SEED YIELD AND QUALITY IN AMARANTHUS AS INFLUENCED BY PLANTING SYSTEMS AND HARVEST STAGES

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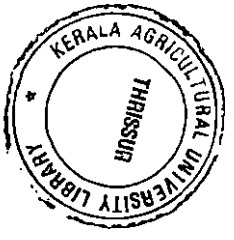

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DECLARATION

I hereby declare that this thesis entitled "**Seed yield and quality in amaranthus as influenced by planting systems and harvest stages**" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title, of any other university or society.

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Dedicated to

Pappa and Amma

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CONTENTS

	Page No.
1. INTRODUCTION	1-3
2. REVIEW OF LITERATURE	4-31
3. MATERIALS AND METHODS	32-39
4. RESULTS	40-69
5. DISCUSSION	70-81
6. SUMMARY	82-86
7. REFERENCES	i-xvii
ABSTRACT	

LIST OF TABLES

Table No.	Title	Page No.
1	Effect of planting systems on days to first flowering	40
2	Effect of planting systems on days to 50% flowering	41
3	Effect of planting systems, harvest stages and their interaction on plant height (cm)	42
4	Effect of planting systems on branches /plant	43
5	Effect of planting systems, harvest stages and their interaction on internode length	44
6	Effect of planting systems, harvest stages and their interaction on leaf length	45
7	Effect of planting systems, harvest stages and their interaction on leaf width	46
8	Effect of planting systems, harvest stages and their interaction on petiole length	47
9	Effect of planting systems, harvest stages and their interaction on weight of weed/plot	48
10	Effect of planting systems, harvest stages and their interaction on dry weight of weed/plot	49
11	Effect of planting systems, harvest stages and their interaction on dry weight of stalk	51
12	Effect of planting systems, harvest stages and their interaction on chaff weight	52
13	Effect of planting systems, harvest stages and their interaction on seed yield/plot	53
14	Effect of planting systems, harvest stages and their interaction on seed yield/plant	54
15	Effect of planting systems, harvest stages and their interaction on seed recovery percentage	56
16	Effect of planting systems, harvest stages and their interaction on percentage of chaffy seeds	57

LIST OF TABLES CONTINUED

Table No.	Title	Page No.
17	Effect of planting systems, harvest stages and their interaction on percentage of bold seeds	58
18	Effect of planting systems, harvest stages and their interaction on thousand seed weight	59
19	Effect of planting systems, harvest stages and their interaction on germination percentage	60
20	Effect of planting systems, harvest stages and their interaction on root length	61
21	Effect of planting systems, harvest stages and their interaction on length of seedling	62
22	Effect of planting systems, harvest stages and their interaction on seed vigour index	63
23	Effect of planting systems, harvest stages and their interaction on fresh weight of seedlings	64
24	Effect of planting systems, harvest stages and their interaction on dry weight of seedlings	65
25	Effect of planting systems, harvest stages and their interaction on dry matter percentage	66
26	Incidence of leaf webber	67
27	Incidence of leaf blight	68
28	Economics of cultivation ha^{-1}	69

LIST OF FIGURES

Fig. No.	Title	Between pages
1	Lay out of the experiment	39-40
2	Effect of planting systems, harvest stages and their interaction on plant height (cm)	41-42
3	Effect of planting systems, harvest stages and their interaction on seed yield/plot (g)	52-53
4	Effect of planting systems, harvest stages and their interaction on seed yield/plant (g)	54-55
5	Effect of planting systems, harvest stages and their interaction on seed recovery percentage	55-56
6	Effect of planting systems, harvest stages and their interaction on germination percentage	60-61
7	Effect of planting systems, harvest stages and their interaction on seed vigour index	63-64

LIST OF PLATES

Plate No.	Title	Between pages
1	General view of the experimental field	33-34
2	Plants from 25 day old seedlings before weeding	48-49
3	Plants from 25 day old seedlings after weeding	48-49
4	Plants from 20 day old seedlings before weeding	48-49
5	Plants from 20 day old seedlings after weeding	48-49
6	Plants from 15 day old seedlings before weeding	48-49
7	Plants from 15 day old seedlings after weeding	48-49
8	Broadcasted seedlings before weeding	48-49
9	Broadcasted seedlings after weeding	48-49
10	Line sown seedlings before weeding	48-49
11	Line sown seedlings after weeding	48-49

LIST OF ABBREVIATIONS

CD	–	Critical difference
cm	–	Centimeter
et al.	–	And others
Fig.	–	Figure
g	–	Gram
ha	–	Hectare
kg	–	kilogram
No.	–	Number
viz.	–	Namely

Introduction

1. INTRODUCTION

Leafy vegetables are the store house of many essential nutrients. The food materials like proteins, carbohydrates, fats, vitamins and minerals are synthesized in the leaves. Minerals like calcium, iron, phosphorus, potassium etc are present in large quantities in leaves. Carotene content present in the leaves are converted into vitamin A in our body. Besides vitamin A they are reservoirs of vitamin C, B2 and K. The leafy vegetables are easy to cultivate, less costly to buy and can be cooked easily. They are a boon to vegetarians and the poor and vulnerable groups.

Amaranthus is the most popular leafy vegetable of the tropics. It is also known as poor man's spinach. It fits well in various cropping systems like rotation and mixed cropping. Amaranthus has high nutritive value and it possesses quick growth giving more yield per unit area per unit time. It is a C-4 plant with efficient photosynthetic abilities that respond best to full sunlight. As in any other C-4 plant amaranth has rapid growth cycles, high NAR, low CO_2 compensation point and low transpiration coefficient.

As in any other vegetable crops use of quality seeds is an important prerequisite in crop production. Amaranthus is a short duration crop and as a result more number of crops can be taken per year from the same land. This necessitates use of large quantity of seeds per unit area per unit time.

There exist different systems of cultivation of amaranthus for vegetable purpose. The cultivation methods include direct sowing in rows, direct sowing by broadcasting and transplanting seedlings at

different stages. The number of harvests varies from one to many in these systems of cultivation. However the method of cultivation of amaranthus for seed production and its economics have not been standardized so far.

There are several problems in the seed production programme in amaranthus. Two important aspects to be considered in the seed production programme in amaranthus are the planting systems and harvest stages. They may decide the economics of seed production as varying amounts of inputs and labour are required depending upon the system of cultivation and method of harvesting and processing of seeds. Arriving at the correct and economic method of cultivation of amaranthus for maximum yield of quality seeds would be a boon for seed producers. Non synchronization of seed maturity in all branches of all plants in a plot is a serious problem. Cutting the seed plants either earlier or later may affect the seed yield and quality. In earlier harvests complete seeds would not be matured. Though delayed harvesting ensures complete maturity of seeds, the chances of shattering the first formed seeds are high. The stages of harvest for seed purpose also affect the processing and cleaning of seeds. Therefore fixing the harvest stage for maximum returns would be of great advantage in seed production programme.

In this view, the present study was undertaken with the following objectives.

(i) To find out the ideal system of planting for amaranthus seed production

(ii) To standardize the stage of harvest for maximum seed yield and quality in amaranthus

(iii) To find out the economics of seed production in amaranthus under different planting systems and harvest stages

Review of Literature

2. REVIEW OF LITERATURE

Amaranthus is an important leafy vegetable of the tropics. It makes a common side dish in most of the families in the country. Amaranthus fits well in various cropping systems like rotation and mixed cropping and is capable of quick growth giving good yield. Amaranthus is rich in vitamins and minerals. As in any other vegetable crops use of quality seeds is an important prerequisite in crop production. Amaranthus is a short duration crop which enables more number of crops to be taken per year from the same land. Therefore, seed required is comparatively higher in amaranthus.

Considerable research work has been done in amaranthus in respect of genetic improvement and standardization of management practices. This resulted in the development of several improved varieties of amaranthus in different parts of the country. However, research work in various aspects of seed production is rather scanty. Therefore the available literature on different aspects of seed production and seed quality in amaranthus and other vegetable crops is reviewed under the following heads.

2.1 FLOWERING, FRUITING AND SEED SET

Several workers have studied the impact of seasons, sowing time and cultural practices on the flowering, fruiting and seed set in different vegetables.

Gill *et al.* (1974) reported in sweet pepper that the highest dose of nitrogen and P_2O_5 in combination considerably reduced the number of days for flowering. Application of P_2O_5 alone induced early flowering. Minimum days for flowering were observed with 187.5kg of

P_2O_5. Nitrogen doses increased the number of days required for flowering. The study revealed that 250kg per ha of nitrogen and P_2O_5 each induced early flowering.

In an experiment with onion, Globerson *et al.* (1981) observed that the number of flowers per umbel varied according to cultivar, date of planting, bulb size and growth conditions. A time lag of 20 to 30 days between umbels at the beginning of flowering was observed. These variations depended mainly on the temperature at flowering time.

Bakker (1989) conducted work in sweet pepper and found that more number of flowers were induced by high temperature.

Olarewaju (1989) studied the effects of night temperature on fruit set and development in sweet pepper and reported that high temperature induced flowering.

Vireshwar *et al.* (1991) studied the effect of date of planting on growth of amaranthus and found significant variations in number of days for maturity with time of sowing. Long days were favourable for flowering in grain amaranthus.

The effect of varieties and sowing dates on seed yield and quality in vegetable amaranthus has been studied in G.K.V.K, Bangalore. Three varieties viz., Arka suguna, AG114 and Local were sown on eight different dates with an interval of 30 days from July to February, 1998. December sown crop took maximum number of days for flowering due to the prevalence of low temperature during November, December and January, while early flowering was obtained in August sown crop. The January sown crop resulted in delayed maturity (113.25 days) while early maturity (93.31 days) was observed in July sown crop (Srinivasaiah *et al.*, 2000).

In an experiment with onion Kanwar *et al.* (2000) found that different levels of population density failed to register any effect on days to flowering, maturity and number of umbels per plant.

Patil *et al.* (2001) studied the effect of plant growth regulators on seed yield and seed quality of sponge gourd and found that Cycocel (500ppm) spray took least number of days (53.26) for maturity of fruits from flowering.

In an experiment with tomato Goudappalavar *et al.* (2002) found that 240:180:80 kg NPK per ha recorded significantly higher plant height, number of branches and delay in 50percent flowering (34 days) compared to other treatments.

Kanwar *et al.* (2005) in an experiment with chilli found that number of days for 50percent flowering was maximum in winter and decreased gradually from winter to spring and summer. Flowering occurred earliest in summer while in winter it took more number of days followed by spring. It was observed that fruit set percentage was significantly more in the crop planted in spring as compared to other planting seasons.

2.2 SEED YIELD

Seed formation in vegetables is a function of varieties and the environment. There exists optimum season for production of any crops. The influence of crop plants with their environment has been worked out by many workers.

Hawthorn (1952) conducted a study on inter relation of soil moisture, nitrogen and spacing in carrot seed production and found that carrot seed yield was raised with increased level of nitrogen.

Shoemaker (1953) stated that wider spacing in vegetables was responsible for increased seed yield per plant but decreased the seed yield per acre.

Eguchi *et al.* (1960) in an experiment with cabbage reported higher seed yield when nitrogenous fertilizer was side dressed at the time of bolting.

In an experiment with cucumber Men'kova (1974) reported that quantity of seeds were highest when they were collected from the fruits formed first on the plant. With a rise in number of fruits per plant, seed weight decreased, but other quality criteria were unaffected.

Gill *et al.* (1974) studied the effect of nitrogen and phosphorus application on seed yield of sweet pepper and found that number of branches, number fruits per plant and seed yield were significantly increased by higher doses of N_2 and P_2O_5. For maximizing the seed yield in sweet pepper 250 kg per ha of N_2 and P_2O_5 is essential.

The effect of ethrel (2-chloro ethyl phosphoric acid) on cauliflower var. Snowball seed production was investigated by Sinha (1974) and it was revealed that ethephon at 250 mg/l sprayed at flowering and full bloom stages increased the seed yield.

In an experiment with cauliflower Gill *et al.* (1975) observed that higher doses of nitrogen and phosphorus significantly increased the number of outer leaves, curd size, plant height and seed yield in late cauliflower. The finding clearly suggested that 250 kg per ha of P and 375kg per ha of N are essential for obtaining highest seed yield. The increase in yield was mainly due to increase in plant height and curd size. It was also found that Phosphorus is important for increasing seed yield of late cauliflower.

Thakur and Gill (1976) studied the effect of N, P and K fertilization on seed yield of cabbage. The highest dose of N_2 (375kg per ha) gave maximum seed yield. The maximum dose of P_2O_5 (250kg per ha) gave the highest seed yield. The highest dose of K_2O (200kg per ha) gave best average performance. The combination of N (250kg per ha), P (125kg per ha) and K (100kg per ha) was optimum and economical doze for maximizing seed yield in cabbage.

In an experiment with okra, Pandey *et al.* (1976) observed the significant increase in seed yield up to two pickings of fruits and the yield from three green fruits pickings was on par with the control of no fruit picking. Four pickings of fruits significantly reduced seed yield.

In his studies on seed production and seed maturation in okra, Velumani (1976) observed that seed yield was significantly high when the first formed two fruits were harvested as vegetables and this was on par with no green picking.

Singh *et al.* (1976) in an experiment with cauliflower reported that significantly higher seed yields were obtained by the application of 150ppm ethrel at the time of initiation of primary floral stalks. Other parameters like number of seeds per siliqua, seed yield per plant and germination percentage were also highest for this treatment.

Saini and Rastogi (1976) in a trial with cabbage observed that closer spacing of 30 x 30 cm gave significantly higher seed yields.

In a field trial with cauliflower, Novak (1977) observed 46.8percent increase in seed yield when the outer branches of the cauliflower curd were removed by scooping.

Pandey and Singh (1979) on their studies on plant population in okra observed that highest seed yield per plant was seen under spacing

45 x 30 cm. The yield of seed per ha was significantly greater under closer spacing of 45 x 15 cm. The experiment concluded that the increase in seed yield of individual plants as a result of more supply of nutrients and better conditions of growth due to increase in the spacing of plants could not compensate for reduction in plant population per hectare.

In an experiment with okra Rode (1979) observed maximum number of seeds per fruit in plants which were left to mature for seeds without vegetable harvests.

The weight of seeds per fruit was found to be superior with zero or two green fruit pickings compared to four, six, eight, ten and twelve fruit pickings in okra. (Velumani and Ramaswamy, 1980).

Mangal *et al.* (1980) reported that in cauliflower maturity was delayed but seed yield increased due to the application of gibberellic acid at 50-250 mg/l.

In an experiment with chilli, Wankhade and Morey (1981) reported that green fruit picking had no significant effect on the number of seeds per fruit.

Gavrar and George (1981) observed that mineral nutrition of *Phaseolus vulgaris* can have a significant effect on seed yield and quality.

Montanari and Lovato (1981) reported that treatments with dessicant sprays on carrot crop never significantly affected the seed yield and the thousand seed weight whereas have decreased seed germination. Chicory seed yield has been negatively influenced by glyphosate, diquat, paraquat etc.

In a trial with carrot Gray (1981) observed that seed yield was increased per hectare when plant density was increased. There were no significant effect of plant density on plant height, time of flowering, crop maturity and there was no consistent effect on mean seed weight.

Sharma and Singh (1981) in field trial with carrot found that spacing had little effect on seed yield.

Low doses of gamma radiations were observed to enhance the number of seeds set per capsule as well as the fruit size and number in chilli. However with higher doses there was reduction in the seed as well as the capsule production. (Joshi and Khalatkar., 1981)

Effect of spacing and time of planting of onion bulbs on seed production was investigated by Lal *et al.* (1982). It was observed that onion plants spaced at 75 x 20 cm produced higher seed yield than those with 75 x 5 cm spacing.

Maksoud *et al.* (1982) observed that picking fruits once at 68 days after transplanting in brinjal increased the seed yield by 40percent over control, but picking twice decreased the yield by 16percent.

In an experiment with sweet pepper Mahmoud (1982) reported highest seed yields from plants treated with 600ppm ethephon in early growth stages.

Dawale (1983) in a trial with pea observed that indole acetic acid and gibberllic acid (10mg/l) gave the best seed yields when compared to the untreated control.

Hariharan and Unnikrishnan (1983) reported enhanced seed yield and seed size in chillies by presowing seed treatment with NAA at 30, 35 and 70 mg/l.

