STUDIES ON SEED VIABILITY IN RELATION TO STORAGE IN LIMA BEAN (*Phaseolus lunatus* L.),

M. RAJANNA

DEPARTMENT OF SEED TECHNOLOGY
UNIVERSITY OF AGRICULTURAL SCIENCES
HEBBAL, BANGALORE

1984

STUDIES ON SEED VIABILITY IN RELATION TO STORAGE IN LIMA BEAN *(Phaseolus lunatus* L.*)*,

M. RAJANNA, B.Sc. (Agri.)

Thesis submitted to the
University of Agricultural Sciences, Bangalore
in partial fulfilment of the requirements
for the award of the Degree of

Master of Science (Agriculture)

in

SEED TECHNOLOGY

BANGALORE DECEMBER 1984

To

My Parents

Department of Seed Technology
UNIVERSITY OF AGRICULTURAL SCIENCES
Bangalore

CERTIFICATE

This is to certify that the thesis entitled "STUDIES ON SEED VIABILITY IN RELATION TO STORAGE IN LIMA BEAN (Phaseolus lunatus L.)" submitted in partial fulfilment of the requirements for the degree of MASTER OF SCIENCE (AGRICULTURE) in SEED TECHNOLOGY to the University of Agricultural Sciences, Hebbal, Bangalore, is a record of bona-fide research work carried out by Mr. M. RAJANNA, under my guidance and supervision and that no part of the thesis has been submitted for the award of any other degree, diploma, associateship, fellowship or other similar titles.

BANGALORE,

December , 1984

(M. Mahadevappa)
Professor of Seed Technology

APPROVED BY:

Chairman: (M. Mahadevappa)

Members 1. (G. Shivashankar)

2. (K.G. Ranganathaiah)

3. (T.G. Prasad)

ACKNOWLEDGEMENT

I wish to express my appreciation and deep sense of gratitude to the following persons for their gracious help and unstined co-operation:

Dr. M. Mahadevappa, Professor of Seed Technology, Chairman of my Advisory Committee, for suggesting the problem, advice, valuable guidance and encouragement throughout the period of this study and during the preparation of the thesis.

The members of my Advisory Committee, Dr. G. Shivashankar, Professor of Agricultural Botany, for providing me the seed materials of Lima bean for their multiplication during the initial stages of the work, Mr. K.G. Ranganathaiah, Plant Pathologist, for his suggestions on seed health test, Mr. T.G. Prasad, Plant Physiologist, for providing me the chemicals required for biochemical studies.

Mr. M. Chidanandappa, Mr.P. Balakrishna, Mr. B.B. Biradar, Mr. M. Venkategowda, Mr. K.H. Nagaraju, Mr. Ramegowda, Mr. N. Sulalappa, T. Shivananda for their help during this study.

All the members of the staff of the Department of Seed Technology, who have helped me in one or the other during this study.

Mr. Surindranath (STL) for STL facilities, Laxmayya and Krishna in field and lab assistance, and also all the members of the Seed Technology Department in one or other way of assistance.

Mr. Govindappa for typing the thesis neatly with abundance patience and care.

Lastly, but foremost, I wish to express my revential thanks to my brothers for their encouragement and inspiration in my education.

Rajanna

(M. RAJANNA)

BANGALORE,

December , 1984

CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

I. INTRODUCTION

Phaseolus lunatus L. is known as Lima bean throughout the world. It is also referred to as 'Burma bean', Butter bean', 'Madagascar (butter) bean', 'Rangoon bean', Double bean' and Sieva bean. In India, it is grown by a large percentage of home gardeners as a vegetable crop. Bold immature seeds of Lima bean are usually cooked and consumed. It forms a chief ingredient of "vegetable palav" and other favourite dishes. Since the immature seeds contain high percentage of sugar and taste sweet, they are very good for canning and freezing (Thompson and Kelly, 1968). The dry beans used as pulse and fresh immature seeds used as vegetables have high nutritive value.

One of the important requisites of successful Lima bean cultivation is production and supply of quality seed. But several biotic and abiotic factors cause rapid loss of seed viability in storage. Hence, storage of seeds after harvest till the next crop season is of utmost importance for successful crop production. Since the loss of viability impairs the biological value or function of a seed (which is to protect and nourish the living cells of the embryo until a seedling is established), it is of special concern for seed technology scientists. The farmer and seedsman are concerned with the longevity of seeds, because the seeds will be unfit for sowing if germination drops below a certain minimum standards. The seed testing officials, such as members of International Seed Testing Association are concerned with seed ageing (senescence) because they must minimise the ageing which occurs between sampling and testing in order to get a true measure of the quality of the lot being tested. The plant breeder needs to know about the duration of seed viability in order to maintain breeding stock and not to loose valuable material through death of seeds. Finally, all mankind should be concerned with seed longevity because the genes in germplasm banks may be essential to our own survival in the changing ecology of the world.

The life span of the Lima bean seed is affected by several factors. They are (1) Seed factors like, inherent capacity or genetic potentiality of seed, initial viability and vigour, seed moisture content and seed borne mycoflora; (2) Storage factors like temperature and relative humidity of the storage atmosphere, packaging material or containers, seed dressing chemicals, fumigants, dehumidifiers, storage flora and fauna and (3) physiological and biochemical changes like seed germination, hypocotyl length, electrical conductivity, loss of reducing sugars and lose of calcium and magnesium.

Several physiological manifestations of the process of ageing are measured to assess the causes for loss in viability, assuming that biochemical changes that occur in the seed are the causes for ageing. A study of these biochemical changes to understand the mechanism of loss in viability and to further develop better storage conditions, especially under local conditions and by the use of such storage practices as are readily available here is essential. Of the many physiological and biochemical changes which occur during seed deterioration, one or more have been used to assess seed quality. Studies on the storage aspect of Lima bean seed viability are essential in India. In a recent classification of places suitable for seed storage under ambient conditions, Bangalore has been grouped under unsuitable place (Agrawal, 1976).

Hence, the present investigations were undertaken with the following objectives:

1. To determine the longevity of Lima bean under ambient conditions.

2. To study the effects of packaging materials on seed viability of Lima bean.

3. To know the effect of seed treatment and fumigation effects on seed viability.

4. To study the effect of seed soaking and dehydration.

5. To study the biochemical and physiological changes during storage and their relationship with seed viability and

6. To study the storage fungi and their effect on seed viability.

REVIEW OF LITERATURE

II. REVIEW OF LITERATURE

Viability of seed varies from crop to crop and is short in Lima bean. It is well known that large number of factors affect seed viability during storage. The relationship between viability and storage conditions is widely studied. The biochemical and physiological changes that occur during storage as related to the loss of viability is also studied. Review of literature essentially on the above factors in relation to seed viability in Lima bean is presented under the following headings.

2.1 Quality of seed entering the storage

Gregg (1982) reported that the seed storage, including adverse pre-harvest conditions, immaturity at harvest, mechanical injury, temperature, moisture content, pests and diseases, seed treatments and fumigation do affect viability. On the basis of duration of life of seeds under optimal conditions Ewart (1908) divided the seeds into three biological classes viz., (i) microbiotic seeds with a life span not exceeding three years, (ii) mesobiotic seeds with a life span of three to 15 years and (iii) macrobiotic seeds with a life span of 15 to over 100 years. Unfortunately the seeds of many agricultural crops including Lima bean come under the microbiotic group. This classification is obviously dependent upon the knowledge of the optimal conditions of storage for each kind of seed. He also opined that fairly cool, dry airy conditions preserve seeds best.

Gupta (1976) suggested that the viability of seeds were affected by a number of separate but interacting factors during storage, which include genetic make up, quality of seed entering storage and storage environment. Regarding genetic make up, amongst tropical crops the viability of soybean is short lived compared to cotton and jowar (Delouche et al., 1973).

The storability of seeds is greatly influenced by the degree to which they have deteriorated prior to storage. The degree of weathering of seed entering the storage depends upon five factors as given below:

(1) Environment before harvesting : Hot dry period at this time generally gives good seeds (Austin, 1972). The moisture level during pre-harvest condition is also important. Only extreme environmental variations during seed development have some effect on viability of the seed.

(2) Mechanical injury : Soybean seeds are highly susceptible to mechanical damage because of their thin and fragile seed coat and hypocotyl, unlike seeds of many other species. The nature of mechanical damage varies. A more intensive injury may result in immediate loss of viability, whereas those less serious may only become important during subsequent storage period (Moore, 1972).

(3) Mycoflora : Seeds that are sound when harvested during storage may be invaded by several storage micro-organisms and these would cause the deterioration of seed viability (Christensen, 1972a).

(4) Initial moisture content of seed : It has been well established by many investigators that the moisture content of seed is of utmost importance as a factor in the determination of their longevity during storage. This applies to absolute moisture content and fluctuations, especially around the critical moisture content, which varies according to the type of seed (Barton, 1961). An initial moisture content range of 8 to 10 per cent in soybean seeds is important.

(5) Storage environment : Environmental factors affecting viability during storage are temperature, relative humidity, and to a lesser extent, oxygen pressure. Lowering any of these increases the period of viability. The quantitative relationship between oxygen pressure and seed viability is still not defined, but the quantitative effects of temperature and moisture are reasonably clear (Roberts, 1972a).

2.2 Relationship of maturity to storability

Seed technologists have considered seed maturity as being that stage when maximum dry weight is attained. Since, in many crop species, flower production and maturity of seeds extend over a period of several days or even weeks, it is important to know the appropriate stage of maturity to harvest the seeds. Healthy, mature, plumpy seeds generally can be stored better than immature seeds. Any study that shows the relationship between seeds of different maturity levels with germination, vigour, field emergence or yield, relate directly to storage and life span. Limited work has been done on seed maturity and storage of large seeds. However, such studies have shown in many instances that immature or partially filled seeds are inferior to mature seeds in viability and vigour (Dimmock, 1947 in Corn; Blackstone et al., 1954 in peanut; Turner and Ferguson, 1972 in cotton).

2.3 Seed vigour in relation to storability

The vigour of seeds at the time of storage is an important factor which affects storage life. Several workers have demonstrated that seed lots that were rapidly declining contained some seeds low in vigour and other seeds that still might be vigorous. This progressive weakening with age continues until all the seeds become non-viable. Barton (1941) found that seeds of high initial viability are much more resistant to unfavourable storage humidities and temperatures than those of low initial viability and that seed deterioration once started proceeds rapidly under unfavourable storage conditions till the death of all seeds.

Hukill (1963) defined a relationship between viability of seeds and moisture content, temperature and storage period. He introduced the concept of an age index as given below, of which he considered seed viability to be a precise function.

$$\text{Age index} = \text{Month of storage} \times 10^{0.143\ \text{m.c}} \times 10^{0.0645T}$$

where, m.c. = moisture content (in per cent)

T = Temperature (°C)

2.4 Effect of storage environment on seed longevity

The storage requirement for the maintenance of viability varies with types of seeds. It can be said that, in general and under ideal storage conditions, both the relative humidity and temperature are kept low. Toole and Toole (1953) recommended that, for long term storage seeds should be stored at a relative humidity of 35 per cent and at a temperature near freezing point. But in practice it is often sufficient to control any one of these factors.

Pelegrini (1982) studied in rice, French bean and soybean on those factors which affect the quality of stored seeds including longevity, initial quality, maturity stage at harvest, moisture content (4-8 per cent moisture content is suitable for storage in air tight containers), physical condition of the seed (mechanical injury during harvesting, drying and processing contributes to reduction in germination capacity and seed vigour), environmental conditions in the store and type of storage.

2.5 Effect of temperature, moisture content and relative humidity

Storage temperature and seed moisture content are the two important factors affecting seed longevity in storage. The seed moisture content is relatively more detrimental than temperature in life of seed. The biological activity of seeds, insects and molds increases as temperature increases. Higher the moisture content of the seeds, more adverse is the effect of temperature. The combination of decreasing temperature and seed moisture, therefore, is an effective means of maintaining seed quality in storage.

Harrington (1960, 1972) proposed some thumb rules, which related seed moisture and temperature to the seeds life span, i.e., the life of seed is halved for every 5°F increase in storage temperature and for every per cent increase in seed moisture content. These simple rules are reasonably accurate particularly in the middle ranges of seed moisture content (5 to 14%) and temperature (0-50°F).

Scott and Mohoney (1946) concluded that in marketing shelled lima beans in consumer package can be kept in acceptable conditions for 11 days at 28° and 32°F. At higher temperature quality deteriorated more rapidly than at the lower temperature mentioned. They found that there was loss in ascorbic acid in storage, the greatest loss was during the first part of the storage period. At the low temperature the beans retained about ⅔ of the ascorbic acid for 11 days.

Oathout (1928) reported that high temperature and lack of ventilation caused rapid loss of viability in soybean seeds with moisture content above 14 per cent. Increasing the moisture content from 9.4 per cent to 19.1 per cent resulted in rapid loss of viability of soybean seeds stored at room temperature at Minnesota (Ramstad and Geddes, 1972). According to Toole and Toole (1946), when the soybean seeds were stored in combination of high temperature (30°C) and high moisture content (18.1% for Mammoth Yellow and 17.9% for Otootan). Only 14 per cent of Mammoth Yellow seeds and more of Otootan seeds were viable after one month of storage. The high moisture content of both cultivars stored at 10°C caused little or no deterioration until after 72 months of storage. No seeds of either cultivar with 9.4 and 8.1 per cent moisture content decreased in viability when stored at -10°, 2° and 10°C for 10 years. McNeal (1966) showed that soybean seeds can be kept for one year without an excessive decline in germination, if the temperature was kept below 16°C and the moisture content was not higher than 14 per cent. Soybean seeds at 18.4 per cent moisture content stored at 10°C exhibited considerable deterioration after seven months of storage. James et al. (1967b) observed a decline in viability of soybean under constant temperatures of 21.1°C and 32.2°C. Also, a loss of viability was observed in seeds with 11.4 per cent moisture content at 32.2°C after 34 weeks of storage. Srivastava and Sareen (1972) observed highest germination percentage in room stored (temperature 14-27°C and relative humidity 20-84%) soybean seeds after seven months of storage than those stored at 20° and 25°C constant temperature. Agrawal (1973) showed for the first time that soybean seeds could be stored under ambient conditions in Delhi without significant loss in viability from harvest (November-December) to subsequent sowing (June-July). Agrawal and Siddiqui (1973) reported that temperature was the most responsible factor for loss in germination of stored soybean seeds. Loss in germination could be minimised by storing seeds of high initial viability with 8 to 11 per cent moisture at 5°C. The work of Singh and Setia (1974) revealed that soybean seeds having 8 per cent moisture maintained the highest germination throughout, followed by 11 per cent and 14 per cent moisture content respectively. Boakye-Boateng and Hume (1975) concluded that soybean seeds stored at high temperature (27°C) and moisture content (17.8%) rapidly lost viability after nine to ten weeks of storage. Lowering temperature (2°C) and seed moisture content (11.2%) preserved viability longer.

Bulat (1963) stored the seeds of 41 species at 5-25°C with 20 to 83 per cent relative humidity in 20 combinations of temperature and humidity. He found that most species were more sensitive to increased humidity than to increased temperature, the humidity at which seeds were damaged generally happened to be between 55 and 73 per cent.

2.6 Effect of desiccants on seed viability

Another method which could be utilized for checking the increase in seed moisture during export of vegetable seeds is mixing of desiccants with the seed. Silicagel is one such desiccants. However calcium oxide may also be used as a desiccant, which is cheaper. Sixteen per cent calcium oxide of seed weight may be mixed with seed and sealed in polythene bags. In about 30 days 3-4 per cent reduction in moisture is expected. Therefore, if seed has an initial moisture of 10 per cent, in about 30 days the moisture content will drop to 7 to 8 per cent which is fairly safe for moisture-vapour resistant container. This method may also be used for drying small quantity of seeds without any adverse effect on germinability (James, 1971).

2.7 <u>Effect of fumigants on seed viability</u>

Effects of fumigants on seed germination are (i) stimulation of germination, (ii) impairment or total loss of germination and (iii) poor growth of seedlings from germinated seeds. Cotton (1932) reported that low oxygen content rendered insects more susceptible to the affect of fumigant used. Cotton (1963) pointed out that many fumigants affect the viability of seeds, particularly when dosages are excessive, seed moisture is more, temperature is high and exposer period is long.

Girish and Krishnamurthy (1972) reported that wheat, jowar, bajra, maize, peas and beans samples with different moisture contents, when fumigated with ethyl dibromide (E.D.B.) at 60 and 120 mg per m^3 at temperature from 27.8–28.9°C with exposure time of seven days, did not affect germination.

Khanna *et al.* (1981) reported that lentil, pigeon pea, *Cicer arietinum* and *Vigna radiata* seeds with moisture content of 11-13 per cent were fumigated thrice with 1 3:1 mixture of Ethylene dichloride and carbon tetrachloride or Ethylene dibromide (EDB), carbon disulphide or hydrogen phosphide during storage for six months. While most of the seeds retained reasonably high germination upto the second fumigation, a majority of the seeds lost viability after the third fumigation especially with carbon disulphide and EDB. The drop in germination was attributed to higher level of moisture content in equilibrium with 65-70 per cent relative humidity.

2.8 Effect of containers on seed viability

Storing of seeds in a container made up of suitable packaging material will prevent direct contact of seeds with the storage environment and this is another method for retaining viability. The packaging materials used gunny bag, earthen pots, urea bag with thin layer of polythene, polythene bag (400 gauge) and metal tins or containers made of various combinations of materials are decided by the kinds and amounts of seeds to be packed, the type of package, duration of storage, storage temperature, relative humidity of the storage area, whether packaging is for whole sale, retail or local use and geographical area where the packaged seeds will be stored, exhibited or sold.

Seeds stored for a short time in porous paper or fabric containers under cold and dry conditions will retain good viability whereas seeds stored or marketed under tropical conditions will lose viability rapidly (Ching, 1959). Except in tropical and sub-tropical climates, many kinds of seeds do not require special moisture protection during the first winter after harvest. However, seeds carried over to the second planting season often require drying and packaging in moisture barrier containers to prevent loss of viability and vigour.

Mazid et al. (1977) compared various containers and found that seeds stored in a $CaCl_2$ desiccator or sealed can or glass bottle had a viability more than 80 per cent after storage at room temperature for one year, whereas seeds stored in polythene bag had 66 per cent viability and storage in paper bag was totally ineffective in maintaining viability.

Gane (1948) reported that soybean seed stored in porous containers like sacs and paper bags will have its water content fluctuating with the humidity of the surrounding atmosphere. The experimental results of Maurya (1971) indicated that seeds under ambient conditions kept in polycoated hessian bags retained viability for longer period than those kept in hessian bag. Srivastava and Sarren (1972) stored soybean seeds in both gunny bags and polythene bags. According to them, the presence of permeable pores in the gunny bag brought about fluctuations in moisture content during storage as affected by the relative humidity of the atmosphere. Hence increase in moisture content (12%) would have initiated the metabolism in seeds, supporting respiration thereby leading to deterioration. According to Boakye-Boating and Hume (1975) soybean seeds kept in polythene bags at 22°C or 2°C and at 11.2 per cent seed moisture did not lose viability in 50 weeks of storage whereas seeds in cloth bags did lose.

According to Jalote and Vaish (1976) storage in gunny bags was less harmful than in polythene bags when paddy seeds with higher moisture content were stored. Rate of viability deterioration was minimum in seeds that were stored at 10 per cent moisture in polythene bags.

Rao (1976) studied the effect of different containers on sunflower seed viability under room and cold storage conditions to find that metal tins proved better than polythene bags, polyethyl lined bags and gunny bags. According to Rao and Vikram Singh (1976) seeds of two sunflower cultivars showed marked decrease in viability and seedling vigour when stored in different containers at room temperature for 10 months as compared to cold storage (14 $\pm$ 10°C and RH 60%). Metal tins were superior to polythene bags for seed storage at any temperature. Vadivelu *et al.* (1976) reported that Captan treated sunflower seed of variety E.C-68415 in paper aluminium foil-polythene laminated pouches gave 85 per cent germination even after 15 months of storage when compared to 76 per cent in seeds stored in cloth bag. The untreated seeds in both the containers gave less than 50 per cent germination. Vadivelu and Ramakrishnan (1977) suggested that, if the sunflower seeds are to be packed in moisture vapour proof containers, the moisture content should be well below 8 per cent.

2.9 Effect of seed soaking and dehydration on seed viability and vigour

The soaking-drying method of seed treatment developed by Basu *et al.* (1974) can be effectively used to improve the vigour and viability of the seeds. Sen and Asborne (1974) working with rye embryos noted that germination could be enhanced by hydration-dehydration pre-treatment of the embryo. They showed that hydration pre-treatments initially enhance the ability of embryo to synthesise protein compared to the control. Further they also suggested that soaking-dehydration of only two hours (followed by drying for one hour) would bring about changes in the vigour viability and productivity of seeds.

Dasgupta at al. (1976) suggested that the beneficial physico-chemical treatments improve the vigour and viability of seed by minimising the free radical damage to the cellular components of stored seeds and the effects of these treatments on productivity are most likely the consequence of the decreased physiological deterioration of the seeds.

Basu et al. (1975) found that soaking seeds like rice, wheat, jute, sunflower, gram, lentil, mung, pigeon pea and *Lathyrus sativus* in water for 2-4 hours followed by drying, significantly increased subsequent storage life under certain temperature and humidity conditions. A range of chemicals including salts such as NaCl, phenols, vitamins and antipathogenic compounds added to the water in low concentrations (10^{-5}, -10^{-3}M) gave further improvement in germinability. Basu (1976) reported that the loss of viability of seeds of wheat, rice, jute, sunflower and several pulses and vegetables, under ambient conditions could be significantly slowed down by soaking the seeds half way during the storage in water or in dilute solutions (10^{-5}, -10^{-2}M) of a range of chemicals for 2-6 hours depending on the material, followed by drying back to original weight in the sun or in a drying cabinet with hot air at 35°C. Water soaking and drying itself has been found to be effective in majority of the seeds investigated but further improvement was noted with chemicals such as sodium phosphate (mono and dibasic), sodium chloride, sodium thiosulphate etc. He also found that a second treatment after several months of storage would further extend the viability. Two or three consecutive cycles of treatments improved germinability of seeds immediately but the beneficial effects were greatly magnified upon storage.

Senaratna and Mckersie (1983) found that soybean seeds were tolerant of drying to 10 per cent moisture content after 6 hour of imbibition, but drying after 36 hours led to loss of germination, growth abnormalities and increased electrolyte leakage from isolated embryo axes. The transition from tolerance to susceptibility to dehydration coincided with radicle elongation. Loss of dehydration tolerance was not affected by the prevention of cell elongation or protein synthesis by treatments with polyethylene glycol or cyclohaxamide, nor by the rates of dehydration or rehydration of the seeds.

Saha and Basu (1981) reported that moisture equilibrium of one year old stored soybean seeds with a water-saturated atmosphere for 24 hours followed by soaking in water for 2 hours and drying to the original weight, markedly increased the viability of seeds during subsequent storage. Without moisture equilibration soaking and drying the seeds accelerated the loss of viability, polyethylene glycol (10% $\frac{\text{Weight}}{\text{Volume}}$) solutions alone or after equilibration followed by drying was not effective in retaining viability during subsequent storage of seed.

2.10 Physiological manifestation of seed deterioration

2.10.1 Laboratory and field germination per cent

Most seeds can be stored for several years before germinability declines. However, the potential storage life of seeds within a given species or variety differs. The causes for the difference in storage life of the same variety are not fully understood, but differences in physiological maturity or injury during harvesting or cleaning are partially responsible (Harrington, 1970; Abdul-Baki and Anderson, 1972). Once the seeds reach physiological maturity (or after they are harvested) they undergo irreversible changes which reduce their survival capacity. The combined effects of these irreversible changes are known as deterioration. The time which marks the first detectable decline in germinability does not coincide with the actual beginning of deterioration. The mechanism causing deterioration are not known. However, many physiological manifestations of seed deterioration, delayed germination (Toole et al.,1948), decreased tolerance to sub-optimal environmental conditions during germination (Abdul-Baki and Anderson, 1972), lowered tolerance to adverse storage conditions (Anderson, 1970), reduced growth of seedlings (Toole et al., 1957), reduced germinability and increased number of abnormal seedlings (Toole et al., 1948). Reduced germinability has been the most widely accepted single criterion of seed deterioration (Abdul-Baki and Anderson, 1972). Roberts(1972a) found that a reduction of viability down to 50 per cent would have no significant effect on final yield.

Deteriorated seeds, often produce seedlings which grow slowly (Kearns and Toole, 1939; Parkinson, 1948; Toole and Toole, 1953; Toole et al., 1957). However, reduction in seedling growth which either preceded or accompanied loss of germinability did not necessarily occur in all cases of seed deterioration (Anderson, 1970). This observation suggested that germinability and seedling growth, though are closely related, were regulated by two mechanisms which seemed to operate independently during deterioration.

Generally, when the germination of a seed lot declines, many of the seedlings obtained were abnormal (Toole et al., 1948) and were not capable of surviving to maturity. Surviving seedlings may show poorly developed roots and/or shoots (Toole *et al.*, 1948).

Barton (1967) showed that, in bean seeds, the first indication of deterioration was reduced speed of germination and vigour of the emerged seedlings rather than the actual number germinating. According to Anderson (1970) natural ageing decreased germination percentage and shoot length in barley seeds. Agrawal (1974) also observed in aged maize seeds reduction in germination percentage as well as shoot length and root length at both room and cold temperatures. Verma and Gupta (1975) showed that germination percentage, root length and hypocotyl length declined with longer storage of soybean seeds. The reduction in root length varied from 15 to 59 per cent and that of hypocotyl length from 22 to 56 per cent during eight months of storage. On comparison between reduction in hypocotyl length and per cent germination, the decline in seedling vigour was faster than the decline in germination per cent. A significant negative correlation was established between hundred seed weight and hypocotyl length during storage.

