SEED YIELD AND QUALITY IN BITTERGOURD (*Momordica charantia* L.) AS INFLUENCED BY VEGETABLE HARVESTS

By

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THESIS

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DECLARATION

I hereby declare that this thesis entitled "**Seed yield and quality in bittergourd (*Momordica charantia* L.) as influenced by vegetable harvests**" is a bonafide record of the research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

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CERTIFICATE

Certified that this thesis entitled "**Seed yield and quality in bittergourd (*Momordica charantia* L.) as influenced by vegetable harvests**" is a record of research work done independently by **DEVI. V.S.** under my guidance and that it not previously formed the basis for the award of any degree, fellowship or associateship to her.

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DEVI. V.S.

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LIST OF ABBREVIATIONS

FYM	-	Farm yard manure
LAI	-	Leaf Area Index
POP	-	Package of Practices
N	-	Nitrogen
K	-	Potash
P	-	Phosphorus
Fig.	-	Figure
t ha^{-1}	-	Tonnes per hectare
et al.	-	and others
m	-	metre
cm	-	centimeter
g	-	gram
kg ha^{-1}	-	kilogram per hectare
Rs.	-	Rupees
CD	-	Critical difference
SE	-	Standard error
viz.	-	namely
KAU	-	Kerala Agricultural University
ml/l	-	millilitre per litre
@	-	at the rate of
pm	-	past meridian
h	-	hours
ie.	-	that is
°C	-	Degree celsius
mg	-	milligram
ANOVA	-	Analysis of variance
EC	-	Electrical conductivity
mmhos/cm	-	millimhos $centimeter^{-1}$
nm	-	nanometer
MAS	-	Months after storage
DAS	-	Days after storage

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INTRODUCTION

INTRODUCTION

The role of vegetables in human diet is cardinal to make the human healthy and wholesome. India is the second largest producer of vegetables in the world next only to China. The country produces 48 million tonnes of vegetables from an estimated area of 4.5 million ha. Cucurbits are the largest group of summer vegetables and bittergourd (*Momordica charantia* L.) is one of the most nutritive and commercially important cucurbitaceous vegetable, which originated in the tropics of the old world. It is widely distributed in China, Malaya, India and Tropical Africa. The fruit of this vegetable is the richest source of minerals and vitamins specially, iron and ascorbic acid. The bittergourd is grown in an area of 26,004 ha with annual production of 1,62,196 t (Gill and Tomar, 1991).

The productivity of vegetables in India and Kerala is very low. One of the major constraints in boosting up vegetable productivity in India is the limited availability of quality seeds.

The use of good quality seed is indispensable for the successful production of any crop. Good seed forms the basic, cheapest and most remunerative input in crop production The cost of seed is a small fraction of the total cost of inputs involved in raising the crop to maturity. However, if poor quality seed is sown all the efforts put together to raise a successful crop go waste since crops raised from poor quality seeds are not healthy and thus rendered uneconomical.

The present requirement of vegetable seeds in the country is 29,500 tonnes annually (Seshadiri, 1990) and 72 tonnes in the state of which, only 20 to 25 per cent are supplied by authorised agencies (KAU, 1991). Hence the vegetable seed yield has to be stepped up from the present level to ensure the timely supply of seeds in adequate quantities to the grower.

It is a common practice among farmers to sell the early formed and best produce as vegetables and keep the worst and last formed for seeds. This neglectance on the production of quality seeds can lead to a rapid decline in productivity of the crop and quality of the produce. Combining vegetable production with seed production may be possible as periodic removal of early formed fruits as vegetable stimulates the growth of the crop and thereby increasing its yielding capacity (Nandpuri *et al.*, 1974). So instead of using the left overs for seed, a good yield of quality seeds along with some vegetable can be obtained by this practice.

The quality seed production and processing as well as timely distribution to farmers ensure a sound foundation for quality crop production. Since the success of vegetable cultivation primarily depends on good quality seed, the results of the present study can be advocated to the growers for producing quality seeds.

The present study is aimed to assess the effect of vegetable harvests on seed yield and quality, and to standardize extraction, drying and storage methods and also to study the influence of seed position in fruit on seed quality in bittergourd.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Among the several factors which account for better quality of seeds, vegetable harvests, seed extraction, drying as well as storage have profound influence in vegetables. The available literature on these aspects are reviewed in the foregoing pages of this chapter.

2.1 Effect of vegetable harvests

Since the research efforts on the effect of vegetable harvests on seed yield and quality in cucurbits are meagre, the information available on other crops are also included in this review.

2.1.1 Effect of vegetable harvests on growth characters

Significant influence of vegetable harvests on plant growth has been reported by several authors.

Velumani and Ramaswamy (1980) in an experiment to findout the effect of vegetable harvests on plant height and seed yield in bhindi observed decrease in height of plants when all fruits were left to mature for seed and increase in height when the first formed twelve fruits were harvested as vegetable. Similar increase in plant height with increasing number of green fruit pickings was also reported by Wankhade and Morey (1981) in chilli.

In bhindi stunted growth of plants was observed when all the fruits were left to mature for seed purpose without green fruit harvest (Garris and Holfmann, 1946; Shanmughasundarum, 1950; Kolhe and Chavan, 1967; Kamalanathan *et al.*, 1968; Bhuibar *et al.*, 1989). However, Khan and Jaiswal (1988) reported that green fruit pickings had no effect on the plant height of bhindi.

In general increase in plant height was observed with vegetable harvesting.

2.1.2 Effect of vegetable harvests on fruit yield and yield attributes

2.1.2.1 Yield of green fruits

Green fruit yield was proportionately high in bhindi when more vegetable harvests were done (Madhava Rao, 1953). Grewal *et al.* (1974) reported a linear increase in the number as well as weight of green fruits per plant and a decrease in length of pods with each picking in bhindi.

Cucumber, summer squash, bittergourd and other cucurbits grown for their immature fruits are more productive if the fruits are harvested frequently (for example, every other day) and not allowed to become large. Large fruits act as a sink for nutrients and inhibit the development of additional fruits on the plants (Robinson and Decker-Walters, 1997).

The green fruit yield is thus found to increase due to vegetable harvests.

2.1.2.2 Yield of mature fruits

Maximum dried fruits per plant was observed with three green fruit pickings in bhindi (Pandey *et al.*, 1976). Khan and Jaiswal (1988) observed that in bhindi the number and weight of dried fruits per plant were significantly influenced by two green fruit pickings over no picking and the maximum weight and number of fruits per plant were harvested under two fruit pickings. Similar results were also obtained by Bhat and Singh (1997) in bhindi.

2.1.3 Effect of vegetable harvests on seed characters

2.1.3.1 Number of seeds per fruit

Rode (1979) observed the maximum number of seeds per fruit in bhindi plants which were left to mature for seeds without vegetable harvests. Similar results in bhindi have also been obtained by Velumani and Ramaswamy (1980), Deshmukhe and Tayde (1986) and Bluibar *et al.* (1989).

Wankhade and Morey (1981) reported that in chilli green fruit picking had no significant effect on the number of seeds/fruit. The same trend was observed in bhindi by Khan and Jaiswal (1988).

2.1.3.2 Weight of seeds/fruit

Velumani and Ramaswamy (1980) reported that the seed weight per fruit in the first picking was significantly more than in the subsequent pickings in bhindi.

In the case of chilli influence of green fruit picking on the weight of seeds per fruit was not significant (Wankhade and Morey, 1981).

2.1.3.3 Seed yield

Manankove (1973) observed that in cucumber the quantity and quality of seeds were best when seeds were collected from the first formed fruits on the plants. With a rising number of fruits plant^{-1} (ie., greater than nine to 15 fruits) seed weight tended to decrease, but the other quality criteria were unaffected. Within the above range seed bearing fruits per mother plant, seed yields from a single fruit were not dependent on the number of fruits plant^{-1} or on their size (Men'kova, 1974).

Sheeba (1995) reported that in bhindi highest seed yield was observed with zero vegetable harvest which was on par with two vegetable harvests.

Two green fruit pickings significantly increased the number and weight of dried fruits and seed yield in bhindi (Randhir Singh and Kanwar, 1995). Significantly higher seed yield was also recorded with two green fruit pickings by Bhat and Singh (1997).

Venkata Reddy *et al*. (1997) reported that retaining 12 fruits plant^{-1} gave maximum seed yield in bhindi compared to six, eight, ten or all fruits.

2.1.3.4 Seed quality

Boose (1966) reported that limiting the number of fruits left for seed production is one of the ways of improving the quality of seeds in cucumber.

Seeds from the early formed fruits gave a higher germination percentage in cotton (Selvaraj and Ramaswamy, 1976) and in chilli (Sriramachandra Murthy, 1979 and Dharmatti and Kulkarni, 1988).

Metha and Ramakrishnan (1986) reported that the seeds of chilli var. CO-1 from second and third pickings showed superiority after twelve months of storage.

In bhindi germination percentage, 1000 seed weight, 100 seed volume, seed protein and seed moisture content were not significantly influenced by the vegetable harvests while seedling root and shoot lengths and vigour index values were better for two vegetable harvest treatments (Sheeba, 1995).

2.2 Standardization of seed extraction methods

The method of seed extraction influences the seed quality. There are different methods of seed extraction in bittergourd, practiced by the vegetable farmers of the State. However, very few attempts have been made in this line of research. The literature available on the different seed extraction methods in cucurbits as well as other crops are presented hereunder.

Harrington (1959) reported that fermented seeds of muskmelon germinated better than those cleaned mechanically. He found that fermentation of pulp together with seeds for twenty four hours, quickened seed separation and enhanced seed germination. Ritchie (1971), recorded satisfactory germination of tomato seeds extracted and cleaned with one per cent HCl and 0.1 per cent pectinase for 24 hours at 60°F. According to Lego and Zink (1976), seed germination of mechanically extracted seeds decreased with increasing fermentation time from 24 to 48 hours.

Seed weight, germination percentage, seedling growth and vigour were superior for tomato seeds treated with concentrated HCl at 1:20 ratio by volume for 20 minutes than those obtained from fermentation for 48 hours and fermentation in alkali solution by adding 125 g sodium bicarbonate in 4.5 litre of water at 1:1 ratio (v/v) and fermenting for twenty four houres (Vadivelu and Ramaswamy, 1977).

Stryapkova and Kononkov (1980) reported that in cucumber and tomato, mechanical seed extraction was most promising method compared to acid and alkali methods of seed extraction. Harrington (1981) reported decreased germination percentage of tomato seeds with increased concentration of HCl from one to sixteen per cent which took increased duration for acid digestion that varied from 22.5 minutes to 300 minutes.

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

Seed extraction studies conducted in cucumber, melon and watermelon indicated that use of two per cent NaOH or two per cent HCl for 10 to 30 minutes or 0.03 per cent pectinase enzyme for 5 to 12 hours were very effective in removing the surrounding mucilage and produced seeds with good germination percentage (Koleve and Boyadzheve, 1983).

Nelson *et al.* (1985a) studied the effect of fruit maturity and fermentation on the seeds of cucumber, *Cucurbita pepo*, *Cucumis melo* and watermelon. They observed that the fermentation did not affect germination percentage but it accelerated seed germination in water melon and cucumber. Germination of seeds from unripe fruits was markedly increased by fermentation in watermelon and cucumber and to a lesser extent in *Cucumis melo*. However, fermentation decreased germination of seeds from unripe *Cucurbita pepo*.

Singh *et al.* (1985a) reported that the muskmelon seeds extracted after twenty four to fourty eight hours of fermentation was superior in germination as compared to washing the seed with water immediately after scooping out the seed ball from the fruits. Fermentation period of twenty four hours was found ideal for getting good quality seed. The best fermentation time for tomato cultivars *Punjab Chhuhara* and *Punjab Kesari* were twenty four hours and fourty eight hours respectively (Singh *et al.*, 1985b).

Edwards *et al.* (1986) showed that short fermentation duration of four days or below gave positive responces but longer fermentation duration for eight and twelve days were deleterious on seed quality of cucumber. Hedayat (1987) reported that seeds extracted after maceration for two hours in HCl (1:6 ratio) were the best in maintaining high viability and vigour compared to seeds extracted by fermentation. Seeds extracted manually and soaked in two per cent H_2SO_4 for thirty minutes were the next best.

Gill and Singh (1987) suggested that fermentation of pulped material should not be prolonged beyond 72 hours in tomato to get seeds of high germination and preferably seeds should be washed free of pulp after 48 hours. They also found that in case the fermentation method is not to be followed 1 to 1.5 litre HCl per quintal of tomato pulp for 10 to 15 minutes can be used. The seeds should be washed as quickly as possible after that.

Seed extraction studies conducted by Furtak (1989) in cucumber indicated that seed losses could be reduced by machine extraction and fermentation of four to six days at 16 to 18°C gave the best seeds. Studies conducted on extraction of tomato seeds using fermentation, acid, alkali and mechanical extraction techniques showed that the use of HCl at five per cent or H_2SO_4 at four per cent for a soaking period of forty five minutes gave better seed germination though the cost was relatively high. Mechanical extraction was found to be optimal in terms of seed quality and cost (Gowda *et al*., 1991).

On comparing acid (three per cent citric acid or 35 per cent HCl), alkali or natural fermentation for twenty seven hours of seed extraction in tomato, the seeds extracted with citric acid showed highest percentage seed recovery, germination percentage and vigour index immediately after extraction. However, after eight months of storage, these seeds had the lowest percentage of germination and vigour Index and the highest Electrical Conductivity of seed leachate indicating poor seed quality. Seeds obtained by HCl extraction recorded relatively highest percentage germination and Vigour Index and lowest leachate EC after eight months of storage with HCl extraction (Karivaratharaju *et al.*, 1992).

Gowda *et al.* (1994) reported that in brinjal, thirty six hours of fermentation of fruit pulp or treating with four per cent HCl for sixty minutes was optimum for seed extraction. The alkali treatment with NaOH was not suitable for brinjal seed extraction.

A single fruit seed extractor for cucumber was developed by Wehner and Humphries (1995) to increase the speed and ease of seed removal from individual, mature cucumbers. They found no reduction in seed recovery or germination in using the seed extractor, compared with hand extraction.

Das *et al.* (1997) reported that among the different techniques of seed extraction, fermentation for fourty eight hours followed by soaking in 2.5 per cent HCl for both thirty and sixty minutes, five per cent HCl for thirty minutes and 2.5 and five per cent NaOH for fifteen minutes were better for quality seed extraction in tomato. As fermentation takes more time, 2.5 to five per cent HCl for 30 minutes or 2.5 to five per cent NaOH for fifteen minutes, may be used for extraction of quality seeds of tomato.

2.3 Standardization of seed drying and storage methods

2.3.1 Drying

The different methods of seed drying practiced by the farmers affect the quality of seeds. The available literature on drying of seeds in cucurbits as well as other crops are given.

Nerson *et al*. (1985b) studied the effect of washing and drying of cucurbit seeds at harvest on their immediate germinability. Seeds of cucumber, muskmelon, watermelon and summer squash from fruits of maturity 21 to 54 days after anthesis were handled with or without fifteen minutes of washing and with or without fourty eight hours of air drying before being germinated. Germination percentage of seeds harvested from ripe fruits was not affected either by washing or by drying. The rate of germination of these seeds was accelerated in muskmelon and inhibited in summer squash by drying.

Gill and Singh (1987) suggested that during the hot months of May-June, the seeds of tomato should not be dried during noon hours on the seed drying floor since the seed losses its germination due to high temperature injury during drying of the seed. Rapid drying of seeds under higher temperature reduced germination in bhindi (Doijode, 1988).

Gowda *et al*. (1990) reported that in tomato, though sundrying of seeds showed better drying performance, the quality attributes were comparatively poor. The better performance of sun drying and shade drying could be due to slow drying without exposure to continuous radiation effects. Sun and shade drying among the traditional methods (Sun, shade, sun and shade) and mechanical drying at an air temperature of 40°C were optimal for safe drying of tomato on commercial scale.

2.3.2 Storage

In the recent period packaging seeds in moisture resistant containers for storage has been explored. Ordinary paper and cloth containers were least effective, while various laminate and poly ethylene materials were moderately effective. Several works are available on the different type of storage containers for maintaining the seed viability under storage in cucurbits as well as other crops.

2.3.2.1 Cucurbits

Zink and Demendonca (1964) recorded maximum germination (88 per cent) in watermelon after eighteen months of storage in cloth bag at 20°C and fourty five per cent relative humidity. However, seeds stored in air tight containers maintained well only for twelve months. Miyagi (1966) reported that cucumber seeds maintained viability when stored in metal soil bags upto twenty two months.

Villareal *et al.* (1972) found that seeds of squash, bottlegourd and ridgegourd when stored in packets made of cellophane - aluminium - polyethylene (CAP) maintained seed vigour and germinability well compared to polyethylene packets or paper packets. The germinability of seeds from paper packets was the lowest.

Harrington (1973) suggested that only dry seeds should be packed in moisture proof or moisture resistant containers for prolonging germination and vigour of seeds. Kuchernko and Lebedeva (1976) reported that seeds of watermelon and pumpkin germinated better when stored in polythene packets than in paper bags. Chandrasekharan (1979) reported that storing seeds at eight per cent moisture content in paper-aluminium-polythene laminated pouches was the best method for maintaining germination and vigour of bottlegourd seeds for more than twelve months.

Bagolepov (1980) observed that pumpkin seeds could be stored in best quality in plastic bags without regulating temperature and humidity. Krishnaprasad (1980) reported that ashgourd seeds treated with thiram and stored in moisture vapour proof containers at eight per cent moisture could maintain viability and vigour of seeds with minimum loss for a period of eight months.

Lebedeva (1981) reported that for storing the seeds in polythene bags, the optimum moisture contents were seven per cent for watermelon, six per cent for melon and six per cent for squash. Pesis (1983) reported that in muskmelon there was a significant decline in germination prior to any significant increase in electrolytic leakage from seeds indicating that electrolytic leakage is not a suitable test for seed quality in muskmelon seeds under storage.

Teotia (1985) reported that the ideal seed moisture for retaining seed germinability for a longer period in muskmelon, longmelon and watermelon was less than 6.6 per cent. Fussa and Zhukova (1985) observed decreased viability with increased abnormality in watermelon seeds after four to five years of open storage, while viability was maintained in hermetically sealed containers over fifteen to twenty three years of storage.

Hedayat (1987) reported that seeds of watermelon treated with thiram or activated clay and stored under ambient conditions in 700 gauge polythene bag recorded high germination and vigour after eight months of storage. Doijode (1989) found that seed germinability in bottlegourd was reduced to fifty per cent after twelve months of storage under ambient conditions. The loss of germinability was associated with high quantity of sugars and amino acids in leachates and low dehydrogenase activity in seeds.

In longmelan high temperature and relative humidity hastened the process of seed deterioration. Seed deterioration was associated with greater leaching of electrolytes, soluble sugars and amino acids from seeds and lower dehydrogenase activity (Doijode, 1991). Renuga devi (1992) reported that in ashgourd, bittergourd and ridgegourd, 700 gauge polythene bags was proved superior to cloth bags in maintaining viability of seeds upto ten months.