In an evaluation of grain amaranthus types at Coimbatore, Mohideen *et al.* (1983) reported variation in yield contributing characters due to time of sowing.

Spraying of urea at 12kg N per ha and micro nutrients at 400g per ha once in 10 days from first flowering increased the yield of good quality seed in amaranthus by 88 percent (Anon., 1984).

Duczmal *et al.* (1984) reported that in capsicum highest yields of seeds of good quality was obtained by picking the fruits as they ripened on the plant.

The increase in seed yield was mainly due to an increase in number of florets produced per seed head. Application of P had no effect on seed yield in the absence of nitrogen. But P together with N led to a highly significant increase in onion seed yield. (Ahmed and Abdullah, 1984)

Singh and Singh (1985) in a field trial with radish found that the closer spacing 30 x 30 cm gave significantly higher seed yield. The per plant seed yields were however higher in wider spaced plants. In respect of per plant as well as per plot seed yield the insitu method gave higher yields.

Edelstein *et al.* (1985) in an experiment with sphagetti squash (*Cucurbita pepo* L.) found that application of 500 to 600 ppm of ethephon at 2, 4 and 6 leaf stages and again about a month later at fruit set resulted in significantly higher seed yield.

Tyagi and Khandelwal (1985) recorded the highest seed yield in okra plants without any green fruit picking.

El-Beheidi *et al.* (1987) in a trial with cucumber obtained significantly higher seed yield by the application of 250 ppm of

ethephon but the germination percentage of seed was unaffected due to the spraying of ethephon.

Rahman *et al.* (1988) reported that siliquae per plant and seeds per siliquae were the major yield attributing characters and scooping increased seed yield in cauliflower cv. Pousali.

Oliva *et al.* (1988) reported that excessive spacing in carrot was not desirable as the plants produced more secondary and tertiary umbels with low germinabilaty of seed.

In an experiment with fenugreek Kanwar and Saimbhi (1989) observed that the number of pods per plant and seed yield per plant was highest in row spacing of 30cm and decreased with decrease in row spacing. Same trend was observed in case of pod length and number of seeds per pod; but the differences were not significant. The seed yield per ha was highest in row spacing of 20cm and decreased with both decrease or increase in row spacing.

In onion the highest seed yield 6.25 q per ha was obtained from plants spaced at 45 x 30cm and receiving 80 kg of N per ha. (Bhonde *et al.*, 1989)

Nazeer and Tanki (1989) in a trial with carrot observed that highest average seed yield was obtained with highest N rate 120 Kg per ha. P had a less pronounced effect on seed yield.

Sitaram *et al.* (1989) reported that foliar sprays of ethephon 200ppm at 1-2 true leaf stage resulted in increased fruit and seed yield in cucumber. This treatment gave 48percent increase in fruit yield and 58percent improvement in seed weight per fruit over the untreated control. But the germination potential of seeds were not influenced by growth regulators.

Arora *et al.* (1989) observed increased seed weight per fruit in pumpkin due to the application of GA_3 at 25 ppm.

Hadavizadeh and George (1989) in a trial with pea reported that increase in N nutrition supply increased seed dry weight. However an increase in seed yield and seed vigour was only achieved by the interaction of high N (1000mg per plant) with medium P supply (500mg per plant).

Jedras (1989) found that in parsley sowing on July 20th gave better winter plant survival and better seed yield than sowing on June 20th or August 20th. The sowing date had no significant effect on the 1000 seed weight or seed germination.

An experiment conducted at Faizabad to determine the optimum dose of nitrogen and plant spacing on seed crop of radish indicated that 60 x 45cm plant spacing and 80Kg N per ha produced the highest seed yield of radish. (Singh *et al.*, 1990)

Digole and Shinde (1990) in an experiment with carrot reported the highest seed yield (15.4 q per ha) with stecklings where shoots and roots were cut back by one quarter by one half respectively.

In a study with radish Sharma and Lal (1991) observed that seed yield showed an increasing trend with increase in plant spacings and the highest values were recorded at widest spacings of 60 x 60 cm. Such response must have been due to the availability of more space providing more nutrients, air and sunlight which led to vigorous growth.

Phookan *et al.* (1991) in a trial with tomato reported that significantly higher fruit and seed yields were obtained by the application of NAA at 20ppm at flowering stage.

Singh *et al.* (1991) found that foliar application of mixatol at the rate of 30ml in 10 l of water causes significant increase in seed yield and quality parameters in bottle gourd.

Effect of sowing date and nutrients on growth, yield and essential oil content in celery was studied by Sudeendra (1993) and reported variation in seed yield due to time of sowing.

Devadas and Ramadas (1994) could observe that in bitter gourd foliar application of triacontanol 5ppm resulted in higher seed number per fruit.

Vijayakumar *et al.* (1995) found that application of 40:30:60kg NPK per ha and maintaining 3 plants per pit at a spacing of 2.5 x 2 m was optimum for getting higher yield of quality seeds in MDU-1 bittergourd.

Effect of green fruit pickings on seed yield of okra was studied by Singh and Kanwar (1995) and found that two green fruit pickings significantly increased the number and weight of dried fruits and seed yield in okra.

Sheeba (1995) reported that in okra highest seed yield was observed with no vegetable harvest which was on par with two vegetable harvests.

In a field trial with bitter gourd Gedam *et al.* (1996) found that NAA at 50 ppm gave the highest number of seeds per fruit which was significantly higher than other treatments.

In a field trial with okra Bhat and Singh (1997) recorded significantly higher seed yield with 2 green fruit pickings.

Khan and Jaiswal (1998) in an experiment with okra obtained maximum seed yield with 2 pickings of green fruits followed by 1, 0 and 3 pickings.

In a field trial with onion Nehra *et al.* (1998) observed that the number of scapes and seed yield per plant were higher under wider spacing but seed yield per ha was significantly higher under the closest spacing 30cm.

Devi (1999) reported that in bitter gourd seed yields increased significantly up to 2 vegetable harvests.

Yadav and Dhankhar (2001) in an experiment with okra found that the seeds sown on 13th June resulted in higher seed yield of better quality. Delayed sowing drastically reduced seed yield and deteriorated seed vigour and viability.

Kanwar *et al.* (2000) in an experiment with onion reported that bulbs planted during second fortnight of October at the spacing of 45 x 30 cm gave highest seed yield in Punjab region. Increase in umbel number and seed size under wider spacing was neutralized by the increased plant population per unit area under closer spacing and consequently higher seed yield was obtained.

In a field trial with amaranthus Srinivasaiah *et al.* (2000) reported that the November sown crop gave the maximum seed yield with fairly good seed quality. The July and February sown crop recorded low seed yield. The yield attributing characters ie., number of panicles per plant, panicle length and weight of panicles per plant were maximum in the November sown crop as compared to other dates of sowing.

Priya *et al.* (2000) conducted an experiment with five varieties of cauliflower from different maturity groups which were subjected to different curd cutting treatments. All curd cutting treatments were effective in increasing the seed yield. However increase in yield was highest (171.4percent) with scooping as compared to control in Pusa Himjyothi.

In a trial with ash gourd Mini *et al.* (2000) observed that seed yield per fruit increased significantly with increase in fruit weight. Seed weight was higher in large sized fruits compared to medium and small fruits.

Patrick *et al.* (2000) observed that preharvest sanitation sprays of endosulphan in pea plots resulted in significantly higher pod and seed yield. This was probably due to highly reduced incidence of pests and diseases.

Yadav *et al.* (2001) reported in okra that date of sowing and planting geometry significantly affect seed yield and various quality parameters, except that spacing had no effect on number of seeds per fruit, seed yield and electrical conductivity. The crop sown on 13th June tended to produce highest number of seeds per fruit and maximum seed yield. Among the various interactions between dates of planting and plant geometry, crop sown on 13th June at 45 x 30cm spacing recorded the highest seed yield and better quality than any other treatment combinations.

In a trial with sponge gourd Patil *et al.* (2001) observed that application of plant growth regulator, cycocel 750 ppm produced highest seed yield. This was due to high number of female flowers, high number of fruits per vine and minimum sex ratio. Cytozyme crop^{+}

showed no significant effect on sex expression, days to maturity, fruit yield and seed yield.

Lokesh *et al.* (2002) in a trial with short day onion varieties, observed that 10th November date of planting bulbs had significant effect on plant height, number of umbels per plants, umbel diameter, seed yield per umbel, seed yield per plant and seed yield per ha followed by 25th November, 10th December and 25th December planting.

Singh *et al.* (2002) stated that the vegetable quality and yield or seed yield or seed quality in a vegetable crop is directly dependent upon the quality of seedlings raised.

Sharma (2002) in an experiment with cauliflower var. Pusa snowball K1 found that maximum plant height, number of branches per plant, number of seeds per pod, seed yield per plant and percent seed germination were obtained when 25 kg borax per ha was applied through soil application. It was concluded that a combination of 25kg borax and 1.5kg molybdenum per ha through soil application was best for obtaining maximum seed yield per ha for cauliflower.

Sharma and Singh (2002) in a field trial with pea reported that the maximum plant height, number of pods per plant, pod length, number of seeds per pod and seed yield per hectare was obtained at 150 Kg seed rate per ha. At 25Kg N + 60Kg P_2O_5 + 40Kg K_2O per ha; maximum seed yield per hectare was obtained along with maximum values for plant height, number of pods per plant, pod length and number of seed per pod along with a cost:benefit ratio of 1:0.94.

Goudappalavar *et al.* (2002) in an experiment with tomato reported that, the plant growth, fruit yield and seed yield increased

significantly with application of increased doses of plant nutrition (120:180:80KgNPK per ha). Further increase did not result in significant increase. Significantly higher number of fruits per plant, fruit yield per plant and hectare and seed yield per plant and hectare when chemical spraying was done at 50percent flowering stage compared to fruit setting stage. Among the chemicals GA3 100 ppm and NAA 50 ppm recorded significantly higher seed yield per ha compared to other chemicals and control. The seed recovery was also maximum with GA_3.

In an experiment with tomato Hamsaveni *et al.* (2002) reported that soil application of gypsm at 150 kg per ha resulted in significantly higher number of fruits per plant, fruit weight, fruit yield, number of seeds per fruit, seed yield and seed recovery. Foliar spray of boron 0.5percent gave more number of fruits per plant, fruit weight, fruit yield and seed recovery. The interaction between gypsm and boron treatment were insignificant.

Balaraj *et al.* (2002) in a field trial with chilli observed that the maximum seed yield per plant and per hectare were observed with 20ppm NAA followed by 1ppm 2.4D. Spraying of growth regulators at 35 and 50 days after transplanting has shown beneficial effect on plant height, number of branches per plant, fruit and seed yield per plant and per hectare.

The results of a field trial consisting of 3 inter-row spacings (30, 45 and 60cm) and 3 inter-row spacing (10, 15 and 20cm) of amaranthus revealed that inter row spacing of 45cm was better than 30cm. The inter-row spacing did not affect the seed yield significantly. The highest average yield was obtained with an inter and intra row spacing of 45 x 15cm. All the growth and yield characters were also improved with

increase in inter row spacing except that of number of fingers per plant. (Arya and Singh, 2004)

Effect of four levels of nitrogen (0,50,100 and 150 Kg per ha) and three spacings (45x45cm, 60x30cm and 60x45cm) were studied on seed yield of carrot cv. Nantes in rainfed midhill conditions of Uttaranchal by Singh and Mishra (2004). Results indicated that transplanting of the roots at 45x45cm spacing along with application of N at 100Kg per ha gave highest seed yield. Closer spacing (60x30cm) favoured the plant height where as, maximum number of branches per plant was recorded with the spacing of 60x45cm.

A field experiment was conducted at college of Agriculture, Vellayani to study the effect of vegetable harvests on seed yield and quality in bitter gourd. The ripe fruit yield and seed yield increased up to two vegetable harvests. Number and weight of seeds per fruit were highest for zero vegetable harvest. Test seed weight was significantly higher for 2 vegetable harvests. (Devi and Pushpakumari, 2004)

Tomar *et al.* (2004) reported significant differences in plant growth, seed yield and seed quality characters under two methods of irrigation in the seed production of onion cv. Pusa Madhvi. Maximum height of flowering stalk, highest number of umbels per plant, highest seed yield per umbel, highest seed yield per plant and highest seed yield was recorded under the low pressure drip irrigation system.

The seed production potential of fifteen genotypes of chilli was evaluated under three planting seasons at Punjab. The spring season recorded maximum under of fruits per plant, number of seeds per fruit, maximum seed weight per fruit, there by giving maximum seed yield,

where as minimum seed yield was obtained in the crop growing in summer season. (Kanwar and Bhuvaneswari, 2004)

Field cum laboratory studies were conducted by Ashok *et al.* (2004) to determine effect of sowing dated during kharif (June 15, July 15) during rabi (November 15 and December 15), spacing (60 x 20, 60 x 30 and 60 x 45 cm) and nitrogen levels (100, 125 and 150 kg per ha) on seed quality of okra. The sowing on July 15 during kharif and November 15 during rabi with spacing of 60x30 cm coupled with application of nitrogen 125 Kg per ha recorded higher seed yield and seed quality.

Singh *et al.* (2005) in an experiment with onion reported that the bulb diameter (6 x 4.5 cm) and bulb spacing (45 x 30 cm) had given maximum seed yield of 9.87q per ha and 9.76q per ha respectively. The maximum net return and the highest cost:benefit ratio were recorded when 4.5 x 3 cm bulbs were planted at 45 x 30 cm spacing. Time of planting of onion bulbs has significant effect on plant height, days to flower, size of umbel, 1000 seed weight, seed yield per umbel and total seed yield. The 11th October planting produced highest size of umbel and significantly higher seed yield per umbel, 1000 seed weight and highest total seed yield over the treatments which were planted late (October – November).

Ravikumar *et al.* (2005) in an experiment with cucumber found that closer spacing of 1.5 x 0.5 m recorded higher fruit yield, seed setting and seed yield as compared to wider spacing (1.5 x 0.75 m). Un nipped treatment recorded higher number of filled seeds per fruit, seed extraction, seed setting percent resulting in more seed yield compared to nipping and CCC application. Retentions of 4 fruits per vine

recorded significantly high seed yield compared to retention of 2 fruits per vine.

Jana (2005) in a field trial with French bean observed that variety Contender gave maximum seed yield of 3.53t per ha and cost:benefit ratio (3.80) at 15th November sowing, while the variety Arka komal recorded highest seed yield of 2.53 t per ha and cost: benefit ratio (2.79) at November 30 sowing.

2.3 SEED QUALITY

The influence of season, sowing per planting time and cultural practices on seed quality has been studied in different vegetables by different workers.

Odland (1937) revealed that if the fruits of cucurbits were allowed to remain on the vine until over ripe, the seed would germinate properly. But if the fruits were picked at ripe stage the germination could be delayed for several weeks.

Seaton (1938) reported a significant correlation between the fruit weight and number of good seeds in cucumber.

According to Garris and Hoffmann (1946) prolonged field exposure after the stage of maturity would result in losses in germinability, longevity and vigour of okra seedlings.

Slobodjani (1958) reported that tomato seeds from the lower half of the fruit were larger, denser and gave rise to more productive plants from those from the upper half.

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.

Singh and Cheema (1972) reported that the lack of moisture at the time of fruit formation and seed development in radish may result in shriveled and undersized seeds of poor quality.

Carrot seed quality as indicated by test weight improved significantly with increasing spacing. The percentage of large seed tended to increase and that of small ones to decrease. The extra small seed and seed viability were relatively unaffected. Nitrogen had a significant effect on test weight and the amount of large seed increased with increasing nitrogen while the small seed suffered a corresponding reduction. Potash application did not influence the quality of carrot seeds. (Malik, 1973)

Grewal *et al.* (1973) in an experiment with okra reported variation in germination percentage as influenced by time of sowing. Significantly lower 1000 seed weight was observed in plants were 3 to 4 green fruit pickings were done. However there was no appreciable difference in 1000 seed weight due to one or two green fruit pickings. Plants in which no green fruit picking was done gave the highest germination percentage.

Chowdhary (1979) reported that scooping in cauliflower may be used to increase seed yields.

Lovoto and Montanari (1979) reported that the seed quality was determined by weather and particularly by the abundant rain at the time of seed maturation in carrot.

Lysenco and Butkevich (1980) in an experiment with capsicum reported that seed quality depended on the extend of fruit maturity and reddening of fruit.