Lovato and Mulazzani (1983) reported that in 28 seed samples representing 11 varieties of pea, the conductivity of seed leachates was negatively correlated with percentage emergence in the field with a sowing date (26 February) one month earlier than normal, and also with the normal sowing date. Laboratory assessments of percentage germination did not always give a reliable indication of field emergence.

Srivastava and Gill (1975a) observed a relatively poor growth of radicle and hypocotyl and lesser leaf elongation in highly deteriorated soybean seed lot as compared to less deteriorated lot.

2.10.2 Vigour index

Vigorous seeds produce healthy seedlings, and the rate of elongation of the hypocotyl in a seed such as soybean is important in the establishment of a crop. A measure of vigour or vigour index is based on germinability (%) x hypocotyl length (Abdul-Baki and Anderson, 1973a, 1973b).

2.10.3 Colour of the seed

Colour of seed changes due to ageing bringing about physiological and biochemical changes which are responsible for seed deterioration. Grain seeds that are damaged by heat or fungi during storage lose their natural luster (Zeleny, 1954; Christensen and Kaufmann, 1969). This was reported in Lima bean (Pollock and Toole, 1966), Snap beans (Toole, 1948) and Crimson cloner (Helmer *et al*., 1962).

Starzinger and West (1982) reported that soybean with yellow or black seed coats when subjected to 100 per cent relative humidity for period upto 12 days for their germination. It was observed that fungal activity on the seed was found to be correlated with reduced germination Black seed had less fungal activity and more germination than yellow seed. Srikantaradhya (1982) reported that out of the sixty germplasm collections of soybean studied under storage for 12 months, most collections retained viability and vigour for 8-9 months. Black seeds were superior to other seeds in both viability and vigour.

2.10.4 Test weight

Pushman (1975) reported that the rate of change in the test weight of four winter wheat varieties, with changing grain moisture content was greater, when the grain was wetted than when it was dried. The test weight of grain which had been dried and brought back to its original moisture content was lower than that of the original sample.

2.11 Biochemical changes associated with seed deterioration

Though much work has been done on chemical changes associated with seed deterioration (Crocker and Barton, 1953; Anderson and Alcock, 1954; Abdul-Baki and Anderson, 1972; Roberts, 1972b) our knowledge of biochemical deterioration of seeds is still inconclusive. Attempts have been made to correlate such factors as depleted food reserves, increased enzyme activity, membrane permeability and similar changes with deterioration.

Of the several biochemical changes, variations in the leaching of sugars and electrolytes from the seeds have been used as an index of seed deterioration by several workers (Ching and Schoolcraft, 1968; Abdul-Baki and Anderson, 1970 and Agrawal and Siddiqui, 1973).

2.11.1 Electrical conductivity

The conductivity of solution in which plant tissues were immersed increases in the case of dead tissue (Weber, 1836; Ranke, 1865). Such an increase in conductivity is caused by increased membrane permeability of the drying tissue. Hibbard and Miller (1928) concluded that the decrease in the resistance of the imbibing solution was caused by increased permeability of membrane which allowed more leaching of salts from deteriorated seeds.

Ching and Schoolcraft (1968) studied the physiological and chemical differences in aged seeds of clover and rye and concluded that the conductivity of leachate could be taken as an index for seed deterioration. The increase in the electrolytes in leachate of deteriorating and dead seeds considered to be resulting from degradation of cellular membranes and subsequent loss of permeability.

According to Pollock and Roos (1972) the method for evaluating relative vigour of seed lots was to measure the amount of material leached from the seeds soaked in water, the lower the vigour the greater the amount of leaching. Seed leachate also resulted in attracting micro-organisms leading to the poor field survival (Persiel et al., 1972).

Verma and Gupta (1975) reported an increased leaching of electrolytes in seed leachate with increase in storage period. The increase was found to be more in the seeds stored at room temperature than seeds kept in cold storage in all the varieties of soybean studied. Similar results were obtained by Srivastava and Gill (1975) in soybean, Rao (1976) and Tewari (1976) in sunflower.

Measurements of electrical conductivity of seed leachate have shown promise in detecting weak lots of peas and French beans (Mathews and Bradnock, 1967; Bradnock and Mathews, 1970). Mathews and Bradnock (1968) reported that samples of peas and French beans that exuded electrolytes readily was measured by the electrical conductivity of seed-steep water after 24 hours of incubation gave low emergence count in the field. Perry (1969) suggested that measurements of electrical conductivity of Steep-water can provide satisfactory method for testing seed vigour. Perry and Harrison (1970) reported success in comparing conductivity measurements on individual pea seeds under field conditions. Abdul-Baki and Anderson (1970) however, reported that experimentally imposed mechanical injury caused increased leaching, but did not reduce vigour. MacKay (1970) reported that the electrical conductivity test had been adopted on a routine basis for peas.

Dharmalingam *et al*. (1976) observed a highly significant negative correlation between electrical conductivity value of seed leachate and loss of viability. Further, they suggested its use as an index for predicting the viability of blackgram seeds.

2.11.2 Leaching of sugars

The most notable biochemical trial to distinguish dead seeds from viable ones was found to be exudation of sugars when soaked aseptically in distilled water. Takayanagi and Murakami (1968) studied exudation of sugars from the deteriorated seeds and found that mono and oligosaccharides were abundant in the exudate of seeds which had lost their viability, but monosaccharides were observed only in traces in viable seeds. So, increased exudation of sugars in deteriorating seed might be a consequence of senescence.

Ching and Schoolcraft (1968) observed reduced sugar content with increase in the seed moisture and storage temperature in both clover and rye seeds. Such a reduction was attributed to the activity of hydrolytic enzymes.

Takayanagi and Murakami (1969) and Agrawal and Siddiqui (1973) observed increased leaching of sugar with increased seed age but could not obtain any relation with the loss of viability in soybean. Further, leaching of sugar was less in seeds stored at cold temperature at all the seed moisture levels tested whereas more leaching was observed from seeds stored at room temperature and with increase in storage period (Verma and Gupta, 1975; Gupta and Shakya, 1976). Though many studies showed an increased leaching of sugars from aged soybean seeds, this could not be used for predicting storability of soybean seeds (Agrawal and Kaur, 1975; Yaklich and Abdul-Baki, 1975; Srivastava and Gill, 1975b). According to Gupta and Shakya (1976) the reducing sugar content of soybean varieties increased with increase in storage period and temperature. The rate of increase was found to be significantly higher at high temperatures than at low temperatures. The rate of increase in reducing sugar content was almost constant throughout the storage period at low temperature.

2.11.3 Leaching of calcium and magnesium content of seed

Imbibition of water by seeds during germination is accompanied by leakage of organic and inorganic substances. Sugar and amino acids constitute the major part of the organic substances, while potassium is shown to be the major inorganic element (Simon and Raja Harun, 1972). Leaking of electrolytes from non-viable seeds is often attributed to the loss of membrane integrity by distortion of the bilayer configuration. Therefore the extent of leakage is directly proportional to the conductivity of the solution in which seeds are germinated (Simon, 1974).

2.12 Effect of storage fungi on seed viability

Saprophytic and parasitic seed borne fungi include *Fusraium*, *Penicillium*, *Macrophomina*, *Aspergillus* and *Alternaria* spp. They remain dormant during seed storage unless seed moisture content increases greatly. Certain molds, not usually present in or on seeds at harvest, can carry out their life cycle on stored seeds. These fungi termed "storage fungi" by Christensen and Kaufmann (1965) to differentiate them from the 'Field fungi', can destroy stored seeds, because they can grow under limited moisture conditions where field fungi and other micro-organisms cannot grow. In fact, many of the storage fungi are actually osmophillic and grow best under relatively dry conditions.

Some can invade the seeds with moisture contents in equilibrium with an ambient relative humidity of 65 per cent.

Storage fungi have been reported to invade and destroy cereal seeds (Christensen and Kaufmann, 1969), cotton seeds (Arndt, 1946), peanuts (Diener, 1960), soybeans (Milner and Geddes, 1946) and sunflower (Christensen, 1969). They can attack almost any kind of seed under favourable environmental conditions, since these molds can grow on most organic materials. Invasion of seeds by storage fungi may result in loss of viability, decrease in non-reducing sugars, development of musty odours, and discolouration. Deterioration can occur in a few days when seeds are stored under unfavourable conditions.

Christensen (1971) reported that no increase in storage fungi occurred even in seeds of high moisture content, so long as the temperature remained below 5°C. But, a combination of moisture content above 11 per cent and a temperature of 21°C or above, resulted in fairly rapid invasion by Aspergillus glaucus.

Sumar and Howard (1983) found that the varying number of seed samples processed and dry peas, beans, faba beans, lentils and soybeans were assayed for seed-borne microorganisms by blotter and agar plate methods. The most common mycoflora found was species of field fungi viz., Alternaria, Penicillium, Rhizopus, Fusarium and Botrytis. Low level of concentrations by known species of pathogenic fungi were detected, though no specific pathogenicity studies were undertaken. All bacteria associated with the seeds were non-pathogens. Christensen (1969) stored seeds of sunflower at moisture contents of 10, 12 and 14 per cent and temperature of 3-5°C, 8-10°C and 27-28°C where he found that invasion by fungi and decrease in germinability were proportional to increasing moisture content, temperature and time of storage.

Christensen (1972)[b] found that all the sunflower seed samples with more than seven per cent moisture initially and atleast six per cent in subsequent storage became heavily infected by Aspergillus glaucus and A. restrictus. The lower limit of the moisture that permitted invasion of sunflower seeds by storage fungi was about six per cent, but at moisture content below 6.5 per cent invasion was very slow.

Jhamaria et al. (1974) detected seven fungi viz., Alternaria, Aspergillus, Chaestomium, Cunnighamella, Curvularia, Rhizopus and Rhizoctonia from the seeds of sunflower. Amongst them Rhizopus, Rhizoctonia and Aspergillus were predominant. They also found that when the seeds were inoculated with different fungi separately and sown in sterilized soil, they reduced the germination percentage considerably and Rhizoctonia, Rhizopus, Aspergillus, Alternaria and Curvularia caused browning and water soaked appearance of seedlings.

The importance of production of toxic metabolites is obvious, when the pathogen is seed borne. In several cases seed-borne fungi are known to affect adversely seed germination and seedling vigour possibly due to the production of toxic metabolites (Mathur and Sehagal, 1964; Chakravarti et al., 1973). Anilkumar and Urs (1975) reported that culture filterates of all the isolates tested were toxic to sunflower seedlings.

2.12.1 Chemical treatment

Lago and Zink (1976) reported that fungicide treated seeds with original moisture content of seven per cent maintained germination power reasonably well upto nine months with 60 per cent germination. Highest germination of 50.2 per cent was observed after 22 months of storage in seeds stored with 4.5 per cent moisture content. Fungicide treated seeds in general showed higher germination than untreated seeds.

Eric (1980) studied six fungicides which were applied as dusts to barley in concentrations of 100 $\mu g^{-}g^{-1}$ for Benomyl and Carbendazin, 1000 $\mu g^{-}g^{-1}$ for fuberidazole and thiabendazole, 10000 $\mu g^{-}g^{-1}$ for thiophanate and thiophanate methyl and the barley was then stored at 20°C and 90 per cent relative humidity for 60, 105 and 150 days, respectively. Fungal development during storage was assessed by counting the visible patches of developing mold and by dilution plating. None of the fungicides completely prevented fungi development. But, for a period upto 60 days, all of them provided a degree of control that was generally greatest for the highest concentrations of fungicide. Benomyl was the most effective of the fungicides but no clear pattern was established for the others. Of the various fungi developed, species of *Aspergillus* and *Penicillium* accounted for 94 per cent of the total count.

Zote and Mayee (1982) stated that seed treatments improved germination of mung bean (*Vigna radiata*). The best results were obtained with Bavistin (Carbendazim) followed by Thiram and Dithane M-45 (Macozeb). All the fungicides inhibited fungal growth and all except Difolaton (Captafol) improved seedling vigour.

Kore and Solanke (1982) found that the treatments reduced the mycoflora but the highest percentage germination was obtained with seed treated with Agrosan GN (Phenylmercury acetate + ethylmercury chloride) in French bean seeds. But in other treatments like Vitavax (Carboxin) and Bavistin (Carbendazim), germination decreased and mycoflora increased with storage time after treatment.

There are two aspects of vigour viz., genetic and physiological. Genetic vigour can be seen in heterosis (hybrid vigour) or the difference in vigour between two genetic lines. Physiological vigour can be seen in the difference in vigour between two seed lots from the same genetic line. However, physiological vigour has its basis in genetic vigour.

A general conclusion is that viability of seeds differs from crop to crop in storage. It is well known that large number of factors influence seed viability during storage. The relationship between viability and storage conditions depends on seed treatments, packaging materials and the environmental conditions which could enhance the storage life of seeds to certain extent. This might be due to the reduction of microbial activity in the combination of above controlled conditions. Thereby the biochemical and physiological changes that occur during storage will reduce the loss of viability.

MATERIAL AND METHODS

III. MATERIAL AND METHODS

The present experiment was conducted on Lima bean to study the effect of packaging materials and seed treatment on seed viability during storage. The storage period was eight months under the ambient conditions. Besides, the study of germination at fixed intervals, seed leachate analysis, vigour index, test weight and seed mycoflora were also carried out with a view to relate these to loss in seed viability.

3.1 Materials

Lima bean seeds were obtained from the early kharif crop harvested during the first week of August, to last week of September 1983, grown at the Main Research Station, Hebbal, University of Agricultural Sciences, Bangalore. Indeterminate, white coloured, bush type seeds of Lima bean strain were used in this experiment.

3.2 Initial seed moisture

The initial seed moisture content of Lima bean was determined immediately after harvest and it was found to vary from 20-24 per cent on dry weight basis. Seeds were sun-dried for about 60 hours by spreading the seeds in seed trays in thin layer with intermittent stirring to bring down the moisture content. The moisture content was again determined and was found to vary between 8.94 to 9.84 per cent on dry weight basis. The same was recorded.

3.3 Seed storage

After recording the first set of observations i.e., germination percentage, vigour index, initial moisture content, colour of the seeds, test weight, electrical conductivity, reducing sugars, calcium and magnesium content of seed leachate and seed mycoflora, the given lot of Lima bean seeds was divided into five equal parts of 10.5 kg each. They were in turn divided into 15 equal parts of 700 g each. The 700 g seed samples were stored in the gunny bags (G.B), earthen pots, urea bag with thin layer of polythene lining, polythene bags (400 gauge) and metal tins, and were subjected to room storage under ambient conditions.

The required seed material was 700 g x 15 containers (10.5 kg seeds per treatment). The treatments were as follows:

A. Control	...	10.5 kg
B. Silicagel	...	10.5 kg
C. Bavistin	...	10.5 kg
D. Fumigant	...	10.5 kg
E. Seed soaking and dehydration	...	10.5 kg

The total amount of seeds used in this experiment was 52.5 kg.

The silicagel (dehumidifier) was used for five different containers in 3 replications, and each 100 g silicagel was packed in a cloth bag and kept in the respective containers.

The 700 g seed sample in each container was treated with Bavistin at the rate of 1.4 g.

Seeds weighing 10.5 kg were fumigated with 3 ml Ethyl dibromide ampules in fumigation chamber for five days and divided into 700 g parts and packed in respective containers.

During the half-way of the storage period i.e., in February 1983, the available quantities of seed samples in each container were subjected to water soaking and dehydration. The seeds of different containers were soaked for 24 hours in water, then dried under shade until the initial moisture was reached.

3.4 Plan of storage

Control (A)	Silicagel (B)
Gunny bag (G.B.) (C_1t_1)	G.B. + Silicagel (C_1t_2)
Earthen pots (E.P.) (C_2t_1)	E.P. + Silicagel (C_2t_2)

Urea bag (U.B.) (C_3t_1)

U.B. + Silicagel (C_3t_2)

Polythene bag (P.B.) (C_4t_1)

P.B.+Silicagel (C_4t_2)

Metal tin (M.T.) (C_5t_1)

M.T. + Silicagel (C_5t_2)

Bavistin (C)	Fumigant (D)
G.B. + Bavistin (C_1t_3)	G.B. + Fumigant (C_1t_4)
E.P. + Bavistin (C_2t_3)	E.P. + Fumigant (C_2t_4)
U.B. + Bavistin (C_3t_3)	U.B. + Fumigant (C_3t_4)
P.B. + Bavistin (C_4t_3)	P.B. + Fumigant (C_4t_4)
M.T. + Bavistin (C_5t_3)	M.T. + Fumigant (C_5t_4)

Seed soaking and dehydration (E)

G.B. + Seed soaking and dehydration (C_1t_5)

E.P. + Seed soaking and dehydration (C_2t_5)

U.B. + Seed soaking and dehydration (C_3t_5)

P.B. + Seed soaking and dehydration (C_4t_5)

M.T. + Seed soaking and dehydration (C_5t_5)

Five main treatments i.e., A; B; C; D and E. and five sub-treatments i.e., G.B.; E.P.; U.B.; P.B. and M.T. in three replications were studied.

Totally = 5 x 5 x 3 = 75 samples (containers)

where, (1) A = t_1; B = t_2; C = t_3; D = t_4 and E = t_5

(2) G.B. = C_1; E.P. = C_2; U.B. = C_3;
P.B. = C_4; M.T. = C_5

3.5 Observations recorded

The following observations were recorded at definite intervals:

3.5.1 Laboratory germination

A standard non-toxic germination paper was used for the between paper (B.P.) method as prescribed by the International Seed Testing Association (Anon., 1966). One hundred seeds from each treatment in each replication were used for seed germination test. The seeds were placed on paper towels. The rolled towels were placed in the germination chamber at the seed testing laboratory, Hebbal, where 29 ± 1°C temperature and 85 per cent relative humidity was maintained. The seeds were considered germinated, when the radicle was visible (Pathak *et al.*, 1976).

Germination count was taken five days after incubation as prescribed by International Seed Testing Association (Anon., 1966). The germination percentage was calculated on the basis of normal seedlings obtained on the fifth day of incubation. The germination test was carried out at monthly intervals.

3.5.2 Field germination

For field germination studies, 100 seeds were sown from each treatment at three replications on a well prepared raised seed bed and adequate soil moisture was maintained. Germination count was taken on the eleventh day of sowing and the germination percentage was calculated taking into account the number of normal seedlings.

3.5.3 Hypocotyl length of seedlings

Ten seedlings from laboratory germination test were selected at random on the fifth day and hypocotyl length measured and recorded in cm.

3.5.4 Vigour index

The vigour index was calculated by multiplying per cent normal germination with hypocotyl length (Abdul-Baki and Anderson, 1973).

3.5.5 Seed moisture content

Known quantities of seeds were taken in aluminium dishes and the dishes containing the seeds were kept in an hot air oven at 130-133°C for a minimum of one hour/or until consistent dry weight was obtained as for the recommendation of "Central Seed Testing Laboratory". The dishes containing the dry seeds were cooled in a desiccator and the weights recorded. The moisture content was expressed on a dry weight basis using the following calculations:

Weight of the empty aluminium dish = X g

Weight of dish + Seed (Before drying) = Y g

Weight of seed (before drying) = (Y-X) g

Weight of dish + Seed (after drying) = Z g

Weight of seed (after drying) = (Z-X) g

$$\text{Weight of water lost in drying} = \frac{(Y-X)\,g - (Z-X)\,g}{(Z-X)\,g}$$

3.5.6 The colour of seed

Prior to the storage and after the storage of the seed, the colour of the seeds was recorded.

3.5.7 Test weight

The test weight was measured by weighing 100 seeds on a top pan precision balance in g.

3.5.8 Seed leachate

Five g of seeds were surface sterilized by using 0.5 per cent $HgCl_2$ solution for five minutes. They were then washed three times with distilled water and soak the seeds 24 hours in distilled water. The soaked seeds were surface washed with another 5 ml of distilled water and that washing was also decanted. The two decanted solutions were combined and filtered to constitute the leachate. The volume was found to be 30 ± 0.5 ml. This leachate was used for further chemical analysis.

3.5.8.1 Electrical conductivity (EC) : Electrical conductivity of the seed leachate was measured with a solute bridge (Type-82T) and it was calculated by using the following formula:

$$EC\ (\mu.mhos/cm) = \frac{\text{Dial reading} \times K}{10}$$

where, K is the cell constant 1.0.

3.5.8.2 Reducing sugars : Reducing sugars in seed leachate was determined by the Somogyi-Nelson Chromogenic method as described by Nelson (1944, 1945) using glucose as standard. The estimation of sugar was carried out at two months interval.

Reagents : Alkali copper reagent (Reagent-A).

Solution (a) : 25 g of Anhydrous sodium carbonate, 25 g of sodium potassium-tartarate (Rochelle's Salt) and 20 g of sodium bicarbonate was dissolved in 200 ml of distilled water. Finally 200 g of anhydrous sodium sulphate was dissolved in 700 ml of distilled water and to this the above mixture was added and the volume was made upto 1000 ml.

Solution (b) : 75 g of 10 per cent copper sulphate ($CuSO_4.5H_2O$) was diluted to 500 ml by adding distilled water. To this, 0.5 ml of concentrated H_2SO_4 was added and mixed and then on the day of use, placed 4 ml of solution, (b) in a standard flask and diluted to 100 ml by using solution(a).

These solutions were stored in amber colour bottles for 48 hours. Then they were filtered and stored in the same bottles.

Nelson's arsenomolybdate reagent (Reagent-B)

Twentyfive g of ammonium molybdate was dissolved in 450 ml of distilled water; to this, 21 ml of conc.

H_2SO_4 was added with constant stirring. Three g of sodium ortho arsenate was dissolved in 25 ml of distilled water and it was mixed thoroughly with earlier solution. This reagent was incubated at 37°C for 48 hours and stored in an amber coloured bottle.

In separate test tubes, 0.5 ml of seed leachate was taken in duplicate and the volume was made upto 2 ml and 2 ml of reagent-A was added. After covering the mouth of test tubes with cotton plugs, they were placed in hot water bath for 10 minutes and cooled to room temperature by keeping in the running water. Then one ml of reagent-B was added to each test tube and shaken well. The absorbance was read at 520 nm. The amount of sugar was calculated per g of seed.

$$\mu g \text{ reducing sugar/g seed} = \frac{\text{O.D.} \times \text{Total volume of leachate} \times 132.31}{\text{Volume of leachate taken for analysis} \times \text{Quantity of seed taken for soaking}}$$

where, the numerical 132.31 is the factor obtained from standard curve.

O.D. = Optical density.

3.5.8.3 Calcium and magnesium : Calcium and magnesium content of leachate was estimated by the procedure reported by Cheng and Bray (1951).

Five ml of leachate was taken into a porcelain cup and to this added 5 ml of ammonium chloride - Ammonium hydroxide buffer solution followed by 3-4 drops of Eriehrome black - T - indicator. The contents after mixing were titrated against 0.01N versanate solution until colour changed from wine red to blue and then the titre value was recorded. Then the calcium and magnesium content of leachate was calculated by using the following formula.

$$\text{Calcium + Magnesium (ml/liter of leachate)} = \text{Volume of versanate solution} \times \text{Normality of versanate solution} \times \frac{1000}{\text{Volume of leachate taken}}$$

3.5.9 <u>Seed health testing (Seed mycoflora)</u>

Detection and identification of storage fungi was done by blotter method as recommended by the International Seed Testing Association (Anon., 1966). Ten seeds were placed equidistantly in glass petri dishes of 10.2 cm diameter containing three moist blotters. Forty seeds of each sample (three replications) were used for the test. The seeds were incubated for seven days at room temperature (25°C) under alternate cycles of 12 hours light and 12 hours dark. After incubation the seeds were examined under Steriobinocular microscope for fungal infection and counts were taken. The test was carried out at two months interval for eight months.

3.6 Statistical analysis

The data recorded in this experiment for all the observations were subjected to statistical analysis. The statistical layout was split-split plot design and data were analysed accordingly (Sundaraj *et al.*, 1972).

EXPERIMENTAL RESULTS

IV. EXPERIMENTAL RESULTS

The experimental results are presented under the following headings :

4.1 Laboratory germination percentage

The results on the germination percentage under laboratory conditions are presented in Table 4.1 and Fig. 4.1.

The initial (Oct. '83) germination percentage was recorded after one week of storage in the experiment and it ranged from 37.0 to 52 per cent, except in Bavistin treatment and did not show significant differences except during the month of April '84. The germination percentage was high in the beginning (first month) of storage and gradually decreased with increased storage period. Seeds stored in gunny bags showed the highest initial (Oct. '83) and final (May '84) germination per cent (52.3 and 21.6 respectively), closely followed by urea bag (50.5% and 20.3%) and polythene bag (45.7% and 21.2%).

