EFFECT OF PINCHING, PLANT NUTRITION AND GROWTH RETARDANTS ON SEED YIELD, QUALITY AND STORAGE STUDIES IN CHINA ASTER [Callistephus chinensis (L.) Nees.]

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INTRODUCTION

China aster [*Callistephus chinensis* (L.) Nees.] belongs to the family Asteraceae and is an important commercial ornamental annual grown in many parts of the world for cut flowers. The wide spectrum of colour ranges available in china aster are pink, bluish, violets, purple and white and their long shelf life have made them a popular cut flowers. Some of the dwarf seedling plant types have potential for use as flowering potted plant. The china aster, a native of china, has been under wide spread cultivation in Europe since 1731 AD but it was to the credit of the German horticulturist, who laid down the basis for its present varied development. Infact, china aster was introduced from China into France by a missionary in the 18^{th} century (Desai, 1967).

In view of china aster adopting well to varying soil and climatic conditions, it can be grown successfully under different agro-climatic conditions. Its flowers last longer and are used for various purposes like keeping in vases, flower decoration, preparation of bouquets, garlands, *etc*., in addition to their cultivation in land scape gardening to provide mass aesthetic effect. Therefore, the growing popularity of china aster in most of the major cities in India has laid to its cultivation as a commercial crop for cut flowers. The major growing states of India are Karnataka, Uttar Pradesh, West Bengal *etc*..

In Karnataka, it is cultivated over an area of 775 lakh ha with an annual production of 6206 tonnes of flowers (Anon., 2000). The demand for cut flowers of china aster is increasing every year but it has not possible to supply the flowers especially during the festival seasons. The area under flower production is increasing year after year and farmers are not getting quality seeds in adequate quantities as very few farmers are taking up seed production. Hence, there is a need to produce adequate quantity of quality seeds of china aster. Further, there is no comprehensive agronomic package for raising seed production crop to obtain higher seed yield and quality in china aster. Like in other crops, seed yield and quality could be increased by adequate fertilization with major nutrients. As there is no recommendation of fertilizer doses for seed production of china aster, there is a need to standerdise the optimum doses of fertilizers.

In most of the flower crops, seed yield is mainly dependent on number of flower bearing branches which could be manipulated by arresting vertical growth of plants and encouraging side shoot by means of apical bud pinching. But, studies on influence of pinching in china aster on seed yield and quality are meagre.

Similarly, the reduction of vertical growth of plants and to encourage flower bearing branches by foliar spray with growth retardants like CCC, MH, *etc*., are being widely used in several horticultural and field crops. However, studies on influence of growth retardants on growth, seed yield and quality in china aster are scanty.

The successful seed production also involves seed storage as the “seed saved is seed produced” the popular adage aptly applies in modern agriculture. Storage potential of seed is basically under genetic control and it differs with species and cultivars. It is also influenced by number of other environmental factors *viz.,* moisture content, relative humidity, temperature, storage containers, provenances *etc.* generally, seeds stored in sealed moisture pervious containers store for longer period compared to those stored in moisture impervious containers as they act as effective barriers against seed moisture fluctuation (Thomson, 1979). Hence, studies on influence of storage containers on storage potential and seed quality under ambient storage conditions in different cultivars of china aster is needed.

Considering the importance of commercial flower crop of china aster studies on effect of pinching, fertilizer application, growth retardants on seed yield and quality and storage potential in china aster was conducted with the following objectives.

1. To ascertain the effect of pinching on plant growth, seed yield and quality of china aster.
2. To find out the effect of fertilizer doses on plant growth, seed yield and quality of china aster.

3. To ascertain the effect of growth retardants on plant growth, seed yield and quality of china aster.
4. To ascertain the combined effect of pinching, fertilizer levels and growth retardants on plant growth, seed yield and quality of china aster
5. To find out the storage potential of china aster varieties.

