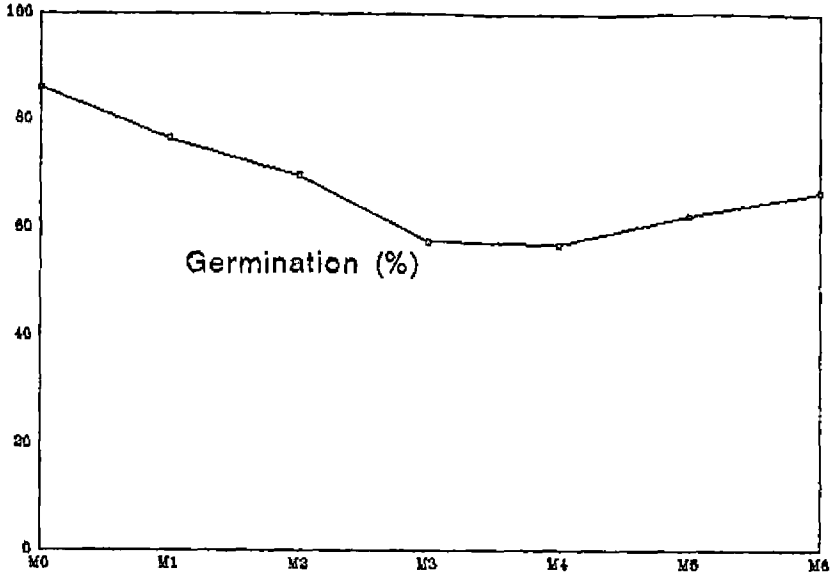
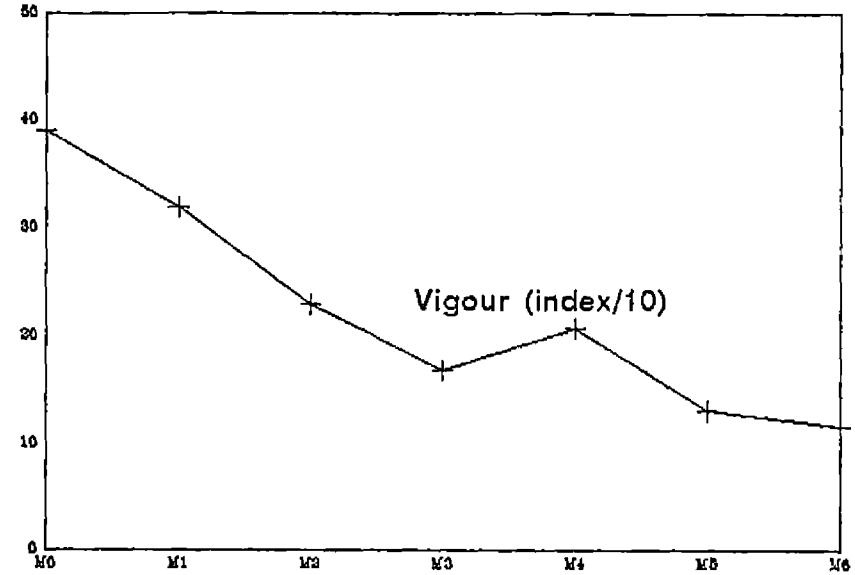


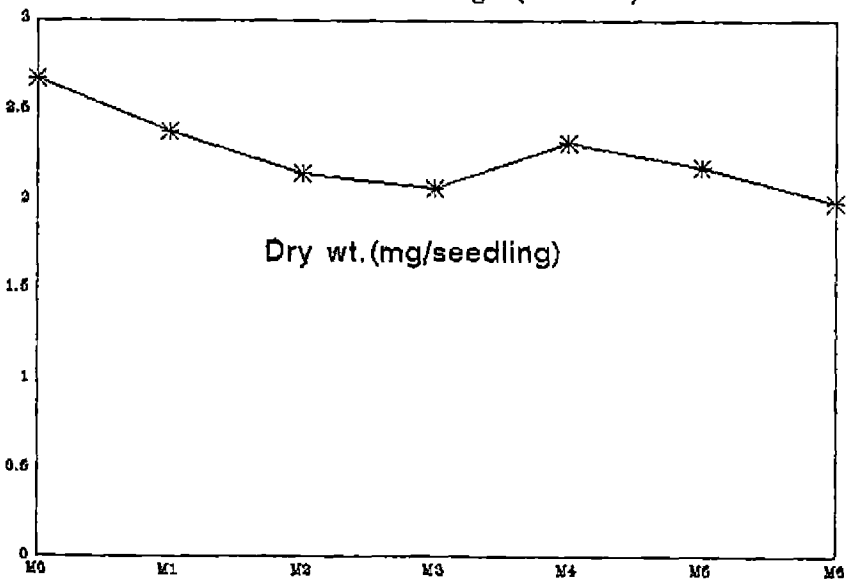
Fig.4b Effect of different packaging materials on germination percentage, vigour index and seedling dry weight in chilli, var. Ujwala

In this study, seeds packed in different packaging materials and fruits unextracted seeds were stored under different conditions. Results on germination percentage revealed that percentage of germination decreased irrespective of the storage container or storage conditions as the period of storage prolonged (Fig.5a and 5b). The mean germination per cent at the time of storage was 76 in variety Jwalasakhi and it was 86.11 per cent in variety Ujwala. It was reduced to 49.00 per cent in Jwalasakhi and 66.78 per cent in Ujwala after six months of storage. This shows that seed is a biological entity and senescence or deterioration is inevitable and irreversible during storage. Studies conducted by Thakur *et al.*(1988) showed that germination percentage of *Capsicum annuum* cultivars Russian Yellow and California Wonder was declined from 88.5% and 92% to 42.5 and 29% respectively after 5 years storage. This process of deterioration is irreversible too. Considering these limitations efforts are to be made to minimise deterioration in seed quality from high level attained at functional maturity.

Jwalasakhi seeds packed in butter paper cover and Ujwala seeds packed in brown paper cover recorded the highest mean germination of 65.62 % and 74.67 % respectively after six months of storage (Fig.4a and 4b). Loss of storage potential is one of the specific consequence of seed deterioration just as the decrease in germination rate and the increase in seedling abnormalities. Open storage of dried fruits recorded the lowest mean germination per cent (56.52 and 57.05 respectively) in both Jwalasakhi and Ujwala. Similar to the present study, Doijode