Significant differences were observed among different treatments for percentage germination in all the months except December '83. The seeds treated with Bavistin showed the highest germination (72.3% - Oct. '83) upto February '84 and subsequently decreased to 23.2 per cent (May '84). In October '83 (initial stage) it showed the lowest germination per cent of the seeds treated with silicagel and fumigant than that of the Bavistin treated

Table 4.1 Laboratory germination (%) of Lima bean seeds stored under room conditions at monthly intervals

Containers, treatments and their combinations	1983			1984				
	Oct.	Nov.	Dec.	Jan.	Feb.	March	Apr.	May
C_1	52.3	49.7	47.3	47.8	31.6	29.6	23.7	21.6
C_2	47.4	44.1	42.1	41.3	32.7	27.0	21.8	20.3
C_3	50.5	47.9	48.0	45.0	33.3	28.6	20.9	20.3
C_4	45.7	44.9	46.1	47.7	33.3	27.9	23.0	21.2
C_5	47.1	47.8	48.3	45.4	34.6	27.7	24.7	18.7
F value	NS	NS	NS	NS	NS	NS	*	NS
S.Em ±							0.52	
C.D. at 5%							1.70	
CV	11.5	12.7	14.4	11.9	8.2	8.8	8.9	9.1
T_1	38.8	33.9	39.4	42.2	37.0	30.7	24.8	22.3
T_2	43.9	43.1	40.9	42.1	38.1	35.5	26.9	24.8
T_3	72.3	71.6	66.1	48.6	40.5	32.3	26.3	23.2
T_4	45.7	46.1	44.3	43.7	38.3	31.8	26.9	23.1
T_5	42.3	39.7	41.0	40.6	11.5	10.5	9.3	8.2
F value	*	*	NS	*	*	*	*	*
S.Em ±	1.05	1.58	1.45	1.90	0.87	0.79	0.50	0.69
C.D. at 5%	3.02	4.52	-	5.43	2.49	2.27	1.44	1.98
CV	8.43	13.1	10.6	16.2	10.3	10.9	8.55	13.2
C_1T_1	42.3	41.0	40.3	40.0	36.0	32.3	25.3	23.0
C_1T_2	46.7	44.0	41.3	43.3	37.0	36.7	30.0	25.0
C_1T_3	75.3	71.7	69.0	57.7	38.7	34.7	26.3	24.7
C_1T_4	48.0	48.0	43.3	40.0	36.7	32.3	28.3	24.3
C_1T_5	49.3	43.7	42.3	48.3	9.7	12.0	8.7	8.3
C_2T_1	37.0	25.3	30.3	40.0	37.3	29.3	24.3	21.3
C_2T_2	40.3	40.7	36.3	36.3	38.3	30.7	25.0	24.0
C_2T_3	71.0	70.0	57.3	48.0	39.3	31.3	26.0	24.0
C_2T_4	43.7	42.3	46.3	48.0	37.0	32.0	23.0	24.3
C_2T_5	43.7	42.0	40.0	34.0	11.3	11.7	10.7	8.0

Table 4.1 contd..)

Containers, treatments and other combinations	1983			1984				
	Oct.	Nov.	Dec.	Jan.	Feb.	March	Apr.	May
C_3T_1	39.7	30.0	40.7	43.0	36.7	31.3	23.0	22.0
C_3T_2	49.7	49.3	47.3	41.7	38.0	36.3	23.0	25.7
C_3T_3	70.7	69.3	66.3	53.7	40.0	31.7	22.2	22.7
C_3T_4	52.7	52.3	45.3	47.0	39.7	33.3	26.7	22.3
C_3T_5	39.7	39.0	40.3	39.7	12.2	10.3	9.7	9.0
C_4T_1	38.0	38.0	40.0	48.0	38.7	30.3	25.7	22.0
C_4T_2	39.3	37.3	40.0	49.7	37.7	37.3	27.3	26.0
C_4T_3	72.7	74.3	67.0	62.3	39.0	32.0	26.7	25.3
C_4T_4	39.7	41.0	40.7	39.7	39.7	36.7	26.7	25.0
C_4T_5	38.7	34.0	42.7	43.7	11.3	9.0	8.7	7.7
C_5T_1	37.0	35.0	45.7	45.0	36.3	30.3	25.7	23.0
C_5T_2	43.7	44.3	39.7	39.3	39.3	36.3	29.1	23.3
C_5T_3	71.7	73.0	70.7	61.3	45.7	32.0	30.0	19.3
C_5T_4	42.7	47.0	45.7	44.0	38.7	30.7	29.7	19.7
C_5T_5	40.3	39.7	39.7	37.3	13.0	9.3	9.0	8.0
F value	NS	NS	NS	NS	NS	NS	*	NS
S.Em ±	-	-	-	-	-	-	1.13	-
C.D. at 5%	-	-	-	-	-	-	3.23	-

C_1 = Gunny bag; C_2 = Earthen pot; C_3 = Urea bag + Polythene layer; C_4 = Polythene bag; C_5 = Metal tin. T_1 = Control; T_2 = Silicagel; T_3 = Bavistin; T_4 = Fumigant; T_5 = Seed soaking and dehydration.

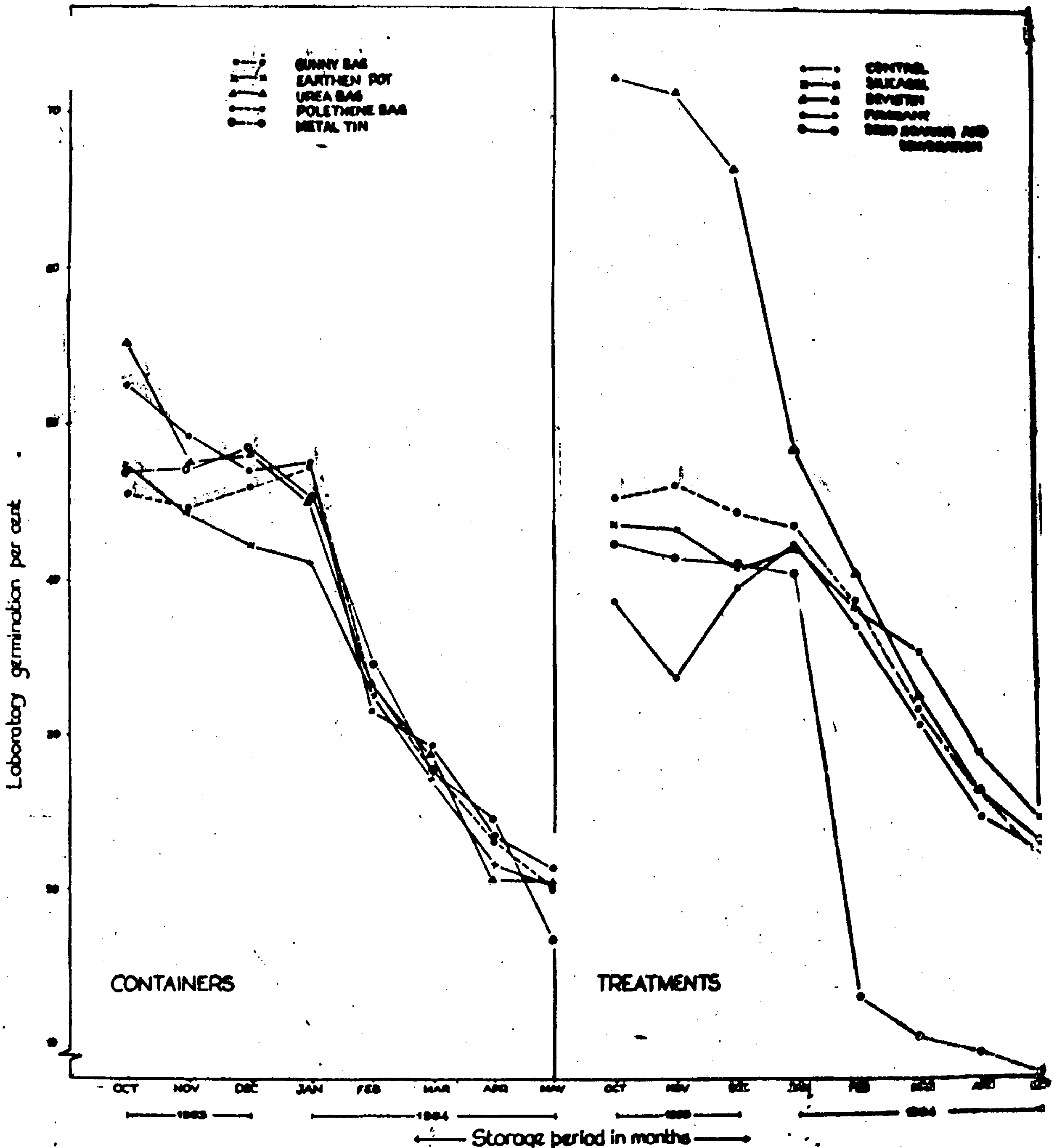

FIG. 4.1 EFFECT OF CONTAINERS AND TREATMENTS ON GERMINATION (PER CENT) OF LIMA BEAN SEEDS IN STORAGE

seeds (i.e., 43.9% and 45.7% respectively), the two treatments showed the same trend of decrease in germination (24.8% and 23.1% respectively in May '84). The soaking and dehydration treatment showed drastic decrease in germination per cent after the month of February '84. There was drastic reduction in the laboratory germination percentage after half way storage of seeds (42.3% - Oct. '83 and 8.2% - May '84).

None of the treatment combinations responded significantly to the interaction effect except during the month of April '84. However, Bavistin treated seeds stored in different containers maintained the highest germination initially (Oct. '83) and decreased subsequently upto final score (May '84). However, Bavistin with gunny bag showed the highest germination (75.3% - initial and 24.7% - final) followed by seeds stored in urea bag with fumigation (52.7% - initial and 22.3% - final), seeds stored in urea bag treated with silicagel (49.7% - initial and 25.7% - final) and seeds stored in gunny bag with fumigation (48.0% - initial and 24.3% - final). The maximum final germination of 9 per cent was recorded in soaking and dehydration treatment irrespective of the containers.

4.2 Field germination per cent

The results on the germination are presented in Table 4.2 and Fig. 4.2.

Table 4.2 The field emergence (%) of Lima bean from October 1983 to May 1984 at monthly intervals

Containers, treatments and their combinations	1983			1984				
	Oct.	Nov.	Dec.	Jan.	Feb.	March	Apr.	May
C_1	38.8	37.4	28.6	29.1	15.9	9.6	11.3	9.7
C_2	37.3	33.3	25.7	22.8	15.1	11.4	11.3	10.8
C_3	46.8	46.5	25.3	27.5	18.3	12.9	11.5	9.0
C_4	39.1	35.5	23.3	21.9	15.9	13.7	11.1	10.6
C_5	42.7	41.2	25.6	26.8	16.5	9.1	9.9	10.0
F value	*	*	*	*	*	*	NS	NS
S.Em ±	0.98	1.60	0.69	0.76	0.30	0.61		
C.D. at 5%	3.21	5.22	2.28	2.51	0.98	1.98		
CV	9.30	15.99	10.52	11.62	7.17	20.76	17.89	21.10
T_1	34.3	32.5	21.0	20.4	16.1	13.3	12.2	12.0
T_2	37.9	36.1	25.7	27.2	20.4	13.8	13.8	11.9
T_3	58.2	55.5	35.6	34.3	22.1	14.3	12.7	11.8
T_4	37.4	36.0	26.0	25.9	20.7	12.9	13.5	11.3
T_5	36.8	33.9	20.3	20.3	2.4	2.3	3.1	3.1
F value	*	*	*	*	*	*	*	*
S.Em ±	1.15	1.05	0.76	0.84	0.48	0.74	0.73	0.74
CD at 5%	3.30	3.00	2.16	2.40	1.36	2.11	2.09	2.10
CV	10.9	10.5	11.4	12.7	11.3	25.3	25.6	28.2
C_1T_1	32.7	29.3	22.7	24.7	16.3	12.0	9.3	11.0
C_1T_2	32.0	30.0	27.3	26.7	17.3	10.0	13.0	11.3
C_1T_3	56.3	54.7	42.0	40.3	21.3	10.7	15.3	10.7
C_1T_4	38.3	36.7	29.0	30.7	22.0	13.3	17.0	12.3
C_1T_5	34.7	36.3	22.0	23.0	2.3	2.0	3.0	3.3
C_2T_1	29.3	26.0	21.0	18.0	16.3	13.0	12.3	13.0
C_2T_2	37.7	36.0	26.0	23.3	18.0	14.0	15.3	13.3
C_2T_3	56.7	54.0	37.3	31.3	19.7	15.0	10.0	12.7
C_2T_4	26.3	24.0	25.0	25.0	18.0	12.0	15.7	12.7
C_2T_5	36.3	26.7	19.3	16.3	3.3	3.0	3.3	2.3

Table 4.2 contd...)

Containers, treatments and their combinations	1983			1984				
	Oct.	Nov.	Dec.	Jan.	Feb.	March	Apr.	May
C_3T_1	43.0	40.0	21.0	24.7	19.0	14.3	10.7	10.7
C_3T_2	49.3	50.0	28.0	32.0	24.3	14.7	15.7	10.7
C_3T_3	60.0	58.7	32.3	34.7	26.3	18.3	14.0	11.0
C_3T_4	42.0	44.7	23.7	22.0	20.0	15.7	13.7	10.0
C_3T_5	39.7	39.3	21.7	24.3	2.0	1.3	3.3	2.7
C_4T_1	29.0	33.7	18.0	18.3	14.7	14.0	14.7	13.7
C_4T_2	30.7	26.0	24.7	25.7	20.7	18.0	14.0	12.3
C_4T_3	52.0	46.7	31.3	27.3	21.3	17.0	14.0	13.3
C_4T_4	43.7	41.3	26.3	23.0	21.0	16.0	11.3	10.3
C_4T_5	40.3	30.0	16.3	15.3	2.0	3.3	1.7	3.3
C_5T_1	38.0	33.3	22.3	16.3	14.3	13.3	14.0	11.7
C_5T_2	39.7	38.7	22.7	28.7	21.7	12.3	11.0	12.0
C_5T_3	66.0	63.3	35.0	37.7	21.7	10.7	10.3	11.3
C_5T_4	36.7	33.3	26.0	29.0	22.3	7.7	10.0	11.0
C_5T_5	33.0	37.3	22.0	22.3	2.3	1.7	4.3	4.0
F value	*	*	NS	*	*	NS	*	NS
S.Em ±	2.57	2.36		1.83	1.067		1.63	
C.D. at 5%	7.34	6.74		5.23	3.049		4.67	

C_1 = Gunny bag; C_2 = Earthen pot; C_3 = Urea bag + Polythene layer; C_4 = Polythene bag; C_5 = Metal tin. T_1 = Control; T_2 = Silicagel; T_3 = Bavistin, T_4 = Fumigant; T_5 = Seed soaking and dehydration.

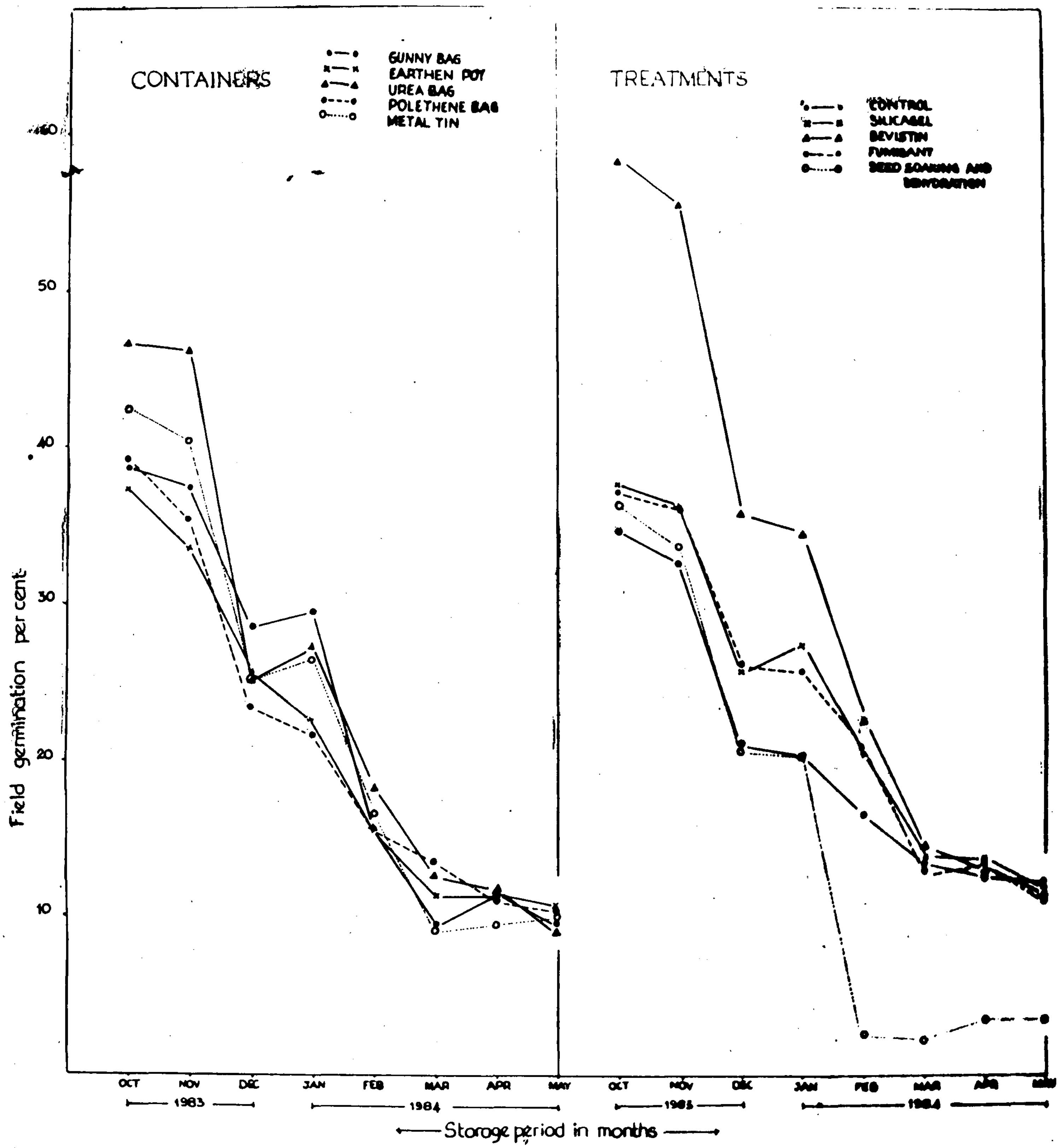

FIG. 4.2 EFFECT OF CONTAINER AND TREATMENT ON FIELD GERMINATION (PER CENT) OF LIMA BEAN SEEDS IN STORAGE

The results on the field germination after storing the seeds in containers showed significant differences due to the different containers in all the periods of observations between Oct. '83 to March '84 and non-significant differences in April '84 and May '84. Seeds from the urea bag container recorded the highest germination (46.8% - Oct. '83) and the lowest germination (9% - May '84), followed by metal tin container (42.7% - Oct. '83 and 10% - May '84).

Significant differences among the treatments were found to exist in all the eight months of field germination study. Bavistin treatment gave effective control of mycoflora during the first five months of storage as evidenced by the highest per cent field germination recorded by the Bavistin treated seeds (58.2, 55.5, 35.6, 34.3 and 22.1% during Oct. '83, Nov. '83, Dec. '83, Jan. '84 and Feb. '84). This was followed by fumigant and silicagel treatments (37.4, 36.0, 26.0, 25.9 and 20.7 and 37.9, 36.1, 25.7, 27.3 and 20.4 respectively). There was sudden reduction in the field germination of seeds soaked in water and dehydrated after fourth month of storage (36.8% - Oct. '83 and 3.1% - May '84).

Significant differences were observed among the container and treatment interactions during Oct. '83, Nov. '83, Jan. '84, Feb. '84 and April '84. The seeds stored in different containers treated with Bavistin recorded better viability showing high germination. However, seeds stored in metal tin with Bavistin treatment were found superior (66% - Oct.'83 and 11.3% - May '84) to others, closely followed by urea bag container with Bavistin treatment (60% - Oct. '83 and 11% - May '84).

4.3 <u>Hypocotyl length of seedlings</u>

The results on shoot length of seedlings are presented in Table 4.3 and Fig. 4.3.

The observations on shoot length of seedlings showed significant differences among containers during January '84 and February '84. The maximum shoot length was observed in case of seeds stored in metal tin (9.1 cm - Oct. '83 and was closely followed by urea bag 8.8 cm - May '84).

The maximum shoot length was measured from the seeds treated with Bavistin (10.0 cm - Oct. '83 and 4.8 cm - May '84). The treatments differed significantly among themselves during Oct. '83, November '83, Jan. '84, March '84 and May '84. There was reduction of shoot length in all the treatments as storage period increased.

Significant differences among interactions were observed in March and April '84. However, the highest shoot length was recorded in seeds treated with Bavistin irrespective of storage containers. Among different

Table 4.3 Shoot length of seedlings (cm) of Lima bean stored under room conditions at monthly intervals

Containers, treatments and their combinations	1983			1984				
	Oct.	Nov.	Dec.	Jan.	Feb.	March	Apr.	May
C_1	8.4	7.6	9.4	9.7	6.8	7.1	5.9	4.7
C_2	8.0	8.2	8.8	8.8	5.6	7.7	5.8	4.7
C_3	8.8	8.2	8.7	8.9	6.2	8.1	5.3	4.6
C_4	8.6	8.0	8.7	8.4	5.5	7.5	6.1	4.9
C_5	9.1	8.5	8.6	8.5	6.2	6.9	5.8	4.7
F value	NS	NS	NS	*	*	NS	NS	NS
S.Em ±				0.18	0.23			
C.D. at 5%				0.59	0.75			
CV	11.9	10.2	14.1	8.06	14.7	37.9	14.8	8.5
T_1	8.4	7.7	9.1	8.7	6.3	7.6	5.9	4.9
T_2	8.8	8.6	8.6	8.9	5.9	7.9	5.7	4.7
T_3	9.9	8.8	9.1	9.1	6.1	8.5	5.9	4.8
T_4	7.9	7.6	8.7	9.1	6.2	7.2	5.9	4.9
T_5	7.8	7.9	8.7	8.3	5.9	6.2	5.6	4.4
F value	*	*	NS	*	NS	*	NS	*
S.Em ±	0.24	0.19		0.16		0.22		0.12
C.D. at 5%	0.68	0.57		0.47		0.64		0.36
CV	10.7	9.54	11.1	7.15	10.4	11.9	8.5	10.2
C_1T_1	8.3	7.1	9.7	9.6	6.8	6.2	6.3	4.8
C_1T_2	7.8	7.4	9.9	10.5	6.7	8.3	5.2	4.6
C_1T_3	9.8	8.8	8.4	9.9	7.3	8.5	5.8	4.8
C_1T_4	7.5	6.5	10.1	10.1	6.3	7.0	5.8	5.1
C_1T_5	8.5	8.4	8.7	8.1	6.9	5.7	6.2	4.1
C_2T_1	8.1	7.5	8.4	8.6	6.1	8.3	5.3	5.4
C_2T_2	8.4	8.7	9.0	8.6	5.4	7.7	6.0	4.3
C_2T_3	9.8	8.9	9.4	9.2	6.1	10.1	6.4	4.7
C_2T_4	7.0	7.9	2.2	9.0	5.7	6.4	5.8	4.8
C_2T_5	6.9	7.7	8.0	8.2	4.9	6.0	5.6	4.3

Table 4.3 contd..)

Containers, treatments and their combinations	1983			1984				
	Oct.	Nov.	Dec.	Jan.	Feb.	March	Apr.	May
C_3T_1	8.3	7.0	8.4	8.6	6.3	8.5	5.6	4.3
C_3T_2	10.1	9.3	7.9	8.9	5.9	8.9	5.2	4.6
C_3T_3	9.7	9.0	9.5	9.5	5.9	8.8	5.4	4.5
C_3T_4	8.3	7.4	8.7	9.0	6.6	7.9	5.1	4.9
C_3T_5	7.7	7.4	8.7	8.2	6.4	6.6	5.4	4.3
C_4T_1	8.0	6.9	8.7	8.3	5.1	7.9	6.0	5.0
C_4T_2	8.4	8.6	8.6	8.3	5.7	8.1	5.8	4.7
C_4T_3	10.0	8.1	8.9	8.7	5.7	7.7	6.2	4.9
C_4T_4	8.6	8.1	7.9	8.5	5.9	7.7	6.8	5.0
C_4T_5	8.1	8.4	9.3	8.2	5.3	6.0	5.8	5.0
C_5T_1	9.1	8.7	9.8	8.1	7.3	7.0	6.0	4.6
C_5T_2	9.2	8.8	7.8	8.5	5.8	6.4	6.5	5.4
C_5T_3	10.6	9.0	9.4	8.3	5.4	7.5	5.8	4.8
C_5T_4	8.3	8.2	7.6	9.0	6.4	6.9	5.9	4.6
C_5T_5	8.0	7.7	8.5	8.5	5.9	6.7	5.2	4.3
F value	NS	NS	NS	NS	NS	*	*	NS
S.Em ±						0.50	0.28	
C.D. at 5%						1.44	0.81	

C_1 = Gunny bag; C_2 = Earthen pot; C_3 = Urea bag + Polythene layer; C_4 = Polythene bag; C_5 = Metal tin. T_1 = Control; T_2 = Silicagel; T_3 = Bavistin; T_4 = Fumigant; T_5 = Seed soaking and dehydration.