Umalkar *et al.* (1981) observed that sodium azide induced large variability in *Capsicum annum*. The number of seeds per capsule varied 18-84 while the weight of 100 seeds was in the range of 0.5 to 1.3 g. These mutants also exhibited high germination percentage and vigour over parental variety.

Variation in vigour index as influenced by time of sowing was reported in soy bean. (Mugnisyah *et al.*, 1984)

Difference in field emergence of seedlings as influenced by sowing dates was reported in soyabean. (Nakagawa *et al.*, 1984)

In Brazil, Alvarenga *et al.* (1984) studied the influence of age and post harvest stage of watermelon cv. Charleston Gray on seed quality and opined that best quality in relation to germination, vigour, dry weight, and moisture content was generally in seeds from fruits harvested 35 and 45 days after anthesis and stored for 4 days.

Szalay (1984) in an experiment with onion reported that between August 8th and 15th was the most appropriate time for harvesting for seed production as the seeds harvested at this time showed optimum germination ability, highest 1000 seed weight and minimum seed losses due to shattering during mechanical harvesting.

Ashok and Ramakrishnan (1986) reported that the seeds of chilli variety CO-1 from second and third picking showed superiority after 12 months of storage.

In a field trial with okra Palanisamy *et al.* (1986) observed that the viability and vigour of seeds were the highest in seeds obtained from March, April and May sown crops as compared to other methods of sowing. Wider spacing recorded more seed weight, longer root and shoot length, higher dry weight of seedlings and greater vigour index.

The effect of spacing on germination of seeds was however negligible. Seed quality was better in wider spaced crops.

Singh *et al.* (1988) reported highest 1000 seed weight and maximum seeds per fruit recorded in okra sown in the month of June.

Reports on positive influence of large fruits on seed content, seed size and vigour have been made in bitter gourd (Vanangamudi *et al.*, 1989)

Krishnaveni and Palaniswamy (1990) found that onion planting in the 2nd and 3rd weeks of November gave the highest bulb and seed yields and the best seed quality.

In an experiment with chilli Doijode (1990) reported that seeds from basal region of the fruit exhibited higher germination than from the top and middle position of fruit. Seedling emergence was earlier in seeds of basal region.

Sreemathi *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.

Sanchez *et al.* (1993) observed that the germination percent of bell pepper seeds were significantly increased when the seeds were allowed to remain within the fruit for 14 days post harvest maturation.

The seeds of bitter gourd collected from the proximal 1/3rd portion registered higher seed weight, germination percentage, shoot length and 100 embryo weight. The seeds from the distal 1/3rd portion was of poor quality which was due to the poor seed development. (Vijayakumar *et al.*, 1994)

Vijayakumar *et al.* (1995) in an experiment with bitter gourd observed that application of 40:30:60 kg NPK per ha and maintaining 3 plant per pit at a spacing of 2.5 x 2m was found optimum for getting higher quality seeds in MDU-1.

Influence of fruit ripeness at the time of seed extraction on pepper (*Capsicum annum*) seed germination was studied by Cavero *et al.* (1995). It was concluded that seeds from half ripe fruits had a poor germination than those from fully ripe fruits.

Sheeba (1995) in a trial with okra observed that germination percentage, 1000 seed weight, 100 seed volume, seed protein and seed moisture content were not significantly influenced by vegetable harvests while seedling root and shoot lengths and vigour index values were better for two vegetable harvest treatments.

Krishnamurthy (1995) reported higher laboratory germination, field emergence, shoot length, root length and vigour index when chilly fruits were harvested after obtaining 100 percent red colour than those harvested earlier.

Significant influence of vegetable harvests on 100 seed weight in bitter gourd was reported by Devi (1999). Two vegetable harvests had the highest value which was on par with zero vegetable harvests.

In an experiment with amaranthus Srinivasaiah *et al.* (2000) observed that July and February sown crop recorded low seed yield but had better seed quality. The November sown crop gave the maximum seed yield with fairly good seed quality. The crop sown in July recorded the highest germination percentage (94.67percent) than in October sown ones (89.33percent).The highest seedling dry weight (7.78mg) was recorded in February sown crop while the lowest

(7.04mg) was recorded in November sown one. Vigour index was highest in February sown crop while it was lowest in November sown one.

Priya *et al.* (2000) in an experiment with cauliflower reported that curd cutting methods could not influence the seed weight, germinability and seedling dry weight.

In a study conducted in Karnal it was reported that among the different seed umbel shapes, carrot seeds from open or flat shape was superior to other types which could be attributed to its flower shape being predominantly bell or semi-bell shaped with larger surface area for pollination, seed setting and proper drying. (Pandita and Shantha, 2000)

Kanwar *et al.* (2000) in a field trial with onion reported a significant increase in umbel size and seed size under wider spacing. But percent seed germination remained unchanged over different population density levels.

Ash gourd seeds from large fruits recorded the highest 100 seed weight and the lowest value was recorded from the small fruits. Seeds from fruits of different sizes recorded no significant difference in germination percentage. Seeds from fruits of different size showed a gradual increase in vigour index with increase in fruit size. (Mini *et al.*, 2000)

In an experiment with sponge gourd Patil *et al.* (2001) observed that Cytozyme crop^{+} 1500ppm spray gave highest 100 seed weight and seed density. Seed quality parameters like 100 seed weight, seed density and seed vigour were unaffected with cycocel treatment.

In a study to determine variation in seed quality during maturity in tomato results showed that the occurrence of maximum tomato seed quality is related to changes in fruit colour, but not in seed dry weight (Demir and Samit, 2001)

Yadav and Dhankhar (2001) reported that seeds obtained from lower and middle position fruits of okra gave higher test weight, vigour index and viability than in seeds of upper position fruits.

In an experiment with okra Yadav *et al.* (2001) observed highest values in test weight, germination percentage, seedling length, vigour index and germination percentage in 30th June sown crop, while very poor performance of these parameters was recorded in later dates of sowing. Significantly higher values were observed for test weight, standard germination, seedling length, vigour index, and germination in crop sown under 45 x 30 cm spacing.

Pandita and Shantha (2001) reported that chilli seeds from matured green and half red fruits had poorer germination, vigour and field emergence than those taken from red ripe fruits. Post harvest ripening upto 10 days in half red fruits improved seed germination, vigour and field emergence significantly.

Position of seeds in the inflorescence influences the quality of seeds. The inflorescences have been collected from the seed crop of amaranthus tricolor cv.CO-5. The seeds of middle position possessed higher germination (95percent) and vigour than seeds of proximal and distal position. The developing seeds of the middle position might have utilized adequate assimilate from the mother plant for the development of seeds associated with higher germination and vigour. (Menaka *et al.*, 2002)

Okra seeds (var. Salkeerthy) were collected from fruits developed at different nodes and evaluated for different yield and quality parameters. Seeds obtained from 9^{th} and 10^{th} nodes were found superior with regard to germination percentage, speed of germination and vigour index. Such seeds gave an assured germination as high as 96 percent. Fruits from upper and lower most nodes should be avoided for seed purpose since they recorded lower values for all the parameters evaluated. (Krishnakumari and Mini, 2002)

Studies were carried out by Vijayakumar *et al.* (2002) in bitter gourd cv. MDU-1 using 6 fruit size grades to find out the relation of fruit weight and position of seeds in the fruit on seed quality. Seed quality attributes were higher in the fruits weighing more than 201 g irrespective of the position of seeds in the fruit. Seed quality was higher at the proximal $1/3^{rd}$ portion followed by those in middle $1/3^{rd}$ position. Seed development was poor at the distal portion and is associated with poor quality.

Brinjal fruits were harvested at turning yellow stage, fully mature stage and fully ripened stage. It was concluded that in both the cultivars of brinjal ie, Pusa Purple Cluster and Pusa Kranti, maximum seed recovery, germination percentage, 1000 seed weight and vigour index was recorded when the fruits were harvested at fully ripened stage. (Dev and Sharma, 2002)

Muscolo *et al.* (2002) hypothesized that humic substances inhibit seed germination by affecting metabolic processes.

In experiment with tomato fruits harvested in first picking resulted in maximum 1000 seed weight and seed vigour index having significant differences over other picking except second, third and

fourth picking. However maximum seed recovery was obtained in 3rd picking having significant differences over other pickings except fourth picking. Results with respect to germination percentage remained nonsignificant. It was concluded that for quality seed production in Roma cultivar of tomato, fruits harvested from first picking proved superior. (Dev and Sharma, 2002)

Goudappalavar et al. (2002) in a trial with tomato reported that seed quality parameters like 1000 seed weight, germination, seedling length, seedling vigour index and seedling dry weight were significantly high when the application of 120:180:80 NPK was made. Seed quality attributes were significantly highest when chemical spraying was done at 50percent flowering stage compared to fruit setting stage. Among the chemicals GA3 spray recorded higher seed quality followed by NAA. Among the 4 pickings, seeds obtained from first 3 were superior for all seed quality parameters.

Hamsaveni *et al.* (2002) in an experiment with tomato observed that seed from fruits harvested at full red colour was significantly higher in 100 seed weight, germination percentage, vigour index, seedling dry weight and field emergence compared to either fruits harvested at yellow or half red colour stage. Gypsm levels at 150kg per ha resulted in significantly higher 1000 seed weight, germination, vigour index and field emergence. Foliar spray of boron (0.5percent) gave lower values. The interaction between gypsm and boron treatments were insignificant.

Singh *et al.* (2002) reported that in chilli the growth regulators, NAA (10 and 20 ppm), 2,4-D (1ppm) and GA_3 (50ppm) increased 1000 seed weight, percentage seed germination, seedling length, seedling vigour index, seedling dry weight and field emergence. Higher seed

quality parameters were noticed with 20 ppm NAA and 1ppm 2,4-D followed by 50ppm GA3 and 10ppm NAA sprayed at 35 and 50 days after transplanting.

In a field trial with onion Tomar *et al.* (2004) observed that maximum 1000 seed weight, highest germination percentage and maximum seed vigour index was recorded under the low pressure drip irrigation system.

Rajkumar *et al.* (2004) in an experiment with field pea found that effect of natural ageing significantly influenced the germination, speed of germination, vigour index etc. Significant differences among these parameters also showed gradual decline in their values with the increase of age of seed. Laboratory germination was found drastically affected only in 68 months old seeds while vigour and speed of germination were marginally reduced after 32 months onwards.

The effect of boron on cauliflower seed yield and quality was tremendous; i.e., 9 times for seed yield per ha, 7-8 times on number of pods per plant, 5-6 times of seed yield per plant and 2 times in seed per pod. This was so because the initial level of boron was extremely low (0.23- 0.27 ppm). Thus significantly higher seed yield and seed quality were observed by applying boron at the rate of 20 kg borax per ha as compared to no boron application. Application of molybdenum and zinc had not significant effect on this crop. The combined effect of boron, molybdenum and zinc showed significant increase in number of primary inflorescence stalks, pods per plant, seed yield and germination percentage (Jana, 2004).

Ash gourd seed crop was raised during July, 2002 to study the effect of fruit and seed position in the vine coupled with their maturity

for getting quality seed. The results revealed that seeds from peduncle segment fruits produced low germination. The seeds which are extracted from top, positioned fruits (46 and above node) out performed middle (37-40th node) and bottom (27-30th node) positioned fruits in terms of seed germination. This study also confirmed that harvesting of fruits at 70 days after anthesis was found to be correct and suitable stage for best seed quality in rainy season crop (Murukeshan and Vanangamudi, 2005)

Ashok and Vyakarnahal (2005) in a trial with okra observed that the optimum stage of harvest for seed quality was found to be 40 days after anthesis. This coupled with shade drying of fruit resulted in higher test weight, germination, root length, shoot length, seedling dry weight, vigour index and reduced electrical conductivity.

Ravikumar *et al.* (2005) in an experiment with cucumber observed that seed yield, seed quality and benefit:cost ratio were higher in Kharif by adopting narrow spacing, no nipping and retention of 4 fruits per vine.

Bitter gourd genotypes (8 parental lines and 28 F1 hybrids) were subjected to seed quality assessment under laboratory conditions utilizing standard germination tests. The genotypic differences were highly significant in both the seasons for number of seeds per fruit, seed yield per fruit and seed vigour index. (Singh and Ram, 2005)

Effect of sowing date and variety of French bean on seed yield and quality was studied by Jana (2005). Highest value of 100 seed weight was obtained in 15th November sowing. 100 seed weight and germination percentage decreased significantly with delay in seed sowing.

Materials and Methods

3. MATERIALS AND METHODS

A field investigation was carried out during February-May 2006 to find out the influence of planting systems and harvest stages on seed yield and quality of amaranthus. The materials used and methods adopted are given below.

3.1 MATERIALS

3.1.1 Experimental site

The experiment was carried out at the Department of Olericulture and the Instructional Farm, College of Agriculture, Vellayani. The area is situated at 8.5°N latitude, 77.1°E longitude at an altitude of 29m above mean sea level. Predominant soil type of the experimental site was red loam belonging to Vellayani series texturally classified as sandy clay loam.

3.1.2 Planting material

Amaranthus seeds of variety Arun were used for the experiment.

3.2 METHODS

3.2.1 Design and layout

The experiment was laid out in a split plot design with planting systems in the main plots and harvest stages in the sub plots. The details of lay out were as follows.

Net plot size = $6m^2$

Number of main plots = 5

Number of sub plots/ main plot = 4

Replications = 4

3.2.2 Treatments

Main plot (5 planting systems)

M_1 – Transplanting 25 days after sowing

M_2 – Transplanting 20 days after sowing

M_3 – Transplanting 15 days after sowing

M_4 – Broadcasting

M_5 – Line sowing and thinning

Subplot (4 harvest stages)

S_1 – Harvesting seeds 30 days after flowering

S_2 – Harvesting seeds 40 days after flowering

S_3 – Harvesting seeds 50 days after flowering

S_4 – Harvesting seeds 60 days after flowering

3.3 FIELD CULTURE

3.3.1 Land preparation

The land was prepared as per the Package of Practices Recommendations of Kerala Agricultural University (KAU, 2002). The field was dug twice, clods broken and the experimental plot was made into main plots and sub plots as per treatments. The different planting systems were assigned in the main plots.

3.3.2 Manures and Fertilizer application

Basal dose of farm yard manure at the rate of 50 tons ha^{-1} was uniformly applied in all treatments. Recommended dose of fertilizers,

Plate 1. General view of the experimental field

$N:P_2O_5:K_2O$ at the rate of 50:50:50 kg ha^{-1} was applied. Another 50 kg of N was applied at regular intervals as topdressing.

3.3.3 Seeds and sowing

Amaranthus seeds of variety Arun were used for sowing. First nursery was prepared 25 days before transplanting, second nursery was prepared 20 days before transplanting and third nursery, 15 days before transplanting. Seedlings 25, 20 and 15 days old were transplanted in the main field. The other two main plot treatments such as broadcasting and line sowing were also done on the same day. The length and weight of seedlings at transplanting were 16.6 cm and 1g (15 days), 27.3 cm and 1.4g (20 days) and 32.5 cm and 2g (25 days) respectively.

3.3.4 After cultivation

Weeding operations were carried out to keep the plot free of weeds and crops were irrigated every day.

3.3.5 Plant protection

Severe disease or pest attack were not seen in the crops. Malathion 0.1 percent was applied to control leaf webber.

3.3.6 Harvesting

Harvesting was done according to the different sub plot treatments. There were 4 stages of harvesting namely, harvesting 30 days after flowering, 40 days after flowering, 50 days after flowering and 60 days after flowering.

3.4 OBSERVATIONS

Four plants were selected at random from each treatment and the following observations were made by adopting standard procedures and the average values were worked out.

3.4.1 Flowering

(a) Days to first flowering

Number of days taken from planting/sowing to the appearance of first flower was recorded.

(b) Days to 50 percent flowering

Total number of days taken for 50 percent of the plant population to flower in each treatment was recorded.

3.4.2 Vegetative characters

(a) Plant height (cm)

The height of the plants at harvest time were measured, average worked out and expressed in centimeters.

(b) Branches per plant

The number of branches per plant at harvest time was counted and the average worked out.

(c) Internode length (cm)

The distance between two nodes (6^{th} and 7^{th}) at harvest time were measured and the average was expressed in centimeters.