II. REVIEW OF LITERATURE

Cultivation of china aster has received more attention only in recent years and information available on effect of pinching, levels of fertilizer and use of growth retardants on seed yield and quality and storage potential of china aster are meagre. Hence reviews on these aspects in china aster and other closely related flower, ornamental plants and vegetable crops have been included and presented in this chapter.

2.1 INFLUENCE OF PINCHING

2.1.1 Growth parameters

Physical manipulation of the size and shape of transplants by removing the top portion (apical bud) of shoot or portion of root, either during raising the plants or just before transplanting has been claimed to be advantageous. In obtaining higher yield in several crops.

Sen and Naik (1977) observed that pinching of apical bud in chrysanthemum variety Early white caused significant reduction in plant height (62.8 cm) compared to control (68.8 cm).

Malleshappa (1984) observed significantly reduced plant height increased number of branches, leaves, stem and total dry weight with pinching. While, leaf area and leaf area index were found reduced with pinching in china aster.

Jayanthi *et al*. (1987) reported in balsam that among pinching at 20, 27, 34 and 50 days after sowing (DAS), significant height reduction but highest number of shoots (7.5) per plant were obtained by pinching at 27 DAS.

Bhati and Chitkara (1987) reported that in marigold, pinching at 30 days after transplanting significantly reduced the plant height but increased the spread of plants.

Jhon and Paul (1995) reported that maximum plant height, plant spread, number of branches were noticed in plants pinched once (4 weeks after planting) as compared to plants pinched twice or thrice in chrysanthemum.

Verma *et al*. (2002) reported in carnation cv. Impale that between two pinching methods (single pinch and one and-a-half pinch), single pinch method produced flowers of better quality but total yield per square metre was maximum in one and-a-half pinch method.

Ramesh Kumar *et al*. (2002) reported that pinching (removal of 2.0-2.5 cm shoot apex once in every 4 weeks or twice in 4 and 8 weeks) of carnation cv. Red corso gave shorter plants with shorter leaves but increased the number of branches, leaves and dry matter content.

Joshi *et al*. (2002) reported that pinching significantly increased fresh and dry weight of the plant compared to no pinching in marigold.

Ramesh Kumar *et al*. (2003) reported in carnation that, pinching twice resulted in decrease of plant height, leaf length with higher number of side shoots, leaves and dry weight of plant compared to unpinched plants.

Seharawat *et al*. (2003) reported that pinching in marigold increased the number of branches, number of days to flower bud initiation, number of days to 50 per cent flowering and flowering duration.

Sudarshan (2004) noticed higher plant height, more number of branches and leaves with pinching at 30 DAS in fenugreek.

2.1.2 Flowering, seed yield and yield parameters

In *Tagetes erects* cv. African giant double orange, the greatest flower yield was obtained with plants pinched at 40 days after transplanting (Arora, 1980).

Malleshappa (1984) found delayed flowering in china aster plants pinched after transplanting but pinching in nursery reduced the number of days for flowering, increased the number of flowers per plant, yield per ha but it reduced the diameter of flowers. The similar results were obtained by Hiremath (1984) in marigold with pinching.

Mc. Craw and Greig (1986) concluded that in a field trial with four capsicum cultivars, transplanting of pruned plants at 11 weeks resulted in increased number of early marketable fruits in all cultivars compared to non pruned plants.

Huang (1987) opined that seed yield of *Vicia faba* was higher when topped at early flowering and pod filling stage compared to control besides increased pods (15.8 /plant) and 100 seed weight (10.6 g). Topping at pod filling stage resulted in higher leaf area, early poding and less pod shedding.

Kohnt *et al*. (1988) reported that the field bean plants topped immediately after flowering increased the seed yield by 0.16 to 1.92 t per ha. The differences in yield were due to differences in number of pod per plant, number of seeds per pod and 1000 seed weight.