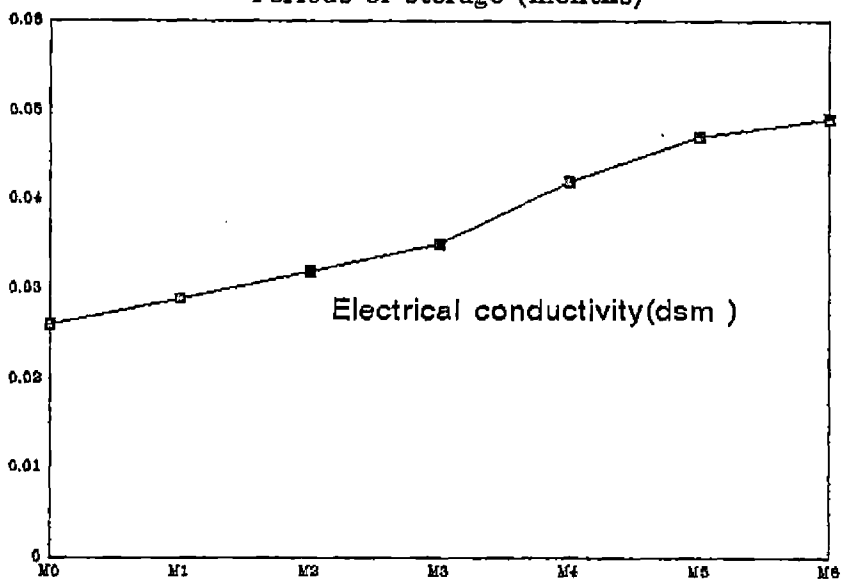
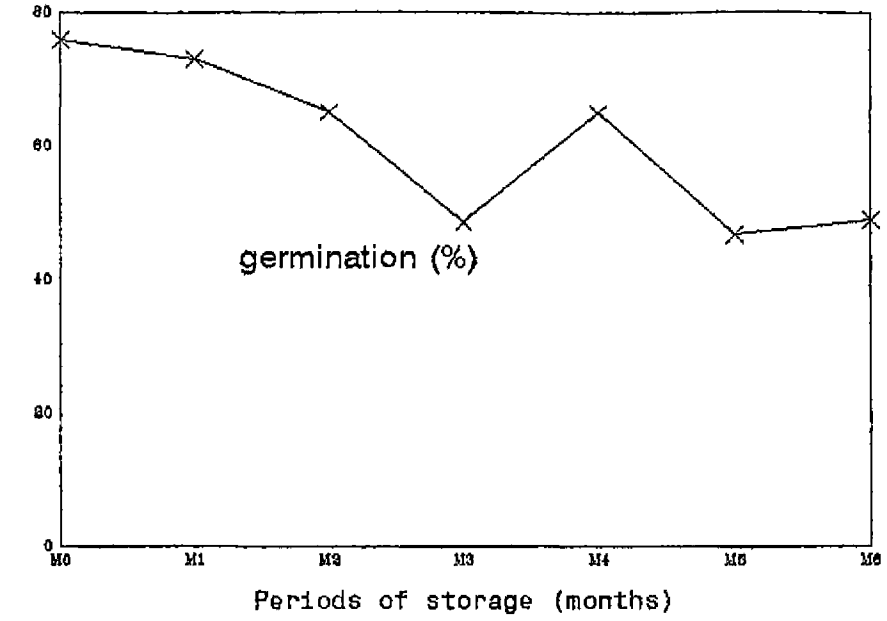
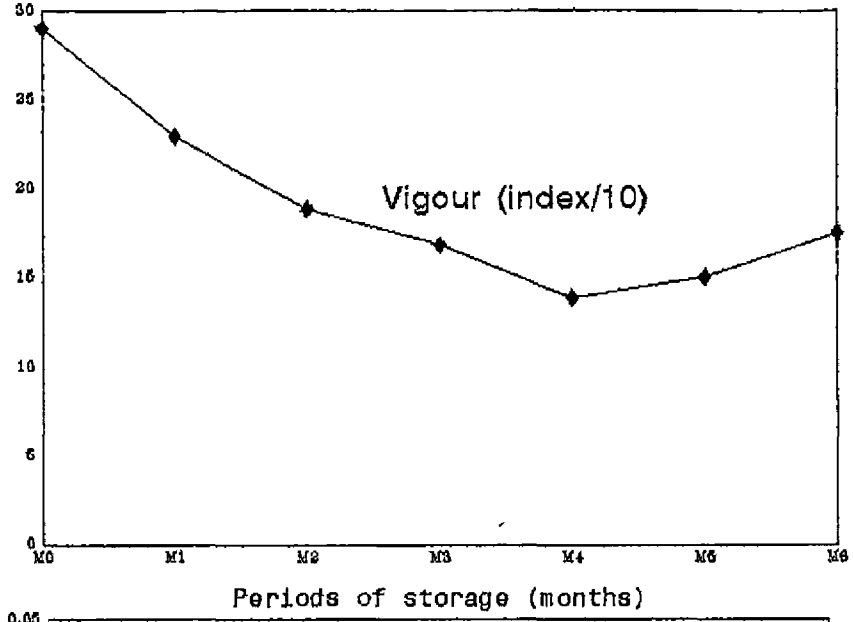
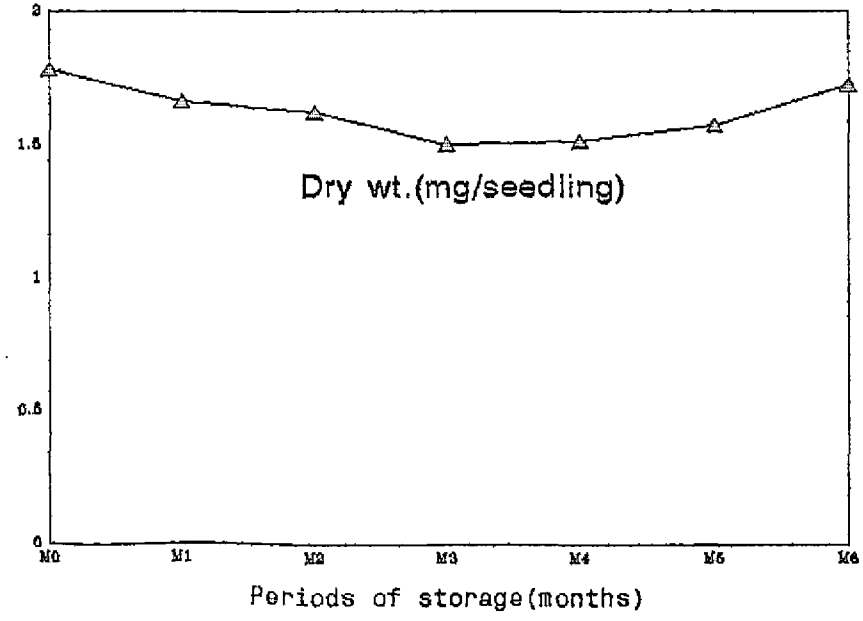


Fig.5a Changes in seed quality parameters during storage of seeds in chilli, var. Jwalasakhi







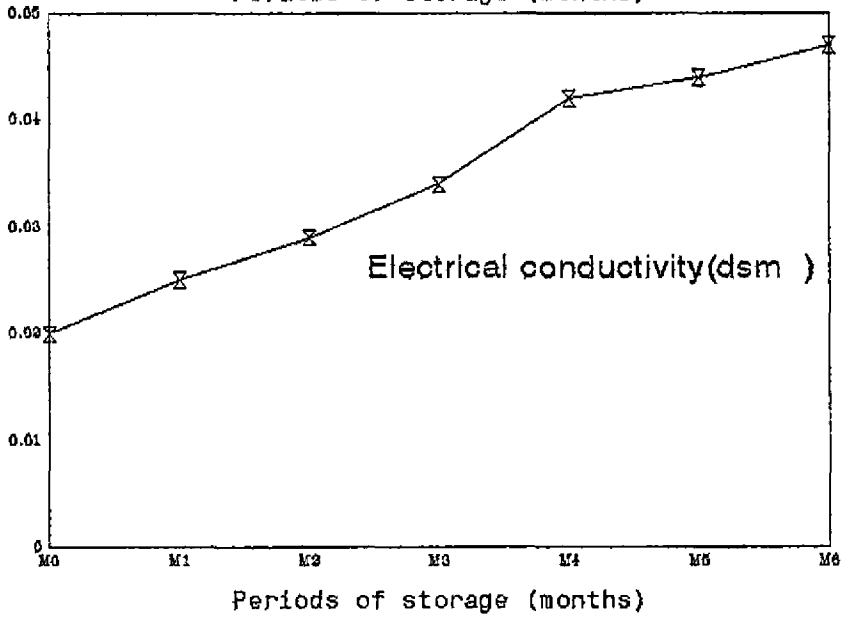
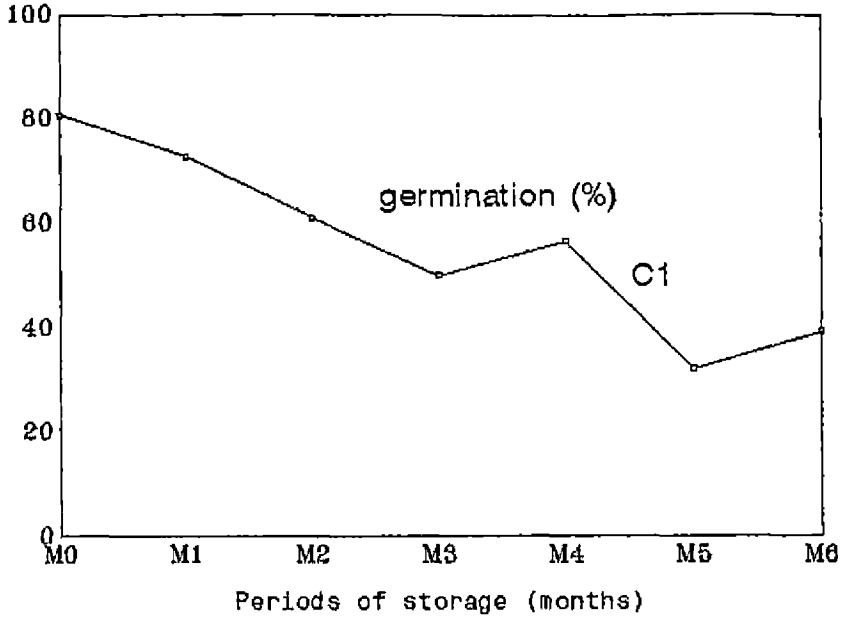