(d) Leaf length (cm)

The length of 5^{th} leaf was measured along the midrib 30 days after planting/sowing, average worked out and expressed in centimeters

(e) Leaf width (cm)

Leaf width was taken by measuring the broadest portion of the 5^{th} leaf 30 days after planting/sowing. The average value was worked out and expressed in centimeters.

(f) Petiole length (cm)

The length of petiole of the 5th leaf was measured 30 days after planting/sowing and the average value was expressed in centimeters.

3.4.3 Weeds

(a) Weight of weeds/ plot (kg)

Weeds from each plot were weighed and expressed in kilograms.

(b) Dry weight of weed/ plot (g)

Weeds from each plot were dried separately, weighed and expressed in grams.

3.4.4 Stalk and chaff

(a) Dry weight of stalk (g)

After removing the branches, the stalks from each plot were dried in the sun. Then they were weighed separately and the weight was expressed in grams.

(b) Weight of chaff (g)

After threshing and winnowing, the weight of chaff was taken and expressed in grams.

3.4.5 Seed yield

(a) Seed yield/ plot (g)

The seeds from each plot were weighed and the weight was expressed in grams.

(b) Seed yield/ plant (g)

The seed yield from the observational plants on each plot were weighed and average worked out and was expressed as seed yield/plant in grams.

(c) Seed recovery percentage

Seed recovery percentage was calculated from seed weight, weight of stalk and weight of chaff, and expressed in percentage.

(d) Percentage of chaffy seeds

The amount of chaffy seeds in each plot were expressed in percentage.

(e) Percentage of bold seeds

The amount of bold seeds in each plot were expressed in percentage.

3.4.6 Seed quality

(a) Thousand seed weight (g)

1000 seeds were counted at random from each treatment and weighed to obtain the 1000 seed weight and expressed in gram.

(b) Germination percentage

100 seeds from all treatments were sown and the percentage of seeds germinated was recorded.

(c) Root length of seedlings (cm)

Seeds collected at random from each treatment were sown and allowed to sprout with daily watering. After 14^{th} day they were uprooted and the length of roots were measured, the mean worked out and expressed in cm.

(d) Seedling length (cm)

The length of seedlings were measured, the average value worked out and expressed in centimetres.

(e) Vigour index of seedling

Seedling vigour index was calculated by adopting the formula suggested by Abdul-baki and Anderson (1973) and expressed as a number.

VI = Germination percentage × (Root length + Shoot length)

(f) Fresh weight of seedlings (g)

Weight of seedlings were taken and average value was expressed in grams.

(g) Dry weight of seedlings (g)

After drying in a hot air oven, the seedlings were weighed, average worked out and expressed in grams.

(h) Dry matter percentage

The amount of dry matter in the seedlings was worked out and expressed in percentage.

3.4.7 Incidence of pests and diseases

The incidence of leaf webber and leaf blight through out the crop period was recorded and the severity was scored using an index scale.

Incidence of pests and diseases

0	No incidence
Below 50%	Mild incidence
Above 50%	Severe incidence

3.4.8 Economics of cultivation

The economics of cultivation was worked out based on the various input cost. Gross income was calculated using the prevailing cost of seed @ Rs.800/Kg.

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

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

3.4.9 Statistical analysis

The experimental data were analyzed statistically by applying the technique of analysis of variance for split plot design (Gomez and Gomez, 1984).

In cases where the effects were found significant, critical difference were calculated for making multiple comparisons among the means. The critical difference for comparison of all the main effects and interaction effects were also computed based on the formula for split plot design. Break up of total degree of freedom in the analysis of variance of the present study is as given below.

Source	df
Replications	3
Main plot (Planting systems)	4
Error (a)	12
Sub plot (harvest stages)	3
Interaction between planting systems and harvest stages	12
Error (b)	45
Total	79

Treatment combinations

$M_1S_1 - T_1$

$M_1S_2 - T_2$

$M_1S_3 - T_3$

$M_1S_4 - T_4$

$M_2S_1 - T_5$

$M_2S_2 - T_6$

$M_2S_3 - T_7$

$M_2S_4 - T_8$

$M_3S_1 - T_9$

$M_3S_2 - T_{10}$

$M_3S_3 - T_{11}$

$M_3S_4 - T_{12}$

$M_4S_1 - T_{13}$

$M_4S_2 - T_{14}$

$M_4S_3 - T_{15}$

$M_4S_4 - T_{16}$

$M_5S_1 - T_{17}$

$M_5S_2 - T_{18}$

$M_5S_3 - T_{19}$

$M_5S_4 - T_{20}$

Fig.1. Lay out of the experiment

Replication I

T_2	T_4	T_1	T_3
T_{11}	T_{10}	T_9	T_{12}
T_{18}	T_{20}	T_{17}	T_{19}
T_{15}	T_{14}	T_{13}	T_{16}
T_6	T_5	T_8	T_7

Replication III

T_{12}	T_{11}	T_{10}	T_9
T_3	T_1	T_2	T_4
T_{15}	T_{13}	T_{16}	T_{14}
T_{19}	T_{17}	T_{20}	T_{18}
T_5	T_7	T_8	T_6

Replication II

T_{15}	T_{13}	T_{14}	T_{16}
T_8	T_6	T_7	T_5
T_{10}	T_{11}	T_{12}	T_9
T_4	T_1	T_3	T_2
T_{18}	T_{17}	T_{20}	T_{19}

Replication IV

T_4	T_2	T_3	T_1
T_{14}	T_{16}	T_{13}	T_{15}
T_{20}	T_{17}	T_{19}	T_{18}
T_{12}	T_{11}	T_9	T_{10}
T_7	T_5	T_6	T_8

Results

4. RESULTS

The result of the present experiment depicting the influence of planting systems and harvest stages on the seed yield and quality in amaranthus (*Amaranthus tricolor*) is presented in this chapter. The data on biometric observations, quality and yield characters were statistically analyzed, their direct and interaction effects worked out and presented in the tables 1 to 28.

4.1 FLOWERING

4.1.1 Days to first flowering

4.1.1.1 Effect of planting systems

There was highly significant variation on the days to first flowering due to difference in planting systems (Table 1). The earliest flowering was seen in M_2 (18 days) and the latest flowering was seen in M_5 (25.06 days).

Table 1. Effect of planting systems on days to first flowering

	S_1	S_2	S_3	S_4	Mean (M)
M_1	8.25	13.50	17.00	36.75	18.87
M_2	33.25	8.25	13.75	16.75	18.00
M_3	36.75	33.50	8.50	13.75	23.12
M_4	16.75	36.75	33.25	8.25	23.75
M_5	13.50	17.00	36.50	33.25	25.06

CD (M) = 0.27

4.1.2 Days to 50 percent flowering

4.1.2.1 Effect of planting systems

There was highly significant variation on the days to 50 percent flowering due to difference in planting systems (Table 2). The earliest (20.56 days) flowering was exhibited by M_2 and latest flowering (27.87 days) was exhibited by M_5.

Table 2. Effect of planting systems on days to 50 percent flowering

	S_1	S_2	S_3	S_4	Mean (M)
M_1	10.50	16.00	19.25	39.50	21.31
M_2	36.00	10.25	16.50	19.50	20.56
M_3	39.50	36.50	10.75	16.50	25.81
M_4	19.50	39.50	36.00	10.50	26.37
M_5	16.25	19.75	39.25	36.25	27.87

CD (M) = 0.43

4.2 VEGETATIVE CHARACTERS

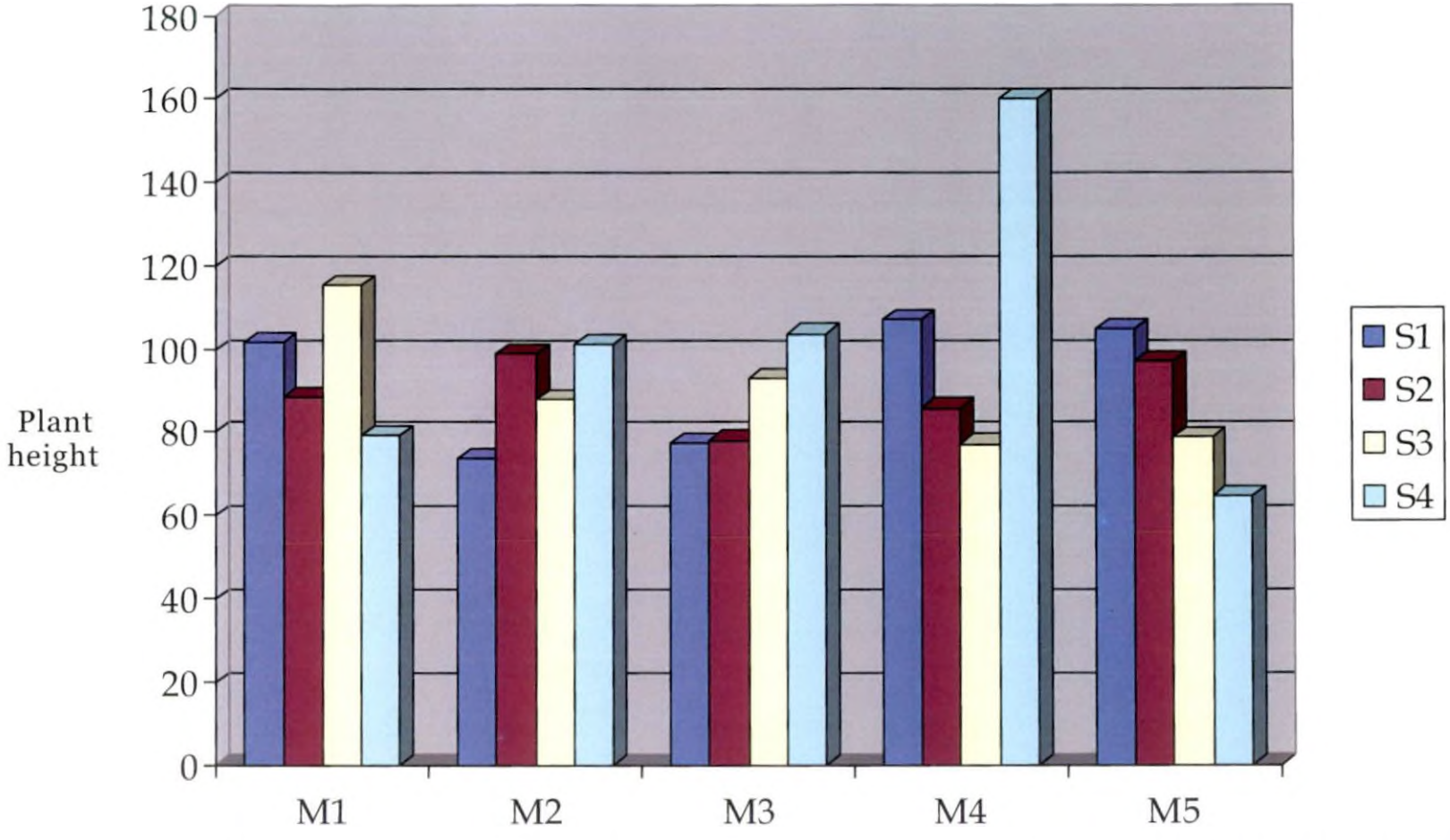
4.2.1 Plant height (cm)

4.2.1.1 Effect of planting systems

Planting systems showed significant differences on plant height (Table 3). Among the five planting systems, M_1 (96.188cm) had the tallest plants, and the minimum height was observed in M_5 (86.4cm)

4.2.1.2 Effect of harvest stages

Perusal of the data revealed that there was no significant effect among the different harvest stages on plant height (Table 3).



M_1 – Transplanting 25 days after sowing
M_2 – Transplanting 20 days after sowing
M_3 – Transplanting 15 days after sowing
M_4 – Broadcasting
M_5 – Line sowing and thinning

S_1 – Harvesting seeds 30 days after flowering
S_2 – Harvesting seeds 40 days after flowering
S_3 – Harvesting seeds 50 days after flowering
S_4 – Harvesting seeds 60 days after flowering

Fig.2. Effect of planting systems, harvest stages and their interaction on plant height (cm)

4.2.1.3 Effect of M x S interaction

Highly significant difference in plant height was observed among the interaction between planting systems and harvest stages (Table 3). Maximum height was recorded in M_1S_3 (115 cm) and minimum in M_5S_4 (64.68cm).

Table 3. Effect of planting systems, harvest stages and their interaction on plant height (cm)

	S_1	S_2	S_3	S_4	Mean (M)
M_1	101.62	88.43	115.31	79.37	96.18
M_2	73.75	98.75	88.12	101.37	90.50
M_3	77.50	78.12	93.12	103.75	88.12
M_4	107.18	85.93	77.18	106.12	94.10
M_5	105.00	97.18	78.75	64.68	86.40
Mean (S)	93.01	89.68	90.50	91.06	

CD (M) = 5.4

CD (S) = NS

CD (M x S) = 11.35

4.2.2 Branches/plant

4.2.2.1 Effect of planting systems

Branches/plant was not significantly affected by the different planting systems (Table 4).

Table 4. Effect of planting systems on branches /plant

	S_1	S_2	S_3	S_4	Mean (M)
M_1	12.99	10.16	9.74	8.12	10.25
M_2	9.06	10.52	10.14	8.82	9.63
M_3	7.68	7.89	10.64	11.00	9.30
M_4	10.06	9.08	8.77	12.38	10.07
M_5	10.99	10.82	9.21	8.47	9.87

CD (M) = NS

4.2.3 Internode length

4.2.3.1 Effect of planting systems

Highly significant difference in internode length was observed among the different planting systems (Table 5). M_2 showed the longest internode (4.53cm) followed by M_1 (4.48cm), M_3 (3.92cm), M_4 (3.70cm) and M_5 (3.57cm).

4.2.3.2 Effect of harvest stages

Among the different harvest stages, highly significant difference in internode length was observed (Table 5). S_1 showed the longest internode (4.49cm) followed by S_4 (4.01cm), S_3 (3.89cm) and S_2 (3.78cm).

4.2.3.3 Effect of M x S interaction

Highly significant difference in internode length was observed among the interaction between planting systems and harvest stages (Table 5). Maximum internode length was recorded in M_2S_1 (6.78cm) and minimum in M_5S_2 (3.24 cm).

Table 5. Effect of planting systems, harvest stages and their interaction on internode length

	S_1	S_2	S_3	S_4	Mean(M).
M_1	4.04	4.25	4.47	5.15	4.48
M_2	6.78	3.95	3.68	3.73	4.53
M_3	4.41	3.67	4.08	3.53	3.92
M_4	3.37	3.78	3.58	4.08	3.70
M_5	3.85	3.24	3.66	3.56	3.57
Mean(S)	4.49	3.78	3.89	4.01	

CD (M) = 0.42

CD (S) = 0.4

CD (M x S) = 0.91

4.2.4 Leaf length

4.2.4.1 Effect of planting systems, harvest stages and their interaction

The different planting systems, harvest stages and their interaction did not produce any significant effect on leaf length (Table 6).

Table 6. Effect of planting systems, harvest stages and their interaction on leaf length

	S_1	S_2	S_3	S_4	Mean (M)
M_1	19.31	20.37	19.64	19.50	19.709
M_2	20.12	19.46	20.12	19.12	19.708
M_3	20.29	20.24	20.92	20.12	20.397
M_4	20.16	19.20	19.93	19.64	19.740
M_5	20.60	20.54	19.64	20.03	20.206
Mean (S)	20.10	19.96	20.05	19.68	

CD (M) = NS

CD (S) = NS

CD (M x S) = NS

4.2.5 Leaf width

4.2.5.1 Effect of planting systems, harvest stages and their interaction

The different planting systems, harvest stages and their interaction had no significant effect on leaf width (Table 7).

Table 7. Effect of planting systems, harvest stages and their interaction on leaf width

	S_1	S_2	S_3	S_4	Mean (M)
M_1	7.49	8.42	8.81	8.24	8.24
M_2	9.15	7.86	8.36	7.84	8.30
M_3	8.63	8.73	8.52	8.33	8.55
M_4	7.91	8.55	8.41	8.38	8.31
M_5	8.75	8.47	7.99	8.37	8.40
Mean (S)	8.39	8.41	8.42	8.23	

CD (M) = NS

CD (S) = NS

CD (M x S) = NS

4.2.6 Petiole length

4.2.6.1 Effect of planting systems, harvest stages and their interaction

There was no significant variation in petiole length due to the effect of planting systems, harvest stages and their interaction (Table 8).