Seeds of pumpkin preserved in polyethylene bags at ambient conditions remained viable for four years. But high germination was maintained for two years only (Doijode, 1995).

Seed storage studies indicated that packing seeds in moisture impervious 700 gauge polythene bag was best in maintaining high germination, vigour and dehydrogenase activity during storage in ash gourd. Brown paper bag and gada cloth bag were not suitable to maintain the seed viability (Kannath, 1996).

2.3.2.2 Other crops

Dharmalingam *et al.* (1976) reported that when seeds of black gram were stored in paper - aluminium - polythene pouches, they remained viable upto twenty four months, recording seventy eight per cent germination. Treating the seeds before storage in cloth bags or paper - aluminium - polythene pouch was helpful in minimizing the loss of viability and vigour. Seeds of lablab treated with thiram and stored in aluminium foil pouches recorded high germination and field emergence after storage (Shanmugaraj, 1978).

Gill *et al.* (1983) stored tomato seeds successfully in paper bags for three years under ambient conditions. Freshly extracted tomato seeds when dried to seven per cent moisture content and treated with thiram or captan and packed in cloth bags or moisture proof paper - aluminium - polythene laminated pouches could be stored upto thirty months. (Vadivelu and Ramaswamy, 1983).

Doijode (1986) found that cluster bean seeds when stored in butter paper, kraft paper, polythene, laminates and glass containers under ambient conditions, retained viability upto twelve months in polythene or laminates or glass containers. Seed deterioration was associated with excessive leaching of electrolytes and soluble sugars from the seeds.

Warham (1986) suggested that in humid tropical conditions packaging of seeds result in exclusion of moisture insects and micro organisms by creating a barrier to these factors. Vanagamudi (1986) reported that cowpea seeds dried to seven to eight per cent moisture content, dry treated with captan 2 g per kg of seed and stored in 700 gauge polythene recorded high germination and vigour after storage.

Kanawade *et al*. (1987) reported that the seeds of chilli, brinjal, bhindi and guar, stored in polythene bag and moulded plastic jar maintained a better quality than those stored in ordinary cloth bag. Seeds of lablab when stored in 700 gauge polythene bag showed maximum germination compared to mud pot and gada cloth bag. The seeds stored in cloth bag and mud pot showed similar germination.

Saxena *et al*. (1987) found that in radish the seed quality is affected by improper storage and causes excessive leaching of electrolytes, soluble sugars and amino acids from seeds and decrease in dehydrogenase activity.

The seeds of tomato capsicum, brinjal and bhindi when stored in aluminium foil pouch were best in maintaining the seed viability than those stored in cloth bag (Jayaraj *et al*., 1988).

Selvaraj (1988) studied the storage of brinjal seeds and reported that the efficiency of paper - aluminium -

polythene was greater compared to that of polythene bag and cloth bag. Doijode (1989) reported that polythene and laminated (paper - aluminium soil - poly) bags were effective for preserving viability for five years at 5°C or - 18°C in storing onion seeds.

Varier *et al*. (1989) studied the long term storability of seeds of carrot, onion and tomato. They found that the moisture content of the seed varied according to the relative humidity of the atmosphere when stored under ambient conditions. Krishnasamy and Ramaraja Palaniappan (1989) reported that in tomato and brinjal there was significant association of seed leachate, electrical conductivity and field emergence of seeds. Soaking brinjal seeds for two hours and tomato seeds for four hours was optimum for measuring seed leachate electrical conductivity.

Vyas *et al*. (1990) reported that in soyabean seeds, a decrease in germination percentage was accompanied by an increase in leaching of electrolytes and electrical conductivity of seed leachate was a good indicator of seed storability and germinability.

Vijayakumar *et al*. (1991) reported that onion seeds packed at eight per cent moisture content in 700 gauge polythene bag was beneficial in maintaining viability than gada cloth bag. Verma *et al*. (1991) reported that seeds of cauliflower and tomato stored in laminated bags maintained the germination under ambient conditions over a period of eleven months compared to those of bamboo paper bags and 150 gauge unsealed polythene bags.

Thiagarajan (1994) reported that chilli seeds dried to a moisture content of eight per cent with an initial germination of eighty five per cent, recorded seventy three per cent germination after thirty months of storage under ambient conditions. He observed that seed germination decreased with increase in storage; where as electrical conductivity increased with increase in storage period.

2.4 The influence of seed position in fruit on seed quality

The position of seed in fruit influences seed germination. Tomato seeds from the lower half of the fruit were larger and denser and gave rise to more productive plants than those from the upper half (Slobodjanik, 1958). Seeds from basal region of the fruit exhibited higher germination than from top and middle position of fruit in chilli. Seedling emergence was earlier in seeds of basal region (Doijode, 1990).

Srimathi *et al*. (1992) reported that the seed size, weight, germination and vigour of the seeds collected from the distal and other portions of cowpea pods did not vary widely excepting the reduced vigour of seedlings of small sized seeds.

The distal end seeds recorded the higher germination and lower vigour compared to others.

The seeds of bittergourd collected from the proximal one third portion registered higher seed weight, germination percentage, shoot length and hundred embryo weight. The seeds from the distal one third portion was of poor quality which was due to the poor seed development (Vijayakumar *et al*., 1994).

MATERIALS AND METHODS

MATERIALS AND METHODS

The present investigation on bittergourd was conducted at the College of Agriculture, Vellayani during the period from 30-1-1998 to 30-4-1998. The main objectives were assessing the effect of vegetable harvests on the seed yield and quality, standardization of seed extraction, seed drying and storage methods and studying the influence of seed position in fruit on seed quality. The following four experiments were conducted for the study.

3.1. Effect of vegetable harvests on the seed yield and quality
3.2. Standardization of seed extraction methods
3.3. Standardization of seed drying and storage methods
3.4. Influence of seed position in fruit on seed quality

Details of the materials used and the methods adopted for the study are presented in this chapter.

3.1. Effect of vegetable harvests on seed yield and quality

3.1.1 Materials

3.1.1.1 Experimental site

The experiment was carried out at the Instructional Farm attached to the College of Agriculture, Vellayani, situated at an attitude of 29 m above mean sea level, between 8.5° North latitude, 76.9° East longitude.

3.1.1.2 Soil

The soil of the experimental site was lateritic red loam belonging to the order oxisol and of the Vellayani series. The important physico-chemical properties of the soil and the methods adopted for the analysis are presented in Table 1.

3.1.1.3 Cropping history of the field

The experimental area was previously cropped with a bulk crop of bittergourd prior to the layout of the experiment.

3.1.1.4 Season

The experiment was conducted during 30.1.1998 to 30.4.1998. (Summer season)

3.1.1.5 Weather conditions

The weekly averages of the weather parameters viz. temperature, relative humidity and rainfall received during the cropping period, collected from the meteorological observatory of the College of Agriculture are presented in Appendix I and Fig. 1.

3.1.1.6 Cultivar used

The variety used for the experiment was 'Preethi' which was released by the Kerala Agricultural University. The fruits are large, medium long, spiny and white. The average yield is 20 t ha^{-1}.

Table 1 Physico chemical properties of soil

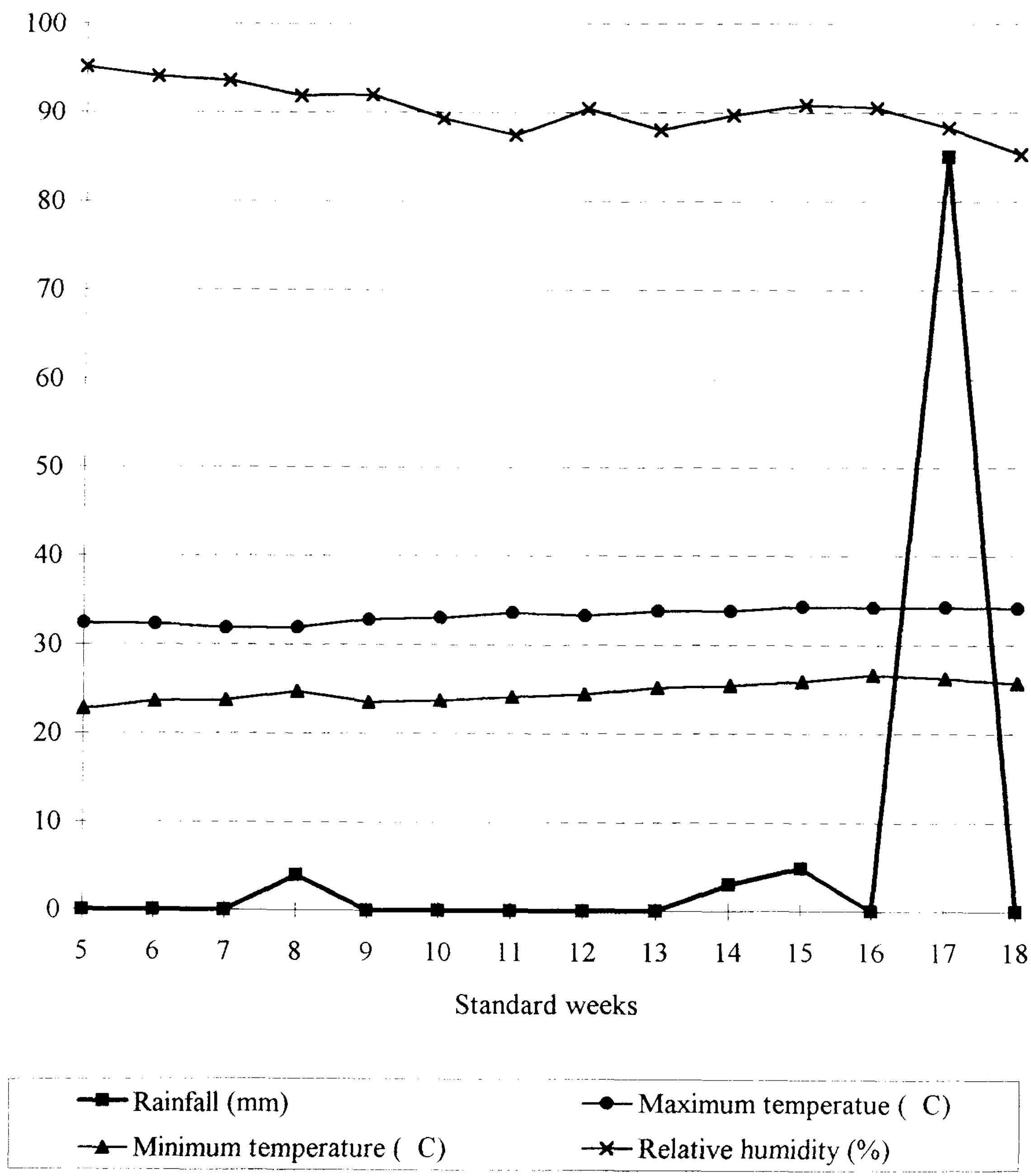
A. Physical composition

Sl No.	Parameter	Content in soil (%)	Method used
1.	Coarse sand	36.35	Bouyoucos
2.	Fine sand	15.00	Hydrometer method (Bouyoucos)
3.	Silt	17.50	
4.	Clay	30.00	

B. Chemical composition

Sl.No.	Parameter	Content	Rating	Method used
1.	Available N	485.60 kg ha^{-1}	Medium	Alkaline potassium permanganate method (Subbiah and Asija, 1956)
2.	Available P_2O_5	65.00 kg ha^{-1}	High	Bray colorimetric method 1 (Jackson, 1973)
3.	Available K_2O	29.00 kg ha^{-1}	Low	Ammonium acetate method (Jackson, 1973)
4.	pH	4.70	Acidic	pH meter with glass electrode (Jackson, 1973)

Fig. 1 Weather data during the cropping period starting from 30th January 1998 to 30th April 1998



Layout of the Experiment

H_3	H_5	H_1	H_4	H_2	Replication 1
H_2	H_4	H_5	H_3	H_1	Replication 2
H_5	H_4	H_1	H_2	H_3	Replication 3
H_3	H_1	H_2	H_5	H_4	Replication 4

3.1.1.7 Source of seed material

Seeds of the variety Preethi obtained from the Instructional Farm, College of Agriculture, Vellayani was used for the experiment.

3.1.1.8 Manures and fertilizers

FYM (0.4 per cent N, 0.3 per cent K, 0.2 per cent P) was used as the organic manure. Urea (46.0 per cent N), mussori rock phosphate (20.0 per cent P_2O_5) and muriate of potash (60.0 per cent K_2O) were used as the source of inorganic fertilizers.

3.1.2 Methods

3.1.2.1 Design and Layout

The field experiment was laid out in Randomised Block Design. The details of the layout are given below.

Number of treatments	-	5
Number of replications	-	4
Total number of plots	-	20
Net plot size	-	6x4 m
Number of plants/net plot	-	12
Spacing	-	2x2 m
Number of plants/block	-	60

3.1.2.2 Treatments

The treatments consisted of different number of vegetable harvests.

H_1 - 0 vegetable harvest and left for seeding

H_2 - 1 vegetable harvest and then left for seeding

H_3 - 2 vegetable harvests and then left for seeding

H_4 - 3 vegetable harvests and then left for seeding

H_5 - 4 vegetable harvests and then left for seeding

3.1.2.3 Field culture

3.1.2.3.1 Land preparation

The experimental area was first cleared of weeds and stubbles. The field was laid out into blocks and plots as per the design. Each plot was dug thoroughly and pits of 60 centimeters diameter at 45 centimeters depth were taken at 2x2 m spacing. Each pit was applied with a mixture of powdered well decomposed FYM and top soil before sowing.

3.1.2.3.2 Application of manures and fertilizers

The manures and fertilizers were applied as per the POP recommendations by the Kerala Agricultural University. All the other cultural and management practices were given uniformly to all the treatments.

3.1.2.3.3 Seeds and sowing

Bold seeds selected for planting were soaked in water for six hours and then sown at the rate of four seeds per pit.

Two weeks after sowing the excess plants were thinned out and two healthy seedlings were retained in each pit. Bamboo sticks of 1.5 m length were fixed in each pit and the plants were allowed to trail on it. After 15 days of sowing a 'pandal' with casuarina poles and coir rope was erected over the entire plots and the plants were trailed on it.

3.1.2.3.4 After cultivation

The crop was irrigated and weeded as and when necessary. Top dressings with nitrogen were done three times at an interval of 14 days commencing from 21 days after sowing.

3.1.2.3.5 Plant protection

Kelthane at the rate of 3 ml/l was sprayed at 10 days interval to control the mite infestation. Malathion @ 2 ml/l and 20 g garlic paste/l mixture were applied to control white flies and jassids. Magnesium sulphate ($MgSO_4$) was sprayed at the rate of 10 g/l 'to improve green colour in plants affected by yellowing. Inorder to control fruit flies, bait traps were prepared using banana fruits and furudan granules which were suspended at the rate of one bait trap per plot.

3.1.2.3.6 Harvesting

Fruits for vegetable purpose were harvested at five days interval from all treatments except H_1. Thus a total of four vegetable harvests were conducted. Ripe fruit harvests for seed purpose were carried out at an interval of four days and a total of eight ripe fruit harvests were taken up.

The green fruits were harvested at vegetable maturity stage as judged by visual observations. The ripe fruits were harvested when the tip of the fruits turned yellowish.

The entire harvesting operation was completed within 90 days after sowing the crop.

3.1.3 Observations recorded

Two plants per plot were selected at random for taking observations and the following biometric and yield attributes were recorded from these plants.

3.1.3.1 Biometric observations

3.1.3.1.1 Length of main vine

The length of the observation plants was measured by uprooting the plants after final harvest. The length of main vine was measured from base to the tip, average worked out and expressed in meters.

3.1.3.1.2 Number of main branches plant^{-1}

The number of main branches per plant was recorded from the observation plants after uprooting them.

3.1.3.1.3 Leaf Area Index (LAI)

LAI was worked out after second as well as final vegetable harvests. Area of five leaves per plant was worked out from one sample plant at each stage of observation. The area of five leaves per plant representing the three parts of the plant (base, middle and top) were recorded using graph paper method and area per leaf was calculated. Then the total number of leaves produced per plant was counted and the total leaf area worked out. Then LAI was worked out with formula suggested by Watson (1952).

$$LAI = \frac{\text{Leaf area}}{\text{Land area}}$$

3.1.3.2 Yield observations

3.1.3.2.1 Length and girth of fruits

The length of the fruits harvested from the observation plants in each vegetable harvest was measured, the mean was worked out and expressed in centimeters. From the same fruits the girth was measured by winding a thread around the individual fruits. The mean girth was worked out and expressed in centimeters.

3.1.3.2.2 Number of green fruits $plant^{-1}$

The number of green fruits from the observation plants was recorded at each harvest (as per the treatment), the total number for the entire harvests was calculated and the average number per plant was worked out.

3.1.3.2.3 Number of green fruits $hectare^{-1}$

The total number of green fruits from each plot was recorded at each harvest (as per treatment) and the number per hectare was estimated.

3.1.3.2.4 Green fruit yield $plant^{-1}$

The weight of green fruits obtained from the observation plants were recorded at each vegetable harvest (as per the treatment) and the total yield for the entire harvests was worked out. Then the average yield per plant was worked out and expressed in kilograms.

3.1.3.2.5 Green fruit yield $hectare^{-1}$

The total weight of green fruits from the net plot area was recorded after each vegetable harvest (as per treatment) and the yield ha^{-1} worked out and expressed as kg ha^{-1}.

3.1.3.2.6 Number of ripe fruits plant^{-1}

The total number of ripe fruits from the observation plants were noted from the entire harvests and the mean was calculated.

3.1.3.2.7 Number of ripe fruits ha^{-1}

The total number of ripe fruits from each plot was recorded at each treatment (as per treatment) and the number ha^{-1} was estimated.

3.1.3.2.8 Ripe fruit yield plant^{-1}

The total weight of the ripe fruits from the observation plants was noted from all harvests and the average worked out and expressed as kg^{-1}.

3.1.3.2.9 Ripe fruit yield ha^{-1}

The total weight of ripe fruits from the net plot area were noted from the entire harvests and the yield ha^{-1} worked out and recorded as kg ha^{-1}.

3.1.3.2.10 Days to fruit harvest

On the day of flower opening five flowers per plant per plot were labelled using tag labels and the date of anthesis noted. The green fruits were harvested at proper stage by visual observations and the days taken for vegetable harvest was recorded as the mean of five observations. Mature fruits were harvested when the fruit tips turned yellow, the dates noted, the mean worked out and the value recorded as the days to maturity.

3.1.3.2.11 Total crop duration

Days taken from the date of sowing of seeds to the final harvest were recorded as the total crop duration.

3.1.3.3 Seed characters

Ripe fruits harvested from the observation plants were used for taking the following seed observations.

3.1.3.3.1 Number of seeds fruit^{-1}

The number of seeds from all the ripe fruits of the observation plants was counted at each harvest and the average was worked out.