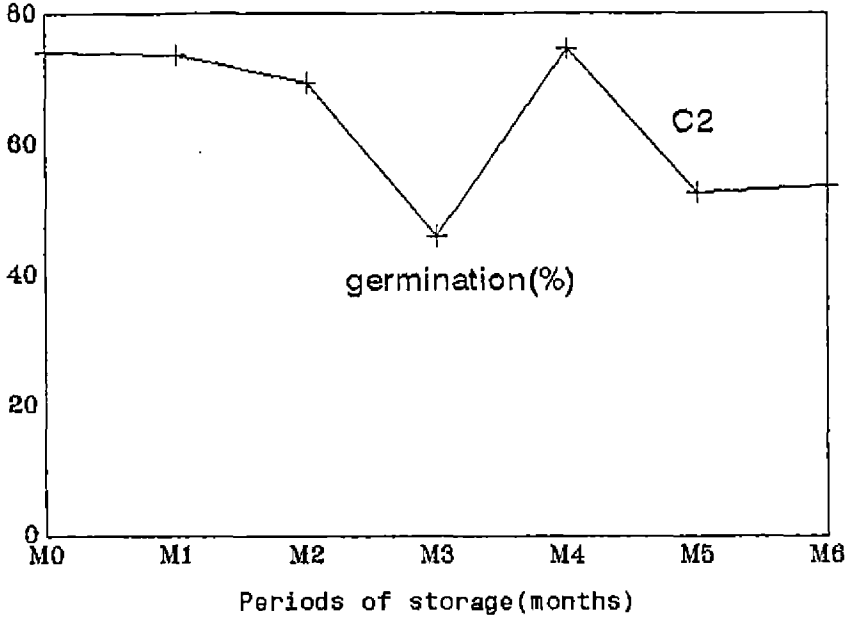
Fig. 5b Changes in seed quality parameters during storage of seeds in chilli, var. Ujwala

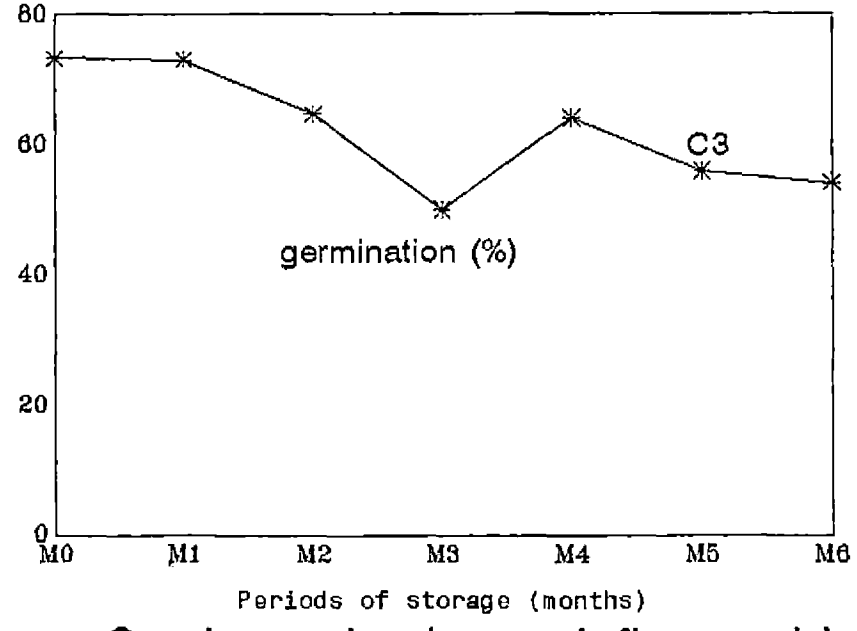
(1996) reported that seed viability was significantly affected by the storage period in chilli cv.Arka Lohit. The percentage of germination was greater in seeds of fruits stored in paper (75.00%), cloth bags (74.00%) and open containers (64.00%) than polyethene (5.00%) and aluminium foil laminated pouches (zero germiantion) suggesting thereby that sealed storage is not suitable for the seed.

Speed of germination was maximum for the seeds stored in brown paper cover and butter paper cover in both varieties. Seedling dry weight was also higher for seeds stored in paper and cloth bags, Suggesting better retention of vigour during storage of fruits in cloth and paper bags. Seed germinability was greater in seeds stored in paper bags, might be due to escape of excess moisture released in seeds during storage (Fig.4a and 4b).

Seed viability and storability are largely dependent on seed moisture. High seed moisture at high temperature hasten the process of seed deterioration resulting in loss of viability. Present study was conducted under the humid tropical condition. Mean germination per cent in both chilli varieties was significantly influenced by the storage conditions. Air conditioned storage of seeds recorded the maximum germination per cent, speed of germination and seedling dry weight in both chilli varieties and it was the lowest for the seeds stored under ambient conditions (Fig.6a and 6b). Similar results were obtained for in cluster bean seeds stored under three different storage conditions such as sub zero temperature (-18^{0}C, RH 40%), low temperature (5^{0}C,RH 40%) and room