Table 8. Effect of planting systems, harvest stages and their interaction on petiole length

	S_1	S_2	S_3	S_4	Mean (M)
M_1	7.83	7.99	8.54	7.84	8.05
M_2	7.93	7.69	8.16	7.62	7.85
M_3	7.47	7.81	8.08	8.51	7.97
M_4	7.49	7.75	7.87	7.95	7.76
M_5	8.16	8.45	7.47	7.61	7.92
Mean (S)	7.78	7.94	8.02	7.91	

CD (M) = NS

CD (S) = NS

CD (M x S) = NS

4.3 WEEDS

4.3.1 Weight of weed/plot (kg)

4.3.1.1 Effect of planting systems

Significant difference was noticed between weight of weed/plot due to planting systems (Table 9). The maximum weight (1.9kg) was seen in M_4 and the minimum weight (1.22 kg) was observed in M_1.

4.3.1.2 Effect of harvest stages

There was no significant difference between the weed weight on different plots due to various harvest stages (Table 9).

4.3.1.3 Effect of M x S interaction

There was highly significant difference between weed weight /plot due to interaction between planting systems and harvest stages (Table 9). Maximum weed weight (2.35kg) was observed in M_3S_3 while the minimum weed weight was seen in M_2S_3 (0.837 kg).

Table 9. Effect of planting systems, harvest stages and their interaction on weight of weed/plot

	S_1	S_2	S_3	S_4	Mean (M)
M_1	1.11	0.90	1.52	1.35	1.22
M_2	1.26	2.22	0.83	2.12	1.61
M_3	1.00	0.92	2.35	2.00	1.56
M_4	1.86	2.07	1.95	1.75	1.90
M_5	1.70	1.25	1.30	0.90	1.28
Mean (S)	1.38	1.47	1.59	1.62	

CD (M) = .46

CD (S) = NS

CD (M x S) = .79

4.3.2 Dry weight of weed/plot

4.3.2.1 Effect of planting systems

There was highly significant difference between the dry weights of weed/plot due to the effect of planting systems (Table 10). The maximum dry weight (430.62g) was seen in M_4 and the minimum dry weight (288.12g) was observed in M_1.

Plate 2. Plants from 25 day old seedlings before weeding

Plate 4. Plants from 20 day old seedlings before weeding

Plate 5. Plants from 20 day old seedlings after weeding

Plate 6. Plants from 15 day old seedlings before weeding

Plate 7. Plants from 15 day old seedlings after weeding

Plate 8. Broadcasted seedlings before weeding

Plate 9. Broadcasted seedlings after weeding

Plate 10. Line sown seedlings before weeding

Plate 11. Line sown seedlings after weeding

4.3.2.2 Effect of harvest stages

No significant difference was noticed between weed weight/plot due to variation in harvest stages (Table 10).

4.3.2.3 Effect of M x S interaction

Highly significant difference was observed between dry weight of weed/plot due to the interaction effect between planting systems and harvest stages (Table 10). The maximum dry weight (615g) was observed in M_2S_2 while minimum dry weight of weed/plot was seen in M_5S_4 (195g).

Table 10. Effect of planting systems, harvest stages and their interaction on dry weight of weed/plot

	S_1	S_2	S_3	S_4	Mean (M)
M_1	280.00	257.50	312.50	302.50	288.12
M_2	282.50	615.00	213.75	461.25	393.12
M_3	262.50	223.75	587.50	387.50	365.31
M_4	425.00	530.00	392.50	375.00	430.62
M_5	417.50	375.00	265.00	195.00	313.12
Mean (S)	333.50	400.25	354.25	344.25	

CD (M) = 70.14

CD (S) = NS

CD (M x S) = 174.48

4.4 STALK AND CHAFF

4.4.1 Dry weight of stalk

4.4.1.1 Effect of planting systems

Highly significant effect was observed among the planting systems on dry weight of stalk (Table 11). M_4 showed the maximum dry weight of stalk (310 g) while M_3 showed minimum dry weight (230g)

4.4.1.2 Effect of harvest stages

Harvest stages had no significant effect on dry weight of stalk (Table 11).

4.4.1.3 Effect of M x S interaction

There was highly significant interaction between planting systems and harvest stages on dry weight of stalk (Table 11). M_4S_1 showed the maximum (357.5g) dry weight of stalk while M_3S_1 showed minimum dry weight (187.5).

Table 11. Effect of planting systems, harvest stages and their interaction on dry weight of stalk

	S_1	S_2	S_3	S_4	Mean (M)
M_1	247.50	257.50	342.50	217.50	266.25
M_2	190.00	240.00	212.50	322.50	241.25
M_3	187.50	212.50	215.00	305.00	230.00
M_4	357.50	290.00	325.00	267.50	310.00
M_5	252.50	312.50	287.50	232.50	271.25
Mean (S)	247.00	262.50	276.50	269.00	

CD (M) = 32.66 CD (S) = NS CD (M x S) = 90.65

4.4.2 Chaff weight (g)

4.4.2.1 Effect of planting systems

Significant effect was observed among the planting systems on chaff weight (Table 12). M_4 showed the maximum chaff weight (559.5g) while M_3 showed the minimum weight (406.25g).

4.4.2.2 Effect of harvest stages

There was no significant effect of harvest stages on chaff weight (Table 12).

4.4.2.3 Effect of M x S interaction

Interaction effect between planting systems and harvest stages was highly significant with regard to chaff weight (Table 12). M_4S_4 showed maximum chaff weight (885g) and M_3S_1 had the minimum chaff weight (207.5g).

Table 12. Effect of planting systems, harvest stages and their interaction on chaff weight

	S_1	S_2	S_3	S_4	Mean (M)
M_1	638.75	465.00	802.50	282.50	547.18
M_2	320.00	640.00	437.50	617.50	503.75
M_3	207.50	300.00	527.50	590.00	406.25
M_4	622.50	342.50	387.50	885.00	559.37
M_5	560.00	627.50	407.50	295.00	472.50
Mean (S)	469.75	475.00	512.50	534.00	

CD (M) = 86.59 CD (S) = NS CD (M x S) = 164.91

4.5 SEED YIELD

4.5.1 Seed yield/plot

4.5.1.1 Effect of planting systems

There was significant difference between seed yield/plot due to the effect of planting systems (Table 13). M_2 showed the highest (214.5g) seed yield/plot which was on par with M_1 (212.12g) followed by M_4 (190.5g) while M_5 recorded the lowest (181.37g).

4.5.1.2 Effect of harvest stages

There was significant difference between seed yield/plot due to different harvest stages (Table 13). S_3 recorded the maximum (210.4g) seed yield/plot which was on par with S_1 (193.25g) while S_4 recorded the minimum (173.2g).

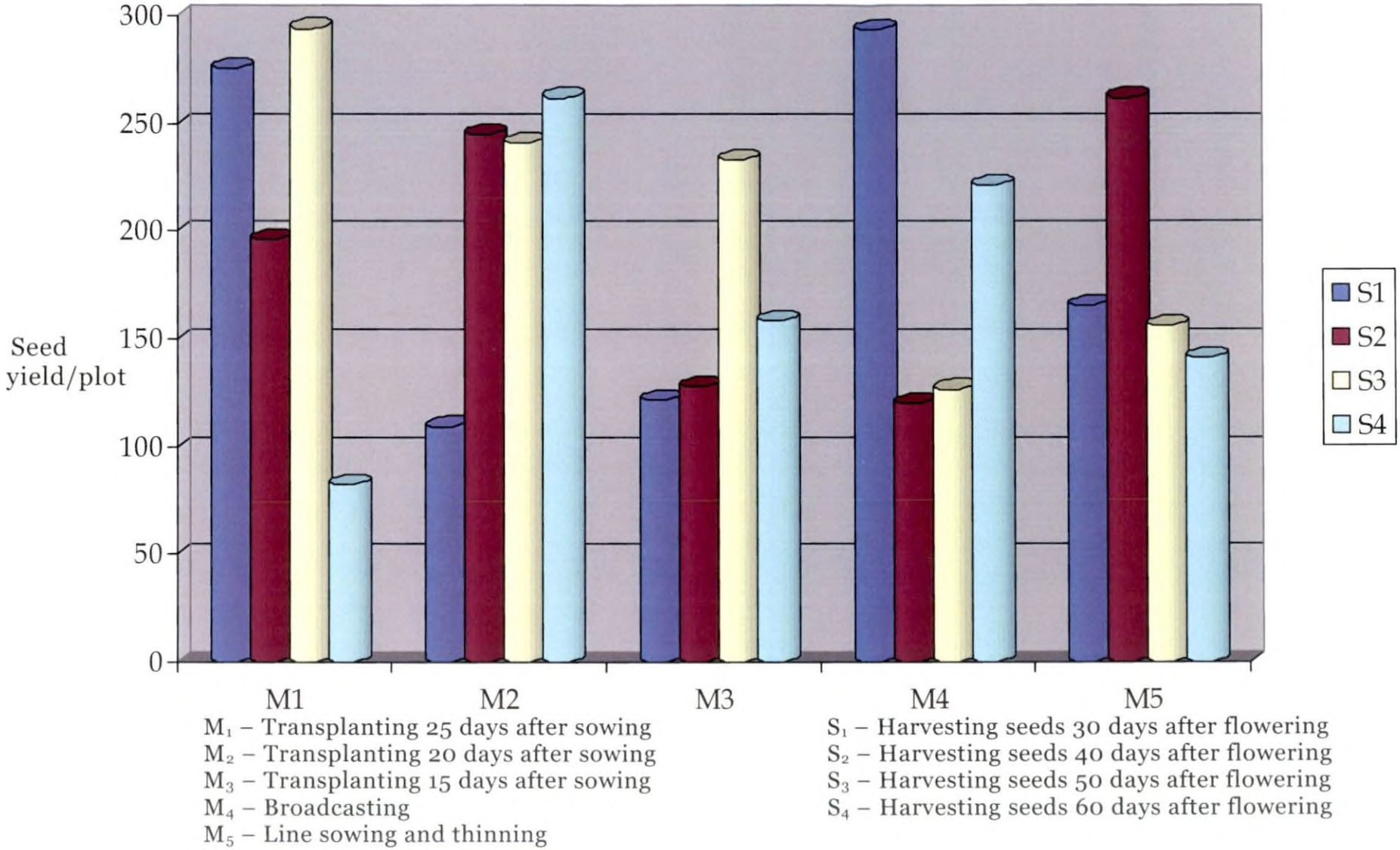


Fig.3. Effect of planting systems, harvest stages and their interaction on seed yield/plot (g)

4.5.1.3 Effect of M x S interaction

The effect of interaction between planting systems and harvest stages in seed yield/ plot was highly significant (Table 13). M_1S_3 showed maximum seed yield /plot (294.25g) which was on par with M_4S_1 (293.5g) while M_1S_4 showed minimum value (82.5g).

Table 13. Effect of planting systems, harvest stages and their interaction on seed yield/plot

	S_1	S_2	S_3	S_4	Mean (M)
M_1	275.50	196.25	294.25	82.50	212.12
M_2	109.50	245.25	241.25	262.00	214.50
M_3	121.75	128.00	233.50	158.75	160.50
M_4	293.50	120.25	126.75	221.50	190.50
M_5	166.00	262.00	156.25	141.25	181.37
Mean (S)	193.25	190.35	210.40	173.20	

CD (M) = 22.6

CD (S) = 20.4

CD (M x S) = 60.4

4.5.2 Seed yield /plant

4.5.2.1 Effect of planting systems

The seed yield/plant was significantly affected by planting systems (Table 14). M_2 gave the highest (4.46g) seed yield/plant which was on par with M_1 (4.41g) while M_3 recorded the lowest (3.34g).

4.5.2.2 Effect of harvest stages

Harvest stages had significant effect on seed yield/plant (Table 14). S_3 gave the highest (4.37g) seed yield/plant which was on par with S_1 (4.02g) while lowest (3.6g) reading was given by S_4.

4.5.2.3 Effect of M x S interaction

The interaction between planting systems and harvest stages on seed yield/plant was significant (Table 14). M_1S_3 recorded the maximum seed yield/plant (6.125g) which was on par with M_4S_1 (6.11g) while M_1S_4 recorded the minimum (1.71g).

Table 14. Effect of planting systems, harvest stages and their interaction on seed yield/plant

	S_1	S_2	S_3	S_4	Mean (M)
M_1	5.73	4.08	6.12	1.71	4.41
M_2	2.27	5.10	5.02	5.45	4.46
M_3	2.53	2.66	4.86	3.30	3.34
M_4	6.11	2.50	2.63	4.61	3.96
M_5	3.45	5.45	3.25	2.94	3.77
Mean (S)	4.02	3.96	4.37	3.60	

CD (M) = 0.7

CD (S) = 0.15

CD (M x S) = 1.04

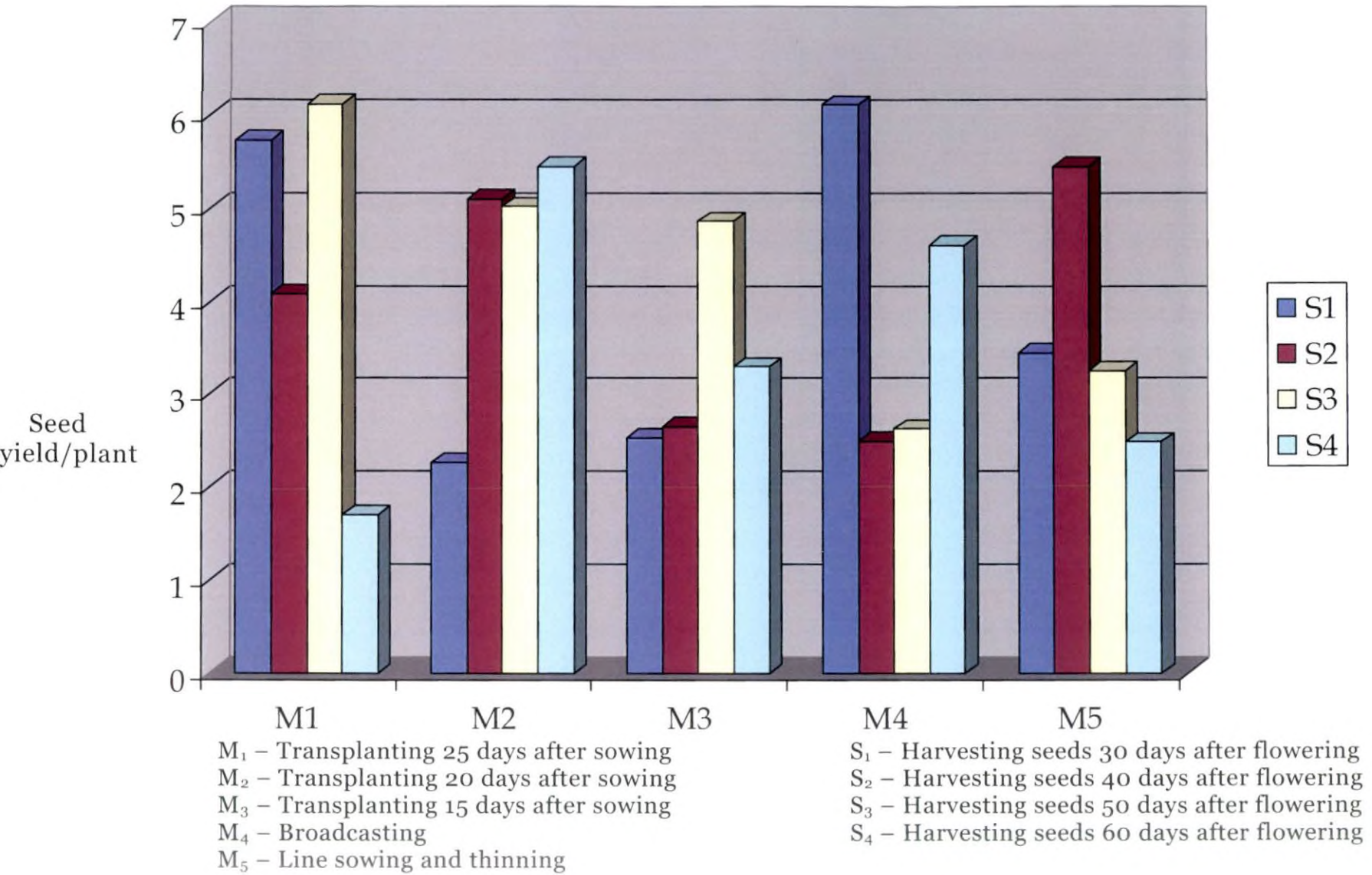


Fig.4. Effect of planting systems, harvest stages and their interaction on seed yield/plant (g)

4.5.3 Seed recovery percentage

4.5.3.1 Effect of planting systems

Significant difference was observed in seed recovery percentage due to the effect of planting systems (Table 15). The highest (21.61) seed recovery percentage was observed in M_2 while the lowest (17.65) was seen in M_4.