3.1.3.3.2 Weight of seeds fruit^{-1}

The weight of seeds from all the ripe fruits of observation plants was recorded at each harvest and the average worked out.

3.1.3.3.3 Fruit to seed ratio

The fruit to seed ratio was worked out at each harvest by dividing the weight of all fruits from the observation plants with the weight of seeds from the respective fruits and the mean worked out.

3.1.3.3.4 Pulp to seed ratio

The weight of seeds along with pulp from all the fruits of the observation plants was recorded at each harvest and the seed weight was substracted from this to obtain the weight of pulp then the pulp to seed ratio was worked out.

3.1.3.3.5 Seed yield plant^{-1}

Weight of the seeds from the observation plants was recorded at each harvest and the mean was worked out and expressed as g plant $^{-1}$.

3.1.3.3.6 100 seed weight

Hundred seeds were counted at random from all the plots at each harvest, weighed and the mean value was expressed in g.

3.1.3.3.7 Germination percentage

The seeds from each treatment were tested for germination. Twenty seeds from each treatment were selected randomly and were sown in sterilized sand medium in petridishes. The sand was kept moist until the final count was taken on the fourteenth day after sowing. The number of normal seedlings produced was counted on the final count day (14th day after sowing) and the percentage was worked out.

3.1.5 Economics of cultivation

The economics of cultivation was worked out based on the various input-costs

$$\text{Net income (Rs.ha}^{-1}\text{)} = \text{Gross income} - \text{Cost of cultivation}$$

$$\text{Benefit-Cost ratio} = \frac{\text{Gross income}}{\text{Cost of cultivation}}$$

3.1.6 Statistical analysis

The data generated from the experiment were subjected to ANOVA technique as applied to RBD as described by Cochran & Cox (1965). When the effects were found to be significant critical differences were calculated for effecting comparison among the means.

3.2 Standardization of seed extraction methods

Selected fruits of uniform size were cut longitudinally and the seeds along with pulp were removed. From this, six lots of seed and pulp of equal weight (150 g) were taken and six different extraction treatments were tried in four replications. The seed extraction treatments employed in the study were

E_1 - Manual extraction (Fruits were cut longitudinally and seeds separated manually.

E_2 - Mixing ash with seed and pulp and extracting (equal volume)

E_3 - Rubbing pulp + seed on rough surface and extracting

E_4 - Fermenting pulp + seed for one day and extracting

E_5 - Soaking in water for 12 h and extracting

E_6 - Acid extraction (fruit pulp + seed treated with concentrated HCl @ one per cent weight of the pulp, mixed thoroughly and kept for 30 minutes.

The seeds extracted by different extraction treatments were washed under running tap water to remove the adhering pulp in all the treatments and also to remove ash or acid in the case of treatments E_2 and E_6. Then the seeds were dried under sun avoiding peak hours of sunshine (12 noon to three p.m.). (drying time - 6 hours)

3.2.1 Observations recorded

3.2.1.1 Germination percentage

Twenty seeds from each replication of the six extraction treatments were placed in sterilized sand medium and allowed to germinate under ambient conditions. The seedlings were watered daily and evaluated on the fourteenth day after placing for germination and the total number of normal seedlings were recorded. The germination percentage was calculated.

3.2.1.2 Speed of germination

From the samples kept for germination, the number of seedlings emerged was recorded daily until the final count day (14 days after sowing). The speed of germination was then calculated by adding the quotients of the daily count divided by the number of days of germination (Agrawal, 1980).

3.2.1.3 Root length of seedling

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

3.2.1.4 Shoot length of seedling

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

3.2.1.5 Vigour index of seedlings

Vigour Index (VI) was computed adopting the following formula (Abdul-Baki and Anderson, 1970).

VI = Germination percentage x (mean length of root and shoot in centimeters)

3.2.1.6 Seedling dry weight

Five normal seedlings after measuring their length were air dried first for six h and then in hot air oven maintained at 85°C for 24 h. Then the dry weight of seedlings was recorded in g and the average worked out.

3.2.2 Statistical analysis

The data evolved from the experiment were subjected to ANOVA technique as applied to Completely Randomised Design described by Cochran & Cox (1965).

3.3 Standardization of seed drying and storage methods

Mature fruits of uniform size were selected and seeds were extracted after fermenting the seed along with pulp for one day. The seeds were subjected to different drying treatments.

A. Drying methods

Treatments

D1 - Drying fully under shade (18 hours)

D2 - Drying fully under direct sun (9 hours)

D3 - Drying in direct sun avoiding peak hours (12 noon to three p.m.) (6 hours)

D4 - Artificial drying in a seed drier (40°C for 8 hours)

The seeds dried by the above methods were kept in different containers for three months.

B. Seed containers

C1 - Butter paper cover

C2 - Polythene bag (700 gauge)

C3 - Cloth bag

C4 - Mud pots

C5 - Metal tin

Thus a total number of 20 treatment combinations (four methods of seed drying and five treatments of seed containers) were compared in two replications.

3.3.1 Observations recorded

3.3.1.1 Germination percentage

A total number of 2x10 seeds from each treatment was kept for germination. The germination percentage was recorded as described under item 3.2.1.1. The germination percentage was noted at 30 days interval during storage.

3.3.1.2 Speed of germination

From the samples kept for germination, number of seedlings emerged were recorded daily upto the final count day (14 days after sowing) and the speed of germination was estimated as described under item 3.2.1.2.

3.3.1.3 Root length of seedling

Recorded as detailed under item 3.2.1.3.

3.3.1.4 Shoot length of seedling

Recorded as detailed under item 3.2.1.4.

3.3.1.5 Vigour index of seedling

Recorded as detailed under items 3.2.1.6.

3.3.1.6 Seedling dry weight

Recorded as detailed India item 3.2.1.6.

3.3.1.7 Electrical conductivity of seed leachate

(Presley, 1958)

From each treatment 2x10 seeds were separated and washed in distilled water. The seeds were then soaked in 20 ml of distilled water for four hours, by occasionally stirring the contents. Then the seed leachate was decanted and seeds were washed with distilled water and all seed leachate was collected. Then the seed leachate was filtered and made upto 50 ml. The electrical conductivity of seed leachate was measured in a digital conductivity meter (Model MSW-554) with cell constant of electrode, one. The E.C. of seed leachate was expressed in mmhos cm^{-1}. EC was estimated at 30 days interval.

3.3.1.8 Hydrogenase enzyme activity

Hydrogenase activity was measured as per the procedure suggested by Kittock and Law (1968). For measuring hydrogenase enzyme activity, two replicates of 10 seeds from each treatment were soaked in distilled water overnight to allow imbibition. The next day seed coat was removed carefully and cotyledons were split longitudinally and placed in 10 ml of 0.5 per cent tetrazolium solution for four hours for the development of red coloured formazan. Then excess tetrazolium solution was decanted and seeds were washed thoroughly in distilled water. Red coloured formazan was extracted in 20 ml methyl cellosolve (2-methoxy ethanol) by soaking the cotyledon for 22 h until the cotyledons became colourless. Then the red coloured methyl cellosolve was made upto 20 ml and absorbance was read at 480 nm in Sepctronic 20 spectrophotometer. The hydrogenase enzyme activity was observed at 45 days and 90 days after storage of seeds.

3.3.2 Statistical analysis

The data obtained from the experiment was analysed using the ANOVA as applied to completely randomised design described by Cochran and Cox (1965).

3.4 The influence of seed position in fruit on seed quality

For this experiment, 30 fruits of uniform size were selected and each fruit was cut into five pieces of equal length and seeds from each piece were extracted separately and labelled. Thus each part of a fruit formed a treatment. So there were five treatments and a total of 30 replications.

3.4.1 Observations Recorded

In this experiment the number of seeds for different treatments were not equal. Hence all the seeds available from each treatment were used for recording the observations.

3.4.1.1 Germination percentage

The seeds were tested for their germination as described under item 3.2.1.1 and the germination percentage worked out.

3.4.1.2 Speed of germination

The seeds obtained from different treatments were tested for their speed of germination as described under item 3.2.1.2.

3.4.1.3 Root length of seedling

Recorded as detailed under item 3.2.1.3.

3.4.1.4 Shoot length of seedling

Recorded as detailed under item 3.2.1.4.

3.4.1.5 Vigour Index of seedling

Recorded as detailed under item 3.2.1.5.

3.4.1.6 Seedling dry weight

Recorded as detailed under item 3.2.1.6.

3.4.2 Statistical analysis

Since all the fruits when cut equally into five portions did not provide seeds, the data were subjected to ANOVA as applied to completely randomised design with unequal replications.

Plate No. 1 A general view of the crop

Plate No. 2. Stage of harvest of green fruits


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Plate No. 3. Stage of harvest of ripe fruits

Plate No. 4, A fruit cut into five equal pieces exposing the seed positions

RESULTS

RESULTS

The research programme entitled seed yield and quality in bittergourd (*Momordica charantia* L.) as influenced by vegetable harvests was carried out at the Instructional Farm attached to the College of Agriculture during the period 30th January to 30th April, 1998 with the objectives of finding out the influence of vegetable harvests on seed yield and quality, the effect of different seed extraction, drying methods and storage containers and position of seed in fruit on seed and seedling attributes in bittergourd.

4.1 Experiment I. Effect of vegetable harvesting on the seed yield and quality

The results regarding the effect of vegetable harvests on the growth, seed yield and quality of bittergourd are given in Tables 2 to 8.

4.1.1 Growth characters

4.1.1.1 Length of main vine

The mean vine length of the plants recorded after final harvest are presented in Table 2.

Table 2 Length of main vine and number of branches plant^{-1} as influenced by vegetable harvests

Treatments	Main vine length (m)	Number of main branches plant^{-1}
H1	4.19	8.88
H2	4.81	12.63
H3	4.93	12.63
H4	5.06	11.00
H5	5.11	13.50
F (4,12)	5.15*	3.51*
SE	0.16	0.98
CD	0.48	3.01

* Significant at 1% level

Length of main vine was significantly influenced by the different vegetable harvests. The highest vine length (5.11 m) was recorded for the treatment involving four vegetable harvests (H_5). This was however on par with all other vegetable harvests except H_1, where no vegetable harvesting was done. The treatment H_1 had shortest vines compared to all other treatments.

4.1.1.2 Number of main branches plant^{-1}

The data on the number of main branches recorded at the final harvest stage are given in Table 2.

The vegetable harvests treatments showed significant influence on the number of main branches plant^{-1}. The treatment having four vegetable harvests (H_5) recorded the highest value of 13.5 and was on par with one (H_2) and two (H_3) vegetable harvests. The lowest number of main branches was observed for zero vegetable harvest (H_1) which was on par with three vegetable harvests (H_4).

4.1.1.3 Leaf Area Index (LAI)

The data on LAI was recorded at two stages viz. after two vegetable harvests and last vegetable harvest. The data are presented in Table 3.

Table 3 LAI as influenced by vegetable harvests

Treatments	LAI after second harvest	LAI after the final harvest
H1	1.23	0.92
H2	1.52	1.43
H3	1.71	1.43
H4	1.33	1.36
H5	1.75	1.72
F (4,12)	4.25*	6.07**
SE	0.11	0.12
CD	0.34	0.36

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

Vegetable harvests significantly influenced the LAI. The highest value was obtained for H_5 (four vegetable harvests) at both the stages which was on par with H_2 and H_3 at the first stage and H_2, H_3 and H_4 at the last vegetable harvest stage. Lowest value was obtained for zero vegetable harvest (H_1) which was on par with one (H_2) and three (H_4) vegetable harvests at the first stage and significantly inferior to all other treatments at the last stage of vegetable harvest.

4.1.2 Yield observations

4.1.2.1 Length and girth of green fruit

The mean length and girth of fruits are given in Table 4.

It is evident from the table that neither the length nor the girth of green fruits varied significantly with vegetable harvests. However, minimum (one) vegetable harvest (H_2) showed shortest fruits with minimum girth. The longest fruits (18.91 cm) were obtained for H_5 (four vegetable harvests).

4.1.2.2 Number of green fruits plant^{-1}

The mean number of green fruits plant^{-1} are presented in Table 4.

The vegetable harvests significantly influenced the number of green fruits plant^{-1}. The number of green fruits increased with increasing vegetable harvests with H_5 (four vegetable harvests) recording significantly higher value (16.88). H_2 (one vegetable harvest) recorded significantly lower number (2.25).

4.1.2.3 Number of green fruits ha^{-1}

The mean number of green fruits ha^{-1} are furnished in Table 4.

Vegetable harvests showed significant influence on the number of green fruits ha^{-1}. It increased significantly with increase in the vegetable harvests and H_5 recorded the maximum number of 32708.33 green fruits ha^{-1}.

4.1.2.4 Green fruit yield plant^{-1}

The mean green fruit yield plant^{-1} are presented in Table 4.

The green fruit yield plant^{-1} was significantly affected by different vegetable harvests. As expected, with increase in the number of vegetable harvests the weight of green fruit plant^{-1} also increased. Significantly highest (2505.00 g) and lowest (300.00 g) values were obtained for the maximum (H_5) and minimum (H_2) number of vegetable harvests, respectively.

Table 4 Green fruit yield and yield attributes as influenced by vegetable harvests

Treat-ments	Length of fruit (cm)	Girth of fruit (cm)	No. of green fruits $plant^{-1}$	No.of green fruits ha^{-1}	Weight of green fruits $plant^{-1}$(g)	Weight of green fruits ha^{-1}(kg)
H2	16.30	14.78	2.25	5104.17	300.00	672.92
H3	16.77	15.67	7.13	10625.01	922.50	1622.92
H4	16.38	15.06	9.13	21145.83	1297.50	2796.88
H5	18.91	15.56	16.88	32708.33	2505.00	5141.67
F(3,9)	1.80^{ns}	0.96^{ns}	58.65^{**}	19.52^{**}	39.53^{**}	17.90^{**}
SE	0.92	0.43	0.64	2757.74	147.70	455.91
CD	-	-	2.55	8821.86	472.48	1458.42

ns - not significant
** - Significant at 1% level

4.1.2.5 Green fruit yield ha^{-1}

The mean green fruit yield ha^{-1} are presented in Table 4.

The effect of vegetable harvests on the green fruit yield ha^{-1} was highly significant. The highest yield of 5141.67 kg was obtained for four vegetable harvests (H_5). The lowest value was recorded for one vegetable harvest (H_2) which was on par with two vegetable harvests (H_3).

4.1.2.6 Number of ripe fruits $plant^{-1}$

The data on number of ripe fruits $plant^{-1}$ are presented in Table 5.

The number of ripe fruits $plant^{-1}$ was highest (23.38) for the treatment involving two vegetable harvests (H_3). The treatment with a single vegetable harvest (H_2) also produced almost equal number of ripe fruits (22.60). But all other treatments were significantly inferior to H_3 and H_2. As expected, the ripe fruits $plant^{-1}$ was lowest for H_5 where green fruits were harvested for four times.

4.1.2.7 Number of ripe fruits ha^{-1}

The mean number of ripe fruits ha^{-1} are given in Table 5.

The treatments differed significantly in the number of ripe fruits ha^{-1}. It was maximum in H_2 (48020.84) where vegetable harvests was done only ones closely followed by H_3 (44479.17) with two vegetable harvests. These treatments were significantly superior to all others, which were on par with each other. Here also the lowest value was observed for the treatment with maximum vegetable harvests (H_5) as in the case of ripe fruits $plant^{-1}$.

4.1.2.8 Ripe fruit yield $plant^{-1}$

The mean weight of ripe fruits $plant^{-1}$ are presented in Table 5.

Ripe fruit yield $plant^{-1}$ was significantly influenced by vegetable harvesting treatments. The weight of ripe fruits $plant^{-1}$ showed an increasing trend upto two vegetable harvests (H_3) with the highest value of 3560.30 g $plant^{-1}$. This was on par with H_2 but significantly superior to H_1, H_4 and H_5. Four vegetable harvests recorded the lowest value of only 1473.13 g $plant^{-1}$ which was on par with H_4 but significantly inferior to H_1 (zero vegetable harvest).

4.1.2.9 Ripe fruit yield ha^{-1}

The mean yield of ripe fruits are given in Table 5.

The same trend for the weight of ripe fruits $plant^{-1}$ was observed for the ripe fruit yield ha^{-1} also.

Table 5 Ripe fruit number and yield as influenced by vegetable harvest

Treatment	No. of ripe fruits $plant^{-1}$	No. of ripe fruits ha^{-1}	Weight of ripe fruits $plant^{-1}$ (g)	Weight of ripe fruit ha^{-1} (kg)
H1	14.25	31145.84	2348.25	4318.44
H2	22.63	48020.84	3121.88	6373.54
H3	23.38	44479.17	3560.30	7822.82
H4	14.38	27291.67	1910.10	3455.05
H5	11.88	26458.33	1473.13	2733.91
F(4,12)	17.38**	21.53**	13.10**	16.05**
SE	1.27	2169.46	236.70	526.93
CD	3.92	6685.35	729.42	1623.78

** Significant at 1% level

4.1.2.10 Days to fruit harvest

The mean number of days from anthesis to green as well as ripe fruit harvests are presented in Table 6.

Days from anthesis to fruit harvest was not influenced appreciably by the different vegetable harvest treatments in case of both green as well as ripe fruits.

4.1.2.11 Total crop duration

The total crop duration was uniform for all the treatments, taking 90 days.

4.1.3 Seed characters

4.1.3.1 Number of seeds fruit^{-1}

The mean number of seeds fruit^{-1} are presented in Table 7.

Seeds fruit^{-1} was significantly influenced by the number of vegetable harvests. The highest value (21.61) was obtained for zero vegetable harvest (H_1) which was on par with H_3 and H_2 (two and one vegetable harvests, respectively) and the lowest (15.47) for four vegetable harvests (H_5).

4.1.3.2 Weight of seeds fruit^{-1}

The mean weight of seeds fruit^{-1} are given in Table 7.

Table 6 Number of days from anthesis to green and ripe fruit harvests influenced by vegetable harvests

Treatments	Days from anthesis to green fruit harvest	Days from anthesis to ripe fruit harvest
H_1	-	18.93
H_2	12.49	19.65
H_3	11.88	19.65
H_4	11.90	19.36
H_5	11.85	19.07
F value	0.42^{ns}	0.69^{ns}
SE	0.47	0.40
CD	1.51	1.23

ns - not significant

The mean weight of seeds fruit^{-1} was also appreciably modified by the vegetable harvest treatments and the trend was the same as with number of seeds fruit^{-1}.

4.1.3.3 Fruit to seed ratio

The data on the mean fruit to seed ratio are furnished in Table 7.

The vegetable harvests showed no significant variation in fruit to seed ratio. However, the zero vegetable harvest recorded the lowest fruit to seed ratio.

4.1.3.4 Pulp to seed ratio

The data on mean pulp to seed ratio are depicted in Table.

The pulp to seed ratio was also not significantly affected by the number of vegetable harvests.

4.1.3.5 Seed yield plant^{-1}

The mean seed yield plant^{-1} are given in Table 7.