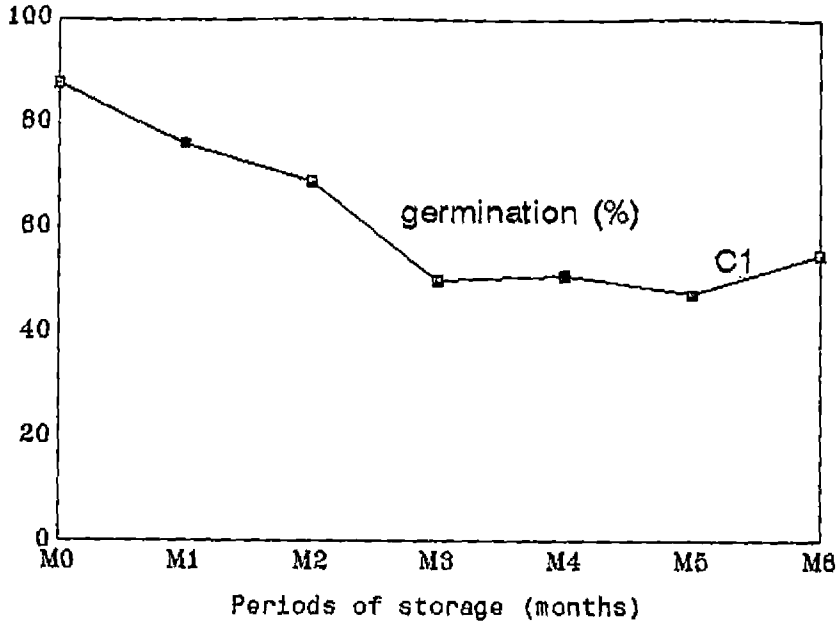


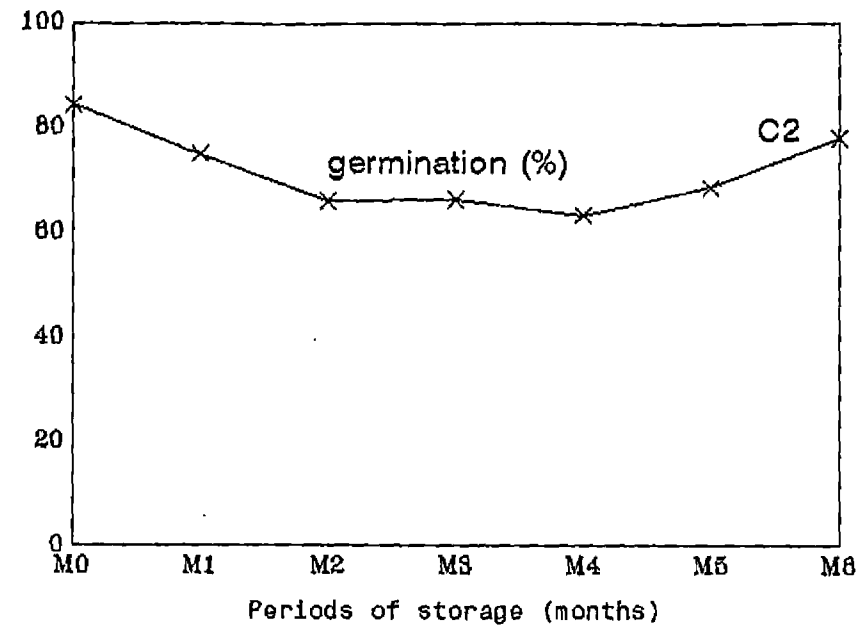
C1 - Ambient condition

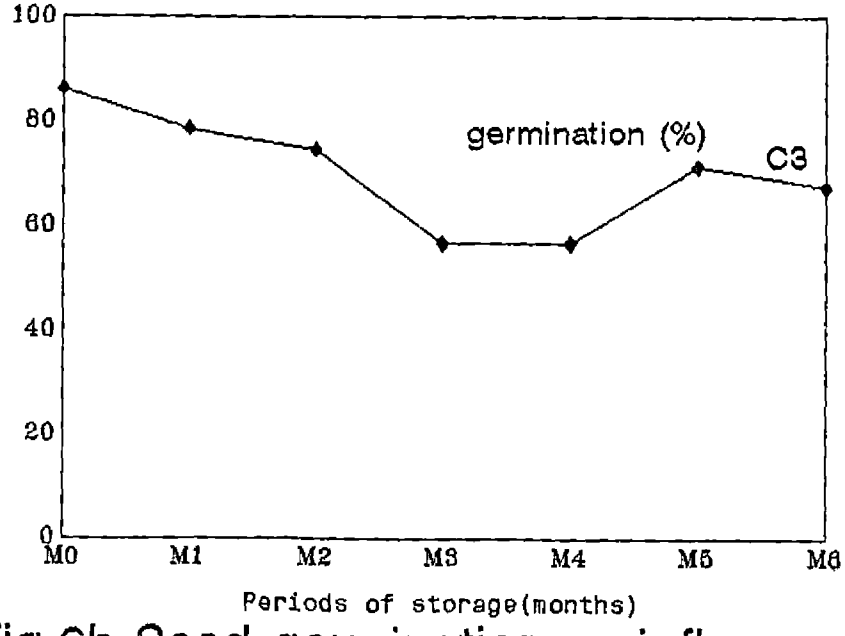
C2 - A/C storage

C3 - storage at 5°C temperature

Fig.6a Seed germination as influenced by storage conditions in chilli, var. Jwalasakhi







C1 - Ambient condition

C2 - A/C storage

C3 - Storage at 5°C temperature

Fig.6b Seed germination as influenced by storage conditions in chilli, var. Ujwala

temperature (16-35^{0}C, RH 25-90). In this study Doijode (1989) observed that there was no germination of seeds under ambient conditions suggesting the process of deterioration increase under high temperature.

In varieties Ujwala and Jwalasakhi seed deterioration under ambient storage condition was supported by the high value for mean electrical conductivity of seed leachate. In variety Jwalasakhi, the overall mean electrical conductivity before storage (0.026 dsm^{-1}) was increased to 0.049 dsm^{-1} after six months storage. The overall mean electrical conductivity was raised from 0.020 dsm^{-1} to 0.047 dsm^{-1} in variety Ujwala after six months storage. Germination per cent in both varieties reduced considerably after six months storage. Similar to this study Doijode (1995a) reported that leaching of electrolytes, soluble sugars and free amino acids were higher in seeds stored at ambient temperature than at 5^{0}C or -20^{0}C. Loss of germinability was positively correlated with extent of leaching of metabolities from seeds. This was attributed to the degradation of cell membrane.

From this study it is clear that packaging materials and storage conditions have a profound influence on the storage life of chilli. Sealed storage is not suitable in humid tropical condition and seed deterioration can be minimised by storing seeds under low temperature conditions.

Summary

SUMMARY

Investigations on the "Sandardization of seed processing techniques in chilli (*Capsicum annuum* L.) were conducted in the Department of Olericulture, College of Horticulture, Vellanikkara, with the following objectives during 1997-'98,

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.
2. To find out the effect of seed extraction and fruit drying methods on seed quality in chilli.
3. To standardise the packaging materials and storage conditions for prolonged storability of seeds.

The results of the investigations are summarized below:

Maximum fruit length in variety Jwalasakhi was attained by 30 d.a.a. (S_6). In variety Ujwala it was at 40 d.a.a. (S_8). Fresh weight of fruits reached maximum at 35 d.a.a. (S_7) in variety Jwalasakhi and it was on par with the fresh weight of fruits at 30 and 40 d.a.a. In variety Ujwala, maximum fresh weight was attained at 40 d.a.a. This stage of maximum fruit development can be designated as phase I and it is the optimum time for vegetable harvest. After attaining maximum growth in the vegetable harvest stage, fruit length and weight was decreased. It shows the beginning of phase II. This reduction in weight was continued upto 70 d.a.a.

Like fruit development, the pattern of seed development followed three distinct phases. The dry weight of seed was very low upto 30 d.a.a.(S_6) in both the varieties and it is the phase I of seed development. The structural development of the seed was

completed during phase I, and fruits also attained maximum size at this stage. This was followed by the second phase of seed development. During phase II, the dry weight of seed increased because of the synthesis and deposition of storage materials. The highest 1000 seed weight in variety Jwalasakhi was attained by 45 days maturity and it was at 40 d.a.a. in variety Ujwala. At the end of phase II, of seed begins to loose water and there was a decline in the dry weight of seeds in both varieties upto 70 d.a.a. Reduction in fruit weight drying and shrinkage of pericarp was observed towards the later stages (60-70 d.a.a.) in both varieties.

Germination studies were conducted in seeds from fruits of different maturity viz. 5 d.a.a. to 70 d.a.a (S_1-S_{14}) for both varieties. Seeds collected from fruits at 45 d.a.a. recorded the maximum germination percentage. When these seeds were stored for six months germination percentage reduced considerable and seeds of 45 days maturity recorded the maximum value in both varieties. Apart from germination percentage, seeds attained maximum speed of germination, vigour index and seedling dry weight by 45 d.a.a. These parameters of seeds at 45 d.a.a. and 50 d.a.a were on par with each other.

Seed quality was found to be influenced by the different combinations of seed extraction and fruit drying methods. In this study, sun drying of fruits avoiding the peak hours (12 noon to 3 p.m.) and hand extraction of seeds recorded the maximum mean germination percentage in both varieties. Speed of germination, vigour index and seedling dry weight was maximum for the seeds obtained by this method. Machine and hand extracted seeds of fruits dried by mechanical drier recorded the

lowest mean germination percentage, speed of germination, vigour index and seedling dry weight in both varieties . A high value for electrical conductivity of seed leachate was recorded in seeds of fruits dried using mechanical drier. This may be due to the thermal injury to the seeds when dried at high temperature with high initial moisture content.

Among the different packaging materials used, Jwalasakhi seeds packed in butter paper cover and Ujwala seeds packed in brown paper cover recorded the highest mean germination percentage after six months of storage. Speed of germination and seedling dry weight were maximum for the seeds stored in paper and cloth bags. This might be due to the escape of excess moisture released in seeds during storage. The storage condition significantly influenced the germination percentage of the chilli seeds. Air conditioned storage of seeds recorded the maximum germination percentage, speed of germination and seedling dry weight in both varieties and it was lowest for the seeds stored under ambient conditions. Seed deterioration under ambient storage condition was supported by the high value for mean electrical conductivity. Under ambient storage conditions, high seed moisture along with high temperature hasten the process of seed deterioration resulting the loss of viability of seeds.