4.5.3.2 Effect of harvest stages

The effect of harvest stages was significant in seed recovery percentage (Table 15). S_1 gave the highest (21.45) seed recovery percentage while S_4 recorded the lowest (17.33).

4.5.3.3 Effect of M x S interaction

Interaction between planting systems and harvest stages were significant on seed recovery percentage (Table 15). M_2S_3 gave the highest (26.61) seed recovery percentage while the lowest (14.36) was shown by M_1S_4.

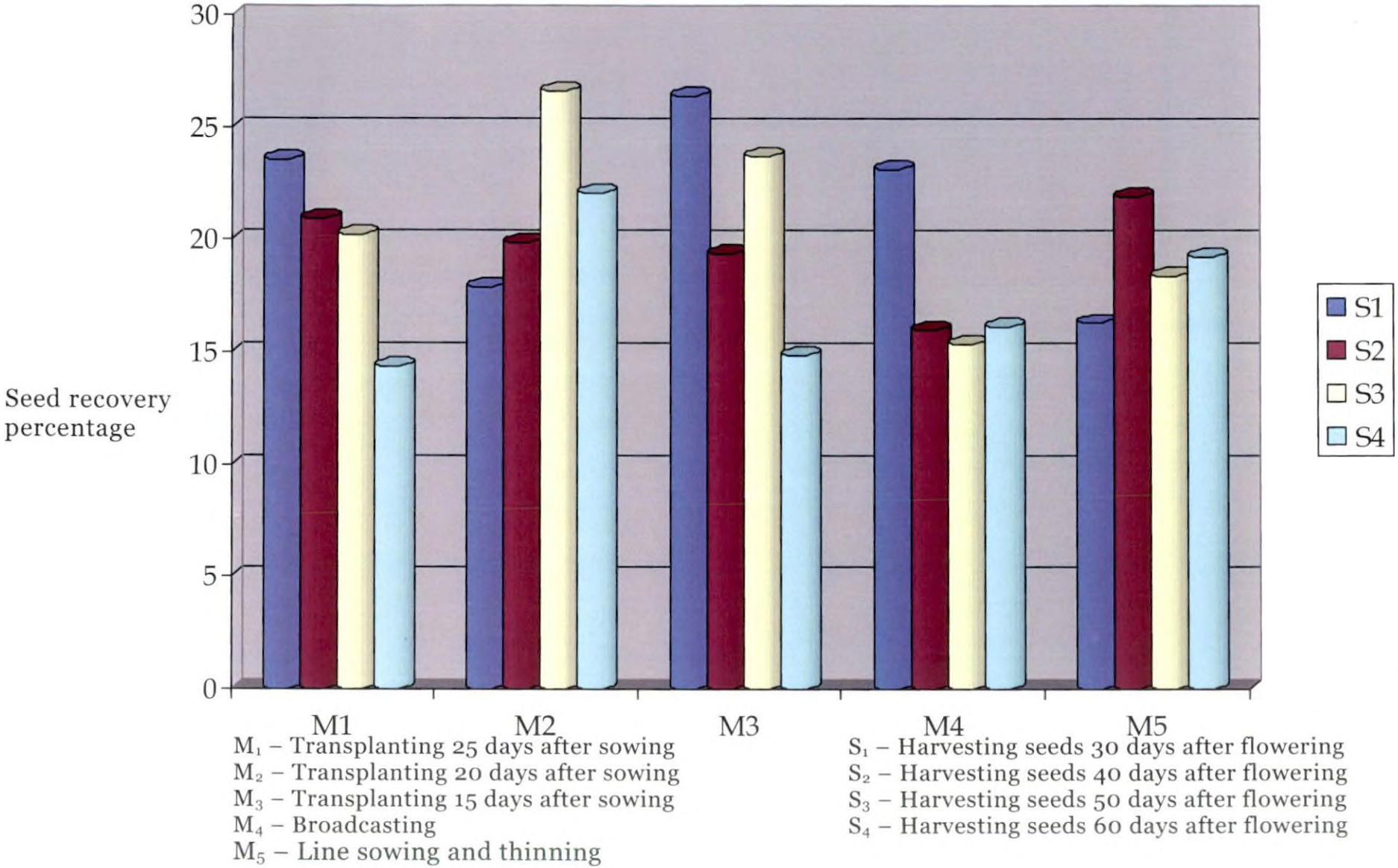


Fig.5. Effect of planting systems, harvest stages and their interaction on seed recovery percentage

Table 15. Effect of planting systems, harvest stages and their interaction on seed recovery percentage

	S_1	S_2	S_3	S_4	Mean (M)
M_1	23.57	20.96	20.24	14.36	19.78
M_2	17.87	19.88	26.61	22.08	21.61
M_3	26.38	19.38	23.73	14.86	21.09
M_4	23.12	16.00	15.38	16.12	17.65
M_5	16.31	21.94	18.43	19.24	18.98
Mean (S)	21.45	19.63	20.88	17.33	

CD (M) = 1.75

CD (S) = 1.04

CD (M x S) = 1.2

4.5.4 Percentage of chaffy seeds

4.5.4.1 Effect of planting systems, harvest stages and their interaction

Different planting systems, harvest stages and their interaction were not significant on percentage of chaffy seeds (Table 16).

Table 16. Effect of planting systems, harvest stages and their interaction on percentage of chaffy seeds

	S_1	S_2	S_3	S_4	Mean (M)
M_1	2.37	3.07	2.25	2.87	2.64
M_2	3.10	2.80	2.97	2.92	2.95
M_3	2.65	2.60	2.85	3.20	2.82
M_4	2.62	2.72	3.15	2.37	2.71
M_5	2.72	2.92	2.42	3.05	2.78
Mean (S)	2.69	2.82	2.73	2.88	

CD (M) = NS

CD (S) = NS

CD (M x S) = NS

4.5.5 Percentage of bold seeds

4.5.5.1 Effect of planting systems, harvest stages and their interaction

Different planting systems, harvest stages and their interaction were not significant on percentage of bold seeds (Table 17).

Table 17. Effect of planting systems, harvest stages and their interaction on percentage of bold seeds

	S_1	S_2	S_3	S_4	Mean (M)
M_1	97.62	96.92	97.75	97.12	97.356
M_2	96.90	97.20	97.02	97.07	97.050
M_3	97.35	97.40	97.15	96.80	97.175
M_4	97.37	97.27	96.85	97.62	97.281
M_5	97.77	97.07	97.57	96.95	97.344
Mean (S)	97.40	97.17	97.27	97.11	

CD (M) = NS

CD (S) = NS

CD (M x S) = NS

4.6 SEED QUALITY

4.6.1 Thousand seed weight (g)

4.6.1.1 Effect of planting systems, harvest stages and their interaction

Different planting systems, harvest stages and their interaction were not significant on thousand seed weight (Table 18).

Table 18. Effect of planting systems, harvest stages and their interaction on thousand seed weight

	S_1	S_2	S_3	S_4	Mean (M)
M_1	0.85	0.83	0.81	0.83	0.83
M_2	0.82	0.89	0.85	0.89	0.86
M_3	0.88	0.87	0.87	0.87	0.87
M_4	0.90	0.81	0.87	0.89	0.87
M_5	0.91	0.84	0.91	0.86	0.88
Mean (S)	0.87	0.85	0.86	0.87	

CD (M) = NS

CD (S) = NS

CD (M x S) = NS

4.6.2 Germination percentage

4.6.2.1 Effect of planting systems

Significant difference was observed in germination percentage due to variations in planting systems (Table 19). The maximum germination percentage (72.56) was observed in M_2 and the minimum (66.125) germination percentage was observed in M_1.

4.6.2.2 Effect of harvest stages

There was significant difference between germination percentage of different treatments (Table 19). S_2 (70.5), S_3 (70.150) and S_4 (70.25) showed only slight variation due to harvest stages while S_1 (67.15) showed minimum germination percentage.

4.6.2.3 Effect of M x S interaction

Significant difference between germination percentage was observed due to interaction between planting systems and harvest stages (Table 19). The maximum (75.75) germination percentage was observed in M_3S_3 followed by M_2S_2 (73.75) while the minimum was observed in M_1S_1 (63.25).

Table 19. Effect of planting systems, harvest stages and their interaction on germination percentage

	S_1	S_2	S_3	S_4	Mean (M)
M_1	63.25	67.25	65.00	69.00	66.12
M_2	73.25	73.75	71.75	71.50	72.56
M_3	66.75	68.00	75.75	69.25	69.93
M_4	63.50	71.25	70.00	72.00	69.18
M_5	69.00	72.25	68.25	69.50	69.75
Mean (S)	67.15	70.50	70.15	70.25	

CD (M) = 3.62

CD (S) = 2.37

CD (M x S) = 5.30

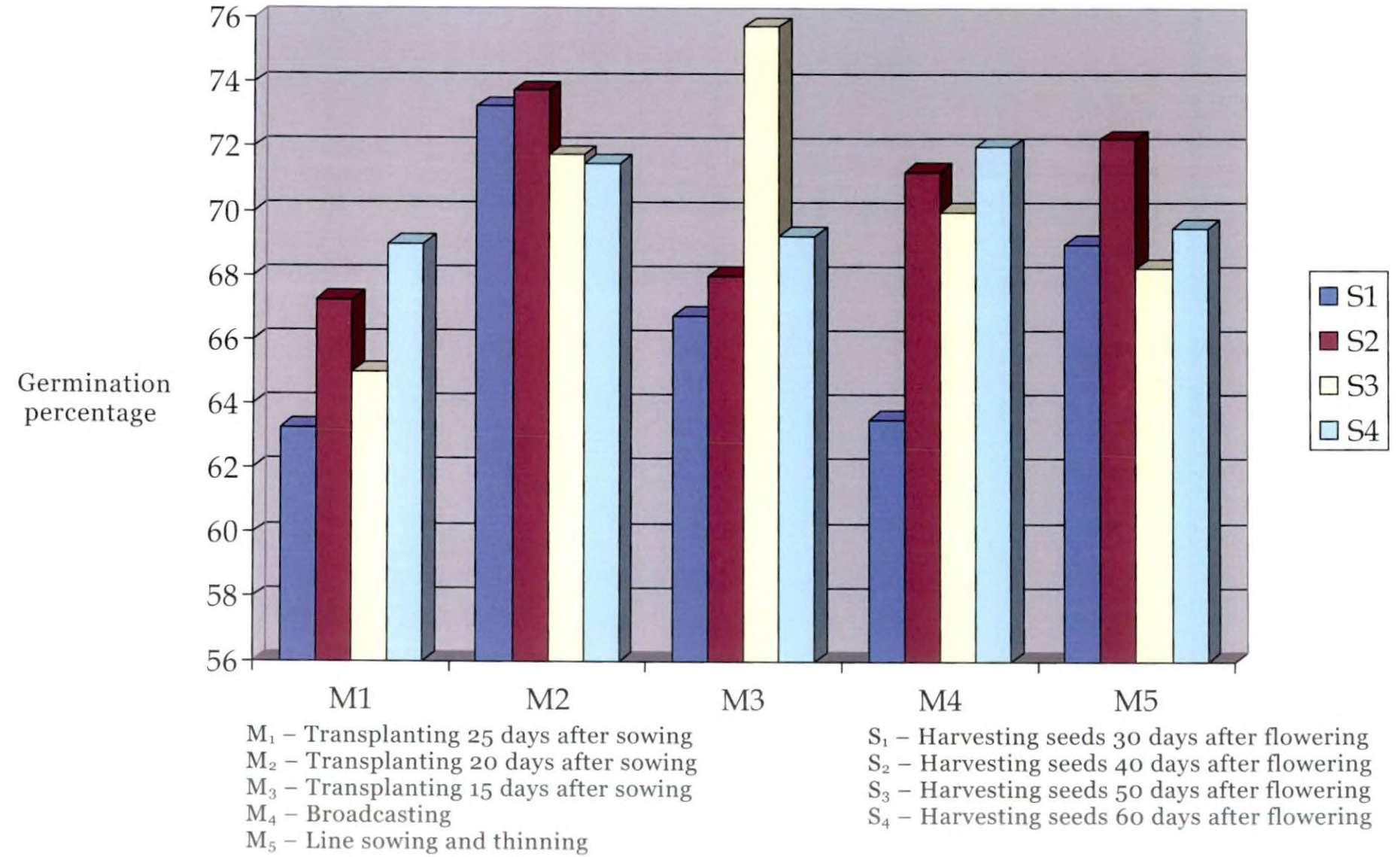


Fig.6. Effect of planting systems, harvest stages and their interaction on germination percentage

4.6.3 Root length (cm)

4.6.3.1 Effect of planting systems

Difference in root length of seedlings was highly significant due to planting systems (Table 20). Longest root (8.875 cm) was observed in M_4 while shortest root observed was (7.225cm) M_1.

4.6.3.2 Effect of harvest stages

Harvest stages had no significant effect on root length of seedlings (Table 20).

4.6.3.3 Effect of M x S interaction

Highly significant difference was observed in root length due to the interaction effect of planting systems and harvest stages (Table 20). Longest root was observed in M_4S_4 (9.87cm) while shortest root was seen in M_2S_1 (5.5 cm).

Table 20. Effect of planting systems, harvest stages and their interaction on root length

	S_1	S_2	S_3	S_4	Mean (M)
M_1	8.12	6.90	8.00	5.87	7.22
M_2	5.50	8.75	7.75	7.37	7.34
M_3	8.00	6.37	8.37	8.00	7.68
M_4	8.12	8.25	9.25	9.87	8.87
M_5	8.75	8.25	8.75	8.50	8.56
Mean (S)	7.70	7.70	8.42	7.92	

CD (M) = .87 CD (S) = NS CD (M x S) = 1.84

4.6.4 Total length of seedling (cm)

4.6.4.1 Effect of planting systems

There was significant difference between seedling length due to the effect of planting systems (Table 21). M_4 showed the maximum seedling length (28cm) while M_3 showed the minimum length (24cm).

4.6.4.2 Effect of harvest stages and M x S interaction

No significant difference was noticed between seedling length due to the effect of harvest stages and interaction between planting systems and harvest stages (Table 21).

Table 21. Effect of planting systems, harvest stages and their interaction on length of seedling

	S_1	S_2	S_3	S_4	Mean (M).
M_1	26.25	28.25	24.75	26.25	26.37
M_2	25.50	30.00	26.25	25.75	26.87
M_3	26.00	20.75	26.25	23.00	24.00
M_4	26.25	27.00	29.75	29.00	28.00
M_5	27.50	26.50	30.25	26.50	27.68
Mean (S)	26.30	26.50	27.45	26.10	

CD (M) = 2.66

CD (S) = NS

CD (M x S) = NS

4.6.5 Seed vigour index

4.6.5.1 Effect of planting systems

Variation in seedling vigour index was highly significant due to the effect of planting systems (Table 22). The highest vigour index (19.43) was noted in M_2 while the least vigour index (16.8) was observed in M_3

4.6.5.2 Effect of harvest stages

Harvest stages had no significant effect on seed vigour index (Table 22).

4.6.5.3 Effect of M x S interaction

The effect of interaction between planting systems and harvest stages on seed vigour index was significant (Table 22). The highest seed vigour index (22.195) was observed in M_2S_2 while the least value (14.13) was recorded in M_3S_2.