Seed yield plant^{-1} varied significantly with vegetable harvests. It increased with increase in number of vegetable harvests upto two (H_3) and then decreased with further increase in vegetable harvests. The highest value of 97.19 g of seed plant^{-1} was recorded by H_3 which was significantly superior to all other treatments except H_2.

Table 7 Fruit to seed and pulp to seed ratios, number and weight of seeds $fruit^{-1}$ and seed yield as influenced by vegetable harvests

Treatment	Fruit to seed ratio	Pulp to seed ratio	No. of seeds per fruit	Weight of seeds per fruit	Seed yield per plant (g)	Seed yield per hectare (kg)
H_1	28.47	7.65	21.61	4.56	67.81	169.53
H_2	32.84	8.59	18.65	3.84	84.38	210.94
H_3	36.01	8.10	21.08	4.34	97.19	242.97
H_4	33.82	8.07	17.79	3.69	53.75	134.38
H_5	34.68	8.05	15.47	3.39	40.31	100.79
$F_{4,12})$	1.84^{ns}	0.39^{ns}	4.52^{*}	4.45^{*}	10.46^{**}	10.46^{**}
SE	2.12	0.54	1.18	0.23	7.06	17.68
CD	-	-	3.64	0.699	21.77	54.42

ns - not significant
* - Significant at 5% level
** - Significant at 1% level

4.1.3.6 Seed yield hectare^{-1}

Data on seed yield hectare^{-1} are given in Table 7.

The per hectare seed yield was also significant due to the vegetable harvests and followed the same trend as in the case seed yield fruit^{-1}. The highest seed weight hectare^{-1} was recorded for H_3 (242.97 g).

4.1.3.7 100 seed weight

The mean of 100 seed weights are presented in Table 8.

The vegetable harvests significantly influenced the 100 seed weight. Two vegetable harvests had the highest value (21.48) which was on par with zero vegetable harvest (21.24). H_4 recorded the lowest value.

4.1.3.8 Germination percentage

The data on mean germination percentage are given in Table 8.

The germination percentage was not significantly affected by number of vegetable harvests.

4.1.3.9 Economics of cultivation

The data on net income and B.C. ratio are given in Table 9.

Table 8 Hundred seed weight and germination percentage as influenced by vegetable harvests

Treatment	100 seed weight(g)	Germination percentage
H_1	21.24	90.00 (9.48)
H_2	20.76	88.75 (9.41)
H_3	21.48	91.25 (9.53)
H_4	20.38	87.50 (9.34)
H_5	20.75	91.25 (9.54)
$F_{(4,12)}$	5.57^{**}	0.073^{ns}
SE	0.18	0.30
CD	0.57	-

** Significant at 1% level
ns not significant
() square root transformed values

Table 9 Economics of cultivation (Rs. ha^{-1})

Treatment	Cost of cultivation	Gross income	Net income	Benefit-cost ratio
H_1	75033.00	119354.38	44321.38	1.59
H_2	101633.00	153712.51	52079.51	1.51
H_3	108733.00	184684.38	75951.38	1.70
H_4	85033.00	119234.40	34201.40	1.40
H_5	84633.00	128812.47	44179.47	1.52
F (4,12)			1.52^{ns}	0.63^{ns}
SE			12747.55	0.14

There was no significant variation among the net income and B.C. ratio due to the different vegetable harvest treatments tried. However, highest net income (Rs.75951.38) as well as B.C. ratio (1.7) were obtained for H_3 (two vegetable harvests).

4.2 Experiment II Standardization of seed extraction methods

The results on the effect of seed extraction methods on seed and seedling character in bittergourd are presented in this section.

4.2.1 Germination percentage

The mean germination percentage of seeds as influenced by different extraction methods are presented in Table 10.

Extraction methods exerted profound influence on the germination percentage of seeds. The highest value of 95.0 per cent was obtained for the treatment in which seeds were soaked in water for 12 h and then extracting (E_5) and was significant with all other methods except E_3 (rubbing seed plus pulp on rough surface and extracting). All other methods were found to be on par with each other. However, the lowest germination percentage of 77.5 per cent was obtained for seeds extracted by mixing ash with pulp and seed and extracting (E_2).

4.2.2 Speed of germination

The data on speed of germination of seeds are presented in Table 10.

The different extraction methods showed significant influence on the speed of germination of seeds. As in the case of germination percentage, the speed of germination was highest for the treatment E_5 (Soaking in water for 12 h) and extracting) and the lowest was for the treatment in which the seeds were separated by mixing seed and pulp with ash (E_2) which was on par with treatments E_1 (manual extraction) and E_6 (acid extraction).

4.2.3 Seedling root length

The mean root length of seedlings are presented in Table 10.

The seedling root length was also influenced by the different extraction methods significantly. The highest value (16.58) was recorded for seeds from soaking in water for 12 h and extracting (E_5) and was significantly superior to all other treatments except acid extraction (E_6). Seeds obtained from the treatment, fermenting pulp plus seed for one day and extracting (E_4) recorded the lowest root length.

4.2.4 Seedling shoot length

The mean seedling shoot length are given in Table 10.

The influence of different extraction methods on seedling shoot length was not significant. However, the highest shoot length was recorded for seeds obtained from E_5 (soaking in water and extracting).

4.2.5 Seedling Vigour Index (VI)

The data on mean VI values are furnished in Table 10.

The effect of different extraction methods on the VI was highly significant. As in the case of other seedling characters, VI was also highest for E_5 (3642.25). All other extraction methods were on par with each other. However, the lowest value was observed for E_2 (mixing with ash and extracting).

4.2.6 Seedling dry weight

The mean dry weight of seedlings are presented in Table 10.

Different extraction methods did not exert any appreciable influence on the seedling dry weight. The dry weight ranged from 0.158 g to 0.132 g recording the highest for E_5 and lowest for E_3.

Table 10 Effect of seed extraction methods on seed and seedling characters

Treatment	Germination (%)	Speed of germination	Seedling root length cm	Seedling shoot length cm	Vigour Index	Seedling dry weight g
E_1	83.75 (9.15)	3.22	12.55	19.45	2668.75	0.139
E_2	77.50 (8.80)	2.99	13.55	20.33	2629.00	0.139
E_3	87.50 (9.35)	3.97	13.98	19.88	2954.50	0.132
E_4	82.50 (9.08)	4.01	12.51	20.64	2746.25	0.148
E_5	95.00 (9.75)	4.90	16.58	21.73	3642.25	0.158
E_6	78.75 (8.87)	3.13	14.98	20.95	2828.25	0.142
$F_{(5,15)}$	3.15^{*}	6.45^{**}	4.24^{*}	0.44^{ns}	5.10^{**}	2.276^{ns}
SE	0.19	0.29	0.76	1.22	166.81	0.005
CD	0.59	0.87	2.28	-	502.71	-

* Significant at 5% level
** Significant at 1% level
ns not significant
() Square root transformed value

4.3 Experiment III Standardization of drying and storage methods

In this experiment the seeds dried under four different methods were stored in five different containers. Observations on germination percentage, speed of germination, root and shoot lengths of seedlings, Vigour Index, seedling dry weight, electrical conductivity of seed leachate and hydrogenase enzyme activity at one, two and three months after storage (MAS) were taken and presented in Tables 11 to 17.

4.3.1 Germination percentage

The data on mean germination percentage taken after one, two and three months of storage are depicted in Table 11.

The effect of different drying methods was not significant on the germination percentage after one and two months of storage. However, drying exerted profound influence on germination percentage after three months of storage. At this stage, the highest germination percentage (53.12) was recorded by seeds dried under direct sun avoiding peak sunshine hours (D_3) which was on par with drying fully under direct sun (D_2) and drying in artificial drier (D_4). Lowest germination percentage was recorded by drying fully under shade (D_1).

The different storage containers caused significant influence on germination percentage in all the three months of

Table 11 Effect of drying methods and storage containers on germination percentage of seeds

Treatments	Germination percentage		
	1 MAS	2 MAS	3 MAS
Drying			
D_1	69.63 (56.56)	58.42 (49.85)	41.52 (40.12)
D_2	73.63 (59.10)	63.77 (52.99)	48.92 (44.38)
D_3	73.98 (59.33)	69.71 (56.61)	53.12 (46.79)
D_4	72.87 (58.61)	58.79 (50.06)	46.86 (43.20)
F(3,20)	0.20^{ns}	2.07^{ns}	3.66^{*}
SE	2.83	2.20	1.45
CD	-	-	4.27
Containers			
C_1	67.97 (55.53)	60.82 (51.25)	55.05 (47.90)
C_2	86.11 (68.12)	79.05 (62.76)	66.48 (54.62)
C_3	70.38 (57.03)	52.74 (46.57)	29.73 (32.04)
C_4	61.30 (51.53)	48.60 (44.20)	35.97 (36.85)
C_5	74.68 (59.79)	70.51 (57.11)	51.22 (45.70)
F(4,20)	3.84^{*}	9.56^{**}	28.72^{**}
SE	3.16	2.46	1.62
CD	9.33	7.27	4.78

ns - not significant
( ) - angular transformed values
* - significant at 5% level
** - significant at 1% level

storage. After one and two months of storage the highest germination percentages were recorded by seeds kept in polythene bag (C_2) which was on par with metal tin (C_5). The lowest percentage was for seeds stored in mudpot (C_4) which was on par with butter paper cover (C_1) and cloth bag (C_3). Three MAS also the seeds kept in polythene bags showed the superiority over all other treatments recording the highest germination percentage of 66.25. Storing the seeds in cloth bags recorded the lowest germination of only 30 per cent and this was on par with mud pot storage.

Interaction of drying methods and storage containers was not significant.

4.3.2 Speed of germination

The data on mean speed of germination in the three months of storage are presented in Table 12.

Speed of germination was influenced significantly by drying. The influence of drying methods on the speed of germination of bittergourd seeds followed almost the same pattern in all the three months of storage. The highest value was recorded for seeds dried under direct sun avoiding peak hours (D_3), which was on par with seeds dried fully under direct sun (D_2) but significantly superior to all others. The slowest rate of germination was recorded for D_1 (drying fully under shade) in all the three stages.

Table 12 Effect of drying methods and storage containers on the speed of germination of seeds

Treatments	Speed of germination		
	1 MAS	2 MAS	3 MAS
Drying			
D_1	1.210	0.926	0.668
D_2	1.593	1.242	0.776
D_3	1.783	1.342	0.915
D_4	1.346	1.059	0.756
F(3,20)	4.240^{*}	3.874^{*}	3.742^{*}
SE	0.124	0.094	0.053
CD	0.366	0.278	0.156
Containers			
C_1	1.320	1.127	0.928
C_2	1.897	1.372	1.079
C_3	1.413	1.039	0.472
C_4	1.365	0.962	0.606
C_5	1.420	1.210	0.809
F(4,20)	2.871^{ns}	2.267^{ns}	16.963^{**}
SE	0.139	0.106	0.050
CD	0.409	-	0.174

ns - not significant
* - significant at 5% level
** - significant at 1% level

The different containers used also influenced the speed of germination appreciably after one and three months of storage. Polythene bag (C_2) recorded the highest speed of germination in all the three MAS. It differed significantly from all other treatments one MAS and was on par with butter paper cover (C_1) at three MAS. The lowest value was recorded by butter paper cover (C_1), mud pot (C_4) and cloth bag (C_3) at one, two and three MAS, respectively.

The interaction effect DXC was not significant in all the three months of storage.

4.3.3 Seedling root length

The data on the mean seedling root lengths are furnished in Table 13.

The seedling root length did not differ significantly after one and three months of storage but, showed significant variation at two MAS due to drying. After two months of storage D_1 (drying fully under shade) recorded the longest roots (10.14 cm) and was on par with D_3 and D_4. D_2 (drying fully under direct sun) recorded the shortest roots.

The effect of storage containers on root length was significant at two and three months of storage. At both these stages, butter paper cover (C_1) recorded the longest roots

Table 13 Effect of drying methods and storage containers on seedling root length

Treatments	Seedling root length (cm)		
	1 MAS	2 MAS	3 MAS
Drying			
D_1	10.05	10.14	10.15
D_2	9.37	8.36	10.79
D_3	9.41	9.81	10.23
D_4	10.24	9.08	10.63
F(3,20)	0.66^{ns}	3.66^{*}	0.77^{ns}
SE	0.55	0.41	0.35
CD	-	1.22	
Containers			
C_1	9.89	10.69	11.59
C_2	10.81	9.73	11.08
C_3	8.75	7.58	9.71
C_4	9.61	8.39	9.58
C_5	9.77	10.36	10.30
F(4,20)	1.43^{ns}	8.23^{**}	4.88^{**}
SE	0.61	0.46	0.39
CD	-	1.36	1.16

ns - not significant
* - significant at 5% level
** - significant at 1% level

and cloth bag (C_3) and mud pot (C_4) the lowest after two and three months of storage, respectively. However, the C_1 was statistically similar to C_5 at two MAS and to C_2 at three MAS.

DxC interaction had no significant influence on seedling root length at any of the three stages.

4.3.4 Seedling shoot length

The mean shoot length of seedling are presented in Table 14.

Drying methods could not influence in the seedling shoot length at any stage of seed storage.

The storage containers appreciably influenced the seedling shoot length at one and two MAS. Whereas, it was not significant after three months. The longest shoot was recorded for C_2 (polythene bags) in all the three stages (24.43, 22.77 and 21.04 cm, respectively) and shortest for C_3 (cloth bag). C_2 was significantly superior to all other treatments at two MAS but was on par with C_5 (metal tin) at one MAS.

The interaction effect was not significant

4.3.5 Vigour Index (VI)

The data on the mean VI values are furnished in Table 15.

Table 14 Effect of drying methods and storage containers on seedling shoot length

Treatments	Seedling shoot length (cm)		
	1 MAS	2 MAS	3 MAS
Drying			
D_1	22.78	20.53	20.21
D_2	22.72	20.35	19.45
D_3	21.52	21.15	20.48
D_4	22.18	19.79	19.27
F(3,20)	1.18^{ns}	1.64^{ns}	1.14^{ns}
SE	0.54	0.44	0.55
CD	-	-	-
Containers			
C_1	21.81	20.55	19.87
C_2	24.43	22.77	21.04
C_3	20.49	18.59	18.85
C_4	21.71	19.84	19.05
C_5	23.05	20.53	20.45
F(4,20)	6.11^{**}	9.77^{**}	2.28^{ns}
SE	0.61	0.49	0.61
CD	1.79	1.44	-

ns - not significant
** - significant at 1% level

Table 15 Effect of drying methods and storage containers on Seedling Vigour Index

Treatments	Vigour Index		
	1 MAS	2 MAS	3 MAS
Drying			
D_1	2272.91	1792.04	1302.70
D_2	2351.59	1825.69	1503.18
D_3	2268.87	2146.16	1637.17
D_4	2316.15	1717.74	1438.65
F(3,20)	0.09^{ns}	2.88^{ns}	2.32^{ns}
SE	130.32	111.61	91.18
CD	-	-	-
Containers			
C_1	2183.48	1885.79	1735.96
C_2	2949.84	2560.71	2131.99
C_3	2036.83	1384.68	862.53
C_4	1919.39	1375.99	1047.66
C_5	2422.38	2144.88	1573.99
F(4,20)	7.83^{**}	16.58^{**}	25.67^{**}
SE	145.70	124.79	101.94
CD	429.83	368.13	300.72

ns - not significant
** - significant at 1% level

Drying treatments had no profound influence on the VI in any of the stages of storage. However, D_2 recorded the highest value (2351.59) at one MAS and D_3 at two and three MAS.

The VI differed significantly due to the storage containers in all three months of storage and C_2 recorded significantly highest value. Lowest value was recorded by C_4 at one and three MAS and by C_2 at two MAS.

DxC exerted no appreciable effect on VI at any stage of storage.

4.3.6 Seedling dry weight

The mean values of seedling dry weight are depicted in Table 16.

Dry weight of seedlings did not vary statistically with different drying methods.

The storage containers caused profound influence on the dry weight at one and two MAS. In both the cases seedling dry weight was highest (0.128 and 0.114 g, respectively) for polythene bag storage (C_2) which was on par with C_1 (butter paper cover). The lowest value of 0.108 g was recorded by mud pot (C_4) and cloth bag (C_3) storage at one MAS. Eventhough, the effect was not appreciable at three MAS, the highest and lowest values were recorded by C_2 and C_4, respectively.

Table 16 Effect of drying methods and storage containers on seedling dry weight(g)

Treatments	Seedling dry weight(g)		
	1 MAS	2 MAS	3 MAS
Drying			
D_1	0.122	0.096	0.101
D_2	0.111	0.104	0.009
D_3	0.115	0.102	0.089
D_4	0.117	0.099	0.098
F(3,20)	3.01^{ns}	2.310^{ns}	1.10^{ns}
SE	0.003	0.002	0.005
CD	-	-	-
Containers			
C_1	0.122	0.106	0.104
C_2	0.128	0.114	0.108
C_3	0.108	0.095	0.092
C_4	0.108	0.087	0.089
C_5	0.117	0.100	0.092
F(4,20)	9.612^{**}	15.833^{**}	2.09^{ns}
SE	0.003	0.003	0.006
CD	0.008	0.008	-

ns - not significant
** - significant at 1% level

Table 16a Combined effect of drying methods and storage containers on seedling dry weight two MAS (g)

Treatments	C_1	C_2	C_3	C_4	C_5	Mean
D_1	0.100	0.108	0.089	0.078	0.105	0.096
D_2	0.112	0.125	0.108	0.086	0.092	0.104
D_3	0.109	0.120	0.086	0.098	0.096	0.102
D_4	0.105	0.103	0.096	0.087	0.107	0.099
Mean	0.106	0.114	0.095	0.087	0.100	

F(12,20)	2.63*
SE	0.005
CD	0.015

* Significant at 5% level

DxC interaction was significant only at two MAS (Table 16a). The highest dry weight (0.125 g) was recorded for seeds kept in polytheneafter drying fully under direct sun which was however, on par with the combination of drying under direct sun avoiding peak hours (D_3) in polythene storage and drying fully under sun in butter paper cover storage. Seeds dried fully under sun and stored in mud pots recorded the lowest value.

4.3.7 Electrical conductivity of seed leachate

The mean electrical conductivity values are given in Table 17.

The effect of drying on electrical conductivity values of seed leachate was not significant after one and two months of storage but, appreciable at three MAS. The electrical conductivity of leachate was lowest (0.129) for D_4 (artificial drier) and was on par with all treatments except D_1 which recorded the highest value at three MAS.