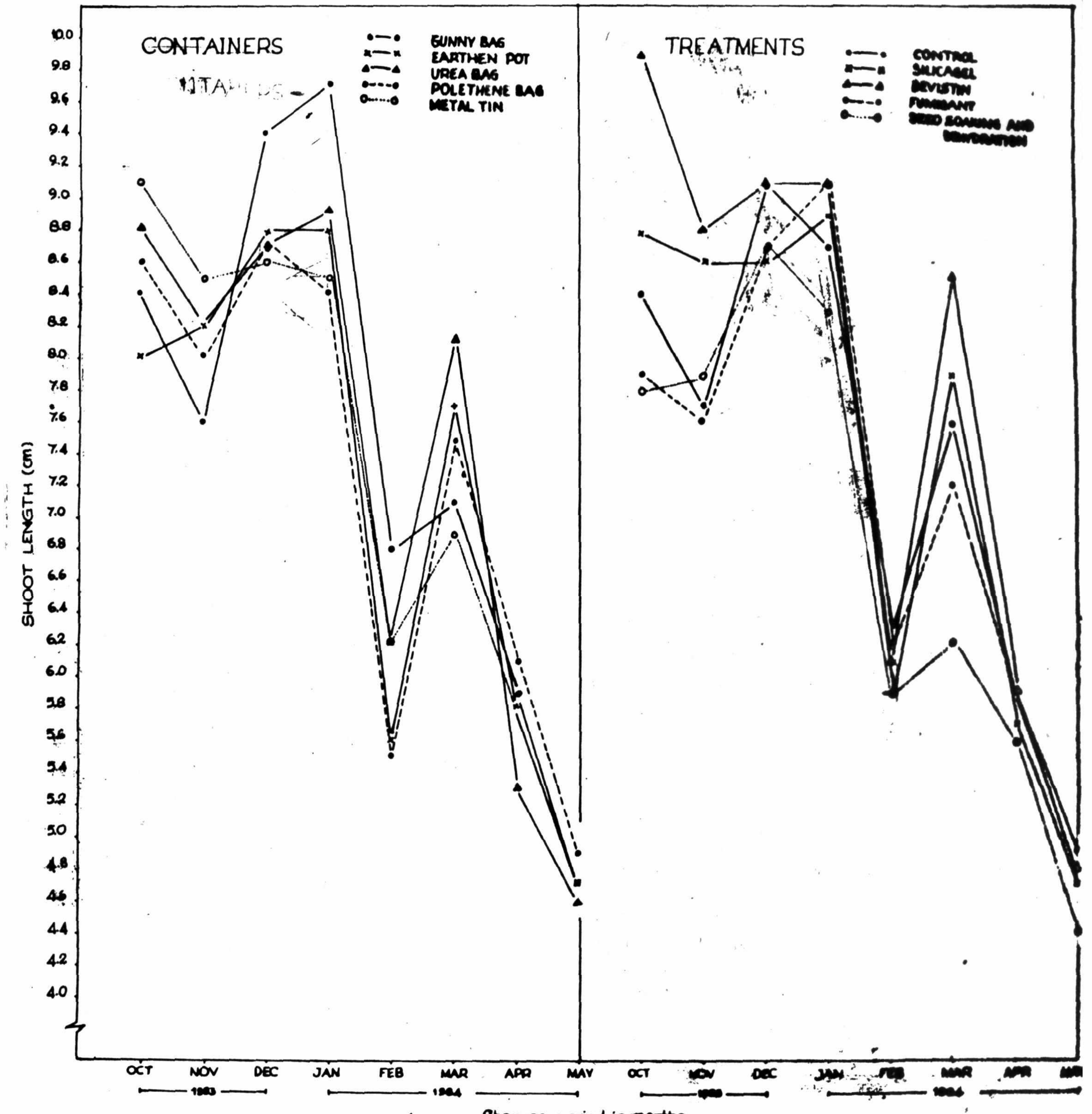

Fig. 4.3 Effect of containers and treatments on shoot length (cm) of Lima bean seeds in storage

containers seeds stored in metal tin with Bavistin treatment produced the highest shoot length (10.6 cm - Oct. '83) followed by the seed stored in urea bag with silicagel treatment (10.1 cm - Oct. '83) and polythene bag with Bavistin treatment (10 cm - Oct. '83). The least shoot length was recorded from seeds stored in gunny bag after soaking and dehydration (4.1 cm - May '84).

4.4 Vigour index (V.I.)

Vigour index based upon hypocotyl length was worked out with a view to find out whether storage period and method had any effect on the initial seedling growth. The data are presented in Table 4.4 and Fig. 4.4.

Significant differences were found among the various containers during the months from October '83 and April '84. Seeds stored in gunny bag showed the highest vigour index of 446.2 during the month October '83. The vigour index was reduced in all the containers to a greater extent after soaking and dehydration treatment.

The different treatments varied significantly in all the treatments. The seedlings resulting after treating the seeds with Bavistin were found to be superior to all other treatments (701.7 - Oct. '83 and 110.8 - May '84). There was drastic reduction in the vigour

Table 4.4 Vigour index (based on hyprocotyl length x per cent normal germination) of Lima bean seeds stored under room conditions at monthly intervals

Containers, treatments and their combinations	1983			1984				
	Oct.	Nov.	Dec.	Jan.	Feb.	March	Apr.	May
C_1	446.2	385.6	416.9	463.1	254.9	220.5	137.7	102.1
C_2	386.4	383.9	372.4	364.3	186.7	207.8	127.1	96.4
C_3	445.3	397.9	418.4	401.6	206.4	240.0	111.3	95.2
C_4	382.7	365.0	404.0	399.0	190.7	210.8	142.9	103.9
C_5	435.7	395.1	422.7	391.5	213.2	192.7	147.5	87.7
F value	*	NS	NS	NS	NS	NS	*	NS
S.Em ±	16.11						4.96	
C.D.at 5%	52.53						16.17	
CV	14.89	86.56	19.97	22.55	44.74	21.47	14.42	15.66
T_1	325.2	259.4	337.0	368.0	232.9	220.9	145.7	107.4
T_2	385.7	369.4	353.7	384.2	229.7	280.4	154.5	116.6
T_3	701.7	611.6	602.2	535.0	244.8	257.7	155.3	110.8
T_4	352.7	354.8	284.1	398.5	236.5	232.9	158.2	113.9
T_5	331.5	324.2	357.4	333.8	108.1	70.8	52.9	36.5
F value	*	*	*	*	*	*	*	*
S.Em ±	15.94	47.58	20.69	19.72	21.05	10.88	4.45	3.10
C.D.at 5%	45.55	134.31	59.13	56.35	60.15	31.09	12.72	10.56
CV	14.72	99.32	17.40	18.91	39.34	19.65	12.94	14.74
C_1T_1	348.7	294.1	290.8	392.9	245.5	202.8	160.4	111.7
C_1T_2	363.2	319.6	409.2	457.4	248.9	299.6	156.7	116.0
C_1T_3	739.4	632.1	580.3	668.9	281.6	292.9	154.7	121.5
C_1T_4	360.8	314.3	435.9	405.9	231.0	227.6	164.6	123.7
C_1T_5	419.1	367.9	368.3	390.6	267.4	79.5	53.6	37.5
C_2T_1	300.2	191.5	254.8	355.6	228.9	220.6	129.8	112.9
C_2T_2	339.3	349.8	328.8	312.1	206.5	275.4	148.3	102.6
C_2T_3	697.4	622.2	537.2	443.9	238.6	227.9	164.9	113.5
C_2T_4	302.4	341.1	425.8	443.6	203.9	225.8	132.0	119.1
C_2T_5	292.4	324.2	315.6	276.1	55.6	89.5	60.4	34.1

Table 4.4 contd..)

Containers, treatments and their combinations	1983			1984				
	Oct.	Nov.	Dec.	Jan.	Feb.	March	Apr.	May
C_3T_1	335.1	238.8	342.8	371.4	232.0	265.8	128.9	107.2
C_3T_2	491.0	458.2	373.4	369.3	225.5	322.3	119.1	117.0
C_3T_3	687.7	619.7	630.1	517.7	234.1	279.9	119.7	102.7
C_3T_4	405.5	385.6	393.9	422.8	262.5	263.9	136.4	110.2
C_3T_5	307.1	287.6	351.7	327.0	78.1	68.1	52.5	38.9
C_4T_1	304.1	265.7	347.2	355.8	196.4	249.9	155.5	109.8
C_4T_2	330.9	322.8	342.4	409.0	239.9	269.7	160.5	122.7
C_4T_3	626.4	603.0	598.3	536.0	221.8	244.8	165.7	124.5
C_4T_4	339.6	347.6	316.4	335.0	234.0	235.8	182.4	125.4
C_4T_5	312.5	285.8	416.0	359.3	61.5	53.9	50.5	37.4
C_5T_1	337.8	367.1	449.4	364.4	261.9	210.9	154.2	95.4
C_5T_2	403.4	396.9	314.6	373.3	227.7	235.0	188.0	124.8
C_5T_3	757.8	580.9	665.1	508.6	247.9	242.9	172.6	92.2
C_5T_4	353.0	385.5	348.5	395.0	250.9	211.6	175.4	91.4
C_5T_5	326.3	305.7	336.0	315.9	77.4	62.8	47.0	34.7
F value	NS	NS	NS	NS	NS	NS	*	NS
S.Em ±							9.96	
C.D.at 5%							28.46	

C_1 = Gunny bag; C_2 = Earthen pot; C_3 = Urea bag + Polythene layer; C_4 = Polythene bag; C_5 = Metal tin; T_1 = Control; T_2 = Silicagel; T_3 = Bavistin; T_4 = Fumigant; T_5 = Seed soaking and dehydration.

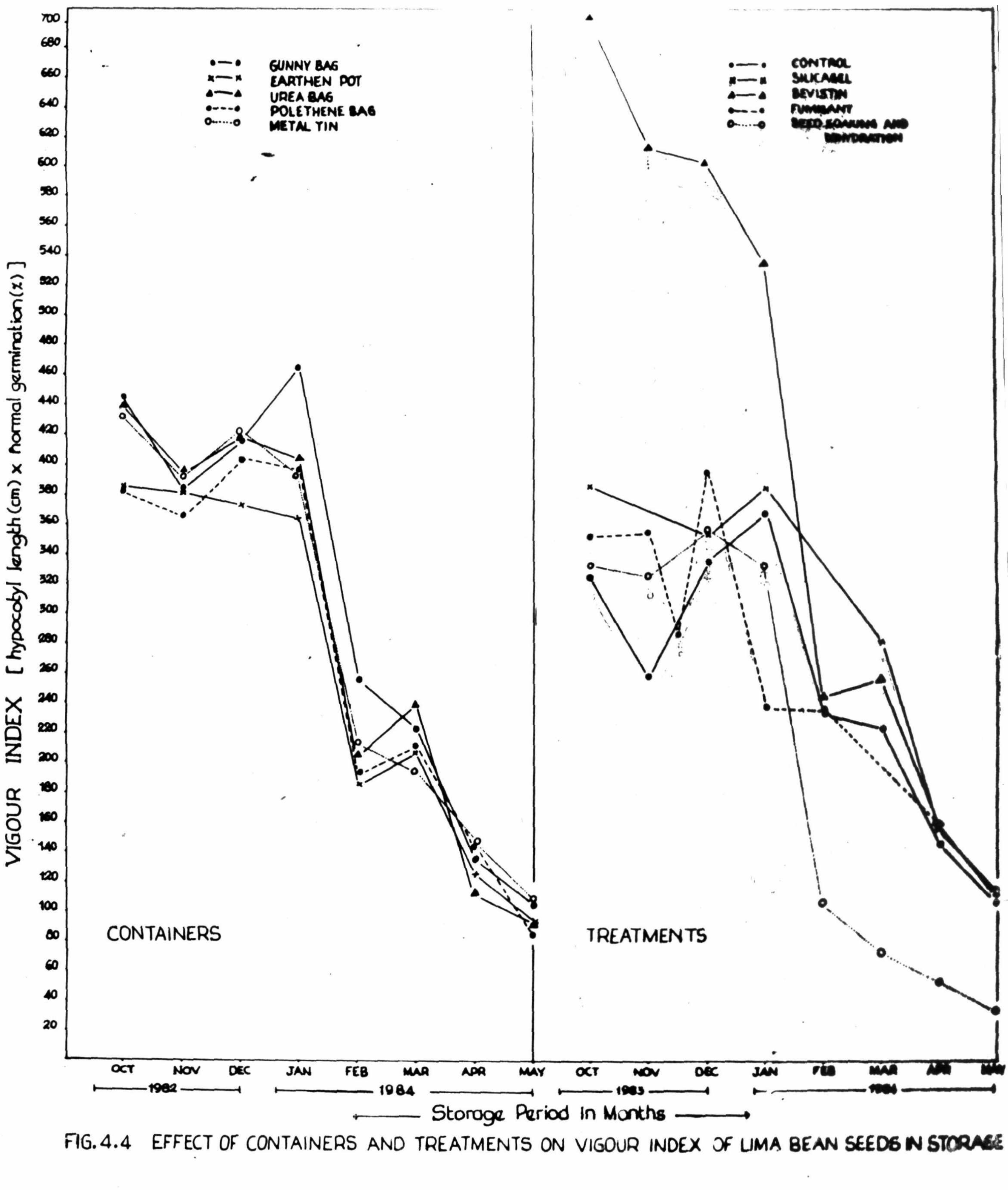

FIG. 4.4 EFFECT OF CONTAINERS AND TREATMENTS ON VIGOUR INDEX OF LIMA BEAN SEEDS IN STORAGE

index of seed soaked in water and dehydrated after half way storage of seeds (331.5 - Oct. '83 and 36.5 - May '84).

Interactions between different containers and treatments showed significant differences in vigour index in April 1984. However, seeds treated with Bavistin irrespective of storage containers recorded the highest vigour index. Seeds stored in metal tin with Bavistin treatment (757.8 - Oct. '83) showed high vigour index closely followed by gunny bag with Bavistin treatment (739.3 - Oct. '83). Some of the treatment combinations maintained high vigour index at the final (May '84) stage. They were polythene with fumigation (125.4), metal tin with silicagel (124.8), urea bag with silicagel (117.0) and gunny bag with fumigation (123.7).

4.5 Seed moisture content

The data on moisture content are presented in the Table 4.5 and Fig. 4.5.

The initial (Oct. '83) moisture content remained constant in all the containers. The moisture content in seeds increased in gunny bag followed by earthen pot, as the storage period increased (i.e., 12.8% - and 12.4% during May '84 respectively). The lowest moisture content was recorded in metal tin followed by urea bag 12.1% - and 12.2% during May '84) respectively.

Table 4.5 The moisture content (%) of Lima beans stored under room conditions at monthly intervals

Containers, treatments and their combinations	1983			1984				
	Oct.	Nov.	Dec.	Jan.	Feb.	March	Apr.	May
C_1	9.5	9.8	10.8	10.8	11.4	11.5	11.8	12.8
C_2	9.5	9.9	10.7	10.7	11.5	11.4	11.7	12.4
C_3	9.5	9.8	10.7	10.6	11.2	11.1	11.9	12.2
C_4	9.5	9.8	10.7	11.1	11.0	10.9	11.6	12.4
C_5	9.5	9.8	10.4	10.9	11.3	9.9	11.6	12.1
F value	NS	NS	NS	NS	NS	NS	NS	NS
S.Em ±								
C.D.at 5%								
CV	1.70	0.02	7.73	3.82	3.95	14.28	5.94	4.98
T_1	9.5	9.8	10.9	10.8	11.5	11.2	11.7	13.0
T_2	9.5	9.8	10.6	10.9	11.2	11.1	11.5	12.9
T_3	9.5	9.9	10.6	10.5	11.9	10.8	11.7	12.0
T_4	9.5	9.9	10.8	11.1	11.4	10.9	11.5	12.1
T_5	9.5	9.8	10.6	10.9	11.3	10.9	11.6	12.0
F value	NS	*	NS	NS	NS	NS	NS	NS
S.Em ±		0.00026						
C.D.at 5%		0.000074						
CV	1.9	0.03	9.00	6.40	6.19	8.40	5.00	3.12
C_1T_1	9.3	9.8	10.6	10.4	11.6	11.6	11.3	12.6
C_1T_2	9.2	9.8	10.5	10.8	10.9	11.0	10.9	12.0
C_1T_3	9.7	9.8	10.5	11.0	11.2	11.8	11.7	12.1
C_1T_4	9.7	9.8	10.7	11.4	10.9	10.1	11.8	11.8
C_1T_5	9.7	9.8	10.6	10.4	11.0	11.2	11.5	11.8
C_2T_1	9.6	9.8	10.6	10.6	11.2	10.5	11.4	12.8
C_2T_2	9.6	9.9	10.8	10.7	11.3	10.8	11.6	12.0
C_2T_3	9.5	9.8	10.3	10.4	11.7	10.8	11.5	12.3
C_2T_4	9.3	9.9	10.7	11.2	11.8	12.6	11.4	11.7
C_2T_5	9.4	9.8	10.9	10.8	11.6	12.1	11.7	11.9

Table 4.5 contd..)

Containers, treatments and their combinations	1983 Oct.	Nov.	Dec.	1984 Jan.	Feb.	March	Apr.	May
C_3T_1	9.5	9.8	10.7	10.8	11.3	11.3	11.4	12.3
C_3T_2	9.4	9.8	10.5	11.0	11.1	11.9	11.7	12.5
C_3T_3	9.4	9.8	10.8	10.5	10.8	10.9	11.9	12.2
C_3T_4	9.5	9.8	10.9	10.8	11.3	10.7	11.4	11.5
C_3T_5	9.6	9.8	10.6	10.9	11.5	10.8	10.9	12.4
C_4T_1	9.6	9.8	10.6	11.3	11.2	11.0	11.4	12.4
C_4T_2	9.5	9.8	10.8	11.5	11.3	11.4	11.5	13.2
C_4T_3	9.5	9.8	10.5	10.8	10.6	10.5	11.9	13.1
C_4T_4	9.4	9.8	10.0	11.1	11.0	11.0	11.7	12.7
C_4T_5	9.4	9.8	10.5	10.6	10.8	10.9	11.6	12.6
C_5T_1	9.5	9.8	10.7	10.7	11.3	9.1	10.9	11.3
C_5T_2	9.5	9.8	10.4	10.8	11.3	10.6	11.6	12.7
C_5T_3	9.4	9.8	10.4	10.7	10.2	10.3	11.8	12.6
C_5T_4	9.4	9.8	10.5	10.8	12.2	9.8	11.4	12.6
C_5T_5	9.5	9.8	10.2	11.9	11.5	10.0	12.2	11.4
F value	*	*	NS	NS	NS	NS	NS	*
S.Em ±	0.103	0.00054						0.219
C.D.at 5%	0.294	0.000154						0.626

C_1 = Gunny bag; C_2 = Earthen pot; C_3 = Urea bag + Polythene layer; C_4 = Polythene bag; C_5 = Metal tin. T_1 = Control; T_2 = Silicagel; T_3 = Bavistin; T_4 = Fumigant; T_5 = Seed soaking and dehydration.

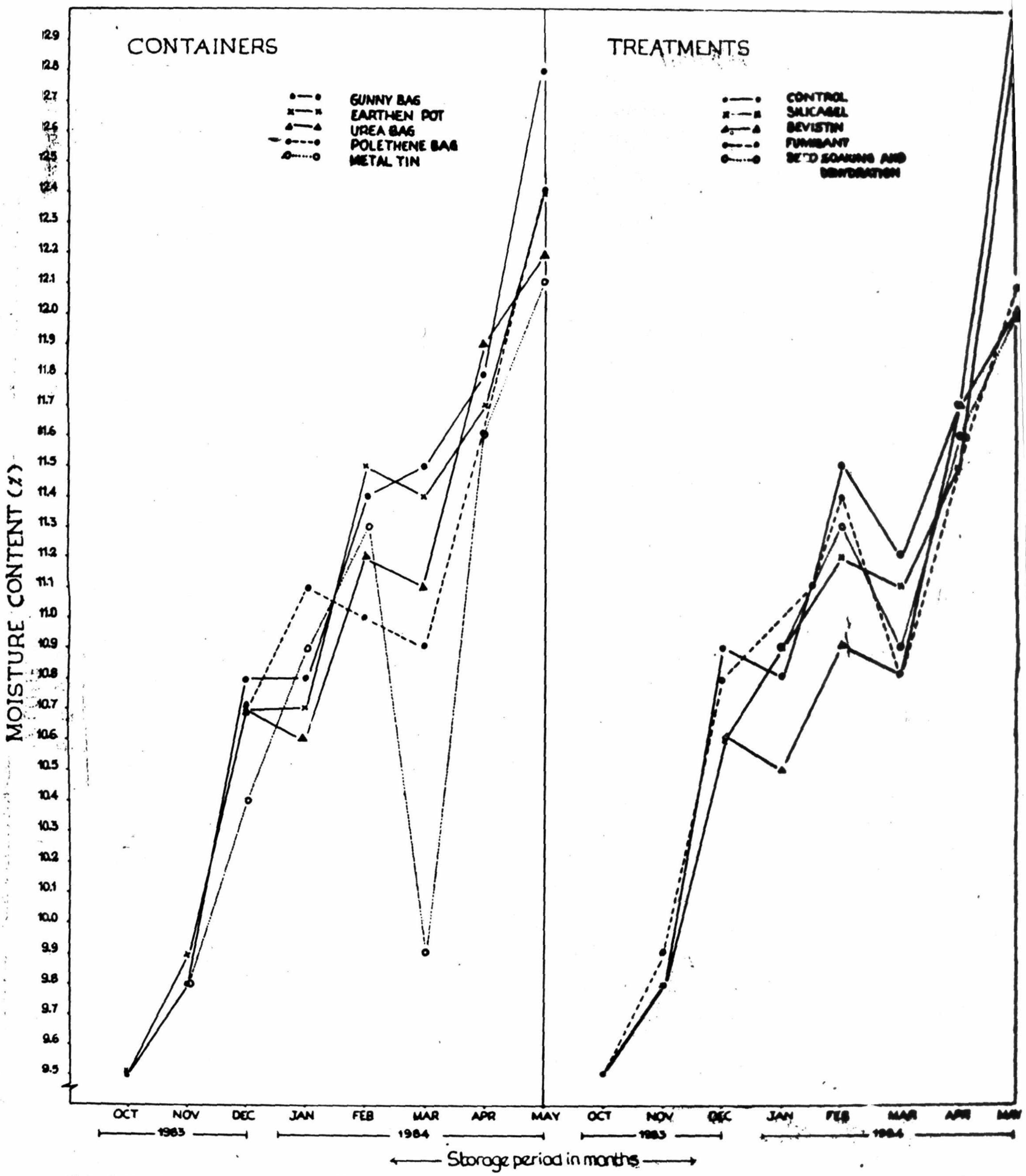

FIG. 4.5 EFFECT OF CONTAINERS AND TREATMENTS ON MOISTURE CONTENT (PER CENT) OF LIMA BEAN SEEDS IN STORAGE

Different treatments on stored seeds differed significantly during the month Nov. '84.

The results varied significantly due to interactions on moisture content of seed only for three observations during the study. The percentage of moisture content in the seed increased with the duration of storage. The moisture content in the seed was found to increase in gunny bag with Bavistin treatment (9.7% - Oct. '83) and also in seed soaking and dehydration (9.7% - Oct. '83 and 11.8% - May '84) earthen pot with control (9.6% - Oct. '83 and 12.8% - May '84), polythene bag with control (9.6% - Oct. '83 and 12.4% - May '84), urea bag with seed soaking and dehydration (9.6% - Oct. '84 and 12.4% - May '84) and metal tin with silicagel (9.5% - Oct. '83 and 12.7% - May '84).

4.6 <u>The colour of seed</u>

Physical appearance of the seed became slightly brown in colour as storage period increased.

4.7 <u>Test weight (g)</u>

The data on test weight are presented in Table 4.6 and Fig. 4.6.

Significant differences among containers were found only during the month January '84. The highest test

Table 4.6 Test weight (g) of Lima bean seeds stored under room conditions at monthly intervals

Containers, treatments and their combinations	1983			1984				
	Oct.	Nov.	Dec.	Jan.	Feb.	March	Apr.	May
C_1	31.7	31.8	32.0	32.5	31.9	32.1	32.3	33.3
C_2	31.6	31.6	32.4	33.0	32.3	32.1	32.4	33.0
C_3	31.3	31.5	31.7	32.2	31.8	32.0	32.4	32.9
C_4	31.6	31.4	32.1	32.5	32.0	32.0	32.7	33.1
C_5	31.4	31.7	32.1	32.3	31.7	32.1	32.3	32.4
F value	NS	NS	NS	*	NS	NS	NS	NS
S.Em ±				0.119				
C.D.at 5%				0.389				
CV	1.07	1.32	2.97	1.420	2.13	3.61	3.15	2.40
T_1	31.7	31.7	32.3	32.7	32.6	32.6	32.6	33.4
T_2	31.4	31.5	31.7	32.3	32.1	32.2	32.2	33.2
T_3	31.5	31.7	32.2	32.6	32.9	32.1	32.4	33.0
T_4	31.6	31.7	31.9	32.7	31.8	32.5	32.4	33.0
T_5	31.4	31.5	32.1	32.2	31.2	31.2	32.4	32.8
F value	NS	NS	NS	NS	*	*	NS	NS
S.Em ±					0.213	0.226		
C.D.at 5%					0.609	0.646		
CV	1.31	1.33	2.61	2.10	2.58	2.75	2.32	2.87
C_1T_1	31.9	31.9	32.2	32.8	32.2	32.2	33.0	33.6
C_1T_2	31.5	31.8	31.2	32.2	32.3	32.4	31.9	32.9
C_1T_3	31.6	32.0	32.3	32.6	32.7	32.2	32.2	33.3
C_1T_4	31.9	31.8	32.0	32.9	31.5	31.8	32.5	33.0
C_1T_5	31.5	31.4	32.4	32.1	31.5	31.8	32.3	33.7
C_2T_1	32.0	31.6	33.1	33.0	32.2	32.3	32.6	32.9
C_2T_2	31.6	31.6	31.6	32.5	32.4	32.3	32.0	33.7
C_2T_3	31.6	31.8	32.4	32.7	32.0	32.2	32.6	32.8
C_2T_4	31.3	31.5	32.2	33.3	32.5	32.9	32.4	33.3
C_2T_5	31.4	31.5	32.5	33.5	32.1	30.9	32.5	32.8

Table 4.6 contd..)