The study reveals that the optimum stage of harvest for seed purpose of chilli is at 45-50 d.a.a for the var. Jwalasakhi and Ujwala. Sundrying of chilli fruits avoiding the peak hours of sunlight and hand extraction of seeds was found to be the effective method in chilli. The optimum storage condition of the chilli seed is air conditioned

storage and the best packaging materials are paper containers such as brown paper cover and butter paper cover to get satisfactory germination and seedling vigour upto to six months.

References

REFERENCES

Abdul-Baki, A.A. and Anderson, J.D. 1970. Viability and leaching of sugars from germinating barely crop. *Crop Sci.* **10**:31-34

Abdul - Baki, A.A. and Baker, J.E. 1973. Are change in cellular organelles membranes related to vigour loss in seed ?. *Seed Sci. Technol.* **1**:89-125

Agrawal, P.K., Dadlani, M. and Kumari, G.V. 1988. Viability of onion seeds: storage with low and high seed moisture. *Pl. Physiol. Biochem.* **15**:97-106

Anitha, P. 1997. Fruit maturity, method of seed drying and storage conditions on seed quality in okra, (*Abelmoschus esculentus* (L.) Moench). M.Sc. (Hort.) Thesis, Kerala Agricultural University, Vellanikkara, p.95

*Araujo, E.F., Silva, R.F.DA., Silva, J.De.S and Sediyama, C.S. 1984. Influence of pod drying on the germination and vigour of bean seeds. *Revista Brasileria de semente,* **6(2)**:97-110

Baldo, N.B., Valladar, D.M. and Fonollera, V.C. 1985. Effect of fermentation period on germination and vigour of tomato (*Lycopersicon esculentum* L.) K.ex. Farw. *CMU J. agric. food Nutrition,* **7(2)**:78-82

*Barbedo, C.J., Coelho, A.S., Zanin, A.C.W. and Nakagawa, J. 1993. Influence of age of cucumber fruits on seed quality. *Horticulturae Brasileira,* **11(1)**: 18-21

Barbedo, C.J., Nakagawa, J., Barbedo, A.S.C., and Zanin, A.C.W. 1994. Effect of fruit age and the duration of post harvest period on seed quality in the cucumber cultivar. *Horticulturae Brasileira,* **12 (2)**:118-124

Basavaraja, N. and Dutta, O.P. 1992. Studies on fruit bearing pattern, rate of fruit growth and rate of seed development in Brinjal (*Solanum melongena* L.). *Karnataka J. Agric. Sci.,* **5(3)**:229-233

Cavero, J., Ortega, G.R. and Zaragoza, C. 1995. Influence of fruit ripeness at the time of seed extraction on pepper (*Capsicum annuum*) seed germination. *Scientia Horticulturae,* **60(3-4)**: 345-352

Chandrasekaran, M. 1979. Studies on maturation, storability and quality of seeds in bottlegourd . M.Sc. (Ag.) thesis, Tamil Nadu Agricultural University, Coimbatore, p.85

Chauhan, K.S. and Bhandari, Y.M. 1971. Pod development and germination studies in okra. *Indian J. Agric. Sci.* **41(1)**:852-856

Currah, L. and Msika, L.1994. Cheap methods of storing small quantities of onion seeds without refrigeration. *Onion Newsl. Trop.* **6**:61-62

Delouche, J.C. 1973. Seed maturation. (In) *Seed Production Manual.* National seed corporation and Rock Feller Foundation, p.162-165

Demir, I. and Ellis, R.H. 1992a. Changes in seed quality during seed development and maturation in tomato. *Seed Sci. Res.* **2**:81-87

Demir, I. and Ellis, R.H. 1992b. Developmentrn of pepper (*Capsicum annum*) seed quality. *Ann. Applied Biol.* **121(2)**:385-399

Demir, I. 1994. Development of seed quality during seed development in okra. *Acta Horticulturae*, **362**: 125-131

Demir, I., Cockshull, K.E., Tuzel, Y. and Gul, A.1995. Changes in seed quality during seed development in tomato and pepper. *Acta Horticulturae.* **366**:221-227

Dhanelappagol, M.S., Shashidhara, S.D. and Kulkarni, G.N. 1994. Effect of stages of harvesting and methods of drying of chilli fruits on seed quality. *Karnataka J. Agric. Sci.* **7(1)**:36-39

Dharmatti, P.R. and Kulkarni, G.N. 1987. Physiological maturation studies in bell pepper (*Capsicum annum* L.). *S. Indian Hort.* **35**:395-396

Doijode, S.D. 1986. Effect of packaging on longevity of cluster bean seeds under ambient conditions. *Veg. Sci.* **13(1)**:26-29

Doijode, S.D. 1988a. Seed storability as affected by different stages of fruit development in chilli. *Veg. Sci* **15(1)** : 15-20

Doijode, S.D. 1988b. Seed germination in relation of drying methods in okra. (In) *Annual Report.* Indian Insititute of Horticultural research, Bangalore, p.42

Doijode, S.D. 1988c. Effect of storage environment on bringal (*Solanum melongena*) seed viability. *Prog. Hort.* **20 (3-4)**:292-293

Doijode, S.D. 1988d. Studies on partial vacuum storage of onion and bell pepper (*Capsicum annuum* L.) seeds. *Veg. Sci.* 15(2):126-129

Doijode, S.D. 1988e. Comparison of storage containers for storage of french bean seeds under ambient conditions. *Seed Res.* **16(2)**:245-247

Doijode, S.D. 1989. Deteriorative changes in clusterbean seeds stored in different conditions. *Veg. Sci.* **16(1)**:89-92

Doijode, S.D. 1990a. Germinability and longevity of onion seeds under different drying methods. *Prog. Hort.* 22(1-4): 117-120

Doijode, S.D. 1990b. Preservation of okra (*Abelmoschus esculentus* (L) Moench) germplasm. *Int. Sem. New Front. Hort.*, Bangalore, 73

Doijode, S.D. 1990c. The influence of storage conditions on germination of onion seeds. *J. Maharashtra Agric. Univ.* **15(1)**:34-35

Doijode, S.D. 1991. Conservation of radish germplasm. *Golden Jubilee Symp. Genet. Res. Edn.*, New Delhi, **1**:75

Doijode, S.D. 1993. Seed germination and conservation in vegetable crops. *Advances in Horticulture* (Ed. Chadha, K.L. and Kalloo, G.), Vol.6, Vegetable crops. part-2, Malhotra publishing House, New Delhi, p.988-989

Doijode, S.D. 1995a. Effect of silica gel and storage containers on seed viability and vigour in onion (*Allium cepa* L.). *Seed Res.* **23(2)**:67-70

Doijode, S.D. 1995b. Influence of temperature on storability of pumpkin (*Cucurbita moschata* poir) seeds. *Veg. Sci.* **22(1)**:55-58

Doijode, S.D. 1996. Effect of packaging and fruit storage on seed viability, vigour and longivity in chilli(*Capsicum annuum* L.). *Veg. Sci.* **23(1)**:36-41

Dourado, A.M. and Carson, R. 1994. Experimental storage of onion (*Allium cepa* L.) seeds undner simulated tropical conditions. *Onion Newsl. Trop.* **6**:53-55

*Duczmal, K.W. and Kaczmarkiewicz, M. 1984. Effect of planting time and harvesting method on capsicum seed yield and quality. *Roezniki Akademi Rolnicze W Poznanin ogrodrictwo,* **150(11)**:19-26

Edward, R.L. and Sundstrom, F.J. 1987. After ripening and harvesting effects on tabasco pepper seed germination performance. *Hort. Sci.* **22(3)**:473-475

*Fischer, I. 1994. Sweet pepper gene conservation in long-term storage. *Zoldsegtermesztesi Kutato Intezet Bulletinje*, **26**:47-54

Garris, E.W and Hoffmann, G.P. 1946. Okra enterprises. (In) *South Indian Horticulture* Enterprises. (Ed. R.W. Gregory, J.B. Lippin) Cotton company, Chicago, Philadelphia, New York, p.223-232