Storage containers exerted profound effect on electrical conductivity of seed leachate at all the stages of storage. Among the containers C_2 (polythene bag) recorded the lowest (0.114, 0.118, 0.118, respectively) electrical conductivity in all the three months of storage but was on par with C_5 (metal tin) and C_1 (butter paper cover) at one MAS and

Table 17 Effect of drying and storage containers on electrical conductivity of seed leachate (mmhos/cm)

Treatments	EC of seed leachate		
	1 MAS	2 MAS	3 MAS
Drying			
D_1	0.124	0.133	0.137
D_2	0.129	0.131	0.135
D_3	0.122	0.129	0.133
D_4	0.124	0.127	0.129
F(3,20)	1.806^{ns}	1.64^{ns}	3.551^{*}
SE	0.002	0.002	0.002
CD	-	-	0.005
Containers			
C_1	0.120	0.126	0.132
C_2	0.114	0.118	0.118
C_3	0.135	0.144	0.147
C_4	0.135	0.136	0.140
C_5	0.120	0.128	0.131
F(4,20)	14.645^{**}	16.350^{**}	28.836^{**}
SE	0.002	0.002	0.002
CD	0.007	0.007	0.006

ns - not significant
** - significant at 1% level
 * - significant at 5% level

Table 17a Combined effect of drying methods and storage containers on EC of seed leachate three MAS (mmhos cm^{-1})

Treatments	C_1	C_2	C_3	C_4	C_5	Mean
D_1	0.139	0.124	0.143	0.145	0.135	0.137
D_2	0.135	0.117	0.154	0.142	0.130	0.135
D_3	0.128	0.119	0.159	0.137	0.123	0.133
D_4	0.129	0.114	0.131	0.136	0.137	0.129
Mean	0.132	0.118	0.147	0.140	0.131	

$F(12,20)$ 3.071*

SE 0.004

CD 0.012

* Significant at 5% level

Table 17b Combined effect of drying methods and storage containers on EC of seed leachate two MAS (mmhos cm^{-1})

Treatments	C_1	C_2	C_3	C_4	C_5	Mean
D_1	0.128	0.121	0.141	0.144	0.133	0.133
D_2	0.113	0.119	0.150	0.130	0.125	0.131
D_3	0.121	0.117	0.157	0.135	0.119	0.129
D_4	0.123	0.114	0.128	0.136	0.133	0.127
Mean	0.126	0.118	0.144	0.136	0.128	

F(12,20)	2.305*
SE	4.980
CD	0.015

* Significant at 5% Level

was significantly lowest at two and three MAS. C_3 (cloth bag) recorded the highest electrical conductivity which was on par with C_4 (mud pot) at one MAS and was statistically highest to all other at two and three MAS.

DxC interaction was appreciable after both two and three months of storage and the mean values are furnished in Tables 17a and 17b, respectively. At both the stages artificial drying and polythene bag combination recorded the lowest value, and drying under direct sun avoiding peak hours and cloth bag combination the highest.

4.3.8 Hydrogenase enzyme activity

The data on hydrogenase enzyme activity or optical density (absorbance) at 45 and 90 DAS (days after storage) are presented in Table 18.

Drying, storage containers as well as DxC interaction caused significant variation in the hydrogenase enzyme activity of seeds.

Drying under direct sun avoiding peak hours (D3) was superior over all other treatments at both 45 and 90 DAS (0.613 and 0.409 respectively). D_2 (drying fully under direct sun) recorded the lowest values (0.537 and 0.333 respectively) but, was statistically on par with D_1 and D_4 at 45 days and to D_1 alone at 90 DAS.

Table 18 Effect of drying methods and storage containers on hydrogenase enzyme activity of seeds

Treatments	Optical density	
	45 DAS	90 DAS
Drying		
D_1	0.546	0.366
D_2	0.537	0.333
D_3	0.613	0.409
D_4	0.544	0.386
F(3,20)	3.146*	5.07**
SE	2.004	0.014
CD	0.059	0.042
Containers		
C_1	0.615	0.431
C_2	0.821	0.489
C_3	0.361	0.285
C_4	0.366	0.305
C_5	0.636	0.358
F(4,20)	76.780**	28.75**
SE	0.022	0.016
CD	0.066	0.047

* - significant at 5% level
** - significant at 1% level

Table 18a Combined effect of drying and storage containers on hydrogenase enzyme activity 45 DAS

Treatments	C_1	C_2	C_3	C_4	C_5	Mean
D_1	0.615	0.720	0.395	0.370	0.630	0.546
D_2	0.570	0.815	0.410	0.340	0.550	0.537
D_3	0.620	0.945	0.315	0.380	0.805	0.613
D_4	0.655	0.805	0.325	0.375	0.560	0.544
Mean	0.615	0.821	0.361	0.366	0.636	

F(12,20)	2.502*
SE	0.045
CD	0.132

* Significant at 5% level

Table 18b Combined effect of drying and storage containers on hydrogenase enzyme activity 90 DAS

Treatments	C_1	C_2	C_3	C_4	C_5	Mean
D_1	0.415	0.510	0.255	0.305	0.345	0.366
D_2	0.390	0.445	0.330	0.220	0.280	0.333
D_3	0.450	0.455	0.330	0.380	0.430	0.409
D_4	0.470	0.545	0.225	0.315	0.375	0.386
Mean	0.431	0.489	0.285	0.305	0.358	

F(12,20)	2.294*
SE	0.032
CD	0.094

* Significant at 5% level

Among the storage containers C_2 (polythene) recorded the highest value while C_3 (cloth bag) recorded the lowest which was on par with C_4 (mud pot).

The combined effect of DxC are presented in Tables 18a and 18b.

Among the different combinations of drying and storage drying under sun avoiding peak hours (D_3) plus polythene bag (C_2) combination recorded the highest (0.945) and D_3 plus cloth bag (C_3) the lowest (0.315) values after 45 days of storage. At 90 DAS, highest and lowest values were recorded by seeds dried in artificial drier (D_4) stored in polythene and seeds dried fully under sun stored in mudpots, respectively.

4.4 Experiment IV Influence of seed position in fruit on seed quality

The results on the effect of seed position in fruit on seed quality of bittergourd are presented below in Tables 19-21.

4.4.1 Germination percentage

The data on the effect of seed position in fruit on germination percentage are presented in Table 19.

Position of seed in fruit influenced the germination percentage remarkably. Seeds from proximal end position (P_1)

Table 19 Effect of seed position in fruit on germination percentage and speed of germination

Treatments	Germination percentage				Speed of germination
P1	39.28 (6.35)				0.209
P2	72.64 (8.58)				0.187
P3	92.61 (9.68)				0.189
P4	90.79 (9.58)				0.186
P5	86.76 (9.37)				0.189
F (4,123)	7.18^{**}				0.333^{ns}
CD (i,j)	1.37				
i from 2 to v	1.37	1.14			
j from 1 to i-1	1.38	1.15	1.15		
	1.44	1.23	1.23	1.24	

() Square root transformed values
** Significant at 1% level
ns not significant

was significantly inferior to all other positions with only 39.28 per cent germination. The seeds from other positions did not differ significantly from each other though the highest germination was obtained for seeds from middle position (P_3) with a value of 92.6 per cent. Germination percentage decreased in seeds from distal portions (P4 and P5) compared to P_3, where as they exceeded that of seeds from P_2 (position immediately above middle).

4.4.2 Speed of germination

The data on speed of germination are furnished in Table 19.

Seed position did not exert any significant influence on the speed of germination.

4.4.3 Seedling root length

The mean seedling root lengths are given in Table 20.

Seedling root length was influenced profoundly by the different positions. P_1 recorded shortest roots (8.83 cm) while seeds from all other positions were statistically on par with each other. The highest value of 11.89 cm was recorded by P_3.

Table 20 Effect of seed position in fruit on root length and shoot length of seedling

Treatments	Root length (cm)				Shoot length (cm)
P1	8.83				19.38
P2	10.78				19.29
P3	11.89				21.15
P4	11.21				20.86
P5	11.17				21.44
F (4,113)	4.04^{**}				1.33^{ns}
CD (i,j), i from	1.57				
2 to v j from	1.54	1.12			
	1.55	1.13	1.10		
1 to i-1	1.61	1.22	1.19	1.20	

** Significant at 1% level
ns not significant

4.4.4 Seedling shoot length

The data on seedling shoot length are presented in Table 20.

The different positions exerted no significant effect on seedling shoot length. It ranged from 19.29 cm (P_2) to 21.44 cm (P_5).

4.4.5 Seedling Vigour Index (VI)

The data on seedling VI are presented in Table 21.

Seedling VI was profoundly influenced by the different positions. Lowest VI was recorded for seeds from P_1 (1615.38). Seeds from all other positions were statistically similar, P_3 having the highest value (3073.02).

4.4.6 Seedling dry weight

The data on seedling dry weight are given in Table 21.

Seed positions in fruit had no significant effect on seedling dry weight.

Table 21 Effect of seed position in fruit on Vigour Index and dry weight of seedling

Treatments	VI	Dry weight (g)
P1	1615.38	0.127
P2	2416.10	0.129
P3	3073.02	0.131
P4	2714.67	0.131
P5	2960.11	0.137
F (4,123)	7.07**	1.104^{ns}
CD (i,j)	592.82	
i from 2 to v	592.82 494.45 596.36 498.69 498.69	-
j from 1 to i-1	623.41 530.73 530.73 534.69	
	1.44 1.23 1.23 1.24	

** Significant at 1% level
ns not significant

DISCUSSION

DISCUSSION

The results of the investigation conducted at the College of Agriculture, Vellayani to assess the vegetable harvests on seed yield and quality, the influence of seed extraction, drying methods and storage containers and also influence of seed position in fruit on various seed and seedling attributes of bittergourd are discussed below.

Vegetable harvests had significant influences on growth and yield of bittergourd. Seed and seedling characters varied widely due to the different extraction and drying methods and storage containers used. The seed position in fruit affected the germination percentage, seedling root length and vigour index.

5.1 Effect of vegetable harvests on the growth of plant, fruit and seed yields

Increase in number of vegetable harvests caused elongation of vine. Proportionate increase in vine length was noticed with increasing vegetable harvests, the longest vine (5.11 m) being in H_5 (four vegetable harvests) and the shortest (4.19 m) in H_1 (zero vegetable harvest). This may be due to the stimulation of the apical growth of plants with perioridic removal of fruits, by which the photosynthates got translocated to the growing tips instead of accumulating in the developing fruits. Sheeba's (1995) report in bhindi is in uniformity with the present finding. Garris and Hoffman (1946) reported that plant height in bhindi is checked if the oldest pods are not removed often, which explains for the significantly lowest vine length for zero vegetable harvest.

Similarly the number of main branches plant^{-1} was affected by vegetable harvests the same way as in the case of vine length with the maximum and minimum vegetable harvests recording the highest and lowest values, respectively.

Increasing the number of vegetable harvests increased the LAI of the crop recording the highest for the treatment with four vegetable harvests and lowest for zero vegetable harvest. Expansion of leaf area is also reported to be a reflection of the positive influence of periodic removal of fruits (Sheeba, 1995). Bhuibar *et al*. (1989) observed production of more number of leaves with periodic picking of green fruits in bhindi. If a sink is available, the plants in general show a tendency to translocate the photosynthates to the sink and not to the source. In zero vegetable harvest, since the fruits (sink) are not periodically removed, the photosynthates always get accumulated in fruits and only less amount of photosynthates will be available for source development.

An appraisal of the LAI values between the two stages of observation showed a general decline in the second stage. This was mainly due to the defoliation towards the maturity of the plant. This decrease at the second phase was however, greatest for the zero vegetable harvest owing to the excessive defoliation caused from the early senescence of leaves as observed for the treatment.

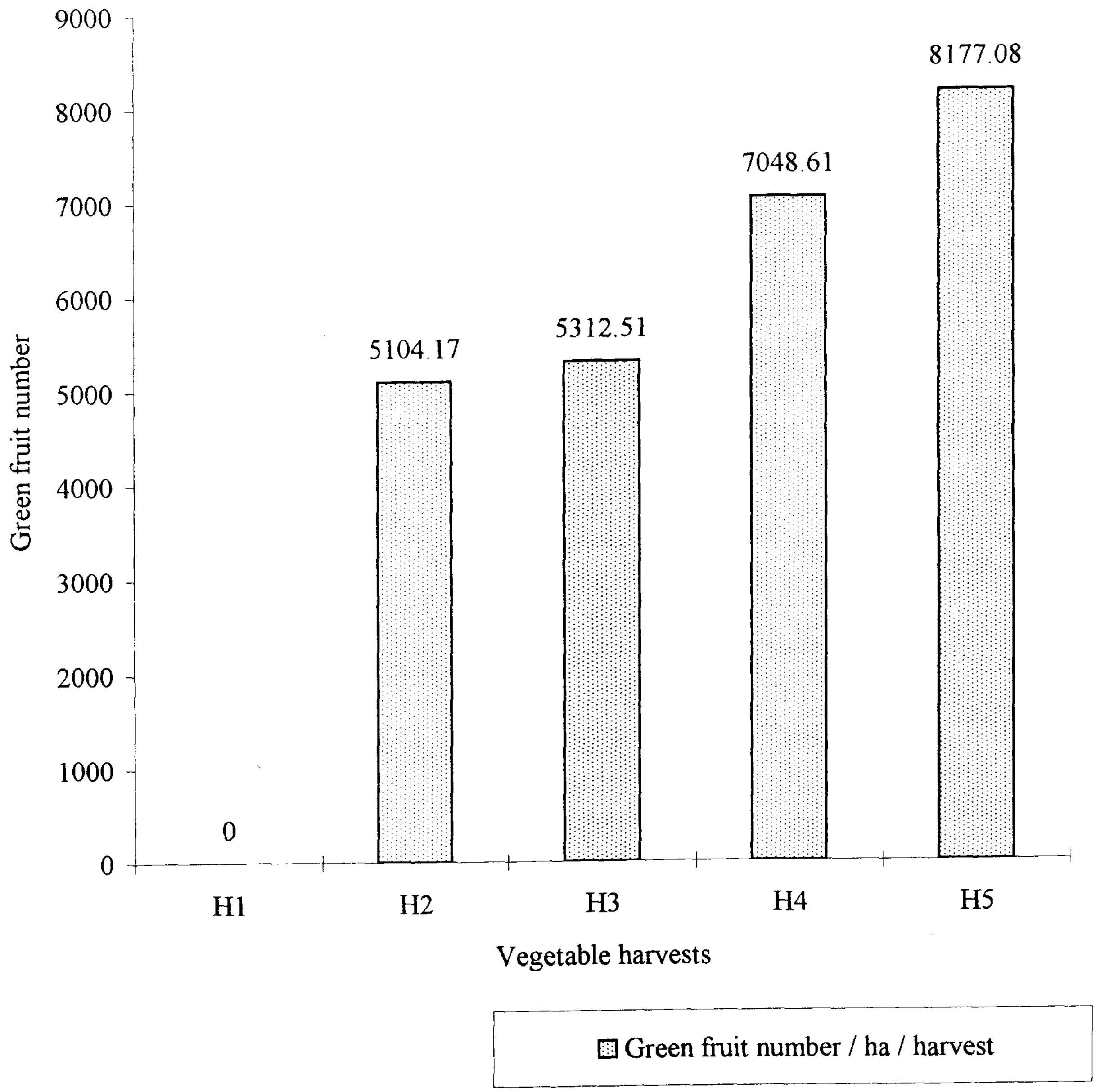
The vegetable harvests did not exert any significant influence on length and girth of fruits. The highest fruit length (18.91 cm) was recorded for four vegetable harvests (H_5) and the lowest (16.30) for one vegetable harvest (H_2). H_5 only could exhibit a fruit length of above 18 cm which is the average fruit length reported for the variety 'Preethi'. All other treatments produced fruit lengths below the average reported for the variety. At the fourth vegetable harvesting stage the plant might have entered the grand growth phase which resulted in the production of maximum photosynthates and hence accumulation and translocation of more photosynthates to the fruit which caused the increased length of fruits. Since the fruits picked in the single vegetable harvest were produced at the initial growth phase of the plant, the photosynthate accumulation was lesser and hence they exhibited lowest length and girth as compared to the fruits picked at later stages. Sheeba (1995) also reported better fruit length for bhindi harvested at the peak growth phase of the crop.

A sharp increase in the number of green fruits $plant^{-1}$ as well as ha^{-1} was observed with increased vegetable harvests. This is in accordance with the works of Perkins *et al.* (1952), Madhava Rao (1953), Khalil and Hamid (1964), Kolhe and Chavan (1967) and Grewal *et al.* (1974) in bhindi. Developing and maturing fruits have an inhibitory effect on further development of flowers and fruits. In those crops where immature fruits are harvested at vegetable stage, this inhibitory mechanism will not be perceptible but in crops where ripe fruits are harvested this will be obvious. The vine strikes physiological balance at the threshold limit of maximum fruits that it can carry to maturity. That is why the number of fruits per vine in a seed crop will be less (Seshadri, 1993).

Single vegetable harvest could produce only 672.92 green fruits $hectare^{-1}$. This goes on increasing with increase in vegetable harvests and for the treatment involving four vegetable harvests the number of fruits produced was 5141.67, showing 86.91 per cent increase over the treatment H_2 (one vegetable harvest). The average fruit number per harvest (Fig. 2) also followed the similar pattern, substantiating the direct effect of continuous harvest on further production of fruits.

The trend of green fruit yield ha^{-1} as well as $plant^{-1}$ was the same as that for green fruit number. This is in accordance with the work of Sheeba (1995)in bhindi. The weight of green fruit was maximum for four vegetable harvests.