Containers, treatments and their combinations	1983			1984				
	Oct.	Nov.	Dec.	Jan.	Feb.	March	Apr.	May
C_3T_1	31.3	31.6	31.7	32.6	32.8	33.0	32.4	33.4
C_3T_2	31.2	31.2	31.2	31.9	31.6	31.9	32.4	33.5
C_3T_3	31.2	31.7	32.1	32.7	31.6	32.4	32.5	33.5
C_3T_4	31.4	31.8	31.6	32.2	32.1	32.8	32.5	33.5
C_3T_5	31.3	31.5	32.1	31.5	30.8	29.9	32.3	33.5
C_4T_1	31.7	31.5	32.3	32.8	33.5	33.5	32.8	33.3
C_4T_2	31.4	31.4	32.2	32.3	32.1	32.2	32.4	33.4
C_4T_3	31.7	31.4	32.4	32.8	32.0	31.8	32.4	33.1
C_4T_4	31.4	31.5	32.0	32.9	31.8	32.7	32.9	32.8
C_4T_5	31.6	31.4	31.5	31.8	30.6	31.5	32.8	32.4
C_5T_1	31.5	31.7	32.2	32.1	31.9	32.1	32.1	33.5
C_5T_2	31.2	31.8	32.3	32.5	32.4	32.3	32.9	32.7
C_5T_3	31.5	31.6	31.9	32.1	31.9	31.7	32.4	32.1
C_5T_4	31.8	31.7	31.9	32.2	31.4	32.2	31.9	32.4
C_5T_5	30.8	31.7	32.2	32.3	30.9	31.8	32.1	32.3
F value	NS	NS	NS	NS	NS	NS	NS	*
S.Em ±								0.522
C.D.at 5%								1.492

C_1 = Gunny bag; C_2 = Earthen pot; C_3 = Urea bag + polythene layer; C_4 = Polythene bag; C_5 = Metal tin. T_1 = Control; T_2 = Silicagel; T_3 = Bavistin; T_4 = Fumigant; T_5 = Seed soaking and dehydration.

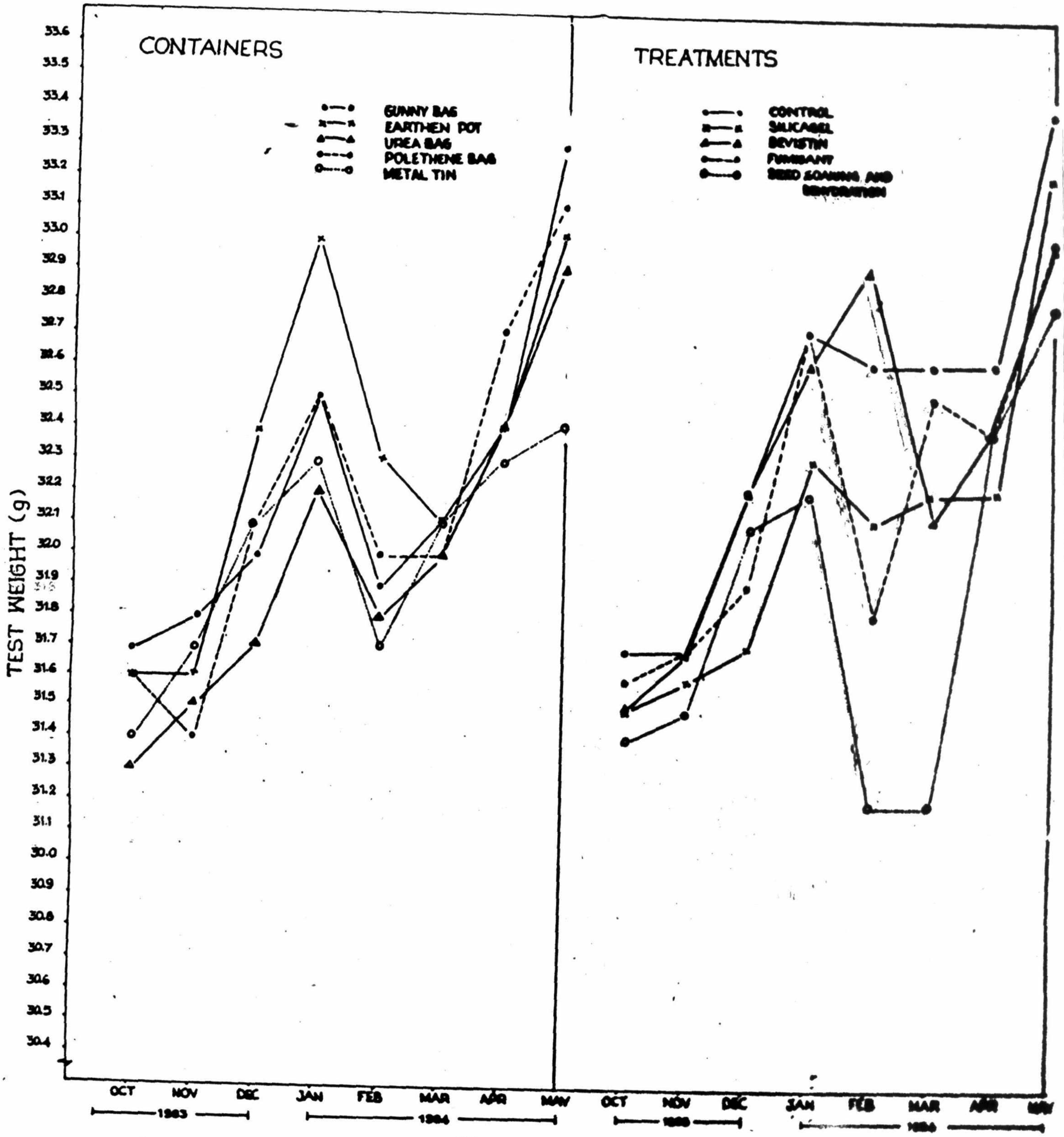

FIG. 4.6 EFFECT OF CONTAINERS AND TREATMENTS ON TEST WEIGHT (g) OF LIMA BEAN SEEDS IN STORAGE

weight was recorded where the seeds were stored in earthen pot (33.0 g - Jan. '84) and lowest in the urea bag (32.2 g - Jan. '84).

Significant differences were observed due to treatments on test weight of seeds during the months February and March '84. The highest and the lowest test weights were recorded in the control (32.9 g - Feb. '84) and the treatment seed soaking - dehydration (31.2 g - March '84), respectively.

None of the combinations of different containers and treatments responded significantly due to the interactions except the month May '84. The highest test weight was recorded in the combination of earthen pot with silicagel (33.7 g - May '84) and gunny bag with the control (33.6 g - May '84) respectively. The seed weight was increased in all containers and treatments at the end of storage period months.

4.8 Seed leachate

4.8.1 Electrical conductivity

Electrical conductivity of seed leachate was determined at monthly intervals for eight months of storage period and the data are given in Table 4.7 and Fig. 4.7. In general E.C. of seed leachate increased with the increase in the time of storage.

Table 4.7 Electrical conductivity (EC) (μmhos/cm) in the seed leachate of Lima bean stored under room conditions at monthly intervals

Containers, treatments, and their combinations	1983 Oct.	1983 Nov.	1983 Dec.	1984 Jan.	1984 Feb.	1984 March	1984 Apr.	1984 May
C_1	56.0	78.0	294.0	587.3	914.7	1080.7	1034.7	1182.7
C_2	56.7	78.1	316.0	420.1	861.3	1032.0	1048.7	1124.0
C_3	66.9	100.7	260.7	393.3	826.0	1045.3	1076.7	1153.3
C_4	55.3	95.3	271.3	368.7	882.7	1055.3	1134.0	1163.3
C_5	38.0	65.3	254.7	374.0	812.0	998.0	1061.3	1044.0
F value	NS	NS	*	*	NS	NS	NS	NS
S.Em ±			10.08	32.55				
C.D.at 5%			32.87	109.40				
CV	42.93	35.15	13.97	30.31	11.02	8.40	7.34	13.56
T_1	56.7	83.3	306.7	462.7	780.7	961.3	1104.1	1123.3
T_2	48.0	64.8	269.3	470.7	828.7	967.3	1070.7	1127.3
T_3	62.7	89.3	257.3	368.1	802.7	1016.0	1009.3	1101.3
T_4	53.6	96.3	266.7	406.7	762.0	1026.7	944.7	1162.1
T_5	52.0	84.7	296.7	435.3	1122.7	1240.0	1226.7	1342.1
F value	NS	NS	NS	NS	*	*	*	NS
S.Em ±					25.58	25.82	30.55	
C.D.at 5%					73.10	73.10	87.30	
CV	42.80	42.14	22.02	25.02	11.53	9.59	11.05	14.54
C_1T_1	60.0	83.3	290.0	670.0	823.3	1013.3	1080.0	1133.3
C_1T_2	50.0	56.7	266.7	690.0	953.3	1040.0	1123.3	1133.3
C_1T_3	40.0	80.0	240.0	450.0	826.7	993.3	966.7	1043.3
C_1T_4	76.7	90.0	336.7	583.3	866.7	1073.3	790.0	1403.3
C_1T_5	53.3	80.0	336.7	543.3	1103.3	1283.3	1213.3	1200.0
C_2T_1	43.3	40.0	346.7	496.7	810.0	966.7	1070.0	1100.0
C_2T_2	56.7	60.7	313.3	430.0	766.7	820.0	1030.0	1123.3
C_2T_3	76.7	110.0	316.7	310.3	813.3	1106.7	1073.3	1136.7
C_2T_4	63.3	93.3	253.3	376.7	850.0	1093.3	843.3	1033.3
C_2T_5	43.3	86.7	350.0	436.7	1066.7	1173.3	1226.7	1226.7

Table 4.7 contd..)

Containers, treatments and their treatments	1983			1984				
	Oct.	Nov.	Dec.	Jan.	Feb.	March	Apr.	May
C_3T_1	76.7	93.3	306.7	423.3	806.7	936.7	1076.7	1183.3
C_3T_2	53.3	96.7	250.0	380.0	706.7	893.3	1040.0	1153.3
C_3T_3	83.3	86.7	236.7	386.7	866.7	1063.3	1030.0	1166.7
C_3T_4	38.0	123.3	270.0	366.7	670.0	1110.0	1830.0	1076.7
C_3T_5	83.3	103.3	240.0	410.0	1080.0	1223.3	1206.7	1186.7
C_4T_1	56.7	123.3	286.7	353.3	763.3	1040.0	1170.8	1086.3
C_4T_2	43.3	46.7	293.3	436.7	913.3	1046.5	1133.3	1150.0
C_4T_3	86.7	90.0	266.7	366.7	743.3	896.7	1073.3	1166.7
C_4T_4	53.3	96.7	243.3	323.3	796.7	1016.7	1030.0	1110.0
C_4T_5	36.7	120.0	266.7	383.3	1196.7	1276.7	1263.3	1306.7
C_5T_1	46.7	76.7	303.3	390.0	700.0	850.0	1123.3	1116.7
C_5T_2	36.7	63.3	293.3	366.7	803.3	1036.7	1026.7	1076.7
C_5T_3	26.7	80.0	226.7	326.7	363.3	1020.0	903.3	993.3
C_5T_4	36.7	73.3	230.0	383.3	626.7	840.0	1030.0	1143.3
C_5T_5	43.3	33.3	290.0	403.3	1166.7	1243.3	1223.3	1118.0
F value	NS	NS	NS	NS	NS	*	NS	NS
S.Em ±						57.12		
C.D.at 5%						163.32		

C_1 = Gunny bag; C_2 = Earthen pot; C_3 = Urea bag + Polythene layer; C_4 = Polythene bag; C_5 = Metal tin. T_1 = Control; T_2 = Silicagel; T_3 = Bavistin; T_4 = Fumigant; T_5 = Seed soaking and dehydration.

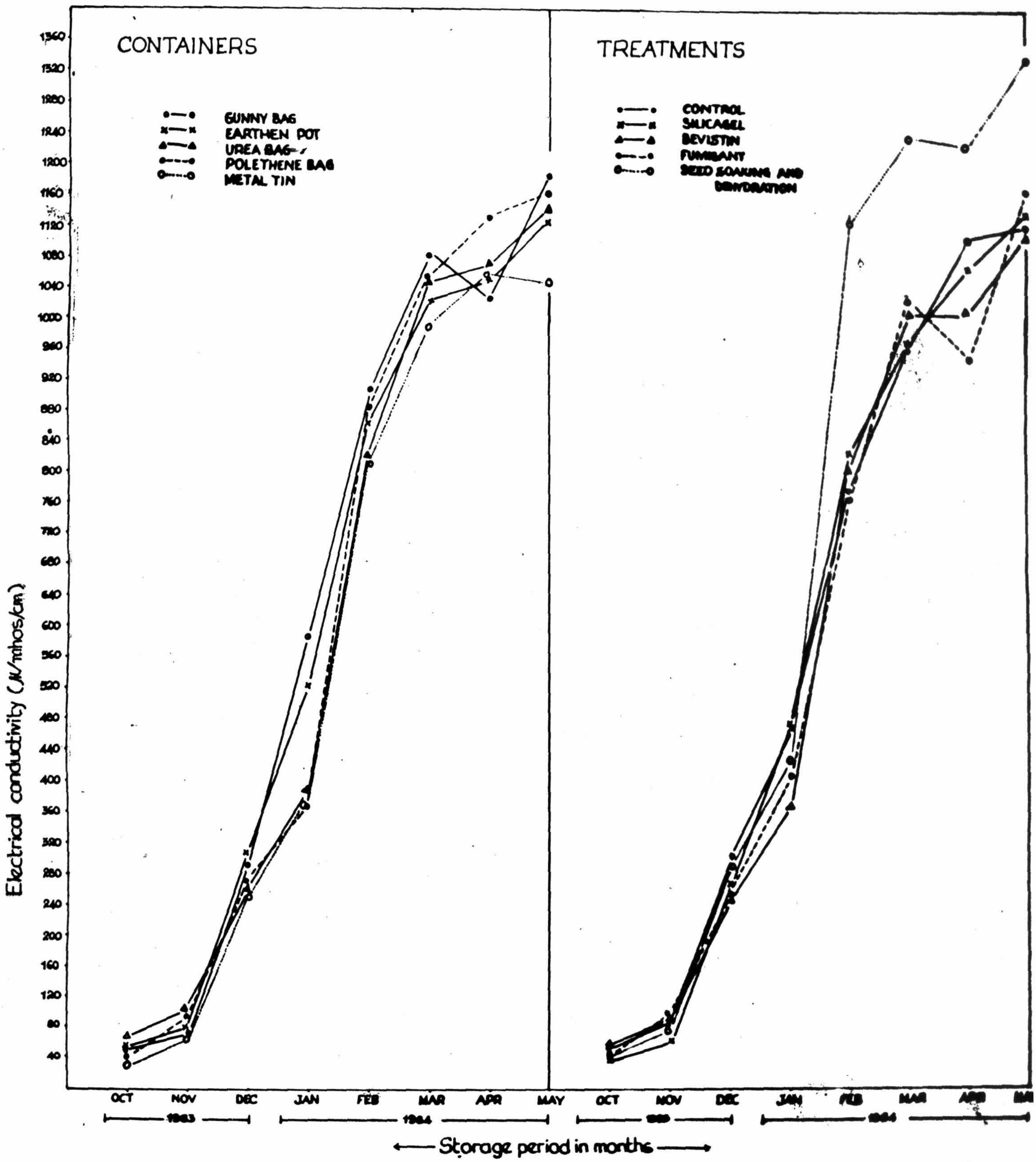

FIG. 4.7 EFFECT OF CONTAINERS AND TREATMENTS ON ELECTRICAL CONDUCTIVITY (μ mhos/cm) OF LIMA BEAN SEEDS IN STORAGE

Significant differences were observed for electrical conductivity between the containers during the months of December '83 and January '84.

Significant differences were recorded for this character for the treatments during the months Feb., March and April '84. There was increased electrical conductivity insseed leachate from seeds soaked in water and dehydrated after the fourth month of storage, when compared to other treatments (i.e., 52 µ/mhos/cm - Oct. 1983 and 1342.1 µ/mhos/cm - May '84). In the initial four months the amount of E.C. was found to be the same in all the treatments (i.e., 62.7 µ/mhos/cm in Bavistin at Oct. 1983 and 470.7 µ/mhos/cm - in Silicagel at January '84).

The interaction effects differed significantly during the month of March 1984. However, electrical conductivity in the seed leachate gradually increased from the starting (Oct. 1983) to the final (May 1984) observations in all the treatments and in E.C. interaction combination there was decrease in viability as storage period of the seed increased.

4.8.2 Reducing sugar (µg/seed)

The results obtained at every two months interval of storage period on reducing sugar content in leachate of seeds are presented in Table 4.8 and illustrated in Fig. 4.8.

The seeds stored in different containers varied with respect to reducing sugar content in leachate of seed alternatively in four observations. However, seeds stored in urea bag container accounted for the lowest leachate and sugar (504.3 µg/g of seed - Nov. '83) and the highest reducing sugar content found leached was in case of seeds stored in gunny bag (515.4 in Nov. '83) and the least in urea bag (212.9 - May '84).

All the treatment differences varied significantly among themselves in leachates of seeds. The lowest final (188.5 - May '84), leachate was recorded in the seeds without treatment (control) and the highest was in seed soaking and dehydration (337.5 - May '84). The highest reducing sugars were found in the control and seed soaking and dehydration.

Significant differences between the container and treatment interaction was observed only during the month of March '84. A trend of decrease in reducing sugar content in leachate of seeds with increase in storage period was noticed in all the treatment combinations.

Table 4.8 Reducing sugar content (µg/seed) in leachate of Lima bean seeds stored under room conditions at monthly intervals

Containers, treatments, and their combinations	1983	1984		
	Nov.	Jan.	Mar.	May
C_1	515.4	485.3	373.9	230.9
C_2	514.4	489.0	371.6	276.1
C_3	504.3	480.1	389.3	212.9
C_4	511.2	484.0	373.3	249.6
C_5	508.6	485.5	389.6	247.1
F value	*	NS	*	NS
S.Em ±	1.285		4.152	
C.D.at 5%	4.190		13.540	
CV	0.974	1.470	4.240	45.540
T_1	518.9	489.1	344.7	188.5
T_2	505.9	482.5	338.9	268.9
T_3	503.4	479.2	372.3	211.7
T_4	508.1	484.0	379.5	210.0
T_5	517.6	488.9	462.3	337.5
F value	*	*	*	*
S.Em ±	0.964	1.430	8.840	28.120
C.D.at 5%	2.760	4.080	25.260	80.360
CV	0.731	1.140	9.024	45.540
C_1T_1	523.6	492.5	300.3	194.4
C_1T_2	510.2	479.4	372.6	176.6
C_1T_3	507.9	479.4	353.4	184.7
C_1T_4	511.3	485.4	372.1	183.6
C_1T_5	524.0	489.8	471.5	415.2
C_2T_1	523.2	491.9	373.9	218.7
C_2T_2	500.1	487.2	358.2	460.9
C_2T_3	505.9	486.0	337.6	171.3
C_2T_4	511.4	488.2	319.3	205.9
C_2T_5	522.9	491.4	468.9	323.5

Table 4.8 contd..)

Containers, treatments and their combinations	1983	1984		
	Nov.	Jan.	March	May
C_3T_1	513.2	484.4	377.9	223.7
C_3T_2	500.2	478.9	266.9	199.7
C_3T_3	495.0	470.1	406.0	164.9
C_3T_4	502.1	483.2	439.7	191.2
C_3T_4	511.1	483.7	456.0	285.1
C_4T_1	519.6	487.7	337.6	104.7
C_4T_2	504.5	482.3	297.9	210.9
C_4T_3	504.1	478.4	420.9	305.4
C_4T_4	508.1	481.5	353.2	263.7
C_4T_5	519.5	490.3	457.2	363.3
C_5T_1	515.1	489.3	334.1	200.9
C_5T_2	505.9	485.0	399.1	296.2
C_5T_3	503.9	482.2	343.6	232.5
C_5T_4	507.6	481.9	413.3	205.4
C_5T_5	510.5	489.3	458.1	300.3
F value	NS	NS	*	NS
S.Em ±			19.78	
C.D. at 5%			56.53	

C_1 = Gunny bag; C_2 = Earthen pot; C_3 = Urea bag + Polythene layer; C_4 = Polythene bag; C_5 = Metal tin; T_1 = Control; T_2 = Silicagel; T_3 = Bavistin; T_4 = Fumigant; T_5 = Seed soaking and dehydration.

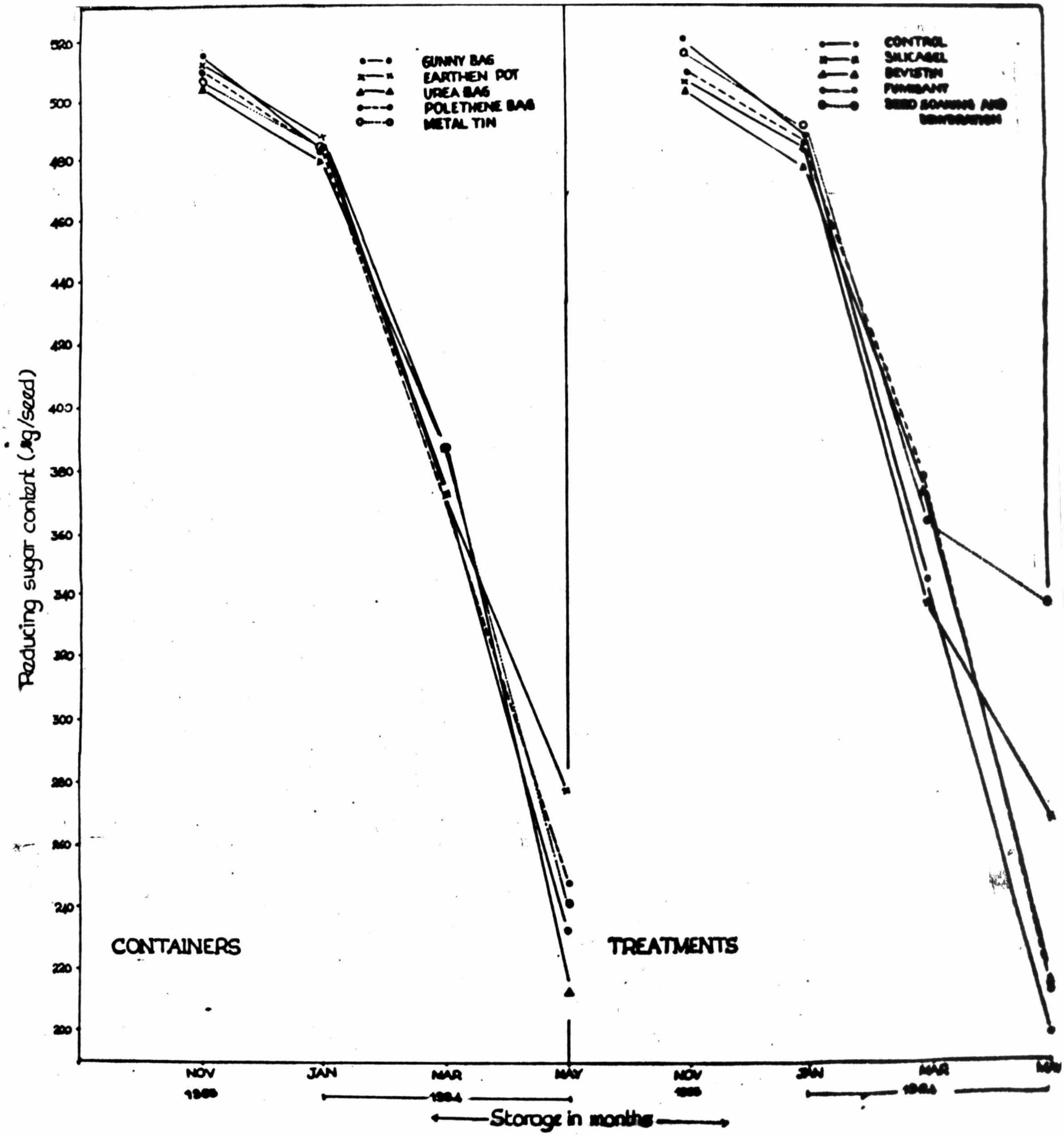

FIG. 4.8 EFFECT OF CONTAINERS AND TREATMENTS ON REDUCING SUGARS (Mg/seed) OF LIMA BEAN SEEDS IN STORAGE

4.8.3 Calcium and magnesium (meq/l)

The results of the study on calcium and magnesium content in seed leachate for eight months are tabulated in Table 4.9 and illustrated in Fig. 4.9.

The different containers showed significant differences in their effect on calcium and magnesium content in seed leachate during the month November '83. The seeds stored in gunny bag had leached the highest of calcium and magnesium (1.2 meq/l - Oct. '83 and 6.3 meq/l - May '84), closely followed by the seeds stored in earthen pot (1.1 meq/l - Oct. '83 and 4.2 meq/l - May '84) accounted for the lowest content of Ca and Mg in the leachate.

Significant differences in the calcium and magnesium content in the leachate existed among the treatments after the third month in storage. The highest amount of calcium and magnesium in leachate was observed in the seeds soaked in water and dehydrated at the final (May '84) observation (8.0 meq/l) and the lowest was recorded in polythene bag (5.0 meq/l).

The container and treatment interactions differed significantly during October '83, January and February '84. However, seed leachate containing minimum of calcium and magnesium was recorded in seeds stored in earthen pot treated with silicagel and control (0.8 meq/l each - Oct. '83 and 5.9 meq/l, 5.6 meq/l - May '84, respectively).