Gowda, S.J., Talukdar, K.C. and Ramaiah, H. (1990). Effect of drying methods on seed qualityo of tomato (*Lycopersicon lycopersicum*). *Seed Res.* **18(2)**:126-129

Gupta, A., Singh, D., Maheshwari, V.K., Gupta, A. and Singh, D. 1992. Effect of containers on the viability of fungicide treated chilli seeds. *Seed Res.* **20(2)**:160-161

Harrington, J.F. 1959. Effect of fruit maturity and harvesting methods on germination of muskmelon seeds. *J. Amer. Soc. Hort. Sci.*, **73**: 422-430

Heaney, R.P. 1997. The roles of Calcium and Vitamin D in skeletal health : an evolutionary perspective. *Fd. Nutr. Agri.* **20**:4-11

Helmer, J.D., Delouche, J.C. and Leinhard, M. 1962. Some indices of vigour and deterioration in seeds of crimson clover. *Proc. Ass. Off. Seed Anal.* **52**:154

Hernandez, E., Front, A. and Hernandez, M. 1994. Preservation of common bean (*Phaseolus vulgaris* L.) in different containers and storage conditions. *Pl. Genet. Resour. Newsl.* **99**:34-35

Hosmani, M.M. 1993. *Chilli Crop*(*Capsicum annuum* L.) Univeristy of Agricultural Sciences, Dharwad-580005, p.232

IPGRI, AVRDC and CATIE. 1995. *Descriptors for Capsicum* (*Capsicum* spp.). IPGRI Institute, Rome, Italy, AVRDC Taipei and the Centro Agronomico Tropical de Investigation Y Ensenanza, Turrialba, Costa Rica. p.49

Jayabarathi, M., Palaniswamy, V., Kalavathi, D. and Balamurugan, P. 1990. Influence of harvesting conditions on the yield and qualityo of brinjal seeds. *Veg. Sci.* **17(2)**:113-118

Jayaraj, T., Vadivelu, K.K., Dharmalingam, C., Vijaykumar, A. and Irulappan, J. 1988. Effect of seed treatments and containers on vegetable seed storage under different agroclimatic conditions. *S. Indian Hort.* **36**:183-187

Kannath, B. 1996. Effect of fruit maturity, seed processing and storage methods on seed quality of ashgourd (*Benincasa hispida* Thumb.) cv. BH-21. M.Sc. (Hort.) thesis, Kerala Agricultural University, Vellanikkara, p.165

Kanwar, J.S. and Saimbhi, M.S. 1987. Pod maturity and seed quality in okra (*Abelmoschus esculentus* (L) Moench). *Punjab Hort. J.* **27(3-4)**:234-238

KAU. 1993. *Package of Practices Recommendations 'Crops'* Kerala Agricultural University, Vellanikkara - 680654, p.176-177

Karivaratharaju, T.V. and Palanisamy,V. 1984. Effect of seed extraction methods on seed quality in chillies. *S. Indian Hort.* **32(4)**:243-244

Karivaratharaju, T.V., Palanisamy, V. and Vanangamudi, K. 1990. Influence of seed treatment and storage container on the viability of lablab (*Lablab prupureus* L) seeds. *S. Indian Hort.* **37**:121-122

Krishnaprasad, S. 1980. Studies on the development, maturation and storage of seeds in ashgourd (*Benincasa hipspida* (Thunb) Cong.) CO.1. M.Sc (Ag) thesis, Tamil Nadu Agricultural University, Coimbatore, p.78

Lassim, M.B.M. and Chin, H.F. 1987. Some trends in the development and maturation of cowpea (*Vigna ungiculata* L.) seeds. *Acta Horticulturae* **215**:25-30

*Lysenko, A.J. and Butkevich, Ts.B. 1980. Capsicum seed quality in relation to the degree of fruit maturity. *Trudy VN11 Selektsii i Semenovod Ovoshch Kul' tur,* **11**:64-67

Maguire, J.D. 1962. Speed of germination aid in selection and evaluation for seedling emergence and Vigour. *Crop Sci.* **2**:176-177

Mantovani, E.C., Silva, R.F. da., Casali, V.W.D. and conde, A.R. 1980. Development and physiological ripening of capsicum seeds. *Revista ceres,* **27(152)**:356-368

Metha, V.A. and Ramakrishnan, V. 1986. Effect of seed maturity on the relative storability of chilli seeds. *S. Indian Hort.* **35 (5)**:345-348

Miyagi, K. 1966. Effect of moisture prooof packing on the maintenance of viability of vegetable seeds. *Proc. Int. seed Testing Ass.* **31**:213-222

*Moreira, C.A., Castro, J.L., Peche, De, Filho, A., Armonel, G. and Braga, C.A. 1990. Influence of mechanical impact occuring during artificial drying on germination of bean seeds. *Agronomico,* **42(3)**:161-164

Murthy, N.S.R. and Murthy, B.S. 1961. Chilli seed viability in relation to period of storage. *Andhra Agric. J.* **8**:246-247

*Nakagawa, J., Zanin, A.C.W. and Pizzigatti., R. 1991. Effects of seed size and storage on seed quality in okra CV. Amarelinho. *Horticultura Brasileria,* **9(2)**:84-86

Nassar, S.H., Sherbenri, E.I.M., Furrag, M., Omar, S. and Sherbeni, M.E.I. (1972). Study of the causes of the unsatisfactory viability of pepper seeds produced in A.R.E. *Agrl. Res. Rev.* **50** (4):59-67

Neelamathi, D. 1989. Seed quality as affected by drying methods in tomato cv. CO-1. M.Sc. (Ag) thesis, Tamil Nadu Agricultural University, Coimbatore, p.79

Nerson, H. and Paris, H.S. 1988. Effect of fruit age, fermentation and storage on germination of cucurbit seeds. *Scientia Horticulturae*, 35:15-26.

Nerson, H., Parris, H.S., Edelstein, M., Zohar, R., Gover, A. and Burger, Y. 1985. Effect of washing and drying of cucurbit seeds at harvest on their immediate germinability. *Hassadesh,* **65(12)**:2426-2428

Noggle, G.R. and Fritz, G.I. 1983. *Introductory Plant Physiology* (2nd ed.), Prentice Hall of India Pvt. Ltd., New Delhi, p.627

*Nowosielska, B. 1978. The quality of differently ripened seeds of vegetable crops. *Post Nauk Rolviezych,* **25(4)**:23-24

Oladiran, J.A and Mumford, P.M. 1990. The longevity of large and small seeds of *Amaranthus gangeticus* and *Amaranthus hybridus*. *Seed Sci. Technol.* **18(3)**:499-506

Palanisamy, V. and Karivaratharaju, T.V. 1990. Effect of humidity levels and periods of storage on seed qualitiy in different genotypes of tomato. *S. Indian Hort.* **38(1)**:28-34

Palanisamy, V. and Karivaratharaju, T.V. 1991. Seed deterioration in some tomato (*Lycopersicon esculentum* L. non. Consv.) genotypes. *Seed. Res.* **19(1)**:54-56

Palanisamy, V., Balakrishnan, K., Karivaratharaju, T.V. and Arumugan, R. 1995. Influencne of seed treatments and containers on the viability of annual moringa seeds. *S. Indian Hort.* **43(142)**:42-43

Pandian, M.1988. Seed quality studies in Co-2 hybrid bhendi and its parents. M.Sc. (Ag.) thesis. Tamil Nadu Agricultural University, Coimbatore, p.91

Pandita, V.K., Randhawa, K.S. and Modi, B.S. 1996. Seed quality in relation to fruit maturity stage and duration of pulp fermentation in tomato. *Gartenbauwisseuschaft,* **61(1)**:33-36

Passam, H.C., Lambropoulose, E. and Khah E.M. 1997. Pepper seed longivity following production under high temperature. *Seed Sci. Technol.* **25**: 177-185

Pereira, A.L, Silva, E.M. and Costa, F.A. 1982. Effect of harvest date of egg plant (*Solanum melongena* L.) on seed quality. *Proc. Trop. Reg., Amer. Soc. Hort. Sci.* **25**:95-98