Table 22. Effect of planting systems, harvest stages and their interaction on seed vigour index

	S_1	S_2	S_3	S_4	Mean (M)
M_1	16.61	18.98	16.07	18.10	17.44
M_2	18.62	22.19	18.86	18.06	19.43
M_3	17.32	14.13	19.81	15.94	16.80
M_4	16.68	19.26	20.80	20.86	19.40
M_5	18.99	19.15	20.64	18.31	19.27
Mean (S)	17.64	18.74	19.23	18.25	

CD (M) = 1.35 CD (S) = NS CD (M x S) = 3.69

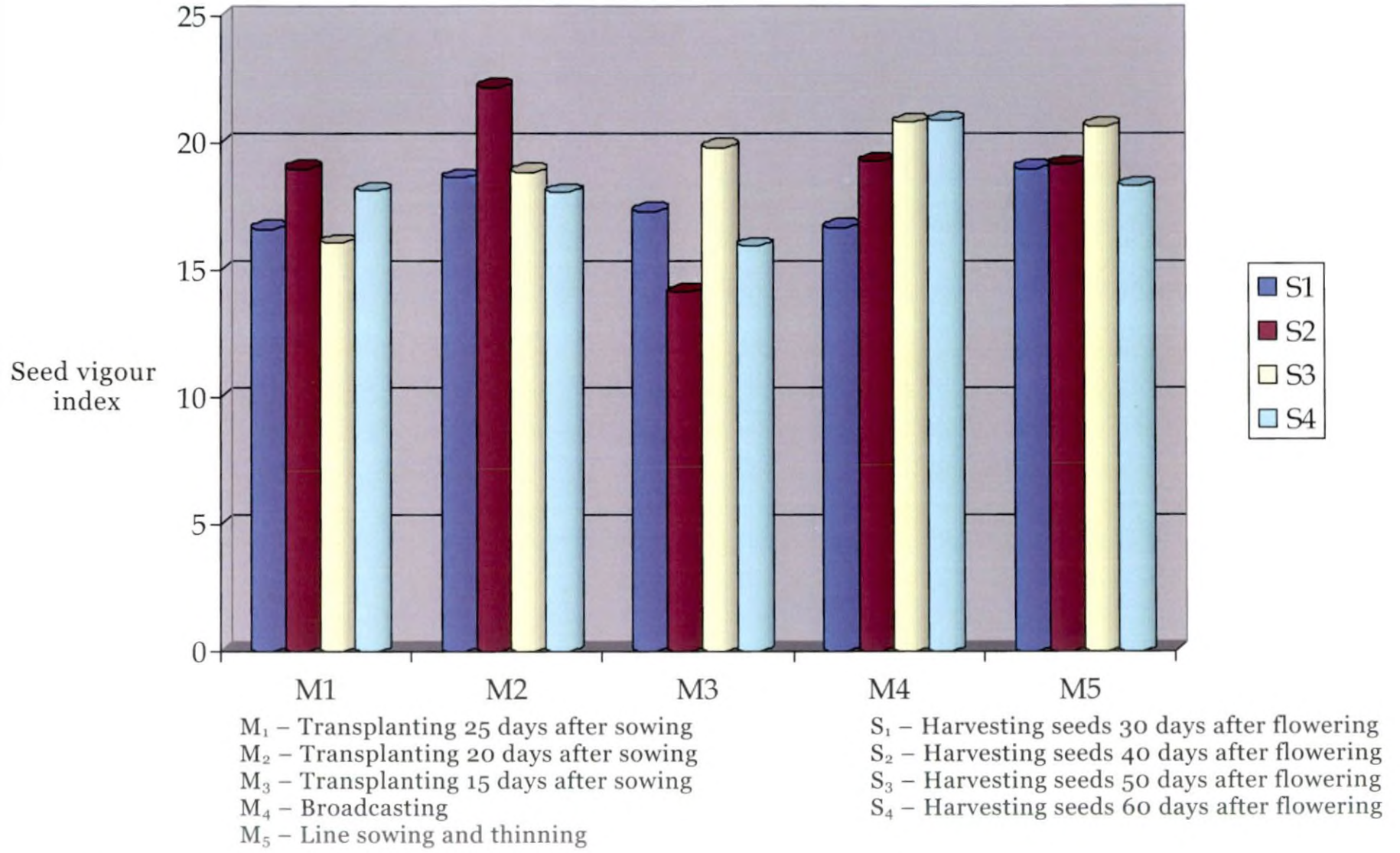


Fig.7. Effect of planting systems, harvest stages and their interaction on seed vigour index

4.6.6 Fresh weight of seedlings (g)

4.6.6.1 Effect of planting systems, harvest stages and their interaction

There was no significant effect of planting systems, harvest stages and their interaction on fresh weight of seedlings (Table 23).

Table 23. Effect of planting systems, harvest stages and their interaction on fresh weight of seedlings

	S_1	S_2	S_3	S_4	Mean (M)
M_1	2.95	3.60	3.55	3.70	3.45
M_2	3.80	3.85	3.40	3.70	3.68
M_3	3.80	3.55	3.40	3.60	3.58
M_4	3.75	3.65	3.35	3.75	3.62
M_5	3.55	3.65	4.00	3.65	3.71
Mean (S)	3.57	3.66	3.54	3.68	

CD (M) = NS

CD (S) = NS

CD (M x S) = NS

4.6.7 Dry weight of seedlings (g)

4.6.7.1 Effect of planting systems, harvest stages and their interaction

No significant variation in dry weight of seedlings was observed due to the effect of planting systems, harvest stages and their interaction (Table 24).

Table 24. Effect of planting systems, harvest stages and their interaction on dry weight of seedlings

	S_1	S_2	S_3	S_4	Mean (M)
M_1	0.21	0.26	0.27	0.24	0.25
M_2	0.24	0.26	0.22	0.21	0.23
M_3	0.28	0.21	0.17	0.19	0.21
M_4	0.30	0.24	0.22	0.21	0.24
M_5	0.24	0.24	0.30	0.24	0.25
Mean (S)	0.25	0.24	0.24	0.22	

CD (M) = NS

CD (S) = NS

CD (M x S) = NS

4.6.8 Dry matter percentage

4.6.8.1 Effect of planting systems

There was no significant effect of planting systems on dry matter content of seedlings (Table 25).

4.6.8.2 Effect of harvest stages

Dry matter percentage of seedlings were affected significantly by harvest stages (Table 25). The highest of dry matter percentage was seen in S_1 (7.106) while the least dry matter percentage (5.993) was observed in S_4.

4.6.8.3 Effect of M x S interaction

Variation in dry matter percentage was not significant due to the effect of interaction between planting systems and harvest stages (Table 25).

Table 25. Effect of planting systems, harvest stages and their interaction on dry matter percentage

	S_1	S_2	S_3	S_4	Mean (M)
M_1	7.02	7.35	7.83	6.48	7.17
M_2	6.41	6.90	6.60	5.81	6.43
M_3	7.42	5.92	5.25	5.26	5.96
M_4	7.87	6.59	6.89	5.66	6.75
M_5	6.79	6.64	7.47	6.73	6.90
Mean (S)	7.10	6.68	6.81	5.99	

CD (M) = NS

CD (S) = .71

CD (M x S) = NS

4.7 INCIDENCE OF PESTS AND DISEASES

4.7.1 Incidence of leaf webber

Attack of leaf webber was only mild in all the planting systems (Table 26). The treatments viz., M_1S_2, M_1S_4, M_2S_4, M_3S_1, M_4S_2, M_5S_2, M_5S_4 were completely free from the attack.

Table 26. Incidence of leaf webber

	S_1	S_2	S_3	S_4
M_1	M	N	M	N
M_2	M	M	M	N
M_3	N	M	M	M
M_4	M	N	M	M
M_5	M	N	M	N

4.7.2 Incidence of leaf blight

Incidence of leaf blight was mild in all the planting systems (Table 27). The treatments viz., M_1S_2, M_1S_4, M_2S_4, M_3S_4, M_4S_3, M_5S_1, M_5S_4 were completely free from leaf blight

Table 27. Incidence of leaf blight

	S_1	S_2	S_3	S_4
M_1	M	N	M	N
M_2	M	M	M	N
M_3	M	M	M	N
M_4	M	M	N	M
M_5	N	M	M	N

4.8 ECONOMICS OF CULTIVATION

Economics of crop production was worked out considering the cost of production, yield and net returns.

Table 28. Economics of cultivation ha^{-1}

	Cost of seed Production(Rs)	Yield/ha (Kg)	Gross income(Rs)	Net income (Rs)	B/C ratio
M_1S_1	103000	458.3	366640	263640	3.55
M_1S_2	106000	327.08	261664	155664	2.46
M_1S_3	109000	490.42	392336	283336	3.59
M_1S_4	112000	137.5	110000	-2000	0.98
M_2S_1	102000	182.5	146000	44000	1.43
M_2S_2	118000	408.75	326540	208540	2.76
M_2S_3	121000	402.08	321664	200664	2.65
M_2S_4	124000	36.67	349336	225336	2.81
M_3S_1	101000	202.92	162336	61336	1.60
M_3S_2	107000	213.33	170664	63664	1.59
M_3S_3	110000	389.17	311336	201336	2.83
M_3S_4	116000	264.58	211664	95664	1.82
M_4S_1	100000	489.17	391336	291336	3.9
M_4S_2	106000	200.42	160336	54336	1.51
M_4S_3	113000	211.25	169000	56000	1.49
M_4S_4	116000	369.17	295336	173336	2.54
M_5S_1	101000	276.67	221336	120336	2.19
M_5S_2	107000	436.67	349336	242336	3.26
M_5S_3	114000	260.41	208328	94328	1.82
M_5S_4	117000	235.83	188664	71664	1.61

Discussion

5. DISCUSSION

Use of quality seeds is an important prerequisite in the production of any vegetable crop. The potential yield of quality seeds of a crop is fully expressed only when optimum cultivation method is adopted. This emphasizes the need for optimum planting systems and harvest stages for a seed crop.

Amaranthus (*Amaranthus tricolor*) is an important leafy vegetable which is extensively grown due to its short duration and high nutritive value. Different systems of cultivation are adopted in amaranthus for vegetable purpose. The cultivation methods include direct sowing in rows, direct sowing by broadcasting and transplanting seedlings at different stages. The number of harvests varies from one to many in these systems of cultivation. Amaranthus is one most extensively cultivated vegetable crops of Kerala. It is grown as a monocrop as well as an intercrop among several other crops. Growing amaranthus in the early stages among bananas is a very common system in many parts of the state. In this system it is grown by broadcasting seeds for a single harvest by uprooting 3-4 weeks after sowing. This gives an additional income to the banana growers. This system necessitates the use of large quantity of seeds. Many times the seed requirement of amaranthus is not completely met in the state. The optimum and economic method of quality seed production has not been standardized so far. At present the seeds are produced by different methods of sowing/transplanting and harvesting. Arriving at the correct method of seed production and fixing the correct stage of harvest for maximum yield of quality seeds would be an important contribution for

the seed growers. Under the circumstance, the present experiment was formulated with the objective of standardizing the method of amaranthus cultivation and harvesting for maximum yield of quality seeds.

The experiment was carried out to study the influence of five systems of planting and four harvest stages on seed yield and quality of amaranthus. It was laid out in a split plot design with four replications. Observations were recorded for various vegetative, seed yield and seed quality characters and the results presented in the tables (1 to 28) are discussed here.

5.1 PLANTING SYSTEMS

The study included five planting systems viz., transplanting 25 days after sowing, transplanting 20 days after sowing, transplanting 15 days after sowing, broadcasting and line sowing with thinning. The response of amaranthus to the above planting systems revealed significant differences on majority of the characters.

In the present study planting systems showed highly significant effect on days to first flowering. The earliest flowering was seen in the plants transplanted 20 days after sowing and the latest in the line sown plants. Planting systems affected the days to 50 percent flowering in the same trend as that of days to first flowering. Flowering is a function of age, plant size and environmental factors. The present result indicated earliness in flowering in moderately aged seedlings suggesting too young or too old seedlings are not better for earliness in amaranth. Early flowering in transplanted crop could be due to the condition of seedlings as well as the micro climate around the plants in the main field. Globerson *et al.* (1981) in an experiment with onion

indicated that variations depended mainly on the temperature at flowering time.

Plant height was significantly affected by planting systems. Plants transplanted 25 days after sowing had the tallest plants while the minimum height was observed in line sown plants. This suggests that initial height and weight of seedlings is positively related to the final height. In short day onion varieties Lokesh *et al.* (2002) reported significant effect of date of planting on plant height. However branches per plant, leaf length, leaf width and petiole length were not significantly affected by different planting systems. The longest internode was observed in plants transplanted 20 days after sowing while the shortest internode was observed in line sown plants. Srinivasaiah *et al.* (2000) reported similar variations in vegetative characters in his experiment with amaranthus.

Planting systems significantly affected weight of weeds per plot. Maximum weight was recorded in the plots of broadcasted plants and the minimum among plants transplanted 25 days after sowing. Dry weight of weeds also showed the same trend. The maximum dry weight was seen among broadcasted plants and the minimum was seen among plants transplanted 25 days after sowing. It is a general phenomenon that weed growth is more in broadcast crop system than in transplanted crop system in any crop. This necessitates more labour and money for weeding direct sown crops like amaranthus than the transplanted crop.

Dry weight of stalk was significantly affected by planting systems. Broadcasted plants showed maximum dry weight of stalk while minimum dry weight was shown by plants transplanted 15 days after sowing. The direct sown crop could have accumulated more dry matter due to their uninterrupted growth than those transplanted. The

transplanted crop generally experiences a shock which temporarily arrests the growth causing lesser accumulation of dry matter than the direct sown crop. Chaff weight also showed a similar trend as that of stalk weight. Broadcasted plants had maximum chaff weight while plants transplanted 15 days after sowing showed minimum weight. The variations in chaff weight could be due to the difference in the quantity of well filled seeds. It is quite possible to have more unfertilized and ill filled seeds in direct sown plants due to their uneven stand compared to uniform stand of the transplanted crop.

Seed yield per plot was significantly affected by planting systems. The maximum seed yield per plot was found among plants transplanted 20 days after sowing which was on par with those transplanted 25 days after sowing followed by broadcasting while the minimum was seen among plants transplanted 15 days after sowing. Similar trend was seen in seed yield per plant also. Maximum seed yield per plant was observed in plants transplanted 20 days after sowing while minimum was seen in plants transplanted 15 days after sowing. This shows the importance of transplanting versus direct sowing from the seed yield point of view in amaranthus. The study reveals that medium aged seedling gave highest yield indicating too young or too old seedlings are inferior for seed production programme. The younger seedlings would not have attained sufficient growth to withstand transplanting shock for better establishment in the field. The over aged seedlings might have passed the correct stage for proper growth and establishment resulting in lower seed yield. The result throws light on the use of optimum aged seedlings for seed production programme in amaranthus. Yadav *et al.* (2001) has also reported in okra that date of sowing and planting geometry significantly affect seed yield.

Seed recovery percentage was significantly affected by planting systems. The maximum seed recovery percentage was seen in plants transplanted 20 days after sowing while the minimum seed recovery was seen in broadcasted plants. It is seen for the study that the age of seedlings which gave maximum seed yield also gave highest seed recovery. Percentage of seed recovery is a function of bold and mature seeds and chaffy material. The transplanted plants might have experienced better environment from light infiltration, pollination and aeration leading to better seed set and development. Singh and Mishra (2004) indicated that transplanting of the roots in carrot increased the seed yield attributes.

Percentage of chaffy seeds, bold seeds and thousand seed weight were not affected by planting systems. Despite non-significance of chaffy seeds and thousand seed weight, the high recovery percentage in medium aged seedlings observed could be attributed to differences in weight of stem, leaf, other stubbles, non-fruiting branches etc. Germination percentage was significantly affected by planting systems. The maximum germination percentage was observed in plants transplanted 20 days after sowing and the minimum was observed in plants transplanted 25 days after sowing. Grewal *et al.* (1973) in an experiment with okra reported variation in germination percentage as influenced by time of sowing.

The seeds from different planting systems were sown and seedling parameters were studied. There was no significant effect of planting systems on fresh weight, dry weight and dry matter content of seedlings raised from seeds of different planting systems and stages of harvest. Difference in root length of seedlings was highly significant due to planting systems. Longest root was observed in seeds from

broadcasted plants while shortest root was observed in seeds from plants transplanted 25 days after sowing. There was significant difference between seedling length due to the effect of planting systems. Seedlings from the seeds of broadcasted plants showed the maximum seedling length while seedlings of seeds from plants transplanted 15 days after sowing showed the minimum length. Similar results in quality aspects were reported by Hamsaveni *et al.* (2002) in tomato.