Table 4.9 Calcium and magnesium content (meq/l) in seed leachate of Lima beans for eight months of storage at monthly intervals

Containers, treatments and their combinations	1983			1984				
	Oct.	Nov.	Dec.	Jan.	Feb.	March	Apr.	May
C_1	1.2	1.9	2.9	3.3	4.9	5.7	6.1	6.2
C_2	1.1	1.8	2.8	3.0	4.6	5.1	6.0	6.2
C_3	1.1	1.6	2.6	2.3	4.3	4.8	5.8	6.2
C_4	1.1	1.6	2.8	2.8	4.6	4.8	4.7	5.1
C_5	1.1	1.7	1.9	2.2	4.5	4.6	4.7	4.2
F value	NS	*	NS	*	NS	NS	NS	*
S.Em ±		0.061		0.166				0.245
C.D.at 5%		0.199		0.541				0.799
CV	27.46	12.99	55.90	22.16	22.22	24.50	29.36	16.72
T_1	1.0	2.0	3.0	2.9	3.7	4.8	4.9	5.5
T_2	1.1	1.6	2.1	2.7	4.0	4.4	4.9	5.3
T_3	1.1	1.8	2.2	2.8	3.5	3.7	4.4	4.8
T_4	1.2	1.9	2.0	2.4	4.0	4.5	5.2	5.0
T_5	1.8	1.5	3.4	2.7	7.1	7.7	8.1	8.0
F value	NS	NS	NS	*	*	*	*	*
S.Em ±				0.17	0.23	0.30	0.37	0.23
C.D.at 5%				0.56	0.77	1.00	1.23	0.76
C_1T_1	1.1	1.9	2.9	3.6	3.9	4.9	5.5	5.7
C_1T_2	0.8	1.1	1.4	2.6	5.6	6.1	5.3	5.6
C_1T_3	1.3	2.0	2.5	3.7	3.1	3.5	4.9	5.3
C_1T_4	1.2	1.5	1.8	3.0	2.7	2.7	6.1	5.1
C_1T_5	1.2	1.7	1.8	3.5	6.3	7.6	9.0	9.5
C_2T_1	0.8	1.7	2.3	2.4	3.6	3.9	5.4	5.5
C_2T_2	0.8	1.8	2.3	2.7	3.6	4.2	5.5	5.9
C_2T_3	1.4	2.1	2.1	3.2	3.4	3.7	4.8	5.3
C_2T_4	1.2	2.0	2.7	4.1	4.9	6.2	4.4	5.2
C_2T_5	1.3	2.0	3.2	2.4	7.6	7.7	9.9	8.7

Table 4.9 contd..)

Containers, treatments and their combinations	1983			1984				
	Oct.	Nov.	Dec.	Jan.	Feb.	March	Apr.	May
C_3T_1	1.1	1.9	2.2	4.1	3.3	3.6	5.4	6.3
C_3T_2	1.2	1.9	3.1	2.9	3.5	3.9	5.4	6.1
C_3T_3	1.1	1.9	2.7	2.7	3.7	4.0	3.8	4.8
C_3T_4	1.1	2.0	2.4	2.9	4.5	5.2	6.6	6.1
C_3T_5	1.2	1.8	2.7	2.7	6.4	7.1	7.8	10.0
C_4T_1	0.9	1.9	1.7	2.3	4.3	4.5	4.3	4.7
C_4T_2	1.4	1.9	2.0	3.3	3.3	4.1	4.3	4.7
C_4T_3	1.0	1.6	2.0	2.1	3.3	3.3	3.9	4.4
C_4T_4	1.3	1.9	2.2	2.8	4.2	4.5	4.5	4.7
C_4T_5	0.8	1.6	6.9	3.2	7.7	7.7	6.7	7.2
C_5T_1	0.9	1.3	1.9	1.9	3.0	3.3	3.3	3.9
C_5T_2	1.3	1.8	1.6	1.9	4.1	4.0	4.3	4.3
C_5T_3	0.9	1.7	1.8	2.5	4.0	3.9	4.4	3.9
C_5T_4	1.2	2.0	1.8	3.2	3.8	3.9	4.1	4.2
C_5T_5	1.0	1.9	2.3	1.7	7.8	8.1	6.9	4.8
F value	*	NS	NS	*	*	NS	NS	NS
S.Em ±	0.502			1.252	1.720			
C.D.at 5%								

C_1 = Gunny bag; C_2 = Earthen pot; C_3 = Urea bag + Polythene layer; C_4 = Polythene bag; C_5 = Metal tin. T_1 = Control; T_2 = Silicagel; T_3 = Bavistin; T_4 = Fumigant; T_5 = Seed soaking and dehydration.

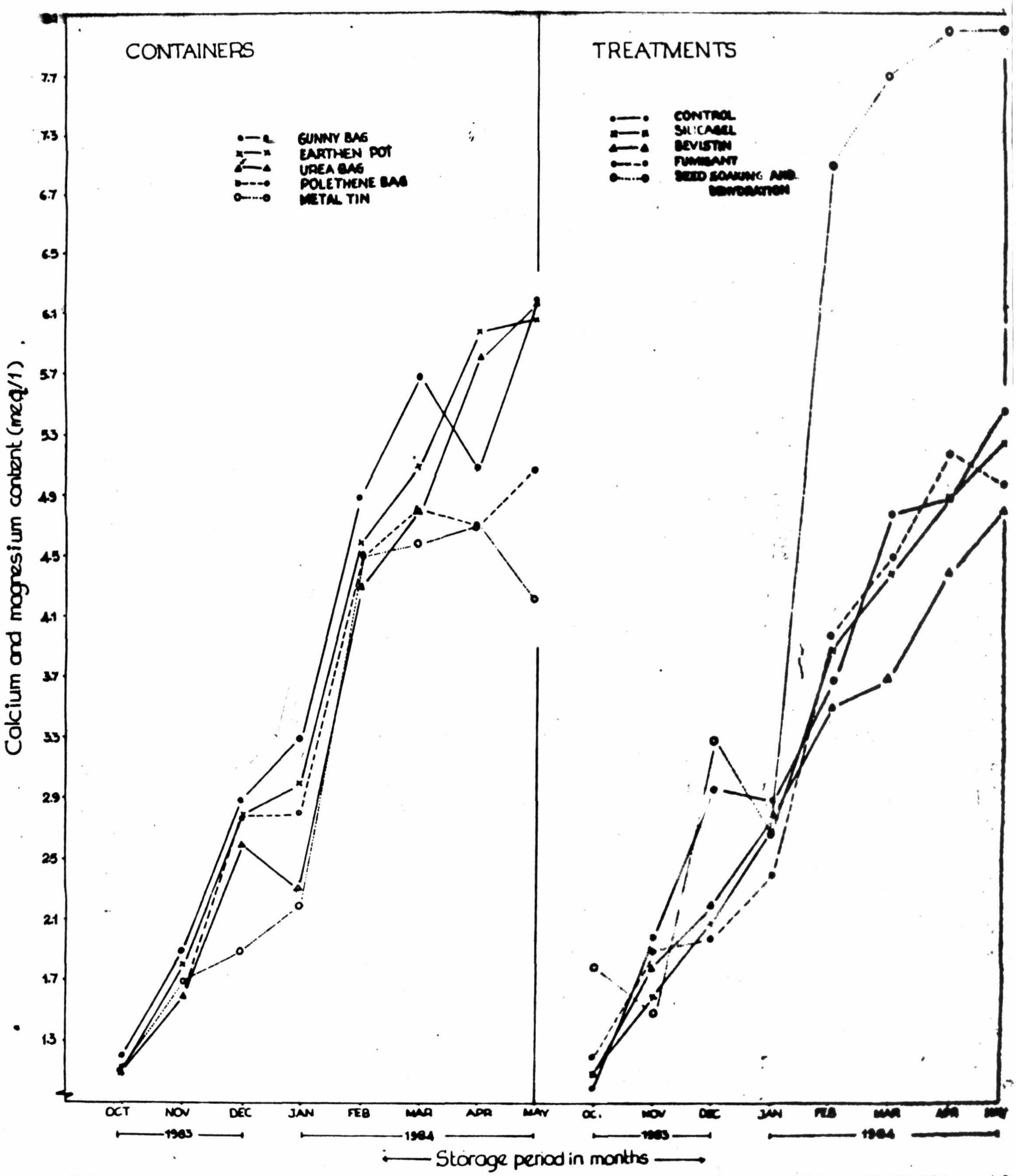

FIG. 4.9 EFFECT OF CONTAINERS AND TREATMENTS ON CALCIUM AND MAGNESIUM CONTENT (meq/1) OF LIMA BEAN SEEDS IN STORAGE

Based upon seed leachate analysis and seed treatments the following generalization could be made.

1. The increase in E.C., calcium and magnesium and reduction in reducing sugar content of seed leachate indicated that membrane permeability was altered during storage.

2. The reverse trend was obtained between germination percentage, EC and calcium + magnesium content of seed leachate, which showed that as the germination per cent decreased the leachate content increased.

3. Seed leachate from the seeds subjected to soaking and dehydration contained more of EC, calcium + magnesium and reducing sugars compared to that of other treatments.

4. Seeds treated with Bavistin could withstand the infection of storage fungi irrespective of the containers and treatment combinations.

5. The physical appearance of the white coloured seeds turned slightly brown as the storage period increased.

4.9 Seed health testing (seed mycoflora)

Storage mycoflora of Lima bean were determined at two months interval and the data are given in Table 4.10. The fungi recorded were *Macrophomina* sp., *Alternaria* sp., *Fusarium* sp. and *Penicillium* sp.

Table 4.10 Effect of different packaging materials and seed treatments on development of storage fungi on Lima bean seeds stored under room conditions for eight months at an interval of the month starting from '83.

Containers x Treatments (✓)	November '83						
	(X)Number of seeds infected by different storage fungi					Total percentage of	
	1	2	3	4	5	Infected	Not infected
C_1T_1	9(22.5)*	2(5.0)*	3(7.50)	2(5.0)	1(2.5)	17(42.5)	23(57.5)
C_1T_2	8(20.0)	0(0.0)	4(10.0)	1(2.5)	3(7.5)	16(40.0)	24(60.0)
C_1T_3	2(5.00)	0(0.0)	2(5.00)	1(2.5)	2(5.0)	7(17.5)	33(82.5)
C_1T_4	7(17.5)	3(7.5)	4(10.0)	0(0.0)	3(7.5)	17(42.5)	23(57.5)
C_1T_5	9(22.5)	2(5.0)	3(7.50)	2(5.0)	2(5.0)	18(45.0)	22(55.0)
C_2T_1	8(20.0)	3(7.50)	4(10.0)	0(0.0)	3(7.5)	18(45.0)	22(55.0)
C_2T_2	8(20.0)	2(5.0)	2(5.0)	2(5.0)	3(7.5)	17(42.5)	23(57.5)
C_2T_3	3(7.50)	0(0.0)	2(5.00)	0(0.0)	2(5.0)	7 (17.5)	33(82.5)
C_2T_4	8(20.0)	2(5.0)	4(10.0)	0(0.0)	2(5.0)	16(40.0)	24(60.0)
C_2T_5	7(17.5)	3(7.5)	3(7.50)	1(2.5)	3(7.5)	17(42.5)	23(57.5)
C_3T_1	8(20.0)	2(5.0)	0(0.0)	3(7.5)	3(7.5)	16(40.0)	24(60.0)
C_3T_2	9(22.5)	3(7.5)	3(7.5)	0(0.0)	2(5.0)	17(42.5)	23(57.5)
C_3T_3	2(5.00)	1(2.5)	1(2.5)	2(5.0)	0(0.0)	6(15.0)	34(85.0)
C_3T_4	9(22.5)	2(5.0)	0(0.0)	2(5.0)	3(7.5)	16(40.0)	24(60.0)
C_3T_5	7(17.5)	2(5.0)	2(5.0)	2(5.0)	3(7.5)	16(40.0)	24(60.0)
C_4T_1	8(20.0)	2(5.0)	4(10.0)	0(0.0)	2(5.0)	16(40.0)	24(60.0)
C_4T_2	9(22.5)	2(5.0)	3(7.50)	1(2.5)	2(5.0)	17(42.5)	23(57.5)
C_4T_3	3(7.50)	1(2.5)	0(0.0)	2(5.0)	0(0.0)	6(15.0)	34(85.0)
C_4T_4	7(17.5)	4(10.0)	2(5.0)	1(2.5)	3(7.5)	17(42.5)	23(57.5)
C_4T_5	8(20.0)	2(5.0)	3(7.5)	2(5.0)	1(2.5)	16(40.0)	24(60.0)
C_5T_1	9(22.5)	1(2.5)	2(5.0)	1(2.5)	3(7.5)	16(40.0)	24(60.0)
C_5T_2	8(20.0)	2(5.0)	3(7.5)	1(2.5)	3(7.5)	17(42.5)	23(57.5)
C_5T_3	2(5.00)	0(0.0)	2(5.0)	0(0.0)	2(5.0)	6(15.0)	34(85.0)
C_5T_4	7(17.5)	2(5.0)	3(7.5)	2(5.0)	2(5.0)	16(40.0)	24(60.0)
C_5T_5	6(15.0)	1(2.5)	3(7.5)	2(5.0)	3(7.5)	15(37.5)	25(62.5)

Table 4.10 contd..)

Containers x Treatments (✓)	January '84						
	(X) Number of seeds infected by different storage fungi					Total percentage of	
	1	2	3	4	5	Infected	Not infected
C_1T_1	10(25.0)	4(10.0)	3(7.5)	1(2.5)	2(5.0)	20(50.0)	20(50.0)
C_1T_2	9(22.5)	2(5.0)	4(10.0)	1(2.5)	3(7.5)	19(47.5)	21(52.5)
C_1T_3	3(7.50)	1(2.5)	0(0.0)	2(5.0)	3(7.5)	9(22.5)	3(77.5)
C_1T_4	8(20.0)	3(7.5)	2(5.0)	2(5.0)	3(7.5)	18(45.0)	22(55.0)
C_1T_5	9(22.5)	2(5.0)	4(10.0)	0(0.0)	4(10.0)	19(47.5)	21(52.5)
C_2T_1	10(25.0)	3(7.5)	4(10.0)	1(2.5)	2(5.0)	20(50.0)	20(50.0)
C_2T_2	9(22.5)	2(5.0)	3(7.50)	2(5.0)	3(7.5)	19(47.5)	21(52.5)
C_2T_3	3(7.50)	0(0.0)	2(5.0)	1(2.5)	3(7.5)	9(22.5)	31(77.5)
C_2T_4	8(20.0)	3(7.5)	4(10.0)	2(5.0)	2(5.0)	19(47.5)	21(52.5)
C_2T_5	10(25.0)	2(5.0)	3(7.5)	2(5.0)	3(7.5)	19(47.5)	21(52.5)
C_3T_1	8(20.0)	2(5.0)	4(10.0)	3(7.5)	1(2.5)	18(45.0)	22(55.0)
C_3T_2	8(20.0)	1(2.5)	3(7.5)	2(5.0)	3(7.5)	17(42.5)	23(57.5)
C_3T_3	3(7.5)	1(2.5)	1(2.5)	2(5.0)	1(2.5)	8(20.0)	32(80.0)
C_3T_4	8(20.0)	2(5.0)	2(5.0)	3(7.5)	2(5.0)	17(42.5)	23(57.5)
C_3T_5	7(17.5)	3(7.5)	2(5.0)	2(5.0)	2(5.0)	16(40.0)	24(60.0)
C_4T_1	9(22.5)	2(5.0)	3(7.5)	1(2.5)	3(7.5)	18(45.0)	22(55.0)
C_4T_2	8(20.0)	2(5.0)	2(5.0)	3(7.5)	2(5.0)	17(42.5)	23(57.5)
C_4T_3	2(5.0)	1(2.5)	2(5.0)	2(5.0)	2(5.0)	9(22.5)	31(77.5)
C_4T_4	9(22.5)	4(10.0)	2(5.0)	1(2.5)	2(5.0)	18(45.0)	22(55.0)
C_4T_5	7(17.5)	2(5.0)	2(5.0)	2(5.0)	3(7.5)	16(40.0)	24(60.0)
C_5T_1	7(17.5)	3(7.5)	0(0.0)	2(5.0)	5(12.5)	17(42.5)	23(57.5)
C_5T_2	7(17.5)	2(5.0)	3(7.5)	1(2.5)	3(7.5)	16(40.0)	24(60.0)
C_5T_3	3(7.5)	1(2.5)	2(5.0)	1(2.5)	2(5.0)	9(22.5)	31(77.5)
C_5T_4	8(20.0)	4(10.0)	3(7.5)	0(0.0)	2(5.0)	17(42.5)	23(57.5)
C_5T_5	8(20.0)	3(7.5)	0(0.0)	2(5.0)	4(10.0)	17(42.5)	23(57.5)

Table 4.10 contd..)

Containers x Treatments (_/)	March '84						
	(X) Number of seeds infected by different storage fungi					Total percentage of	
	1	2	3	4	5	Infected	Not infected
C_1T_1	11(27.5)	3(7.5)	3(7.5)	4(10.0)	2(5.0)	23(57.5)	17(42.5)
C_1T_2	12(30.0)	3(7.5)	0(0.0)	2(5.0)	3(7.5)	20(50.0)	20(50.0)
C_1T_3	8(20.0)	2(5.0)	2(5.0)	1(2.5)	3(7.5)	16(40.0)	24(60.0)
C_1T_4	10(25.0)	2(5.0)	3(7.5)	2(5.0)	4(10.0)	21(52.5)	19(47.5)
C_1T_5	14(35.0)	4(10.0)	4(10.0)	3(7.5)	5(12.5)	31(77.5)	9(22.5)
C_2T_1	12(30.0)	2(5.0)	4(10.0)	2(5.0)	4(10.0)	24(60.0)	16(40.0)
C_2T_2	10(25.0)	3(7.5)	4(10.0)	2(5.0)	3(7.50)	22(55.0)	18(45.0)
C_2T_3	9(22.5)	2(5.0)	0(0.0)	2(50.0)	4(10.0)	17(42.5)	23(57.5)
C_2T_4	9(22.5)	2(7.5)	4(10.0)	2(5.0)	3(7.5)	21(52.5)	19(47.5)
C_2T_5	16(40.0)	3(7.5)	6(15.0)	2(5.0)	5(12.5)	32(80.0)	8(20.0)
C_3T_1	12(30.0)	4(10.0)	2(5.0)	2(5.0)	2(5.0)	22(55.0)	18(45.0)
C_3T_2	10(25.0)	3(7.50)	3(7.5)	2(5.0)	2(5.0)	20(50.0)	20(50.0)
C_3T_3	7(17.5)	3(7.50)	4(10.0)	0(0.0)	1(2.5)	15(37.5)	25(62.5)
C_3T_4	11(27.5)	2(5.00)	4(10.0)	1(2.5)	3(7.5)	21(52.5)	19(47.5)
C_3T_5	18(45.0)	4(10.0)	5(12.5)	3(7.5)	4(10.0)	32(80.0)	8(20.0)
C_4T_1	11(27.5)	0(0.00)	4(10.0)	2(5.0)	5(12.5)	32(80.0)	18(45.0)
C_4T_2	9(22.5)	3(7.50)	2(5.0)	2(5.0)	4(10.0)	20(50.0)	20(50.0)
C_4T_3	8(20.0)	2(5.0)	3(7.50)	1(2.5)	2(5.0)	16(40.0)	24(60.0)
C_4T_4	12(30.0)	2(5.0)	4(10.0)	2(5.0)	2(5.0)	22(55.0)	18(45.0)
C_4T_5	18(45.0)	3(7.5)	5(12.5)	3(7.5)	4(16.0)	33(82.5)	7(17.5)
C_5T_1	12(30.0)	2(5.0)	3(7.5)	2(5.0)	2(5.0)	21(52.5)	19(47.5)
C_5T_2	9(22.5)	3(7.5)	3(7.5)	5(12.5)	0(0.0)	20(50.0)	20(50.0)
C_5T_3	7(17.5)	2(5.0)	3(7.5)	1(2.5)	2(5.0)	15(37.5)	25(62.5)
C_5T_4	10(25.0)	1(2.5)	4(10.0)	3(7.5)	3(7.5)	21(52.5)	19(47.5)
C_5T_5	20(50.0)	3(7.5)	2(5.0)	2(5.0)	3(7.5)	32(80.0)	8(20.0)

Table 4.10 contd..)

Containers x Treatments (/)	May '84						
	(X)Number of seeds infected by different storage fungi					Total percentage of	
	1	2	3	4	5	Infected	Not infected
C_1T_1	9(22.5)	3(7.5)	5(12.5)	3(7.5)	4(10.0)	24(60.0)	16(40.0)
C_1T_2	12(30.0)	3(7.5)	4(10.0)	2(5.0)	4(10.0)	25(62.5)	15(37.5)
C_1T_3	9(22.5)	3(7.5)	5(12.5)	3(7.5)	4(10.0)	24(60.0)	16(40.0)
C_1T_4	8(20.0)	4(10.0)	4(10.0)	4(10.0)	4(10)	24(60.0)	16(40.0)
C_1T_5	16(40.0)	3(7.5)	5(12.5)	4(10.0)	4(10.0)	33(82.5)	7(17.5)
C_2T_1	12(30.0)	4(10.0)	3(7.50)	3(7.50)	3(7.5)	25(62.5)	15(37.5)
C_2T_2	11(27.5)	3(7.5)	4(10.0)	4(10.0)	4(10.0)	26(65.0)	14(35.0)
C_2T_3	13(32.5)	2(5.0)	5(12.5)	2(5.0)	3(7.5)	25(62.5)	15(37.5)
C_2T_4	10(25.0)	2(5.0)	4(10.0)	2(5.0)	6(15.0)	24(60.0)	16(40.0)
C_2T_5	17(42.5)	4(10.0)	5(12.5)	3(7.5)	4(10.0)	33(82.5)	7(17.5)
C_3T_1	12(30.0)	3(7.50)	4(10.0)	2(5.0)	2(5.0)	23(57.5)	17(42.5)
C_3T_2	10(25.0)	2(5.0)	3(7.5)	4(10.0)	5(12.5)	24(60.0)	16(40.0)
C_3T_3	12(30.0)	4(10.0)	3(7.5)	3(7.5)	2(5.0)	24(60.0)	16(40.0)
C_3T_4	12(30.0)	3(7.5)	2(5.0)	3(7.5)	3(7.5)	23(57.5)	17(42.5)
C_3T_5	19(47.5)	4(10.0)	5(12.5)	2(5.0)	3(7.5)	33(82.5)	7(17.5)
C_4T_1	9(22.5)	3(7.50)	4(10.0)	3(7.5)	4(10.0)	23(57.5)	17(42.5)
C_4T_2	13(32.5)	2(5.0)	4(10.0)	2(5.0)	3(7.5)	24(60.0)	16(40.0)
C_4T_3	12(30.0)	3(7.5)	3(7.5)	3(7.5)	3(7.5)	24(60.0)	16(40.0)
C_4T_4	12(30.0)	4(10.0)	2(5.0)	4(10.0)	2(5.0)	24(60.0)	16(40.0)
C_4T_5	20(50.0)	3(7.5)	4(10.0)	4(10.0)	2(5.0)	33(57.5)	7(17.5)
C_5T_1	13(32.5)	2(5.0)	3(7.5)	3(7.5)	2(5.0)	23(22.5)	17(42.5)
C_5T_2	12(30.0)	3(7.5)	2(5.0)	3(7.5)	3(7.5)	23(57.5)	17(42.5)
C_5T_3	10(25.0)	4(10.0)	3(7.5)	3(7.5)	4(10.0)	24(60.0)	16(40.0)
C_5T_4	10(25.0)	2(5.0)	4(10.0)	2(5.0)	4(10.0)	24(60.0)	16(40.0)
C_5T_5	19(47.5)	4(10.0)	6(15.0)	0(0.0)	3(7.5)	32(80.0)	8(20.0)

(/) C_1 = Gunny bag; C_2 = Earthen pots; C_3 = Urea bag + Polythene layer; C_4 = Polythene bag; C_5 = Metal tin. T_1 = Control; T_2 = Silicagel; T_3 = Bavistin; T_4 = Fumigant; T_5 = Seed soaking and dehydration.

(X) 1=*Macrophomina* sp.; 2=*Aspergillus* sp.; 3=*Alternaria* sp.; 4=*Fusarium* sp.; 5=*Penicillum* sp.

*The figures quoted in parentheses are the percentage converted.

The percentage infection of Lima beans differed with the species and storage period. For example, from the beginning of Nov. '83 to end of May '84 Macrophomina sp. was the most predominant seed mycoflora in all the treatments and container combinations (Plate 2). Alternaria sp. and Penicillium sp. were observed to be the next predominent storage fungi. But, Aspergillus sp. (Plate 3) and Fusarium sp. were found to be less ineffective than the other storage fungi.

The percentage infection by the individual species on seeds increased as the storage period increased irrespective of the interaction effects. Seeds stored in gunny bag and earthen pot packaging reeorded the highest storage fungi in all the observations. The highest number of storage fungi and the seeds stored in urea bag recorded the least number of storage fungi followed by metal tin and polythene bag throughout the storage period (Table 4.10). The per cent of storage fungi infection increased as the period of storage progressed.

Among seed treatments, the Bavistin treated seeds showed little storage fungi (i.e., 15.0% - Nov. '83, are infected seeds) and (85% - Nov. '83, are not infected) in all the interaction combinations and the highest infection was in the seeds kept without any fungicide treatment (Table 4.10). In seed soaking and dehydration treatment

Plate 1 Healthy Seeds

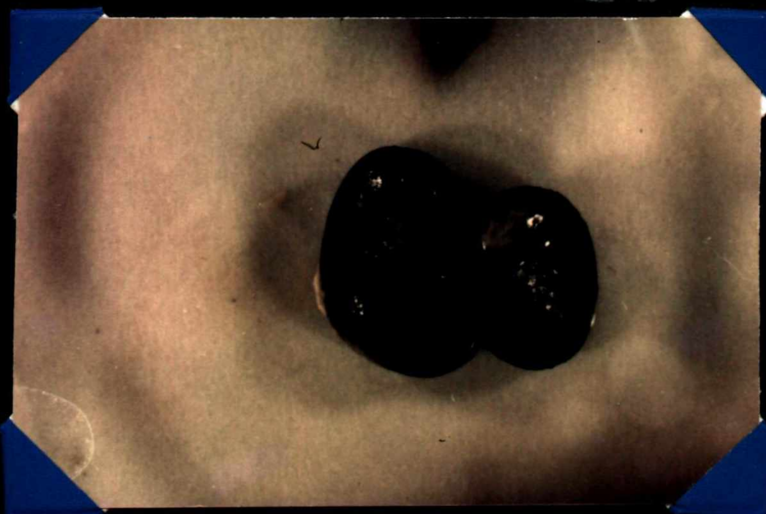

Plate 2 Seed-borne infection of <u>Macrophomina</u> Sp

Plate 3 Seed mycoflora of <u>Aspergillus</u> Sp

during the later half of storage period the per cent of infected seeds was higher than any other treatment combinations (37.5% and 45% Nov. '83 the lowest in metal tin and the highest in earthen pot, respectively 80% and 82.5% - May - '84, the lowest in metal tin and the highest in all the containers, respectively).