Fig. 2 Average green fruit number per harvest as infleunced by vegetable harvests

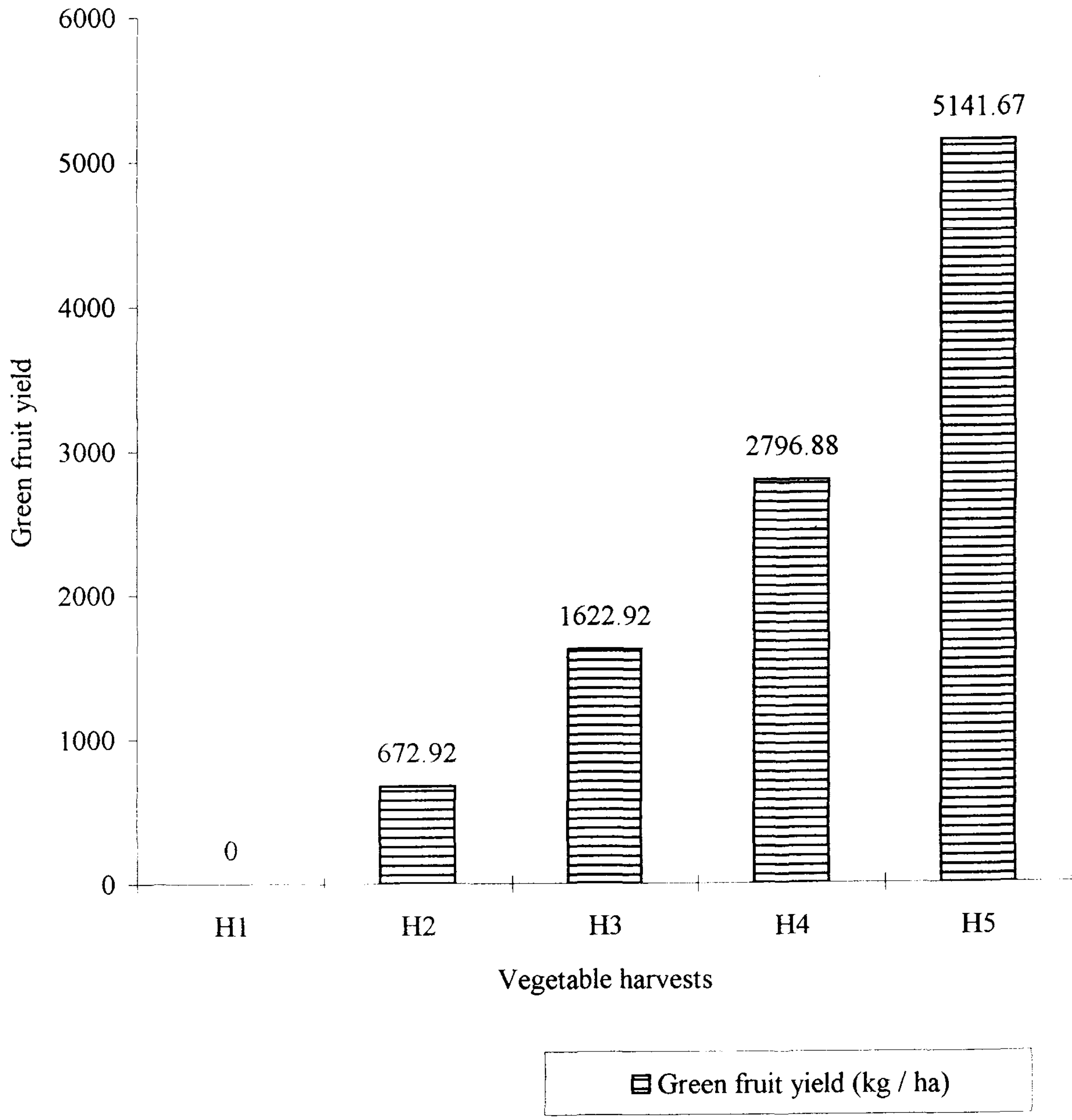


The increase in green fruit yield with increase in vegetable harvests was also reported by Madhava Rao (1953) and Bhuibar *et al*. (1989) in bhindi. According to Robinson and Decker-Walters (1997), the periodic removal of the fruits make the cucurbits more productive when grown for immature fruits. They suggested that fruits act as a sink for nutrients and inhibit the development of additional fruits on the plant if not removed.

The number and weight of mature fruits plant^{-1} as well as ha^{-1} increased upto two vegetable harvests and they decreased with further increase in number of vegetable harvests. The mature fruit weight ha^{-1} was maximum (7822.82 kg) for the treatment H_3, which involved two vegetable harvesting before seed collection, followed by H_2 or one vegetable harvest (6373.54 kg). The zero vegetable harvest could produce only 4318.44 kg of mature fruits. This is a clear reflection of the effect of periodic removal of the sink leading to enhanced production of fruits. The two vegetable harvests could attribute 44.80 per cent increase in the weight of mature fruit over that of zero vegetable harvest.

After two vegetable harvests however, a decrease in the mature fruit yield was observed with increase in the number of green fruit pickings and four vegetable harvests recording the lowest of 2733.91 kg ha^{-1} mature fruits. Each genotype has limited period in its life span to bloom and reproduce and also

Fig. 3 Effect of vegetable harvest on green fruit yield



pulp to seed ratio. This may be due to higher seed weight $fruit^{-1}$ of the treatment. Sheeba (1995) also found the effect there is a limit upon its bearing capacity. When green fruits are picked continuously it reflects adversely on the total fruits that are to ripe on plant. This could be the cause for lower weight of ripe fruits plant^{-1} with more number of ripe fruit harvests. Progressive decrease in mean weight of ripe fruits with increase in number of fruits harvested for vegetable was observed in bhindi by Sheeba (1995) and Shanmughasundaram (1950).

One and two vegetable harvests gave the highest values probably because of the stimulated increase in the number of ripe fruits produced due to a few green fruits removed as reported by Khan and Jaiswal (1988) and Bhat and Singh (1997) in bhindi.

Days to fruit harvests in the case of both green and ripe fruits did not vary significantly with the different numbers of vegetable harvests as evident from the data (Table 6). Similar result has been reported by Sheeba (1995) in bhindi.

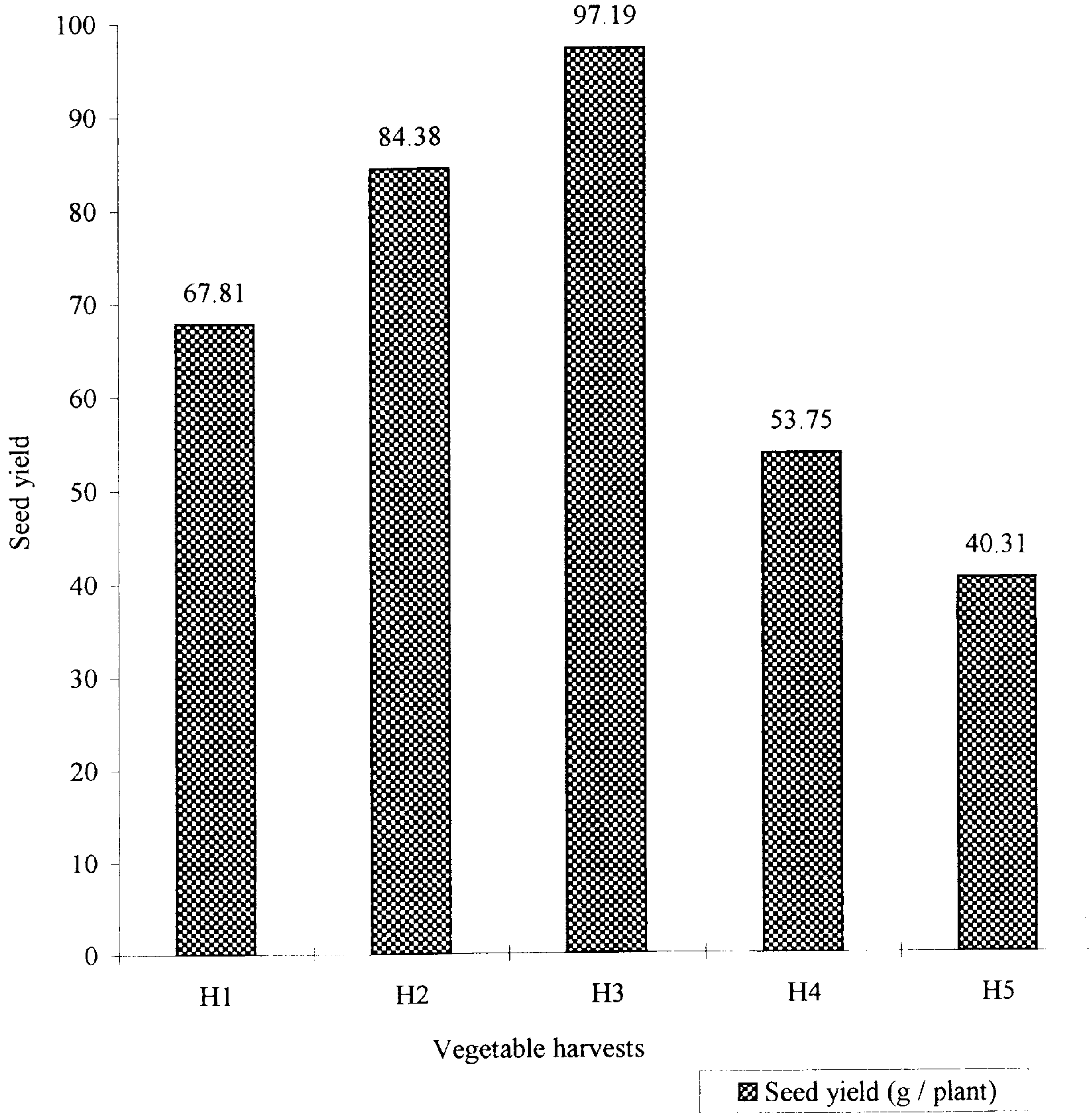
Number and weight of seeds fruit^{-1} were found to be high when all fruits were left for seeding, which was however, similar in values with treatments of two vegetable harvests. Treatment with four vegetable harvests gave the lowest value. This agrees with the result of Sheeba (1995) in bhindi. Manankov (1973) in cucumber reported that quantity and quality of seeds were best when they were collected from the fruits formed first on the plant.

However. the total seed yield plant^{-1} was significantly highest for two vegetable harvests (97.19 g) which was probably due to the higher ripe fruit yield of the treatment. Like the ripe fruit yield, the seed yield also increased with the vegetable harvests upto two and then decreased with further increase in vegetable harvests. The lowest seed yield plant^{-1} of 40.31 g was observed in H_5 (four vegetable harvests) and the highest by H_3 (two vegetable harvests) exhibiting a 43.33 per cent increase over the treatment.

The vegetable harvests did not influence significantly the fruit to seed and pulp to seed ratios, which ranged from 28.47 to 36.01 and 7.65 to 8.59, respectively. The zero vegetable harvest recorded the lowest fruit to seed and pulp to seed ratio. This may be due to higher seed weight fruit^{-1} of the treatment. Sheeba (1995) also found the effect of vegetable harvests to be non significant upon the fruit to seed ratio in bhindi.

The hundred seed weight was highest for two vegetable harvests, which was on par with zero vegetable harvest. The superiority showed by two vegetable harvests is probably because the fruits for seed in the treatment were produced at the peak growth stage of the plant ensuring better filling and hence good quality of seeds.

Fig. 4 Effect of vegetable harvest on seed yield plant^{-1}



Highest germination percentage, though not significant, was obtained with two and four vegetable harvests. The non significant influence of green fruit picking on germination percentage is supported by the works of Tyagi and Khandelwal (1985), Natraj ***et al***. (1992), Sheeba (1995) and Randhir Singh and Kanwar (1995) in bhindi.

The net income as well as the B.C. ratios did not vary significantly due to the vegetable harvests. This agrees with the result obtained in bhindi by Sheeba (1995). However net income and BC ratio were highest for H_3 (two vegetable harvests) due to its highest seed yield (Table 7).

5.2 Effect of seed extraction methods on seed and seedling characters

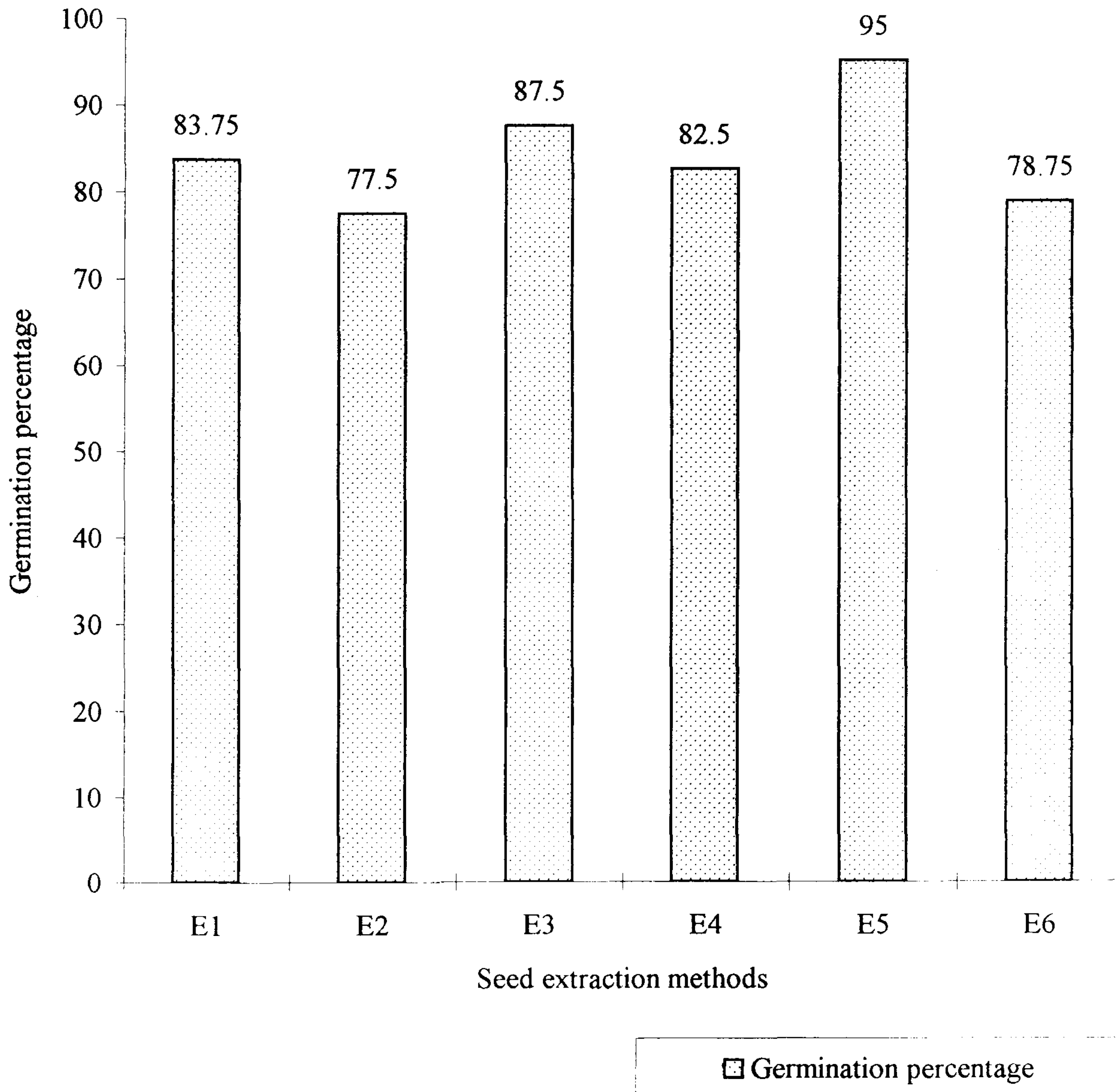
Differential response was observed with respect to seed and seedling characters due to the different seed extraction methods studied. Among the characters, germination percentage, speed of germination, seedling root length and vigour index were profoundly influenced by extraction methods.

Seeds extracted by soaking seed plus pulp in water for 12 h (E_5) recorded significantly higher germination of 95 per cent and germinated faster than any other extraction methods tried. Krishnaswamy and Suthandirapandian (1991) obtained similar results by soaking ashgourd seeds in water and by sowing the pregerminated seeds, by which they obtained early emergence. The basis for accelerated germination due to presoaking seeds in water is uncertain; however, it is likely that by soaking the seeds in water the early events of germination such as imbibition (water uptake), enzyme activation, storage product break down and resumption of embryo growth might have initiated.

Rubbing pulp plus seed on rough surface and extracting (E_3) gave 87 per cent germination, which comes next to soaking in water. In this method, softening of the seed coat occurred during the rubbing process, promoted germination.

Fermentation (E_4) and manual extraction (E_1) methods recorded only 82.5 per cent and 83.75 per cent germination, respectively. In these methods, the removal of gelatinous substances adhered to seeds was rather difficult and might have

Fig. 5 Effect of seed extraction methods on germination percentage



not been removed fully. These adhered pulp is reported to inhibit the germination percentage of seeds (Devlin and Witham, 1983).

The percentage germination of seeds was below 80 per cent for acid extraction (E_6). The speed of germination was also low for this treatment and was on par with the lowest speed, that was recorded by E_2. This may be due to the corrosive nature of the chemical which damaged the seeds as observed by Das *et al*. (1997) in tomato. Similar result was obtained by Said *et al*. (1970) where in soaking peach stone in concentrated HCl for 10 minutes almost totally inhibited germination while, soaking in cold water and mechanical scarification improved germination.

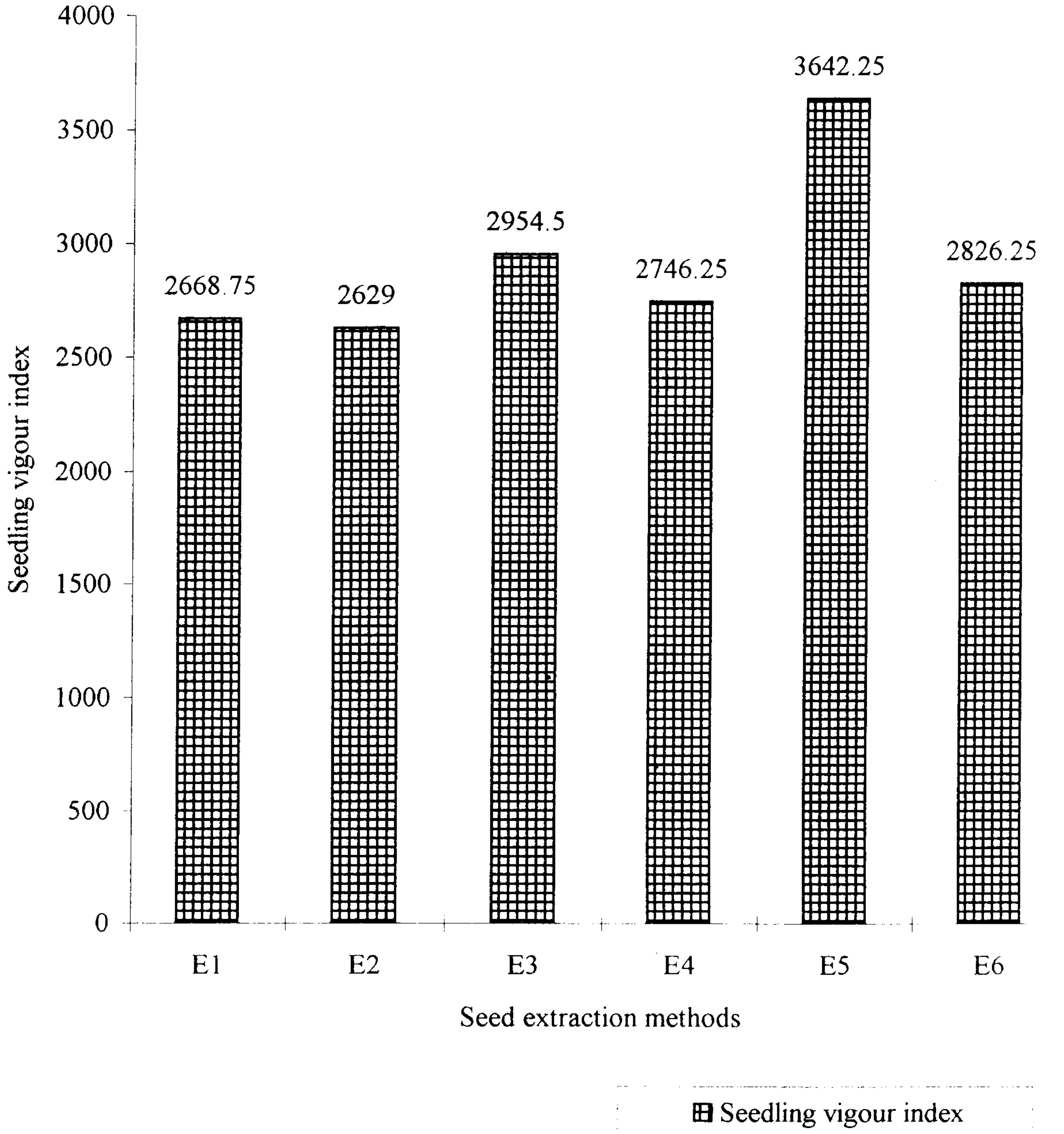
The lowest germination percentage and speed were recorded by E_2 (mixing ash with seed and pulp and extracting). Poor performance of the seeds extracted by mixing with ash may be due to the poisoning of the embryo owing to the toxic effects of certain ions present in ash as reported by Neeman *et al*. (1993) in pinus.