Seedling vigour index was studied using seeds from different planting systems. Variation in seedling vigour index was highly significant due to the effect of planting systems. The highest vigour index was noted in seedlings raised from the seeds collected from plants transplanted 20 days after sowing while the least vigour index was observed in seedlings raised from seeds of plants transplanted 15 days after sowing. Similar variations of seedling vigour was also observed in okra by Yadav *et al.* (2001).

5.2 HARVEST STAGES

Harvest stage is an important factor which decides the seed yield and quality in vegetables. In the present study four harvest stages viz. harvesting 30, 40, 50 and 60 days after flowering were tried and they revealed significant effects on majority of the characters.

There was significant difference in seed yield per plot and per plant due to different harvest stages. Plants harvested 50 days after flowering recorded the maximum seed yield followed by 30 and 40 days after flowering while those harvested 60 days after flowering recorded the minimum seed yield. This could be due to loss of seeds

by shattering because of late harvest. Murukeshan and Vanangamudi (2005) reported similar results in ash gourd when harvested 70 days after anthesis. This indicates that harvesting should not be earlier or later than 50 days after planting.

The effect of harvest stages was significant in seed recovery percentage. Plants harvested 30 days after flowering gave the highest seed recovery percentage while those harvested 60 days after flowering recorded the lowest seed recovery. Ashok *et al.* (2005) in okra reported similar effects due to harvest stages in okra.

Different harvest stages were not significant on percentage of chaffy seeds, percentage of bold seeds and thousand seed weight.

There was significant difference between germination percentage of different treatments. Plants harvested 40, 50 and 60 days after flowering showed only slight variation due to harvest stages while those harvested 30 days after flowering showed minimum germination percentage. The low percentage of germination of seeds obtained from early harvest could be attributed to improper seed maturity. Similar result in quality aspects due to harvest stages was also reported by Murukeshan and Vanangamudi (2005) in ash gourd.

Seedlings raised from seeds collected from plants of different harvest stages had no significant effect on seedling length, root length, seed vigour index, fresh weight of seedlings and dry weight of seedlings. Seed quality determines crop performance due to the various physiological and biochemical phenomenon of the miniature plant within the seed. Seed quality represents genetic, physiological and physical characteristics of seed. The preharvest factors influence the seed quality. Seed quality is influenced likely by time of harvest of

the crop. Seed maturity normally coincides with fruit maturity and matured seeds give high germination percentage and seed vigour (Eguchi and Yamada, 1958). Seed viability is higher at mature stages and is reduced in early or late harvest. Seed germination and seedling vigour increases with fruit age (Welbaum and Bradford, 1991). The present variation in seed quality parameters could be attributed to these factors.

Dry matter percentage of seedlings were affected significantly by harvest stages. The highest of dry matter percentage was seen in seedlings obtained from seeds of plants harvested 30 days after flowering while the least dry matter percentage was observed in those harvested 60 days after flowering. Similar findings were observed by Ashok *et al.* (2005) in okra.

5.3 INTERACTION BETWEEN PLANTING SYSTEMS AND HARVEST STAGES

The effect of interaction between planting systems and harvest stages was significant for majority of the characters. Highly significant difference in plant height was observed among the interaction between planting systems and harvest stages. Maximum height was recorded in the plants transplanted 25 days after sowing and harvested 50 days after flowering. Minimum height was seen in the plants which were line sown and harvested 60 days after flowering. This shows that plant elongation is higher with late transplanted crop and harvested towards the last stage. Lokesh *et al.* (2002) reported similar effects in plant height due to planting systems in onion.

Highly significant difference in internode length was observed among the interaction between planting systems and harvest stages.

Maximum internode length was recorded in the plants transplanted 20 days after sowing and harvested 30 days after flowering. Minimum internode length was seen in the line sown plants harvested 40 days after flowering.

There was highly significant difference between weed weight/plot due to interaction between planting systems and harvest stages. Maximum weed weight was observed in the plants transplanted 15 days after sowing and harvested 50 days after flowering while the minimum weed weight was seen in the plants transplanted 20 days after sowing and harvested 50 days after flowering.

Highly significant difference was observed between dry weight of weed/plot due to the interaction effect between planting systems and harvest stages. The maximum dry weight was observed in the plants transplanted 20 days after sowing and harvested 40 days after flowering while minimum dry weight of weed/plot was seen in the line sown plants harvested 60 days after flowering. The chances of growing weeds could be more among younger seedlings as the smothering effect of plants on weeds is comparatively less for younger plants.

There was highly significant interaction between planting systems and harvest stages on dry weight of stalk. The broadcasted plants harvested 30 days after flowering showed the maximum dry weight of stalk while the plants transplanted 15 days after sowing and harvested 30 days after flowering showed minimum dry weight. Broadcasted seeds might tend to accumulate more dry matter than the transplanted seedlings.

Interaction effect between planting systems and harvest stages was highly significant with regard to chaff weight. The broadcasted plants harvested 60 days after flowering showed maximum chaff weight while the plants transplanted 15 days after sowing and harvested 30 days after flowering had the minimum chaff weight. The content of chaff would be higher in broadcasted plants harvested at a late stage. The higher amount of shattering of mature seeds may increase with duration leading to low percentage of seeds and high percentage of chaff.

The effect of interaction between planting systems and harvest stages in seed yield/plot was highly significant. The plants transplanted 25 days after sowing and harvested 50 days after flowering showed maximum seed yield/plot which was on par with broadcasting and harvesting 30 days after flowering while the plants transplanted 25 days after sowing and harvested 60 days after flowering showed minimum value. The interaction between planting systems and harvest stages on seed yield/plant also showed the same trend. This indicates that seedling age in amaranth has to be 25 days and the seeds are to be harvested 50 days after flowering. Seedlings of the same age at 10 days later harvest leads to significant reduction in yield. This could be due to higher percentage of shattering of seeds in later harvests. Singh and Singh (1985) reported similar results due to planting systems in radish.

Interaction between planting systems and harvest stages were significant on seed recovery percentage. The plants transplanted 20 days after sowing and harvested 50 days after flowering gave the highest seed recovery percentage while the lowest value was shown by the plants transplanted 25 days after sowing and harvested 60 days

after flowering. Mohideen *et al.* (1983) also reported variation in yield contributing characters in grain amaranthus due to planting systems.

Interaction of planting systems and harvest stages were not significant on percentage of chaffy seeds, percentage of bold seeds and thousand seed weight. Jedras (1989) found that in Parsley the sowing date had no significant effect on 1000 seed weight.

Significant difference between germination percentage was observed due to interaction between planting systems and harvest stages. The maximum germination percentage was observed in the seeds obtained from plants transplanted 15 days after sowing and harvested 50 days after flowering while the minimum was observed in the plants transplanted 25 days after sowing and harvested 30 days after flowering. Ashok *et al.* (2005) reported similar findings in okra.

Highly significant difference was observed in root length due to the interaction effect of planting systems and harvest stages. Longest root was observed in the broadcasted plants harvested 60 days after flowering while shortest root was seen in the plants transplanted 20 days after sowing and harvested 30 days after flowering.

No significant difference was noticed between seedling lengths due to the interaction between planting systems and harvest stages

The effect of interaction between planting systems and harvest stages on seed vigour index was significant. The highest seed vigour index was observed in the plants transplanted 20 days after sowing and harvested 40 days after flowering while the least value was recorded in the plants transplanted 15 days after sowing and harvested 40 days after flowering. Hamsaveni *et al.* (2002) reported similar results in seed quality characters due to harvest stages in tomato.

There was no significant effect of interaction between planting systems and harvest stages on fresh weight, dry weight and dry matter percentage of seedlings.

5.4 INCIDENCE OF PESTS AND DISEASES

The treatment combinations of planting systems and harvest stages were scored for the incidence of leaf webber and leaf blight. The incidence of both the leaf webber and blight was mild in most of the treatments. In few of the treatments they were completely absent.

5.5 ECONOMICS OF CULTIVATION

The study revealed that broadcasting and harvesting 30 days after flowering gave maximum net profit of Rs.2,91,336 with the maximum benefit cost ratio of 3.90 : 1.00 in amaranthus. Highest seed yield of 490.42 Kg/ha was obtained by plants transplanted 25 days after sowing and harvested 50 days after flowering which was on par with the above treatment. However the benefit cost ratio was lower due to the cost of nursery raising, transplanting and management of the crop for 20 more days. The study suggested that broadcasting and harvesting 30 days after flowering is suitable for maximum economic returns.

Summary

6. SUMMARY

The study entitled "Seed yield and quality in amaranthus as influenced by planting systems and harvest stages" was carried out in the Department of Olericulture and the Instructional Farm, College of Agriculture, Vellayani during February to May, 2006. The main objective was to find out the ideal system of planting and to standardize the stage of harvest for maximum seed yield and quality.

The experiment was laid out in a split plot design with five planting systems in the main plot and four harvest stages in the sub plot thus constituting twenty treatments with four replications. The planting systems were transplanting 25 days (M_1), 20 days (M_2), 15 days (M_3) after sowing, broadcasting (M_4) and line sowing with thinning (M_5). The harvest stages were 30 days (S_1), 40 days (S_2), 50 days (S_3) and 60 days (S_4) after flowering.

Observations were recorded on important morphological, seed yield and seed quality attributes. The data generated were presented in tables and discussed in the previous chapters. The findings of this study are summarized below:

Among the different systems, transplanting 20 days after sowing was earliest (18 days) to flower. Transplanting 20 days after sowing took minimum days for 50% flowering (20.56 days).

Among the five planting systems transplanting 25 days after sowing had the tallest (96.18 cm) plants. Different harvest stages did not affect the plant height. The planting system and harvest stage interaction influenced plant height. Transplanting 25 days after sowing

and harvesting 50 days after flowering recorded the maximum height (115 cm).

Internode was longest (4.53 cm) in plants transplanted 20 days after sowing and among harvest stages 30 days after flowering recorded longest internode (7.49 cm). The planting system and harvest stage interaction influenced internode length. Plants transplanted 20 days after sowing and harvested 30 days after flowering produced longest internode (6.78 cm).

Leaf length, leaf width and petiole length were not affected by planting systems, harvest stages or their interaction.

Weed weight per plot was maximum (1.9 Kg) in line sown plants. Harvest stages had no effect on weed weight per plot. The planting system and harvest stage interaction influenced weed weight per plot. Plants transplanted 15 days after sowing and harvested 50 days after flowering recorded maximum weed weight per plot (2.35 Kg).

Broadcasting recorded maximum dry weight of weed per plot (430.62 g). Harvest stages did not influence the dry weight. Interaction of planting systems and harvest stages affected dry weight of weed per plot. Transplanting 20 days after sowing and harvesting 40 days after flowering obtained the maximum dry weight of weeds (615 g).

Highest dry weight of stalk (310 g) was observed in broadcasted plants and minimum (230 g) was seen in plants transplanted 15 days after sowing. Harvest stages did not affect the dry weight. The interaction effect of broadcasting and harvesting 30 days after flowering showed the maximum (357.5 g) dry weight of stalk and the minimum (187.5 g) was shown by plants transplanted 15 days after sowing and harvested 30 days after flowering.

Minimum chaff weight (406.25 g) was shown by plants transplanted 15 days after sowing. Chaff weight was not affected by harvest stages. The interaction effect of planting system and harvest stage affected the chaff weight. Transplanting 15 days after sowing and harvesting 30 days after flowering obtained the minimum chaff weight (207.5 g).

Seed yield per plot was highest (214.5 g) in plants transplanted 20 days after sowing which was on par with transplanting 25 days after sowing (212.12g) followed by broadcasting (190.5g). Among harvest stages, harvesting 50 days after flowering obtained the highest seed yield per plot (210.4 g) which was on par with harvesting 30 days after flowering (193.25g). The interaction between planting systems and harvest stages significantly affected seed yield per plot. Transplanting 25 days after sowing and harvesting 50 days after flowering gave the highest seed yield per plot (294.25 g) which was on par with broadcasting and harvesting 30 days after flowering (293.5g).

Transplanting 20 days after sowing gave the maximum seed yield per plant (4.46 g). Among the harvest stages the highest seed yield per plant (4.37 g) was observed in plants harvested 50 days after flowering. The interaction between planting systems and harvest stages showed significant effect on seed yield per plant. Transplanting 25 days after sowing and harvesting 50 days after flowering gave the highest seed yield per plant (6.12 g) which was on par with broadcasting and harvesting 30 days after flowering (6.11g).

Transplanting 20 days after sowing obtained the highest seed recovery percentage (21.61). Among the harvest stages the maximum seed recovery percentage (21.45) was obtained in plants harvested 30 days after flowering. Seed recovery percentage was significantly

affected by planting systems and harvest stages. Transplanting 20 days after sowing and harvesting 50 days after flowering obtained the highest seed recovery percentage (26.61).

Planting systems, harvest stages and their interaction did not affect the percentage of bold and chaffy seeds significantly.

Thousand seed weight was not significantly affected by planting systems, harvest stages and their interaction.

Seeds from plants transplanted 20 days after sowing recorded the maximum germination percentage (72.56). Among the harvest stages the maximum germination percentage (70.5) was shown by plants harvested 40 days after flowering. Germination percentage was significantly affected by the interaction between planting systems and harvest stages. Transplanting 15 days after sowing and harvesting 50 days after flowering showed the maximum germination percentage (75.75)

Broadcasting gave the longest root (8.87 cm) of seedlings raised from seeds of different planting systems. Harvest stages did not affect the root length of seedlings. The interaction of planting systems and harvest stages affected the root length significantly. Broadcasting and harvesting 60 days after flowering gave seedlings with longest root length (9.87 cm).

Maximum seedling length (28 cm) was noted in seeds obtained from broadcasted plants. Harvest stage and its interaction with planting systems had no significant effect on seedling length.

Transplanting 20 days after sowing recorded the maximum vigour index (19.43). Harvest stages did not affect seed vigour index significantly. The interaction between planting systems and harvest

stages had significant influence on seed vigour index. Transplanting 20 days after sowing and harvesting 40 days after flowering obtained the highest seed vigour index (22.19).

Fresh weight and dry weight of seedlings were not influenced by planting systems, harvest stages or their interaction.

Harvesting 30 days after sowing showed the highest dry matter percentage of seedlings (7.106). Planting systems and its interaction with harvest stages had no influence on the dry matter percentage.

Transplanting 25 days after sowing and harvesting 50 days after flowering gave the highest (490.42 Kg/ha) seed yield which was on par with broadcasting and harvesting 30 days after flowering (489.17Kg/ha). Broadcasting and harvesting 30 days after flowering gave the maximum net profit of Rs.2,91,336 with highest benefit cost ratio of 3.9 : 1.

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*Original not seen

SEED YIELD AND QUALITY IN AMARANTHUS AS INFLUENCED BY PLANTING SYSTEMS AND HARVEST STAGES

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ABSTRACT

The present investigation on "Seed yield and quality in amaranthus as influenced by planting systems and harvest stages" was conducted at the Department of Olericulture and the Instructional Farm, College of Agriculture, Vellayani, Thiruvananthapuram during February - May, 2006. Five planting systems viz., transplanting 25 days, 20 days, 15 days after sowing, broadcasting and line sowing were tried with four harvest stages which were 30, 40, 50 and 60 days after flowering. Majority of the characters were significantly influenced by the direct as well as interaction effects of the planting systems and harvest stages.

Among the planting systems the earliest flowering was shown by seedlings transplanted 20 days after sowing. Transplanting 25 days after sowing produced the tallest plants.

Maximum seed yield per plot and per plant was found in plants transplanted 20 days after sowing. Seed quality characters like seed recovery percentage, germination percentage and vigour index was also highest in plants transplanted 20 days after sowing.

Among harvest stages maximum seed yield per plot and per plant were shown by plants harvested 50 days after flowering while those harvested 30 days after flowering gave the highest seed recovery percentage. Seeds from plants harvested 40, 50 and 60 days after flowering showed high germination percentages with slight differences between the values.

Majority of the characters were influenced by the interaction of planting systems and harvest stages. The plants transplanted 25 days after sowing and harvested 50 days after flowering showed the maximum seed yield per plot which is on par with broadcasting and harvesting 30 days after harvesting. The maximum germination percentage was observed in the seeds obtained from plants transplanted 15 days after sowing and harvested 50 days after flowering. Plants transplanted 20 days after sowing and harvested 40 days after flowering showed the highest seed vigour index.

Broadcasting and harvesting 30 days after flowering gave the maximum net income of Rs.2,91,336 with highest benefit cost ratio of 3.90 : 1.00 in amaranthus.