DISCUSSION

V. DISCUSSION

Various factors such as sensitivity of seed to environment, multiplicity of seeds, seasonal demand, specificity of planting time, necessity to carry over and need for buffer stocks make seed storage an imperative and inescapable proposition. Physiological quality of the seed is the highest when it completes structural and functional development on the plant life. Thereafter it deteriorates at varying rates. Rapid deterioration of stored seeds is a serious problem particularly in India, where high temperature and high relative humidity prevail, accelerating the seed ageing phenomenon. The control of temperature and humidity during storage has a profound influence on the vigour and viability of seeds but such facilities are always not available to all the seed producers and small cultivators. So studies on seed viability to find out means to slow down the seed deterioration is very important.

Lima bean was recently introduced to our country and the information available on economically feasible means of storing seeds is meagre. Moreover, the seeds of Lima bean come under the group of poor storers (Delouche et al., 1973 and Ewart, 1908). The present study is an attempt to gain more information on the nature of seed viability, effect of different packaging materials and seed treatments on retention of viability during storage under room conditions.

The results obtained are discussed in the following pages.

5.1 Physiological changes associated with seed deterioration

In the present experiment the initial laboratory germination percentage was found to range from 37.0 to 52.3 per cent. But the minimum percentage of germination prescribed by the International Seed Testing Association (ISTA) for certifying the seeds is 70 per cent (Anon., 1976). The decreased initial germination percentage might be due to the rainfall during the time of harvesting the seed (158.6 mm and 190.4 mm in consecutive months prior to harvest). Austin (1972) reported on the effects of environment before harvesting on ageing which agrees with the present results. Another, reason seems to be heavy rainfall at the time of sowing (272.7 mm). Further the studies have shown that immature or partially filled seeds are inferior to mature seeds in viability and vigour which is in agreement with earlier reports (Dimmock, 1947 in corn; Blackstone *et al*., 1954 in peanut; Turner and Ferguson, 1972 in cotton).

Some of the physiological changes associated with the seed deterioration are germination per cent (Laboratory and field), shoot length, vigour index moisture content colour of the seed and test weight.

Germination per cent (laboratory and field), shoot length, and vigour index are grouped into continuous paragraphs under container, treatment effects and interaction effects for convenience. But the other physiological observations such as moisture content, test weight, colour of the seed are under separate headings.

5.1.1.1 <u>Container effects</u> : Storing of seeds in containers prevents direct contact of seeds with the storage environment and this is practised as a method of retaining viability. The present study with different storing materials (gunny bag, earthen pot, urea bag with thin layer of polythene and metal tin or containers made of various combinations of materials) used to find the effectiveness with which the containers help to prevent the deterioration of seed has produced some useful results.

Out of five containers, seeds stored in gunny bag showed maximum laboratory initial and final germination per cent which was closely followed by urea bag and polythene bag. This is in conformity with the results reported by Jalote and Vaish (1976) in paddy.

The urea bag container showed maximum initial field germination per cent closely followed by metal tin, and the final minimum field germination was observed in metal tin. This confirms the results of Maurya (1971) who reported that the poly-coated hessian bags (urea bags) were superior to hessian bag (gunny bags). Mazid _et al._ (1977) also found polythene bags to be inferior to that of sealed can or glass bottle in retaining viability of seeds.

The maximum initial shoot length (cm) of seedlings was observed in metal tin closely followed by urea bag. Similar results are reported by Maurya (1971) and Mazid _et al._ (1977). The seeds stored in gunny bag showed the highest vigour index in the initial months of storage. Jalote and Vaish (1976) reported similar results in paddy. Reports that are contrary to the above results are presented in the ensuing pages. Gane (1948) reported that soybean seeds stored in porous containers will have its water content fluctuating with the humidity of the surrounding atmosphere reducing viability. Maurya (1971) reported that polycoated hessian bags (urea bag) were superior to hessian bag (gunny bag). Srivastava and Sareen (1972) and Boakye-Beating and Hume (1975) reported that the seeds stored in gunny bags will be lower in viability than that of the ones stored in polythene bag. Ching (1959) found that seeds stored in fabric containers in cold and dry conditions will retain good viability. Jalote and Vaish (1976) reported that the seeds of paddy stored in gunny bag retained viability longer than those in polythene bags, when seeds with higher moisture content were stored. Mazid *et al*. (1977) found polythene bags to be inferior to that of sealed can or glass bottle in retaining viability of seeds.

5.1.1.2 Treatment effects : Because of the omnipresence of mycoflora, the seeds will usually get infected causing deterioration in viability of seeds. To overcome the ill effects of mycoflora, it is better to treat the seeds with fungicides (Bavistin). Silicagel absorbed the increased moisture content from the seeds stored in containers leading to the maintenance in viability of seeds (James , 1971). Fumigation with Ethyl Dibromide (EDB) affects the seed germination either by stimulating or impairing germination. Seed soaking (4-6 hours) and dehydration improves the vigour and viability of seeds. All these treatment effects were compared with control.

The effect of different treatments on laboratory germination per cent, field germination per cent, shoot length and vigour index are discussed below.

The initial laboratory germination was maximum (72.3%) in the seeds treated with Bavistin and this decreased to the minimum at the final stage. This was closely followed by silicagel and fumigant treatments. But the seed soaking and dehydration showed drastic decrease in germination per cent after half way of storage. Similar trend was observed in field germination (initial and final) in seeds treated with Bavistin. This was followed by fumigation and silicagel treatments; seed soaking and dehydration showed drastic reduction in field germination per cent. The seeds treated with Bavistin showed maximum initial and final shoot length of seedlings, and seed soaking and dehydration showed drastic decrease in shoot length of seedlings with storage period, and the vigour index was found to be superior to all other treatments in the Bavistin treated seeds.

The effect of Bavistin was found to be superior to all the other treatments in all the containers in the above observations (laboratory germination per cent, field germination per cent, shoot length (cm) and vigour index). This is in conformity with the result, of Lago and Zink (1976) who reported that treatedseeds in general showed higher germination than untreated; Zote and Mayee (1982) reported that seed treatment improved germination of mung bean and the best results were obtained with Bavistin.

In all the treatments a trend of decreased laboratory germination was observed with increase in storage period. This was also evident in the seeds treated with Bavistin. Similar reports have been published by Lago and Zinc (1976). Eric V. Niles (1980) observed that none of the fungicides completely prevented fungi development but for a period of 60 days. Germination decreased and mycoflora increased with the storage period after the treatment (Kore and Solanke, 1982). But Zote and Mayee (1982) reported that all the fungicides inhibited fungal growth except Difolaton resulting in improvement of seedling vigour. The viability of seeds treated with Ethyl Dibromide (fumigant) was found reduced (Cotton, 1963; Khanna et al., 1981). But Girish and Krishnamurthy (1972) reported that seeds fumigated with Ethyl Dibromide did not affect germination. James (1971) reported that if seed has an initial moisture of 10 per cent in about 30 days, the moisture content will drop to 7-8 per cent if seeds are kept with silicagel (dehumidifier), thereby helping the improvement of laboratory germination with storage period. On the contrary results of the present experiment showed a reduced germinability, when seeds were kept with silicagel. Drastic reduction in the germinability of seeds was found in seed soaking and dehydration which may be due to prolonged (24 hours) soaking and dehydration. Earlier reports (Basu et al., 1974; Sen and Asborne, 1974) reveal that germination could be enhanced by hydration-dehydration treatment of embryo. It was suggested by Sen and Asborne (1974) that soaking in water for 2 hours followed by drying for one hour would bring about changes in vigour, viability and productivity of seeds. Similar results have been reported by

Basu *et al*. (1975) and Senaratna and McKersie (1983). Basu (1976) and Dasgupta *et al*. (1976) suggested that beneficial physico-chemical treatment improves the vigour and viability of seeds by minimising the free radical damage to the cellular components of stored seeds. Saha and Basu (1981) reported that soaking and drying the seeds to original weight markedly increased the viability of seeds.

5.1.1.3 Interaction effects : The experiment also aimed at eliciting the best one out of the twenty five possible combinations. It was noted that Bavistin treated seeds maintained higher initial laboratory germination per cent, field germination per cent, shoot length of seedling and vigour index irrespective of containers. However, maximum laboratory germination per cent was observed in the combination of gunny bag with Bavistin (75.33%). But germination decreased in the subsequent months. Urea bag with fumigation proved next best to Bavistin with other containers Maximum field germination per cent was observed in the combination of metal tin with Bavistin. But germination decreased in the subsequent months. Urea bag with Bavistin fared next to other containers. Similar effect was observed for shoot length of seedlings as in the case of field germination, but least shoot length was observed in the combination of gunny bag with seed soaking and dehydration. The maximum initial vigour index was observed in metal tin with Bavistin followed by gunny bag with Bavistin, and the minimum final vigour index was noticed in polythene bag + fumigation, metal tin + silicagel; urea bag + silicagel and gunny bag + fumigation.

5.1.1.4 <u>Relationship among different observations</u> : In a majority of the treatments, the field germination did not corroborate with laboratory germination. The field germination per cent was lesser than the laboratory germination, because in the field, seeds have to interact with the variable environment and are exposed to unfavourable conditions which are not encountered under laboratory condition.

The germination per cent, shoot length and vigour index correlated with each other. The causes for the difference in storage life of the same variety are not fully understood, but differences in physiological maturity and many physiological manifestations after harvest seeved partially responsible as noted in earlier reports (Harrington, 1970; Abdul-Baki and Anderson, 1972). Deteriorated seeds produce seedlings which grow slowly (Kearns and Toole, 1939; Parkinson, 1948; Toole and Toole, 1953; Toole <u>et al</u>., 1957). However, reduction in seedling growth which either preceded or accompanied loss of germinability did not necessarily occur in all the cases of seed deterioration (Andersen, 1970), delayed germination (Toole <u>et al</u>., 1948), decreased tolerance, sub-optimal environmental conditions during germination (Abdul-Baki and Andersen, 1972), lowered tolerance to adverse storage conditions (Andersen, 1970a), reduced growth of seedlings (Toole *et al*., 1957) as well as germinability and increased number of abnormal seedlings (Toole *et al*., 1948a). Reduced germinability has been the most widely accepted single criterion of seed deterioration (Abdul-Baki and Andersen, 1972). Roberts (1972a) found that a reduction of viability down to 50 per cent would have no significant effect on final yield.

Seed weight and hypocotyl length : During storage there was not much increase in seed weight probably due to less absorption of moisture irrespective of the interaction of containers and treatments or duration of storage period. But the hypocotyl length decreased as the storage period increased. In contrary, Verma and Gupta (1 975) reported negative correlation between hundred seed weight and hypocotyl length during storage in soybean. In the present study the EC increased as the storage period increased in all the interaction combinations, and the field germination per cent decreased as the storage period increased. This is in conformity with the reports of Lovato and Mulazzani (1983) that EC was negatively correlated with field germination per cent.

5.1.2 Moisture content

In soybean and rice, factors which affect the quality of stored seeds such as longevity, initial quality, maturity stage at harvest, physiological condition and environmental parameters such as unfavourable storage period have been discussed (Gregg, 1982).

Retention of viability is also dependent on the storage conditions and packaging materials used. The factors which influence seed viability during storage are, in general, temperature and relative humidity of the ambient atmosphere (Barton, 1961; Bulat, 1963; Harrington, 1960; 1972; Roberts, 1972a). In this study the initial moisture content was low in the seed and increased with the storage period. This is conformity with the report of Singh and Setia (1974) who found that seed with lower moisture content maintained viability and lost viability with increase in moisture content. Some other reports dealing with the moisture, temperature and relative humidity effects on the seed viability are discussed next to this.

Low relative humidity (35%) and low temperature (near to freezing) are ideal for long term storage (Toole and Toole, 1943). The seeds of high initial viability are much more resistant to unfavourable storage humidity and temperature than those of low initial viability and seed deterioration once started proceeds rapidly under unfavourable condition till the death of seeds. Higher temperature would cause loss in viability eventhough the initial moisture content is low in soybean (James et al., 1967). Further, higher moisture coupled with high temperature in soybean also resulted in poor viability (Boakye-Boateng and Hume, 1975; McNeal, 1966; Oathout, 1928). In majority of the cases it has been shown that lower seed moisture coupled with lower temperature in soybean leads to longer period of viability (Boakye-Boateng and Hume, 1975; Agarwal and Siddiqui, 1973; McNeal, 1966; Ramstad and Geddes, 1972).

Scott and Mahoney (1946) reported that at higher temperature, quality of ascorbic acid deteriorated more rapidly than at the lower temperature mentioned in marketing shelled Lima bean in consumer package.

In the present study, seeds stored under room conditions (temperature and humidity both not controlled) in moisture pervious containers like gunny bag and earthen pot, the loss in viability was faster due to maximum moisture content and the minimum moisture content was observed in metal tin and urea bag, because of their impervious nature. Under Bangalore conditions, the temperature variation was not of a higher magnitude and mean maximum temperature ranged from 25.6°C to 37.4°C during the storage period and mean minimum temperatures from 13.4°C to 22.9°C. Similarly the mean maximum relative humidity ranged from 65.0 to 91.0 per cent (Appendix I). As compared to temperature, the relative humidity always remained high under such conditions, and packaging in a moisture pervious containers resulted in an increase in seed moisture content, resulting in faster deterioration. Agrawal (1973) showed that soybean seeds could be stored at Delhi without significant loss in viability from harvest (November-December) to subsequent sowing (June-July). It has been shown that proteinaceous seeds absorb more moisture than starchy seeds (Barton, 1961). Naturally, this results in a situation in pulse seeds including Lima bean where the seed moisture is enhanced during storage and at a given temperature, the loss in viability is hastened.

The rapid deterioration in the viability presently observed in the seeds stored in gunny bag followed by earthen pot, irrespective of storage treatments could only be attributed to fluctuation in the ambient relative humidity and temperature of the storage environment during the storage period. The effect of high relative humidity and temperature of the storage atmosphere on the viability of seeds in storage is evident from the studies of Toole and Toole (1946) in soybean. In this study the seeds stored in metal tin followed by urea bag were found superior to those stored in polythene bag and other containers irrespective of the container and treatment combinations. Similar observations were made in sunflower by Rao (1976) and Rao and Vikram Singh (1976). In the study the gunny bag with Bavistin was found to be superior to all other combinations of containers and treatments. Vadivelu _et al._ (1976) reported that captan treated sunflower seeds in paper aluminium foil polythene laminated pouches gave 85 per cent germination even after 15 months of storage when compared to 76 per cent in seeds stored in cloth bag. The untreated seeds in both the containers gave less than 50 per cent germination. Vadivelu and Ramakrishnan (1977) suggested that, if the sunflower seeds are to be packed in moisture vapour prooof containers, the moisture content should be well below eight per cent.

5.1.3 Physical (colour) appearance of seeds

In this study it was found that the physical appearance of the white coloured seeds became slightly brown as the storage period increased. Causes listed by several workers are: (1) Ageing bringing about physiological and biochemical changes, which are responsible for seed deterioration. (2) damage by heat or storage fungi making seeds lose their natural luster (Zeleny, 1954; Christensen and Kaufmann, 1969). Similar reports are available in Lima bean (Pollock and Toole, 1966), Snap beans (Toole, 1948). It is reported that the damaged seeds of alfalfa and clover with changed colour had low germinability both in laboratory and field conditions. Starzinger and West (1982) reported that soybean with yellow or black seed coats, when tested at hundred per cent relative humidity over 12 days, black seeds had less fungal activity and more germination than yellow seeds. Similarly Srikantaradhya (1982) reported the superiority of black seeds as compared to other sixty germplasm collections when both viability and vigour were studied under storage for 12 months.

5.1.4 <u>Test weight</u>

The maximum test weight was observed in seeds stored in earthen pot and minimum in urea bag. The test weight was more in the control than in the treatment soaking and dehydration. This is in agreement with the results of Pushman (1975) who reported that the test weight of grains which had been soaked and brought back to its original moisture (dried) content was lower than that of the original sample (control). The highest test weight was recorded in the combination of earthen pot with silicagel.

The test weight increased at the end of storage months in all the containers and treatments probably due to increase in seed moisture content.

5.2 Biochemical changes associated with seed deterioration

Though much work has been done on chemical changes associated with seed deterioration (Crocker and Barton, 1953; Anderson and Alcock, 1954; Abdul-Baki and Anderson, 1972; Roberts, 1972), our knowledge of biochemical deterioration of seeds is still inconclusive. Attempts have been made to correlate such factors as depleted food reserves, increased enzyme activity, membrane permeability and similar changes with deterioration. Of the several biochemical changes, variations in the leaching of sugars and electrolytes from the seeds have been used as an index of seed deterioration by several workers (Ching and Schoolcraft, 1968; Abdul-Baki and Anderson, 1970 and Agrawal and Siddiqui, 1973). In the present experiment, the changes that are associated with the loss in viability were studied through the seed leachate analysis. Seed leachate constitutes both inorganic and organic compounds of the seed, suggesting a loss in seed membrane permeability as seen in other reports (Weber, 1836; Ranke, 1865; Hibbard and Miller, 1928; Ching and Schoolcraft, 1968) on aged seeds of clover and rye.

5.2.1 Electrical conductivity (EC) of seed leachate

The EC of seed leachate increased with the time of storage in all the treatment combinations irrespective of their container and treatment effects. It was high in seeds subjected to seed soaking and dehydration at the half way of storage period. However, the per cent increase in EC over the initial showed a particular trend, the loss of germination accompanied the increased leaching of electrolytes as the storage period increased.

The increase was found to be more in seeds stored at room temperature than seeds kept in cold storage in soybean. Similar results were found in soybean (Verma and Gupta, 1975; Srivastava and Gill, 1975a) and in sunflower (Rao, 1976 and Tewari, 1976).

EC was high in seeds subjected to the treatment seed soaking and dehydration at the half way of storage. Mathews and Bradnock (1968) also reported that samples of aged peas and french beans exuded electrolytes readily as measured by the electrical conductivity of seed-steep water after 24 hours of incubation and such seeds showed low emergence count in the field.

Perry (1969) suggested that measurements of electrical conductivity of steep-water can provide satisfactory method for testing seed vigour. Perry and Harrison (1970) reported success in comparing conductivity measurements on individual pea seeds under field conditions. Pollock and Roos (1972) reported a method for evaluating relative vigour of seed lots which envisaged measuring the amount of materials leached from the seeds soaked in water; lower the vigour, greater the amount of leaching.

Persiel et al. (1972) reported that the seed leachate also resulted in attracting micro-organisms leading to the poor field survival. Abdul-Baki and Anderson (1970) however, reported that the experimentally imposed mechanical injury caused increased leaching but did not reduce vigour.

Measurement of electrical conductivity of seed leachate have showed promise in detecting weak lots of peas and French beans (Mathews and Bradnock, 1967; Bradnock and Mathews, 1970). Mackay (1970) reported that the EC test had been adopted on a routine basis for peas. Dharmalingam et al. (1976) observed a highly significant negative correlation between EC of seed leachate and loss of viability. Further, they suggested its use as an index for predicting the viability of blackgram seeds.

5.2.2 Reducing sugar content in seed leachate

In the present study, the minimum reducing sugar leachate of seeds was found in urea bag container and the maximum reducing sugar leachate was in gunny bag. This showed urea bag container to be superior to the gunny bag container. The maximum final sugar leachate was found in the control and seed soaking and dehydration treatment. Results showed the same trend of decreased reducing sugar content in leachate of seeds as storage period increased.

Variation was observed in reducing sugar content in the seed leachates as storage period increased, and there was inverse relationship between the per cent increase in the reducing sugar of leachate and germinability. The seed soaking and dehydration treatment showed maximum loss of reducing sugar content. Takayanagi and Murakami (1968) observed that asceptically soaked dead seeds exude more sugars than viable seeds in distilled water, and increased exudation of sugars in deteriorating seeds might be a consequence of senescence. In this study the reducing sugar content increased with storage period agreeing with the result of Takayanagi and Murakami (1969) and Agrawal and Siddiqui (1973) who observed increased leaching of sugar with increased seed age in soybean. However, leaching of sugars was less in seeds stored at cold temperature than in that stored under room conditions at all the seed moisture levels with increase in storage period (Verma and Gupta, 1975; Gupta and Shakya, 1976). Ching and Craft (1968) reported reduced sugar content with increase in the seed moisture and storage temperature in clover and rye.

Though many studies showed an increased leaching of sugars from aged soybean seeds, this could not be used for predicting storability of soybean seeds (Agrawal and Kaur, 1975; Yaklich and Abdul-Baki, 1975; Srivastava and Gill, 1975b). Gupta and Shakya (1976) reported that the rate of reducing sugar content leaching out in soybean increased with increase in storage period and found to be significantly higher at high temperatures than at low temperatures.

5.2.3 Calcium and magnesium content of seed leachate

In the present study the maximum of calcium and magnesium in leachate was recorded in gunny bag and the minimum in metal tin and in seeds treated with seed soaking and dehydration. However, seed leachate containing minimum of calcium and magnesium was recorded in seeds stored in earthen pot treated with silicagel and in the control.

Simon and Raju (1972) and Harun (1972) reported that the imbibition of water by seeds during germination was accompanied by leakage of organic and inorganic substances, sugar and amino acids constituting the major the organic substances. Simon (1974) reported that the leakages of electrolytes from non-viable seeds was attributed to the loss of membrane integrity and was directly proportional to the conductivity of the solution in which seeds were soaked.

5.3.1 Storage fungi

Storage fungi have been reported to invade and destroy seeds of several species (Christensen, 1969; Christensen and Kaufmann, 1969; Sumar and Howard, 1983). They can attack almost any kind of seed under favourable environmental conditions and molds can grow on most organic materials. Invasion of seeds by storage fungi may result in loss of viability, decrease in non-reducing sugar, development of musty odours and discolouration. Deterioration can occur in a few days when seeds are stored under unfavourable conditions. In the present study the fungi recorded on Lima bean seeds during storage were *Macrophomina* sp., *Alternaria* sp., *Penicillium* sp., *Aspergillus* sp. and *Fusarium* sp. and generally occurrence of storage fungi increased with the increase in storage period. The percentage of infection by the individual fungus also differed with containers, treatment combinations and storage period. For example, *Macrophomina* sp. was the most dominant seed mycoflora in all the treatments and container combinations, followed by *Alternaria* sp., *Aspergillus* sp. and *Fusarium* sp. *Macrophomina*, *Penicillium* and *Aspergillus* sp., were more as the storage period increased. This is because of the fact that these are strictly storage fungi and can invade the seeds and grow under limited moisture conditions, while the field fungi like *Alternaria* and *Fusarium* cannot grow under such conditions. In fact many of the storage fungi are osmophillic and grow best under relatively dry conditions (Christensen and Kaufmann, 1965). Storage fungi not found even in high moisture content with less temperature (5°C) can grow better when there is high moisture content (11%) and temperature (21°C) and *Aspergillus glaucus* fairly invaded under such conditions (Christensen, 1971). The percentage of infection by storage fungi was high in the seeds stored in gunny bag and earthen pot compared to the other three moisture impervious containers. This may be due to fluctuation in moisture content in the seeds stored in gunny bag and earthen pot which is pervious to moisture under room conditions. As the percentage of infection increased the germinability of the seed decreased. The loss of viability due to storage fungi was also reported by Christensen (1969, 1972b) and Jhamaria *et al*. (1974). This was possibly due to production of toxic metabolites by such fungi (Mathur and Sehagal, 1964; Chakravarti *et al*., 1973; Anilkumar and Urs, 1975).

Among seed treatments, Bavistin treated seeds recorded the least number of fungi in all the containers and treatments combinations upto March 1984. Similar observations have been reported (Lago and Zink, 1976; Eric V. Nilas, 1980; Zote and Mayee, 1982 and Kore and Solanke, 1982). Germination per cent of treated and untreated seeds revealed that, in the beginning (after ten days of treatment) of storage, there were some differences between treated and untreated seeds, disappeared later (upto six months). The maximum storage fungi were found in seed soaking and dehydration during the mid way of storage, which may be due to prolonged (24 hours) soaking and dehydration. However, this is not in agreement with the reports of earlier workers (Basu et al., 1974; Sen and Asborne, 1974; Basu et al., 1975; Basu, 1976; Dasgupta et al., 1976 and Saha and Basu, 1981; Senaratna and McKersie, 1983).

The Bavistin treatment was effective upto a period of four months in treated seeds. So treating the seeds again and again with Bavistin can prevent the growth of mycoflora and thereby enhancing the storage life of seeds, and this needs systematic investigation for specific conditions.

SUMMARY

VI. SUMMARY

The present study was envisaged with a view to finding out the retention of seed viability in Lima bean stored under room conditions in five packaging materials with five seed treatments. There were in all twenty five treatment combinations. Besides, to understand the causes for seed deterioration, the seed leachate constituents viz., electrical conductivity, reducing sugars, calcium and magnesium content and seed fungi were studied. The physiological causes for seed deterioration were also studied. The salient findings are summarised below:

1. The retention of viability in Lima bean seed was generally low and it decreased to levels below the acceptable seed standard (22.27%) after the period of storage ranging from 5-8 months. Treatment and container combination differences were observed for the duration of seed viability. The treatment Bavistin showed higher germinability (75.33%) after ten days of treatment in all the container and treatment combinations, but it became ineffective after fifth month as noticed by the low germinability.