Popovska, H.P., Mladenovski, L.T. and Mihajlovski, M. 1981. The influence of packing over germination of pepper and tomato seeds. *Acta Horticulturae,* **11**:281-29

Presley, J.T. 1958. Relaltion of protoplast permiability to cotton seed viability and predisposition to seedling disease. *Pl. Dis. Reptr.* **42**:852

Quagliotti, L. 1977. Effects of ripening stages of the berries and of storage within the fruits on viability of seeds in two varieties of pepper. *Capsicum 77, comptes Rendus du 3e Congress Eucarpia Sur la Genetique et la selection du piment.* 293-301

Quagliotti, L., Antonucci, M. and Lanteri, S. 1981. Effect of post harvest ripening of the seeds within the berry in two varieties of pepper (*Capsicum annuum* L.). *Rivista della Ortoflorofrutticoltura Italiana,* **65(4)**:249-256

Quagliotti, L. 1986. Seed storage behaviour in pepper. *VI th Meeting on Genetics and Breeding on Capsicum and Eggplant,* EUCARPIA, Zaragoza, p.55-56

Rachidian, Z. and Deunff, Y.L. 1986. Germinative capacity of pea seeds - I. Pod and seed development : implication for seed germination with or without drying. *Agronomic,* **6(5)**:463-468

Rodriguez, A.G.F., Garica, B.L.A. and Martinez, J.H.E. 1994. Effect of fruit ripeness and the duration of postharvest ripening on seed quality in Jalapeno chilli. *Revista Fitotecnia Mexicana.* **17(1)**:55-56

Roos, E.E. and Davidson, A.A. 1992. Record longevities of vegetable seeds in storage. *Hort. Sci.* **27(5)**:393-396

*Rudolph, M. 1987. A contribution on the drying and threshing of the umbells of onion (*Allicum cepa* L.). *Arehiv fiir Gartenbau.* **35(5)**:217-223

Sanchez, V.M., Sundstrom, F.J., McClure, G.N. and Lang, N.S. 1993. Fruit maturity, storage and postharvest maturation treatments affect bell pepper (*Capsicum annuum* L.). Seed quality. *Scientia Horticulturae* **54(3)**:191-201

Sandhan, M. 1982. Seed development and maturation, prodouction and storage studies on field bean (*Lablab purpureous* L.). M.Sc. (Ag) thesis, Tamil Nadu Agricultural University, Coimbatore, p.78

Sandhu, J.S., Nandpuri, K.S. and Thakur, J.C. 1972. Studies on the germiantion of freshly harvested mature and immature onion seeds. *Indian J. Hort.* 29:339-341

Selvaraj, J.A. 1988. Studies on sundrying of brinjal seeds. *S. Indian Hort.* **36(5)**: 273-276

Shanmugaraj, K. 1978. Seed maturation and storage studies in lablab (*Lablab purpureus* (L.) sweet) M.Sc. (Ag) thesis, Tamil Nadu Agricultural University, Coimbatore, p.95

Silva, R.F.D.A., Silva, J.F.D.A., Veggano, J., Conto, F.A.D.A. and conde, A.R. 1976. Effect of seed moisture content, type of storage container and storage conditions on the germination of okra seeds. *Revista ceres,* 23 (126) : 77-82

Singh, S., Lal, T. and Rana, R.S. 1985. Effect of fruit maturity and fermentation on seed germination of muskmelon (*Cucumiis melo* L.). *Seed Res.* **13(1)**:171-175

Singh, G., Singh, H. and Dillon, T.S. 1985. Some aspects of seed extraction in tomato. *Seed Res.* **13(2)**:67-72

Singh, H. and Verma, S.R. 1986. A seed extraction machine for tomato, brinjal and chilli. *Indian farmg.* **36(7)**:23-24

Spices Board. 1997. *Spice statistics.* Spices Board, Cochin, p.16-17

*Stryapkova, L.V. and Kononkov, P.F. 1980. Effect of the method of seed extraction in tomatoes and cucumber on seed quality. *Trudy VNII Selektsii somenovod Ovoschch Kul' tur.* **11**:59-63

Suryavanshi, Y.B. and Patil, R.B. 1995. Physiological maturity in Mungbean (*Vigna ungiculata* (L.) Wilczech) cultivars. *Seed Res.* **23(1)**:25-27

Thakur, P.C., Joshi,S., Verma, T.S. and Kapoor, K.S. 1988. Effect of storage period on germination of sweet pepper seeds. *Capsicum Newsl.* 7:58-59

Thiagarajan, C.P. 1994. Storability of chilli (Capsicum annuum L.) *seeds. Madras Agric. J.* **81(8)**:442-445

Thulasidas, G., Selvaraj, J.A. and Thangaraj, M. 1977. Seed storage in brinjal (*Solanum melongena* L). *Madras Agric. J.* **64**:646-649

Tucker, W.G. and Gray, D. 1986. The effect of threshing and conditioning carrot seeds harvested at different times on subsequent seed performance. *J. Hort. Sci.* **61(1)**: 57-70

Usha, H., Gowda, J.S. and Ramaiah, H. 1990. Influence of container, chemical and bio-prodoucts treatments on storability of cowpea (*Vigna ungiculata*) and horse gram (*Dolichos biflorus*) seeds. *Legume Res.* **13(1)**:13-16

Vanraj, S.S. and Kulkarni, S.V. 1977. Studies on mechanical and thermal injuries to the seeds of few important cereal crops. *J. Agric. Engg.* **14**:77-78

Varatharaj, A. 1979. studies on seed maturation and quality of seeds on ribbed gourd and bitter gourd. M.Sc. (Ag) thesis, Tamil Nadu Agricultural University, Coimbatore, p.84

Verma, O.P., Jaiswal, R.C., Singh, K. and Gautam, N.C. 1991. Influence of storage conditions on the longevity of tomato and cauliflower seeds. *Veg. Sci.* **18(1)**: 88-92

*Villaneal, R.L., Balagedan, J.B. and Castra, A.D. 1972. The effect oof packaging materials and storage conditions on the vigour and viability of squash

(*Cucurbita maxima* nuch.), Patola (*Luffa acutaugula* Linn.) and upto (*Lagenaria siceraria* Mol) Seeds. *Phillippine Agriculturist,* **56(314)**:59-79

* Zink, E. and Demendonea, N.T. 1964. Estudos sobue a conservacao de sementer XII. Melonicia. (seed storage studies XI, watermelon). *Bragantia* **23**:343-350

* Original not seen

Appendices

APPENDIX I

General analysis of variance for various fruit and seed characters in chilli var. Jwalasakhi and Ujwala at different stages of fruit maturity

		Mean sum of squares											
ource	degrees of freedom	Length of the fruit		Weight of the fruit		Total number of seeds per fruit		Number of well filled seeds per fruit		Percentage of well filled seeds/fruit		1000 seed weight	
		Jwalasakhi	Ujwala	Jwalasakhi	Ujwala	Jwalasakhi	Ujwala	Jwalasakhi	Ujwala	Jwalasakhi	Ujwala	Jwalasakhi	Ujwala
uit evelopment	13	35.223**	8.088*	52.048**	2.833**	806.138**	226.327**	7393.453**	4486.348**	16845.715**	14704.697**	20.897**	10.193**
rror	98	0.154	0.082	0.186	0.028	79.607	51.501	42.908	22.562	12.146	36.355	0.000	0.010

* Significant at 5% level

** Significant at 1% level

APPENDIX II

General analysis of variance for seedling characteristics of chilli, var. Jwalasakhi at different stages of maturity

Source	Degrees of freedom	Mean sum of squares: Germination percentage	Speed of germination	Vigour index	Root length	Shoot length	Seedling dry weight
Period	6	413.899**	20.944**	8223.172**	1.323**	0.618**	2.338**
Stages of fruit development	7	2416.443**	85.124**	56162.63**	0.303**	1.267**	2.473**
Period x Stages of fruit development	42	85.262	4.62	2231.205	0.100**	0.263**	0.222**
Error	56	64.177	3.385	1699.237	0.034	0.043	0.021

APPENDIX III

General analysis of variance for seedling characteristics of chilli, var. Ujwala at different stages of maturity