Soaking seeds in water for 12h and extracting (E_5) recorded the highest seedling root length. Recalling the data (Table 10), it is evident that the very same treatment exhibited highest germination percentage and speed of germination, by virtue of early imbibition of water and other developmental changes that initiate embryo growth. Protrusion of radicle being the process that completes germination, also might have occurred earlier, for the presoaking treatment. After protrusion, further elongation and cell division, might also have enhanced by rapid mobilisation of break down products of storage tissue. The shortest roots were produced by seeds extracted manually (E_1). This may be due to the presence of inhibitors in the gelatinous substance which adhered to the seeds.

The shoot length was also highest for seeds soaked in water for 12 h (E_5), eventhough the extraction effects were not significant. Since roots are the first part to emerge out from the seed, the beneficial effect of early initiation of developmental changes in the seed may be more for the developing roots than the shoots, which may probably be the reason for the nonsignificant influence.

Vigour Index (VI) varied significantly due to the extraction treatments. The International Seed Testing Association (ISTA) defined vigour as "the sum total of those properties of the seed which determines the potential level of activity and performance of the seed or seedlot during germination and seedling emergence". The VI is calculated as the product of germination percentage and root and shoot lengths of the seedling. The VI values ranged from 2629 to 3642.25 in the

Fig. 6 Effect of seed extraction methods on seedling vigour index



experiment. It was statistically highest for E_5 (soaking in water for 12 h and extracting) because of the combined effect of highest germination percentage and root and shoot lengths of seedling. The rest of the treatments were on par. The lowest V.I. of seeds extracted by mixing with ash (E2) was due to the low germination percentage. E_5 exhibited 38.54 per cent increase in VI over E_2.

Though there was no appreciable effect exerted by the extraction treatments on the seedling dry weight, E_5 exhibited superiority in this character also. The dry weight ranged from 0.132 g to 0.156 g. The superiority exhibited by E_5 was probably due to the longest seedling roots and shoots produced by the treatment.

5.3 Effect of drying and storage containers on the seed and seedling characters

The seeds were stored in five different containers after subjecting them to four different methods of drying. The drying methods and storage containers affected the seed and seedling characters profoundly during the period of storage.

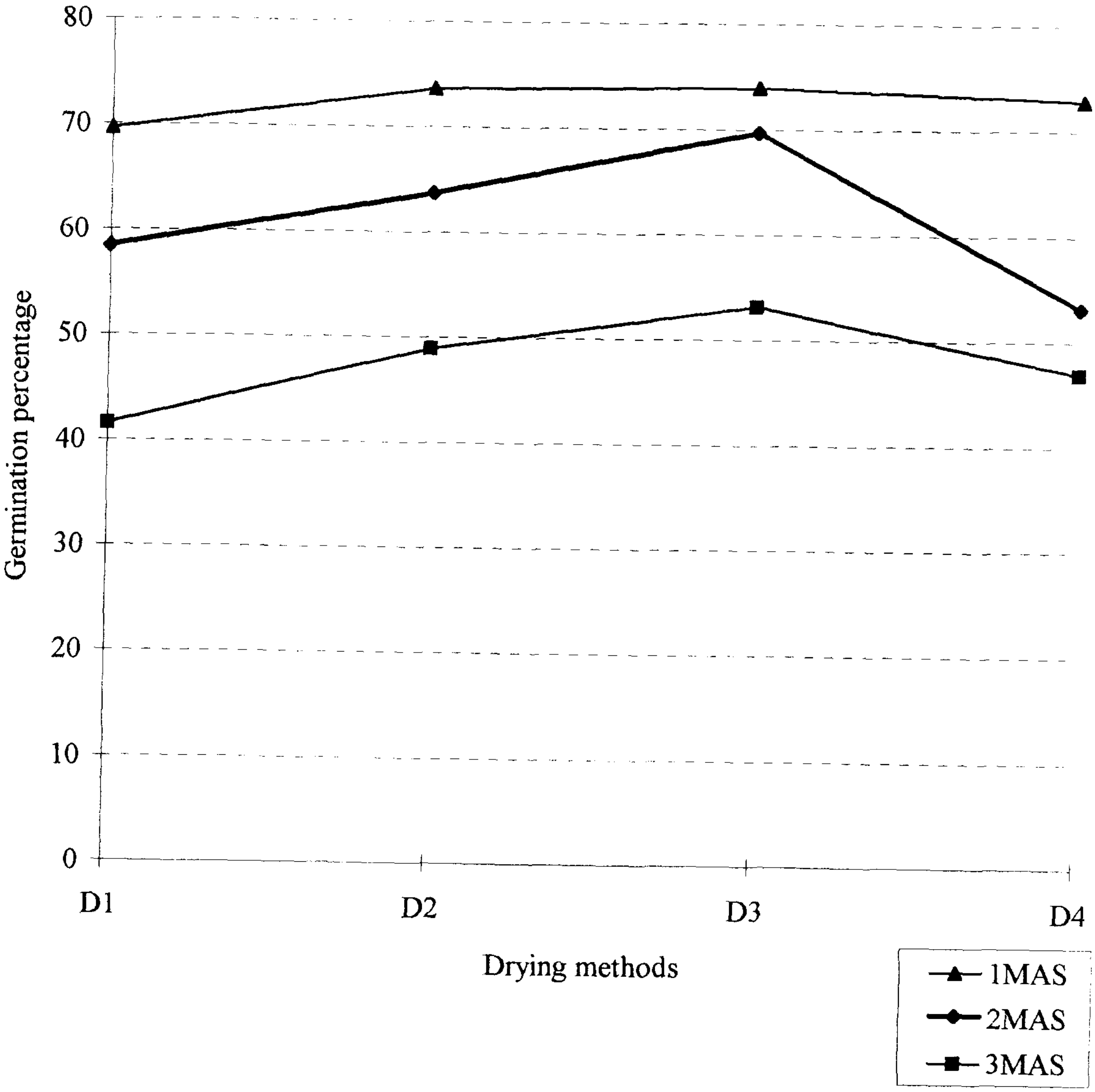
5.3.1 Effect of drying on the seed and seedling characters

The seed and seedling attributes exhibited large variations due to the different drying methods tried.

Germination percentage was appreciably influenced at three MAS only, eventhough the highest value was recorded for the treatment D_3 (drying under direct sun avoiding peak hours of 12 noon to three pm) during all the three months of storage. Drying under sun avoiding peak sunshine hours showed better performance (53.12 per cent germination at three MAS) over D_2, D_1 and D_4 due to the moderately slow drying without exposure to intense radiation. Rapid drying of seeds under higher temperature reduced germination (Doijode, 1988). When seeds were dried in sun avoiding peak sunshine hours, the moisture content was removed safely without causing any damage to structure of the seed. On the other hand drying fully under direct sun (D_2) the intensity of solar radiation is so severe that drying at peak sunshine hours may damage the seed coat as well as the internal structures. This is in accordance with the result obtained by Javare Gouda *et al*. (1990). High temperatures enhance the rate of many enzymatic and metabolic reactions causing a rapid rate of deterioration. Since the seeds immediately after harvest are high in moisture, drying fully under direct sun or high temperature hasten the deterioration by increasing the metabolic activity of hydrolyzed substrates and enzymes.

Drying fully under shade (D_1) recorded the lowest value (41.52% at three MAS), which might be due to the very slow rate of drying making the seeds prone to infectious microorganisms.

Fig. 7 Effect of drying methods on the germination percentage of seeds



Delayed seedling emergence is among the first noticeable symptoms of seed deterioration. The speed of germination was significantly influenced at all three months of storage and followed almost the same pattern of influence as that of germination percentage. Here also seeds dried under direct sun avoiding peak sunshine hours (D_3) showed the highest value, but was on par with D_2 (drying fully under direct sun). The lowest was recorded for D_1 (drying fully under shade).

Seedling root length was appreciably influenced due to drying at two MAS. The highest root length was recorded for D_1, but was on par with D_3. The lowest was recorded for D_2 (drying fully under sun). This might be due to the same reason as described under the germination percentage attribute.

Drying could not exert significant effect on seedling shoot length, vigour index and seedling dry weight, at any of the storage periods.

Electrical Conductivity (EC) of seed leachate was significant due to drying only at three MAS. A frequently observed symptom of deteriorated seeds is their increased leachate content when soaked in water. The association of higher quantity of seed leachate with seed deterioration has been observed by many workers (Saxena *et al.*, 1987; Doijode, 1988; 1991; 1995; Thiagarajan, 1994). These exudates are a reflection of the amount of membrane degradation that has occurred, which is associated with the loss of membrane phospholipids. Phospholipid decrease has been reported in deteriorating cucumber by Koostra and Harrington (1969).

The EC was thus found to increase with the increasing period of storage. The highest EC (0.137 mmhos cm^{-1}) was recorded for D_1 (drying fully under shade) after three months of storage, which indicates the highest deterioration of seeds stored by this method. The lowest EC was recorded by D_4 (drying in artificial drier) with a value of 0.129 mmhos cm^{-1}, suggesting the least deterioration of artificially dried seeds.

The hydrogenase enzyme activity of seeds varied significantly at both stages of observations (ie., 45 and 90 DAS). Loss of enzyme activity is the most sensitive test for measuring incipient seed deterioration, in which the activity of certain enzymes associated with break down of food reserves or biosynthesis of new tissue during germination is tested.

It was found that at 45 as well as 90 DAS, the optical density (hydrogenase activity) was highest for D_3 (drying under direct sun avoiding peak sunshine hours), which recorded values 0.613 and 0.409, respectively. This indicates the better retention of hydrogenase enzyme activity by D_3 than other drying treatments tried. The lowest was recorded for D_2 (drying fully under direct sun), with values of 0.537 and 0.333, respectively at 45 and 90 DAS.

The hydrogenase enzyme activity decreased with increasing period of storage, as expected for all the treatments.

Germination percentage, speed of germination, seedling root length, EC of seed leachate and hydrogenase enzyme activity were significantly influenced due to the different drying methods tried. Drying under sun avoiding peak sunshine hours (D_3) showed superiority over other methods with regard to most of these attributes during the storage period.

5.3.2 Effect of storage containers on seed and seedling characters

The different containers used for seed storage influenced the seed and seedling characters.

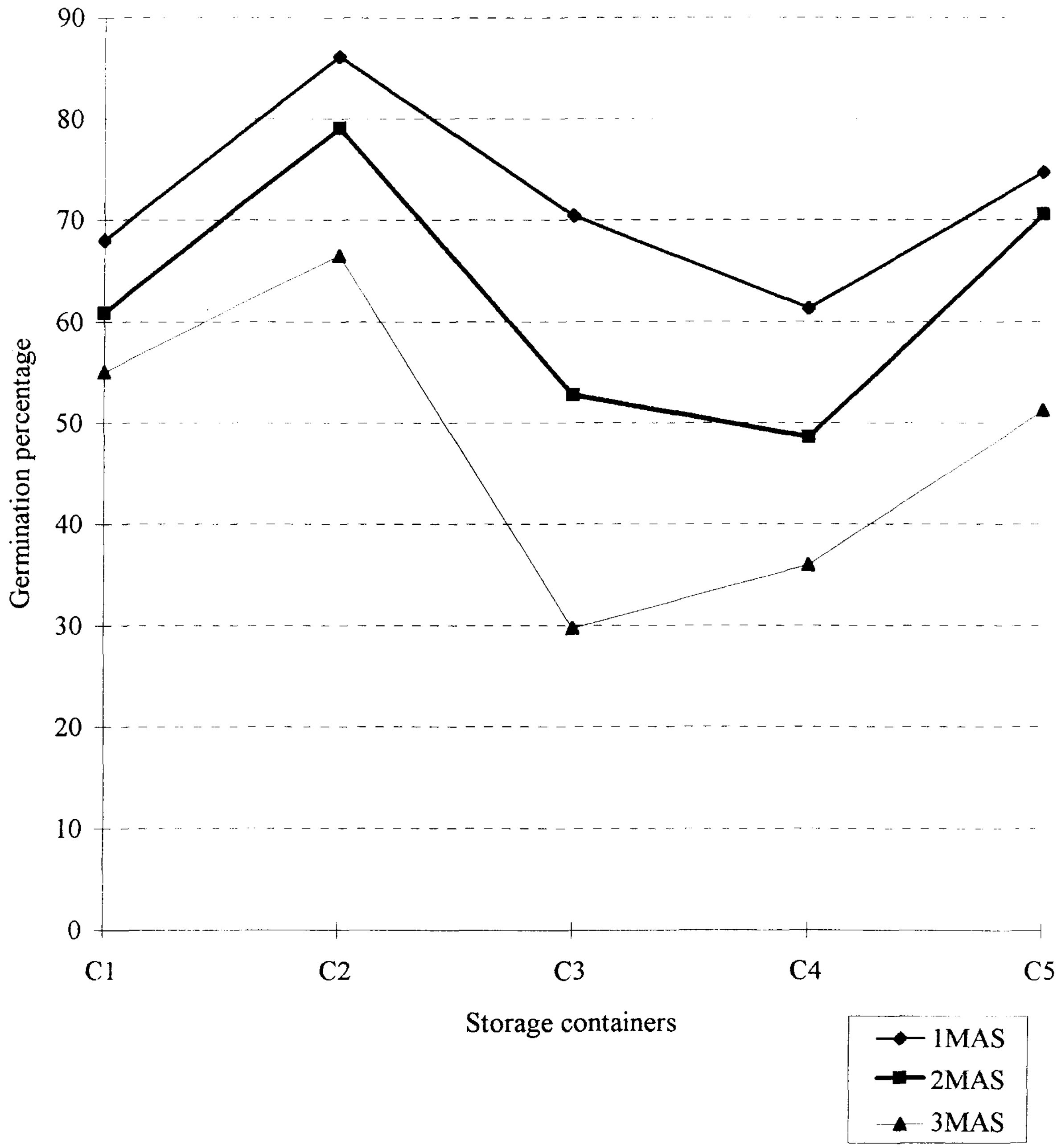
The containers remarkably affected germination percentage of seeds under storage in all the three months of observation. The seeds stored in polythene bags (C_2) showed more than 85 per cent germination at one MAS and they retained germinability (over 65 per cent) much better than all other containers tried, at the end of storage. The advantages of storing vegetable seeds in moisture vapour proof containers such as polythene bags have been proved by various workers (Villareal *et al.*, 1972; Jayaraj *et al.*, 1987; Kanawade *et al.*, 1987; Karivaratharaju *et al.*, 1987; Selvaraj, 1988; Vijayakumar *et al.*, 1991; Doijode, 1997).

At one MAS, mudpot (C_4) recorded the lowest (61.3 per cent) germination, where as at the end of storage, cloth bag (C_3) showed considerable reduction in germination with only 29.73 per cent. The moisture pervious packets such as paper packets and cloth bags have been understood to be poor in storing seeds by Villareal *et al.*, 1972; Jayaraj *et al.*, 1987; Kanawade *et al.*, 1987; Karivaratharaju *et al.*, 1991).

The seeds are hygroscopic and this nature allows them to maintain equilibrium moisture content with any given relative humidity. The high moisture content attained under high relative humidity condition cause increased respiration, heating and fungal invasion that destroy seed viability. The seeds stored in moisture proof or impervious containers such as polythene bags are not permitted to absorb moisture from the outer atmosphere and thus help them to maintain viability over a long period. This is the reason for the better germinability exhibited by seeds stored in polythene bag (C_2) and metal tin (C_5) and least germinability by those stored in cloth bag (C_3) and mudpot (C_4).

The speed of germination also was highest for seeds stored in polythene bag at all the three months of storage, though the treatments were significant only at the third month of storage. At the end of storage, the lowest was recorded by cloth bag (C_3). This was also due to the increased absorption of moisture by stored seeds.

Fig. 8 Effect of storage containers on germination percentage of seeds



Seedling root length was significant due to storage containers at two and three MAS and highest was recorded by butter paper cover (C_1) at both these stages.

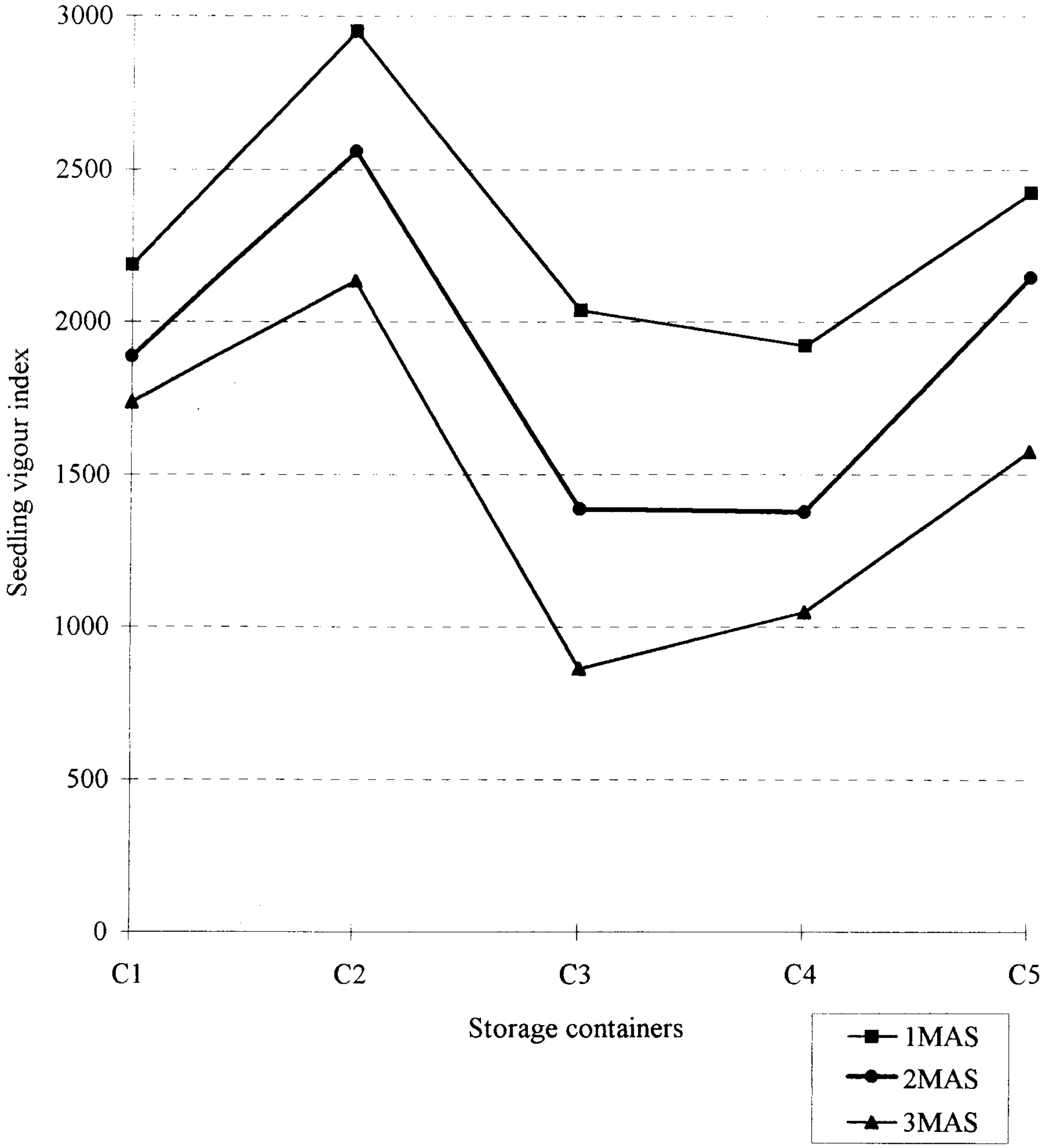
Seedling shoot length was appreciably affected at one and two MAS with polythene bag recording the highest values (24.43 and 22.77 cm, respectively) and cloth bag, the lowest (20.49 and 18.59 cm, respectively). The shoot length showed a general decrease with increase in period of storage due to the deterioration occurred during storage.