2. The Bavistin treated seeds with high initial germination were found to retain viability for a short period of time (4 to 5 months) as compared to all the

other container and treatment combinations. The field germination per cent was always lower than laboratory germination per cent.

3. Among the storage containers, moisture impervious containers like urea bag, metal tin and polythene bag were superior to other moisture pervious containers like gunny bag and earthen pot. Storage of seeds in impervious containers maintained viability to maximum extent than that of the pervious containers. Gunny bag container maintained more laboratory germination per cent than other containers, which is an exception. The earthen pot container showed lower viability within all the observations carried out in the experiment, irrespective of the interaction effects.

4. Under the room conditions the relative humidity fluctuated more than did the temperature; under such conditions storing of seeds in moisture impervious containers (urea bag, metal tin and polythene bag) will be beneficial.

5. Soaking-dehydration treatment did not prolong viability because of the enhanced (24 hours) soaking time, (7.67% - final observation in May). Storing of seeds in moisture impervious containers (urea bag, metal tin and

polythene bag respectively) in combination with soaking-dehydration was less efficient than other treatment combinations.

6. The vigour index (VI) generally reduced with advance in storage time. Storage in metal tin with Bavistin combination was best and maintained higher vigour index. Bavistin treatment was effective in all the containers upto 4-5th months of storage.

7. It can be concluded that Lima bean seeds having lesser than nine per cent initial moisture content could be effectively stored in moisture impervious containers (urea bag, metal tin and polythene bag). Seeds before storage are to be preferably dressed with Bavistin (2 g/kg seeds). Soaking-dehydration treatment during middle of the storage period i.e., after fourth month did not help in prolonging viability and retention of higher seedling vigour.

8. The shoot length (cm) decreased as the storage period increased irrespective of the containers effect, but the seeds treated with Bavistin showed maximum shoot length upto the sixth month of seed storage. In soaking-dehydration treatment the shoot length reduced as in the case of other treatments.

9. Seed leachate studies showed that with increased storage period metabolic changes occurred in the seeds resulting in increased electrical conductivity (EC). EC of seed leachate was inversely related to germinability. Leachate of seeds subjected to soaking-dehydration treatment showed more EC values than any other storage treatments.

10. Reducing sugar content of seed leachate had no apparent relationship with germinability and it decreased as the storage period increased. Seeds subjected to soaking-dehydration treatment showed more reducing sugar than the other storage treatments.

11. Calcium and magnesium content of seed leachates also increased with time of storage. Eventhough an inverse relationship was observed between calcium and magnesium content and germinability, the per cent increase in calcium and magnesium content in seed leachates could not be related to germinability. Again the seeds subjected to soaking-dehydration treatment showed more amount of calcium and magnesium in the leachate.

12. The storage fungi recorded on Lima bean seeds during storage was Macrophomina sp., Alternaria sp., Penicillium sp., Aspergillus sp. and Fusarium sp. Among these fungi, Macrophomina sp. constituted the major part throughout the storage period, followed by Alternaria sp. and Penicillium sp. The per centage of infection increased as the storage period increased. The seeds treated with

Bavistin had least infection and soaking-dehydration treatment had maximum infection by different storage fungi.

13. The seeds treated with Bavistin recorded least infection by storage fungi irrespective of storage containers and also showed higher germination percentage compared to untreated seeds. It appears that seed treatment with Bavistin will be beneficial in prolonging viability by checking growth of storage fungi on seeds.

REFERENCES

VII. REFERENCES

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

Abdul-Baki, A.A. and Anderson, J.D., 1972, Physiological and biochemical deterioration of seeds. In : "Seed Biology" ed. T.T. Kozlowski, Academic Press, New York, pp. 283-315.

Abdul-Baki, A.A. and Anderson, J.D., 1973a, Relationship between decarboxylation of glutamic acid and vigour in soybean seed. Crop Sci., 13 : 227-232.

Abdul-Baki, A.A. and Anderson, J.D., 1973b, Vigour determination in soybean seed by multiple criteria. Crop Sci., 13 : 630-633.

Agrawal, P.K., 1973, Annual Report, Division of Seed Technology, Indian Agricultural Research Institute, New Delhi.

Agrawal, P.K., 1974, Storage studies on maize seeds. Bull. Grain Technol., 12(2) : 109-112.

Agrawal, P.K., and Kaur, S., 1975, Maintenance of germinability of soybean [Glycine max (L) Merr.] seeds from harvest to next planting under ambient conditions in Delhi. Seed Res., 3(2) : 81-85.

Agrawal, P.K., 1976, Identification of suitable seed storage places in India on the basis of temperature and relative humidity conditions. Seed Res., 4(1) : 6-11.

Agrawal, P.K. and Siddiqui, M.N., 1973, Influence of storage temperature and seed moisture on germination, free fatty acid and leaching of sugars of soybean seeds during storage. Seed Res., 1:75-82.

Anderson, J.A. and Alcock, A.W., 1954, Storage of cereal grains and their products. Amer. Asso. Cereal Chem., St. Paul, Minnesota.

Anderson, J.D., 1970, Physiological and biochemical differences in deteriorating barley seed. Crop Sci., 10 : 36.

Anilkumar, T.B. and Urs, S.D., 1975, Production of toxic metabolites by seed borne fungi of sunflower. Oilseed J., 5 : 11-14.

Anonymous, 1966, International rules for seed testing. Proc. Int. Seed Test. Asso., 31 : 1-152.

Anonymous, 1976, Minimum seed certification standards for Lima bean. National Seed Corporation Mannual, p. 189.

Arndt, C.H., 1946, The internal infection of cotton seed and the loss of viability in storage. Phytopathology, 36 : 30-37.

Austin, R.B., 1972. Effects of environment before harvesting on viability. In : Viability of seeds. Ed. E.H. Roberts, Chapman and Hall Ltd., London, pp. 114-149.

*Barton, L.V., 1941, Relation of certain air temperature and humidities to viability of seeds. Boyce. Thompson Inst. Contrib., 12 : 85-102.

Barton, L.V., 1961, Seed Preservation and Longevity. Leonard-Hill (Books) Ltd., Inter-Science Publishers Inc., New York, pp. 248.

Barton, L.V., 1967, The effect of storage conditions on the viability of bean seeds. Boyce. Thompson Inst. Contrib., 23(8) : 281-284.

Basu, R.N., 1976, Physico-chemical control of seed deterioration. Seed Tech. News, 6 : 8.

Basu, R.N., Chattopadhyay, K. and Pal, P., 1974, Maintenance of seed viability in rice and jute. Indian agric., 18 : 75-79.

Basu, R.N., Bose, T.K., Chattopadhyay, K., Gupta, M.D., Dhar, N., Kundu, C., Mitra, R., Pal, P. and Pathak, G., 1975, Seed treatment for maintenance of vigour and viability. Indian Agric., 19 : 91-96.

*Blackstone, J.H., Ward, H.S. Jr., Butt, J.L. 1954, Factors affecting germination of runner pea nuts. Ala. Agri. Expt. Sta. Bull., 289 : 31.

*Boakye-Boateng, K.E. and Hume, D.J., 1975, Effects of storage conditions on germination of soybean [Glycine max (L) Merr.] seed. Ghana Agric. Sci., 8(2) : 109-114.

Bradnock, W.T. and Mathews, S., 1970, Assessing field emergence potential of wrinkled seeded peas. Hort. Res., 10 : 50-58.

Bulat, H., 1963, Stages in the loss of viability in seed tissues and the decline in germination of seed subjected to unfavourable storage condition as demonstarted by the topographical tetrazolium method. Proc. Int. Seed Test. Ass., 28 : 713-51.

Chakravarti, B.P., Shekhawat, P.S. and Anilkumar, T.B., 1973, Control of damping off and root-rot of sesame caused by Thielavia terricola var. minor by soil drenching with fungicides and antibiotics and their efficacy in treatment of seeds. Indian Phytopath., 26 : 646-649.

Cheng, K.L. and Bray,R.H., 1951, Determination of calcium and magnesium in soil and plant materials. Soil Sci., 72 : 449-458.

*Ching, T.M., 1959, Keeping field seed quality in storage and transit. West Feed & Seed, 14 : 21-22.

Ching, T.M. and School Craft, I., 1968, Physiological and chemical differences in aged seeds. Crop Sci., 8 : 407-409.

Christensen, C.M., 1969, Factors affecting invasion of sunflower seeds by storage fungi. Phytopathology, 59 : 1699-1702.

Christensen, C.M., 1971, Evaluating conditions and storability of sunflower seeds. J. Stored Prod. Res., 7 : 163-169.

Christensen, C.M., 1972a, Microflora and seed deterioration. In : Viability of seeds. Ed. E.H. Roberts, Chapman and Hall Ltd., London, pp. 59-93.

Christensen, C.M., 1972b, Moisture content of sunflower seeds in relation to invasion by storage fungi. Plant Dis. Reptr., 56 : 173-175.

Christensen, C.M. and Kaufmann, H.H., 1965, Deterioration of stored grains by fungi. Annu. Rev. Phytopath., 3 : 69-84.

Christensen, C.M. and Kaufmann, H.H., 1969, The role of fungi in quality loss. Grain Storage. p.. 153, illus. Minneapolis, Minn.

Cotton, R.T., 1932, The relation to respiratory metabolism of insects to their susceptibility to fumigants. J. Econ. Ent., 5 : 1088-1103.

Cotton, R.T., 1963, Uniform distribution of fumigant. North West Miller, 26 : 48-56.

Crocker, W. and Barton, L.V., 1953, An introduction to experimental study of seed and germination problems. Physiology of seeds. pp. 267, Waltham, Mars, London.

Dasgupta, M., Basu, P. and Basu, R.N., 1976, Seed treatment for vigour, viability and productivity of wheat, Indian Agric., 20 : 265-273.

Delouche, J.C., Mathews, R.K., Dougherty, G.M. and Boyd, A.H., 1973, Storage of seed in sub-tropical and tropical regions. Seed Sci. Technol., 1 : 663-692.

Dharmalingam, C., Ramakrishnan, V. and Ramaswamy, K.R., 1976, Viability and vigour of stored seeds of blackgram in India. Seed Res., 4(1) : 40-50.

Diener, U.L., 1960, The mycoflora of peanuts in storage. Phytopathology, 50 : 220-223.

*Dimmock, F., 1947, The effects of immaturity and artificial drying upon the quality of seed corn. Can. Dept. Agri. Tech. Bull., 58 : 66.

Eric, V. Niles, 1980, Fungi in stored barley treated with systemic fungicides. Pesticide Science, 11:458-466.

*Ewart, A.J., 1908, On the longevity of seeds. Proc. Roy. Soc. Victoria, 21 : 2-210.

Gane, R., 1948, The water content of the seeds of peas, soybeans, linseed, grass, onion and carrot as a function of temperature and humidity of the atmosphere. J. agric. Sci., 38 : 81-83.

Girish, G.K. and Krishnamurthy, K., 1972, Losses in food grains in storage. Post harvest Technology of cereals and pulses proc. Seminar (New Delhi). Eds. Pingale, S.V., Austin and Nayar.

Gregg, B., 1982, Practical safe seed storage and its management. F.A.O. Plant Production and Protection paper. No.39, pp. 318-349.

Gupta, D.K. and Shakya, B.R., 1976, Design and development of storage for low temperature preservation of foundation seed. Soybean Research at Pantnagar - 1975. Exp. Sta. G.B. Pant Univ. Agric. Tech., Pantnagar, pp. 56-65.

Gupta, P.C., 1976, Viability of stored soybean seeds in India. Seed Res., 4(1) : 32-39.

*Harrington, J.F., 1960, Drying, storing and packaging seed to maintain germination. Seedmen's Digest, 1 : 16-18.

Harrington, J.F., 1970, Seed and pollen storage for conservation of plant gene resources. In : Genetic Resources in plants - Their exploration and conservation. Ed. Frankel and Bennett. Blackwell Scientific Publications, Oxford.

Harrington, J.F., 1972, Seed storage and longevity. In : Seed Biology. Ed. T.T. Kozlowski, V. 3, pp. 145-245, illus, New York and London.

*Helmer, J.D., Delouche, J.C. and Lienhard, M., 1962, Some indices of vigour and deterioration in seed crimson clover. Proc. Asso. Seed Anal., 52 : 154-161.

Hibbard, R.P. and Miller, E.V., 1928, Biochemical studies on seed viability. I. Measurements of conductance. Plant Physiol., 3 : 335.

*Hukill, W.V., 1963, Storage of seeds. Proc. Int. Seed Test Asso., 28 : 871-874.

Jalote, S.R. and Vaish, C.P., 1976, Loss of viability of paddy seed during storage in Uttar Pradesh. Seed Res., 4(2) : 183-186.

James, E., Bass, L.N. and Clark, D.C., 1967, Effects of variable and constant storage temperature and subsequent room storage on the viability of certain seeds. Crop Sci., 7(5) : 495-496.

James, F.H., 1971, Effect of silicagel in moisture absorption. Seed Biology. (Book) Ed. T.T. Kozlowski Academic Press, New York, Vol. III. pp. 228-230.

Jhamaria, S.L., Sharma, K.B. and Gupta, R.B.L., 1974, Fungi intercepted from sunflower seeds and their control. Indian J. Mycol. and Pl. Pathol., 5 : 212-213.

*Kearns, V. and Toole, E.H., 1939, Relation of temperature and moisture content to longevity of chewing fescue seed. U.S. Dep. Agr. Tech.Bull., 670.

Khanna, S.C., Singh, S. and Yadav, T.D., 1981, Tolerances of different leguminous seeds to fumigants. Seed Res., 9(2) : 132-136.

Kore, S.S. and Solanke, R.B., 1982, Efficacy of fungicides on mycoflora of French bean (Phaseolus vulgaris) Indian J. Mycol. and Plant Pathol., 12(1) : 76-78.

*Lago, A.A., Do and Zink, E., 1976, Effect of several moisture content levels and fungicides treatments on the longevity of peanut seeds. Agronomic Campinas, Saopaulo Brazil Bragantia (Brazil), 35 : 335-342.

Lovato, A. and Mulazzani, R., 1983, (Evaluation of the vigour of pea seeds in the laboratory using an electrical conductivity test) La Valutazione del Vigore dei semi di pisello in laboratorio can la "Proua di cendncibilita elettrica". Sementi Elette. 28(5) : 3-7 (Stpen. 10 ref). Laboratorio analisi Sementi Isituto di Agronomica, Universita di Bolònga, Italy. Plant Breed Abstr., 53(4) : 328.

*Mackay, D.B., 1970, Relationship between laboratory germination and field emergence in some vegetable crops. J. Nate. Inst. Agr. Bot., 12 : 40-43.

Mathur, R.L. and Sehagal, S.P., 1964, Fungal microflora of jowar (Sorghum vulgare), its role in reduced emergence and vigour of seedling and control. Indian Phytopath., 17 : 227-233.

Mathews, S. and Bradnock, W.T., 1967, The detection of seed samples of wrinkled - Seeded peas (Pisum sativum L.) of potentially low planting value. Proc. Int. Seed Test. Ass., 32 : 553-563.

Mathews, S. and Bradnock, W.T., 1968, Relationship between seed exudation and field emergence in peas and French beans. Hort. Res., 8 : 89-93.

*Maurya, M.L., 1971, Effect of storage conditions and packaging on germination of soybean seeds. M.Sc.(Ag.) thesis. G.B. Pant Univ. Agric. Tech., Pantnagar.

*Mazid, F.Z., Nahar, L., Rahaman, Q.N. and Akhtar, N., 1977, Oilseed crops in Bangladesh. 6. Effect of storage conditions on safflower. Oilseeds J., 7 : 26.

*McNeal, Xzin, 1966, Conditioning and storage of soybeans. Arkansas Agric. Exp. Sta. Bull., 714.

Milner, M. and Geddes, W.F., 1946, Grain storage studies. III. The relation between moisture content, mold growth and respiration of soybeans. Cereal Chem., 23 : 225-247.

Moore, R.P., 1972, Effect of mechanical injuries on viability. In : Viability of seeds. Ed. E.H. Roberts, Chapman and Hall Ltd., London, pp. 94.

Nelson, N., 1944, A photometric adoptation of the Somogyi's method for the determination of glucose. J. Biol. Chem., 153 : 375-380.

Nelson, N., 1945, A photometric adoptation of the Somogyi's method for the determination of glucose. J. biol.Chem. 160 : 62.

Oathout, C.H., 1928, The viability of soybean seeds as affected by storage conditions and mechanical injury. J. Amer. Soc. Agron., 20 : 837-855.

*Parkinson, A.H., 1948, Seed age and storage effect on cucumber growth. Food Res., 14 : 7.

Pathak, P.S., Shankaranarayan, K.A., Rai, P. and Deb Roy, R., 1976, Effect of reduced levels on seed germination of fodder trees. Forage Res., 2 : 179-182.

Pelegrini, M.F., 1982, Seed storage. Armazenamento. Sementes Informe. Agropecuario., 8(91) : 56-60.

*Perry, D.A., 1969, A vigour test for peas based on seedling evaluation. Proc. Int. Seed Test. Asso., 34 : 265-270.

Perry, D.A. and Harrison, J.G., 1970, The deleterious effect of water and low temperature on germination of pea seed. J. Expt. Bot., 21 : 504-512.

*Persiel, F., Peters, L. and Reiman.Philip, R., 1972, Untersuchungen Zur Kein-Und Auflauffahigkeit bei Verchiedenen Erbscensorten. Gartin blauloissens - Chaft., 33 : 129-142.

Pollock, B.M. and Roos, E.E., 1972, Seed and seedling vigour. In : Seed Biology-I. Ed. T.T. Kozlowski, Academic Press, New York,pp. 313-387.

Pollock, B.M. and Toole, V.K., 1966, Imbibition period as the critical temperature sensitive stage in germination of Lima bean seeds. Plant Physiol., 41 : 221.

Pushman, F.M., 1975, The effects of alteration of grain moisture content by wetting or drying on the test weight of four winter wheats. J. agric. Sci. Camb., 84 : 182-90.

Ramstad, P.E. and Geddes, W.F., 1972, The respiration and storage behaviour of soybeans. Tech. Bull. Minn. Agric. Exp. Sta., 156 : 54.

*Ranke, J.T., 1865, Eine physiologische studie. Engelmann, Leipzig.

Rao, R.S.N., 1976, Sunflower seed viability studies under different storage conditions. Pantnagar J. Res., 2 : 253.

Rao, R.S.N. and Vikram Singh, 1976, Effect of storage period, storage temperature, variety and container on seed viability and field emergence and seedling vigour of sunflower seeds. G.B. Pant Univ. Agric. Technol. Ann. Rept. Res. (1975-76), Pantnagar, India, p .184.

Roberts, E.H., 1972a, Loss of viability and crop yields. In : Viability of seeds. Ed. E.H. Roberts, Chapman and Hall Ltd., London, pp. 313.

Roberts, E.H., 1972b, Chemical changes associated with seed deterioration. In : Viability of seeds. Ed. E.H. Roberts, Chapman and Hall Ltd., London, p . 418.

Saha, R. and Basu, R.N., 1981, Maintenance of soybean seed viability by hydration - dehydration treatment. Indian Agric., 25(4) : 275-278.

Scott and Mohoney, 1946, Preparation of green Lima beans for Market. Vegetable crops. Ed. Thompson, Fourth edition. McGraw Hill Book Company Ltd., London, pp. 464.

Sen, S. and Osborne, D.H., 1974, Germination of rye embryos following hydration - dehydration treatments : Enhancement of protein and RNA synthesis and earlier induction of DNA replication. J. Expt. Bot., 25 : 1010-1019.

Senaratna, T. and McKersie, B.D., 1983, Dehydration injury in germinating soybean (Glycine max L.Merr). Seed Plant Physiol., 72(3) : 620-624.

Simon, E.W. and Raja Harun, R.M., 1972, Leakage during seed imbibition. J. Expt. Bot., 23 : 1076-1085.

*Simon, E.W., 1974, Phospholipids and plant membrane permeability. New Phytol., 73 : 377-420.

Singh, J.N. and Setia, R.K., 1974, The germination of different qualities of soybean seeds under varying storage conditions. Bull. Grain Technol., 12(1) : 3-10.

Srikantaradhya, M.G., 1982, Genetic variability with respect to different seed characters in relation to viability and vigour in soybean (Glycine max L. Merr) (Abstracts). Thesis Abstr., 8(3) : 274(En.).

Srivastava, A.K. and Gill, M.K., 1975a, Physiology and biochemistry of seed deterioration in soybean. III. Seedling growth and seed leachate analysis. Indian J. exp. Biol., 13(5) : 481-485.

*Srivastava, A.K. and Gill, M.K., 1975b, Physiology and biochemistry of seed deterioration in soybean during storage - IV. Seed leachate composition, Seed protein, nucleic acids, inorganic phosphate composition and RNAse activity. Rec. Adv. Pl. Sci., 50 : 387-94.

Srivastava, A.K. and Sareen, K., 1972, Germination of soybean seeds as affected by different storage conditions. Bull. Grain Technol., 10(3) : 190-196.

Starzinger, E.K. and West, S.E., 1982, An observation on the relationship of soybean seed coat colour to viability maintenance. Seed Sci. Technol., 10 : 301-305.

Sumar, S.P. and Howard, R.J., 1983, Seed microflora of pulses grown in Alberta, Canada. Seed Sci. Technol., 11 : 363-369.

Sundaraj, Nagaraju, N., Venkata Ramu, M.N. and Jagannath, M.K., 1972, Design and Analysis of field experiments. Univ. Agric. Sci., Bangalore, pp. 293-317.

Takayanagi, K. and Murakami, K., 1968, Rapid germinability test with exudates from the seed. Nature, 218 : 493-494.

*Takayanagi, K. and Murakami, K., 1969, Rapid method for testing seed viability by using urine sugar analysis paper. JARQ, 4 : 39.

*Tewari, M.N., 1976, Storage studies on sunflower seeds in relation to variety, seed grade and storage conditions. M.Sc.(Agri.) thesis, G.B. Pant Univ. Agric. Technol., Pantnagar, India.

Thompson, H.C. and Kelly, W.C., 1968, Vegetable crops. Tata McGraw Hill Publishing Company Limited, Bombay-New Delhi, pp. 452-458.

*Toole, E.H. and Toole, V.K., 1946, Relation of temperature and seed moisture to the viability of stored soybean seed. U.S. Dept. Agr. Cir., 753 : p. 9.

*Toole, E.H. and Toole, V.K., 1953, Relation of storage conditions to germination and to abnormal seedlings of bean. Proc. Inst. Seed Test. Asso., 18 : 123.

*Toole, E.H., Toole, V.K. and Borthwick, H.A., 1957, Growth and production of snap beans stored under favourable and unfavourable conditions. Proc. Int. Seed Test. Asso., 22 : 418.

*Toole, E.H., Toole, V.K. and Gorman, E.A., 1948, Vegetable seed storage as affected by temperature and relative humidity. U.S. Dep. Agri. Tech. Bull., 572.

Turner, I.H. and Ferguson, D., 1972, Field performance of cotton grown from filled and partially filled seeds. Crop Sci., 12 : 868-871.

Vadivelu, K.K., Karivaratharaju, T.V. and Ramakrishnan, V., 1976, Studies on seed production technology in sunflower. Fifth Ann. Rept. Tamil Nadu Agric.Univ., pp. 195-196.

Vadivelu, K.K. and Ramakrishnan, V., 1977, Studies on seed production technology in sunflower. Sixth Ann. Rept. Tamil Nadu Agric. Univ., pp. 167.

Verma, R.S. and Gupta, P.C., 1975, Storage behaviour of soybean varieties vastly differing in seed size. Seed Res., 3(1) : 39-44.

*Weber, E., 1836, Questions physiologicae de phenomenis galvanomagneticis in Corpore humano observatis. Breikopf and Hartel, Leipzig. Nature : 55:212

Yaklich, R.W. and Abdul-Baki, A.A., 1975, Variability in metabolism of individual seeds of soybean and its relationship to vigour. Crop Sci., 15(3) : 424-426.

Zeleny, L., 1954, Chemical, physical and nutritive changes during storage. In : "Storage of Cereal Grains and their products."Ed. J.A. Anderson and A.U. Alcock, Amer. Ass. Cereal Chem., St. Paul, Minnesota, pp. 46-76.

Zote, K.K. and Mayee, C.D., 1982, Influence of fungicidal seed treatment during storage on seed borne fungi of mung bean. Pesticides, 16(4) : 10-12.

---

*Original not seen.

APPENDICES

Appendix 1

Weather data from May 1983 to May 1984

Month and year	Temperature (°C)		Relative humidity(%)	Total rainfall (mm)
	Maximum	Minimum	Maximum	
May 1983	35.8	22.9	78	80.0
June 1983	37.4	20.8	83	272.1
July 1983	36.6	21.2	87	33.3
August 1983	28.0	20.1	91	158.6
September 1983	27.3	19.6	88	190.4
October 1983	28.5	18.8	81	49.5
November 1983	27.8	15.2	78	9.0
December 1983	25.6	17.0	85	8.1
January 1984	27.2	16.5	83	0.0
February 1984	27.7	17.3	84	57.6
March 1984	31.1	17.0	76	0.0
April 1984	33.4	20.9	79	30.9
May 1984	34.0	20.9	76	10.0

Appendix 2

Absorption of moisture by Silicagel from different containers with Lima bean.

	1983			1984				
	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May
C_1T_2	109.8	109.3	109.7	108.7	107.5	106.9	106.9	106.2
C_2T_2	114.9	113.4	113.8	113.7	112.4	110.7	110.5	110.6
C_3T_2	104.3	104.9	104.5	104.5	103.7	103.8	103.2	103.1
C_4T_2	107.0	106.1	107.2	105.1	106.9	104.6	104.9	104.3
C_5T_2	104.8	104.1	103.2	101.7	102.0	102.9	103.0	102.2

The initial weight of Silicagel was 100 g in all the treatments.