Source	Degrees of freedom	Mean sum of squares: Germination percentage	Speed of germination	Vigour index	Root length	Shoot length	Seedling dry weight
Period	6	736.668**	31.668**	14011.251**	0.034	1.316**	0.639**
Stages of fruit development	7	938.396**	938.396**	19451.515**	0.171*	0.082**	0.444**
Period x Stages of fruit development	42	159.175**	159.175**	3192.72**	0.110*	0.079**	0.106**
Error	56	72.467	72.467	908.357	0.064	0.019	0.034

* Significant at 5% level

** Significant at 1% level

APPENDIX IV

General analysis of variance for effect of different methods of seed extraction and fruit drying on seed quality parameters in chilli, var. Jwalasakhi at different stages of maturity

Source	Degrees of freedom	Mean sum of squares: Germination percentage	Speed of germination	Vigour index	Root length	Shoot length	Seedling dry weight	Electrical conductivity of seed leachate
Seed extraction and fruit drying	5	1841.413**	69.491**	49174.689**	0.376**	0.558*	3.242**	0.00001**
Period	6	1958.338**	85.717**	77262.341**	1.791**	4.058**	2.185**	0.001**
Seed extraction and fruit drying x period	30	78.615	4.626	3185.781**	0.063	0.297	0.341*	0.00001**
Error	84	65.083	1.756	1303.8	0.043	0.196	0.202	0.00001

APPENDIX V

General analysis of variance for effect of different methods of seed extraction and fruit drying on seed quality parameters in chilli, var. Ujwala at different stages of maturity

Source	Degrees of freedom	Mean sum of squares: Germination percentage	Speed of germination	Vigour index	Root length	Shoot length	Seedling dry weight	Electrical conductivity of seed leachate
Seed extraction and fruit drying	5	732.551**	14.582**	12223.756**	0.209**	0.092**	0.070	0.006**
Period	6	1675.434**	42.745**	41065.253**	0.578**	2.429**	0.809**	0.019**
Seed extraction and fruit drying x period	30	42.708	1.638**	1797.997**	0.138**	0.039**	0.059	0.006**
Error	84	36.57	0.814	455.761	0.042	0.014	0.055	0.003

* Significant at 5% level

** Significant at 1% level

APPENDIX VI

General analysis of variance for effect of various packaging materials and storage conditions on seed quality parameters in chilli var. Jwalasakhi

		Mean sum of squares						
Source	Degrees of freedom	Germination percentage	Speed of germination	Vigour index	Root length	Shoot length	Seedling dry weight	Electrical conductivity of seed leachate
Packaging materials	5	277.941*	13.761*	9535.21*	0.110**	0.077	0.529**	0.00001**
Condition	2	492.800**	50.503**	1904.844	0.012	0.132	0.137	0.00001**
Period	6	2171.242**	128.809**	362692.561**	10.266**	8.678**	1.953**	0.003**
Packaging x condition	10	179.043	7.312	5348.603	0.192**	0.302**	0.152*	0.00001**
Packaging x Period	30	86.043	4.807	6595.645**	0.118**	0.342**	0.177**	0.00001**
condition x Period	12	213.925*	10.655*	9471.601**	0.154**	0.332**	0.161*	0.00001
Error	186	111.158	5.724	3688.342	0.037	0.062	0.079	0.00001

APPENDIX VII

General analysis of variance for effect of various packaging materials and storage conditions on seed quality parameters in chilli, var. Ujwala

		Mean sum of squares						
Source	Degrees of freedom	Germination percentage	Speed of germination	Vigour index	Root length	Shoot length	Seedling dry weight	Electrical conductivity of seed leachate
Packaging materials	5	753.186**	24.873**	14396.548**	0.062	0.055	0.195**	0.001
Condition	2	885.068**	30.573**	16815.459**	0.119*	0.079	0.259**	0.00001
Period	6	1671.788**	105.338**	97776.705**	0.146**	3.299**	0.391**	0.005**
Packaging x condition	10	231.799*	9.257**	5345.242*	0.054	0.112**	0.071*	0.00001
Packaging x Period	30	103.769	3.524	6082.677**	1.338**	0.109**	0.070**	0.001
condition x Period	12	238.802*	11.714**	4423.555	0.509**	0.167**	0.03	0.001
Error	186	118.242	3.725	2481.552	0.091	0.031	0.035	0.00001

* Significant at 5% level

** Significant at 1% level

APPENDIX VIII

General analysis of variance for effect of various packaging materials, storage conditions and storage period on seed quality parameters in chilli, var. Jwalasakhi

		Mean sum of squares						
Source	Degrees of freedom	Germination percentage	Speed of germination	Vigour index	Root length	Shoot length	Seedling dry weight	Electrical conductivity of seed leachate
Pacakaging x condition x month	102	247.896**	5.137**	0.217*	0.107*	5349.096**	0.185*	0.0001*
Error	126	293.639	6.451	0.029	0.011	3586.924	0.025	0.0001

APPENDIX IX

General analysis of variance for effect of various packaging materials, storage conditions and storage period on seed quality parameters in chilli, var. Ujwala

		Mean sum of squares						
Source	Degrees of freedom	Germination percentage	Speed of germination	Vigour index	Root length	Shoot length	Seedling dry weight	Electrical conductivity of seed leachate
Pacakaging x condition x month	102	320.197**	5.104*	0.132*	0.09*	4782.611*	0.069*	0.001**
Error	126	232.000	3.322	0.030	0.015	2192.582	0.015	0.000

* Significant at 5% level

** Significant at 1% level

STANDARDISATION OF SEED PROCESSING TECHNIQUES IN CHILLI *(Capsicum annuum* L.*)*

By
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ABSTRACT OF THE THESIS

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ABSTRACT

Studies on seed quality aspects of chilli var. Jwalasakhi and Ujwala were undertaken in the Department of Olericulture, College of Horticulture, Vellanikkara during 1997-98 to fix the optimum fruit maturity stage and to standardise the best seed processing and storage methods for maintaining viability and getting maximum seed quality.

Physiological maturity studies in variety Jwalasakhi indicated that fruits reached maximum size by 30 d.a.a. The fresh weight of fruits was maximum at 35 d.a.a. and it was on par with the fresh weight fruits at 30 and 40 d.a.a. So, vegetable harvest of this fruits can be extended from 30 to 40 d.a.a. In the case of variety Ujwala, both fruit length and fresh weight of fruits was maximum at 40 d.a.a. seeds of 45 days maturity recorded the highest 1000 seed weight in variety Jwalasakhi and it was at 40 d.a.a. in variety Ujwala.

Seed germination studies revealed that seeds of 45 day maturity recorded the highest germination percentage. After six months storage seeds of 45 days maturity recorded the maximum germination percentage. In general, speed of germination, vigour index and seedling dry weight were maximum for seeds of 45-50 days maturity and it is the optimum stage for harvesting fruits for seed extraction.

Seed quality was found to be influenced by different combinations of seed extraction and fruit drying methods. Sundrying of fruits avoiding the peak hours and hand extraction of seeds retained high viability and vigour of seeds during storage. Fruit drying in mechanical drier was deleterious to the seed quality. Both machine and hand

extracted seeds of fruits dried in mechanical drier recorded the lowest mean germination percentage, speed of germination, vigour and seedling dry weight. High value for electrical conductivity of seed leachate was recorded for the seeds from fruits dried using mechanical drier.

The results of the seed storage studies indicated that seed germinability of both varieties was greater in seeds stored in paper bags and this might be due to the escape of excess moisture released in seeds, during storage. Seed viability and storability are largely dependent on the storage conditions and the air conditioned storage of seeds recorded at the maximum germination percentage, speed of germination, seedling dry weight in both chilli varieties and it was lowest for the seeds stored under ambient conditions.

From this study it can be concluded that physiological maturity of seeds in chilli var. Jwalasakhi and Ujwala is attained at 45-50 d.a.a. Hand extraction of seeds and sundrying of well ripe fruits avoiding the peak hours maintained germination and seedling vigour during storage. Air conditioned storage and paper containers were best for maintaining the seed quality upto six months.