The vigour index was influenced statistically in all the stages of storage. Here also C_2 (polythene bag) recorded the highest values. C_2 exhibited a VI of 2949.84 at one MAS, which was 53.69 per cent higher than the lowest VI value recorded by C_4 (mud pot).

The seedling dry weight was significantly influenced at one and two MAS. The highest value was recorded by C_2 (polythene bag) and the lowest by C_4 (mud pot). Dry weight of seedling was mainly contributed by the shoot part of seedling and hence significantly higher length of seedling shoot had resulted in higher dry weight of seedling also when the seeds were stored in polythene bags.

The EC of seed leachate was remarkably affected at all the three months of storage. EC was the lowest for C_2 (polythene bag) at all these stages, which indicates the

Fig. 9 Effect of storage containers on vigour index of seeds



comparatively less degradation of membrane and lesser seed leachates or exudates for seeds stored in polythene bag. The EC values generally increased with increase in period of storage (Doijode, 1995), which proves the deterioration of seeds under storage. The highest value of 0.147 mmhos cm^{-1} was recorded by cloth bag (C_3) after three months of storage.

The hydrogenase enzyme activity was significant at both 45 and 90 DAS. Polythene bag recorded the highest value of 0.821 compared to the lowest of 0.361 by cloth bag. This proves the superiority of polythene bag stored seeds over the others. However, at 90 DAS the values decreased to 0.489 for polythene bag eventhough it was the highest. Doijode (1989) reported a low dehydrogenase activity in bottlegourd seed after certain period of storage due to the seed deterioration.

Thus the seeds stored in polythene bag showed better germination percentage, speed of germination, seedling shoot length and vigour index during the storage period. The extent of deterioration was comparatively less for polythene bag as clearly reflected from the low EC and high hydgrogenase enzyme activity values during storage. The moisture pervious containers such as cloth bag and mud pot performed poorly during storage.

5.3.3 Interaction effect of drying methods and storage containers on seed and seedling characters

The interaction effect was significant for seedling dry weight at two MAS (Table 16a). The highest dry weight was recorded for seeds stored in polybags after drying under direct sun (D_2) which was however, on par with the combination of drying under sun avoiding peak sunshine hours (D_3) in polybag storage and drying fully under sun in butter paper cover storage. This shows that, the best method of drying (D_3, recording 0.104 g (Table 16) and best storage container (polybag, recording 0.114 g (Table 16) gave a good performance in combination also.

DxC was found to be appreciable after two and three months of storage with regard to EC of seed leachate. At both these stages the lowest values were recorded by artificial drying and polythene bag combination showing their better performance under storage. The highest EC values were recorded by the combination of drying under sun avoiding peak hours and cloth bag.

The interaction significantly influenced the hydrogenase enzyme activity at both 45 and 90 DAS (Tables 18a and 18b). Drying under sun avoiding peak hours (D_3) plus polythene bag combination recorded the highest and D_3 plus cloth bag (C_3) the lowest activity at 45 DAS. This clearly indicates the advantage of drying seeds under sun avoiding peak hours and storing in poly bag due to combined effect of least damage to seed structure under this drying method and due to the better exclusion of moisture by polythene bag. At 90 DAS, highest and lowest values were recorded by seeds dried in artificial drier (D_4) stored in poly bags and seeds dried fully under sun stored in mud pots, respectively.

5.4 Influence of seed position in fruit on seed quality

The seed quality varied due to the different positions occupied by it within bittergourd fruit.

The highest germination was obtained for seeds in the middle portion (P_3), but was on par with all other positions except P_1 (Proximal end position). From fruit initiation to full maturity a specific period is required for each crop and for bittergourd this is 15 days. It can be assumed that, always at the mid stage of this period maximum quantity of photosynthates will get translocated to the fruit as is observed by the increased girth of the bittergourd fruit at the mid part. Hence the seeds at the mid part of the fruit will get more photosynthates such as carbohydrates, lipids, proteins and phosphorus containing compounds, and thus will develop properly and exhibit better germinability. The seeds at P_1 and P_2 positions are late formed and may not have all the nutrients in required quantity in them. This probably may be the reason for their poor germination percentage.

Though the speed of germination was not significantly influenced due to seed position, the seeds from P_1 germinated faster. Seed formation is characterised by three different stages. During the first stage 80% seed growth occurs and in the second stage physiological maturity is attained. The third stage is when the seed undergoes further desiccation or decrease in seed moisture occur, which is termed as harvest maturity. Since the seeds from the P1 position are late formed ones, might not have reached the harvest maturity stage and hence moisture content will be more, which facilitates the early germination of these seeds.

Seedling root length was also significantly lowest for P_1 and the highest value was recorded by P_3. As the seed initiates embryo growth, the endosperm nutrients get translocated to the emerging axis. Storage tissues function primarily as reservoirs, from which the emerging axis draws nutrients, and the seeds in the proximal position (P_1) in general have less storage tissue, which may be the reason for reduced root length of seedling developed from these seeds. The seeds of P_1 are comparatively smaller in size, mainly due to less amount of storage food in them. Muchow (1990) reported smaller seeds at the base of the sorghum panicle.

Vigour Index being a product of germination percentage and shoot and root length of seedling, P_3 recording the lowest VI is quite expected as observed from their germination percentage (Table 21). There are abundant informations which demonstrate an association between seed size or weight and seed vigour (Austin, 1972; Heydecker, 1972; McDonald, 1975) as in this experiment, where the seeds of P_1 in general are smaller in size. Burris *et al*., 1971; 1973; Fontes and Ohlrogge, 1972) have reported that large seeds of soybean are superior to small seeds in germination and vigour.

Seedling dry weight did not vary significantly due to the seed position which may be a reflection of the non significant influence of the shoot length (Table 21).

The wine length, LAI and number and weight of green fruits were highest for the treatment with four vegetable harvests. Ripe fruit number and yield, the total seed yield and hundred seed weight were significantly highest for two vegetable harvests. Number and weight of seeds $fruit^{-1}$ were found to be highest for zero vegetable harvests. From the experiment it is evident that H_3 (two vegetable harvests and then left for seeding) provide highest economic returns and hundred seed weight as well as germination percentage. Hence this can be recommended to the farmers for getting good profit along with quality seeds.

Seeds extracted after soaking in water for 12 hours (E_5) recorded significantly highest germination percentage, speed of germination, seedling root length and vigour index. The lowest germination percentage, speed and VI were exhibited by seeds extracted after mixing seed plus pulp in ash.

Germination percentage, speed of germination, seedling root length, EC of seed leachate and hydrogenase enzyme activity were significantly influenced due to the different drying methods tried. Drying under sun avoiding peak sunshine hours (D_3) showed superiority over other methods with regard to most of these attributes during the storage period.

Thus the seeds stored in polythene bag showed better germination percentage, speed of germination, seedling shoot length and vigour index during the storage period. The extent of deterioration was comparatively less for polythene bag as clearly reflected from the low EC and high hydgrogenase enzyme activity values during storage. The moisture pervious containers such as cloth bag and mud pot performed poorly during storage.

The germination percentage, seedling root length and VI were significantly influenced by different seed positions in bitter gourd fruit. Seeds from the middle portion (P_3) recorded the highest and seeds from the proximal end position (P_1), the lowest values.

SUMMARY

SUMMARY

An investigation was carried out at the College of Agriculture, Vellayani to study the influence of vegetable harvests on seed yield and quality, the effect of various extraction methods, drying methods and storage containers and the influence of seed position in fruit on seed and seedling characters in bittergourd. Results of the investigation are summarised below.

The vegetable harvest treatments involved five different numbers of vegetable harvests, *viz*, zero, one, two, three and four. The field experiment was laid out in randomised block design with four replications.

Length of main vine and number of main branches plant^{-1} were significantly influenced by vegetable harvests with H_5 (four vegetable harvests) recording the longest vine (5.11 m) as well as number of branches (13.5).

Leaf area index was appreciably influenced by vegetable harvests, the highest being recorded by H_5 (four vegetable harvests) and lowest by H_1 (zero vegetable harvest) at both stages of observation.

The length and girth of green fruits did not vary significantly due to vegetable harvests.

Significant influence of vegetable harvests was noticed upon number as well as weight of green fruits and they increased with increasing vegetable harvests. The highest number (32708.33 $hectare^{-1}$) and also weight of green fruits (5141.67 kg $hectare^{-1}$) were obtained for H_5 (four vegetable harvests).

Number and weight of mature fruits varied significantly due to vegetable harvests and they increased with vegetable harvests upto H_3 (two vegetable harvests) and decreased with further increase in vegetable harvests.

Days from anthesis to fruit harvest was not significantly influenced by vegetable harvests.

Mean number and weight of seeds $fruit^{-1}$ was appreciably modified by vegetable harvests, the highest being obtained for H_1 (zero vegetable harvest) and lowest for H_5 (four vegetable harvests).

Seed yield varied significantly due to vegetable harvests. The highest was recorded by two (242.97 kg ha^{-1}) and the lowest by four vegetable harvests (100.79 kg ha^{-1}). Fruit to seed and pulp to seed ratios were not significantly influenced due to vegetable harvests.

Significantly highest hundred seed weight was recorded by two vegetable harvests which was on par with zero vegetable harvest.

Germination percentage did not vary significantly due to vegetable harvests. Net income and benefit cost ratio showed no significant variation due to vegetable harvests though, the highest net profit (Rs.75,951.38) and benefit-cost ratio (1.70) were obtained for two vegetable harvests.

There were six extraction methods tried viz. manural extraction, extraction by rubbing on rough surface, mixing with ash and extracting, fermenting seed plus pulp for one day and extracting, acid extraction (concentrated HCl @ one per cent weight of the seed plus pulp treated for thirty minutes), soaking seed plus pulp in water for 12 h and extracting. The six extraction treatments were carried out in randomised block design with four replications.

Extraction treatments exerted profound influence on the percentage and speed of germination of seeds and the highest were recorded by E_5 (soaking in water for 12 h and extracting) and lowest by E_2 (mixing seed plus pulp with ash and extracting). E_5 recorded 95.00 per cent and E_2 77.5 per cent germination.

Seedling root length varied significantly due to extraction methods, with E_5 (soaking in water) producing the longest roots (16.58 cm).

Eventhough the seedling shoot length was not appreciably influenced, the longest shoot length was recorded by seeds soaked in water before extraction. Seedling vigour index varied significantly due to extraction and seeds soaked in water recorded the highest vigour (3642.25).

Extraction methods did not influence seedling dry weight significantly.

Seeds dried under four drying methods were stored in five different containers for a period of three months. The drying methods and storage containers were tried in a treatment combination of 20 in two replications.

Drying methods exerted profound influence on germination percentage during the three months of storage. At these MAS, the highest germination was observed for D_3 (seeds dried under direct sun avoiding peak sunshine hours).

Storage containers caused appreciable influence on germination in all the three months of storage, with the seeds kept in C_2 (polythene bag) recording the highest germination percentage. Lowest was recorded by seeds stored in C_4 (mud pot) at one and two MAS and C_3 (cloth bag) at three MAS. Speed of germination was influenced significantly by drying. Seeds dried under direct sun avoiding peak hours germinated faster in all three months of storage, which was on par with D_2 (seeds dried fully under direct sun). The slowest rate of germination was recorded for D_1 (drying fully under shade).

Storage containers influenced the speed of germination appreciably at one and three MAS. Polythene bag recorded the highest speed in all the three months of storage and (C_1) (butter paper cover), C_4 (mud pot) and C_3 (cloth bag) recorded the lowest at one, two and three MAS, respectively.

Seedling root length varied significantly at two MAS with D_1 (drying fully under shade) producing the longest and D_2 (drying fully under direct sun), the shortest roots.

The effect of storage containers on seedling root length was significant in two and three months of storage with C_1 (butter paper cover) recording the longest roots.

Drying methods did not influence the shoot length and vigour index of seedlings at any of the storage period.

At one and two MAS seedling shoot length varied significantly due to containers. The longest shoots were produced by C_2 (cloth bag) in all the three stages.

Vigour index differed appreciably due to containers in all the stages and polybag recorded significantly higher value.

Drying exerted no statistical influence on the seedling dryweight.

Storage containers profoundly influenced the dry weight at one and two MAS. In both the stages seedling dry weight was highest for polybag stored seeds.

At two MAS, DxC interaction was significant on seedling dry weight, the highest being recorded by seeds kept in polybag after drying fully under direct sun.

Effect of drying on electrical conductivity of seed leachate was appreciable at three MAS and was lowest for D_4 (artificially dried seeds).

Containers exerted profound effect on electrical conductivity at all the stages of storage and polythene bag recorded the lowest values (0.114, 0.118, 0.118) in all the three months of storage.

Interaction of drying and storage containers influenced the electrical conductivity appreciably at two and three MAS. Artificial drying and polythene bag combination recorded the lowest values.

Drying under direct sun avoiding peak hours was significantly superior in hydrogenase enzyme activity at both 45 and 90 DAS.

Significantly highest optical density (hydrogenase enzyme activity) values were recorded by poly bag (0.821 and 0.489) at the two stages.

The combined effect of drying and containers was significant on the hydrogenase enzyme activity of seeds.

Drying under sun avoiding peak hours plus poly bag recorded the highest value at 45 days of storage. At 90 DAS highest optical density was recorded by seeds dried in artificial drier and stored in poly bags.

In order to study the influence of seed position in fruit on seed quality, fruits were cut into five equal portions and the seeds from each were separately extracted and studied. The experiment on five different positions of seeds in fruit was conducted in 30 replications.

Position of seeds in fruit influenced the germination percentage remarkably. Highest germination (92.60 per cent) was obtained for seeds from middle portion (P_3) whereas seeds from proximal end (P_1) was significantly inferior with only 39.28 per cent germination.

Speed of germination, seedling shoot length and dry weights were not influenced appreciably by the different seed positions.

Seedling root length and vigour index were significantly influenced, with the middle portion producing the longest root (11.89 cm) and vigour index (3073.02).

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APPENDICES

APPENDIX 1

Weather data during the cropping period 30th January 1998 to 30th April, 1998

Standard week	Period from		Period to		Rainfall (mm)	Maximum tempera-ture (°C)	Minimum tempera-ture (°C)	Relative humidity (%)
5	January	29	February	04	0	32.38	22.72	95.14
6		05		11	0	32.26	23.61	94.00
7		12		18	2.63	31.83	23.71	93.57
8		19		25	0.06	31.86	24.79	91.86
9	February	26	March	04	0	32.80	23.53	92.43
10		05		11	0	33.01	23.73	89.29
11		12		18	0	33.60	24.11	87.43
12		19		25	0	33.23	24.46	90.43
13	March	26	April	01	0	33.70	25.19	88.00
14		02		08	0.43	33.78	25.44	89.71
15		09		15	0.69	34.30	25.84	90.86
16		16		22	4.71	34.71	26.60	90.57
17		23		29	1.21	34.21	26.23	88.29
18	April	30	May	06	2.91	34.07	25.66	82.29

SEED YIELD AND QUALITY IN BITTERGOURD (*Momordica charantia* L.) AS INFLUENCED BY VEGETABLE HARVESTS

By

DEVI. V.S.

ABSTRACT OF THESIS

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ABSTRACT

The present investigation was carried out at the College of Agriculture, Vellayani to study the influence of vegetable harvests on the seed yield and quality, seed extraction, drying methods and storage containers and the position of seed in fruit on the seed and seedling characters of bittergourd.

Growth characters *viz.* length of main vine number of main branches plant^{-1} and leaf area index were significantly influenced by vegetable harvests and these characters increased with increasing vegetable harvests. The bearing capacity of the bittergourd plant was improved by the frequent picking of green fruits but the ripe fruit yield and seed yield increased only upto two vegetable harvests. Hundred seed weight was significantly higher for two vegetable harvests but the germination percentage was not appreciably influenced. Though the net income and benefit cost ratio were not influenced significantly, the highest were obtained for two vegetable harvests.

Extraction treatments significantly influenced germination percentage, speed of germination, seedling root length and vigour index. Seeds extracted after soaking in water for 12 h recorded the highest seed and seedling characters.

Germination percentage, speed of germination, seedling root length, electrical conductivity of seed leachate and hydrogenase enzyme activity were significantly influenced by drying methods undertaken. Among these characters all except seedling root length and electrical conductivity of seed leachate were superior for the method in which seeds were dried under direct sun avoiding peak sunshine hours. Seedling roots were longest for seeds dried fully under shade and electrical conductivity of seed leachate was lowest for artificially dried seeds.

Storage containers significantly influenced all the seed and seedling characters studied. Germination percentage, speed of germination, seedling shoot length, vigour index, dry weight, electrical conductivity of seed leachate and hydrogenase enzyme activity were superior for seeds kept in polythene bag. Longest seedling roots were produced by seeds kept in butter paper cover.

Interaction between drying and storage containers was significant for seedling dry weight, electrical conductivity of seed leachate and hydrogenase enzyme activity. The highest seedling dry weight was recorded by seeds dried fully under direct sun and stored in polybags at two MAS. Lowest electrical conductivity values were recorded by artificial drying and polythene bag combination at two and three MAS. Hydrogenase enzyme activity was highest for drying under sun avoiding peak hours plus polybag at 45 DAS and for artificial drier plus polybag at 90 DAS.

Position of seed in bittergourd fruit influenced germination percentage, seedling root length and vigour index significantly with middle portion recording the highest values.