Venkatareddy *et al*. (1997) reported that apical pinching in okra seed crop increased seed yield by 9.6 per cent over control. Retaining 12 fruits per plant and pinching resulted in higher (1.24 t/ha) seed yield with increase in other yield attribute and seed quality parameters.

Jana *et al*. (1999) revealed that no cutting in palak gave highest seed yield (9.13 q/ha) and decreased thereafter with increase in the number of cuttings.

Malik *et al*. (1999) reported that pinching of bolts incase of onion recorded highest number of umbels per plant (9.2), number of seeds per umbel (870) and seed yield (15.33 q/ha).

Pathania *et al*. (2000) reported that by employing various pinching methods, double pinching produced maximum number of cut bloom per metre square (177.77) and delayed flowering in carnation. The unpinched plants were early to flower (100.53 days) and recorded maximum flower size (6.98 cm), but the flower yield per metre square was very low (11.11) when compared to pinched (22.22) plants.

Sajjan *et al*. (2002) observed that apical pinching of okra at 20 days after sowing recorded maximum number of fruits per plant (6.67), number of seeds per fruit (45.73) and seed yield per ha (782.8 kg) over no pinching.

Kumar and Singh (2003) reported in carnation that, pinching of shoot tip delayed the flowering. But, flower production was enhanced by pinching.

2.1.3 Seed quality parameters

Phor and Mangal (1991) observed that, no leaf cutting (control) incase of palak recorded highest 1000 seed weight (9.53 g) while, one leaf cutting at 40 DAS recorded highest germination (91.4%) and lowest electrical conductivity (0.69 m mhos/cm).

Bhat (1994) observed that in okra, apical pinching after retaining required number of fruits gave significantly maximum girth of fruits (1.91 cm), seed weight (3.1 g/fruit) and 100 seed weight (6.6 g).

Venkatareddy *et al*. (1997) reported that apical pinching increased seed recovery (3.2%), vigour index (112) and protein content (0.5%) incase of okra seed crop.

No cutting in palak recorded highest 1000 seed weight (10.81 g) and which decreased thereafter with increase in number of cuttings (Jana *et al*., 1999).

In okra, apical bud pinching at 20 days after sowing recorded numerically higher germination compared to pinching at 30 days after sowing (Sajjan *et al*., 2002).

2.2 INFLUENCE OF NPK ON GROWTH, FLOWERING, SEED YIELD AND QUALITY PARAMETERS

2.2.1 Growth parameters

Arora and Saini (1976) observed increased plant height and number of branches in china aster when 40 and 20 grams of nitrogen and phosphorus were applied per square metre area respectively.

Maheshwar (1977) observed the increased plant height in china aster with the application of nitrogen (180 kg/ha) and phosphorus (120 kg/ha). Similarly, Ramachandra (1982) obtained maximum plant height at 120:60:60 kg NPK per ha. While, Venkatesh (1983) recorded the maximum plant height at 100:60:60 kg NPK per ha. Whereas, significantly maximum plant height was recorded at 250:120:75 kg NPK per ha (Mantur, 1988) and at 200:100:50 kg NPK per ha by Ravindra (1998) in china aster.

In marigold, Ingawale (1979) studied the effect of nitrogen and phosphorus and concluded that application of 200:120:60 kg NPK per ha significantly increased the plant height up to 47.7 cm and number of branches (15.8) per plant.

In china aster, Ramachandra (1982) noticed maximum plant height (40.0 cm), number of branches (10.5), leaves per plant (40.0), leaf area index (0.57) and dry matter production (18.67) with application of 120:60:60 kg NPK per ha. Similar results were also observed in eight varieties of marigold by Nalwadi (1982) with the application of higher doses of fertilizer (225 kg N, 120 kg P_2O_5 and 60 kg K_2O per ha).

Venkatesh (1983) observed that china aster plants receiving nitrogen, phosphorus and potassium at the rate of 120:60:60 kg per ha recorded higher plant height (60.4 cm) and number of branches per plant (22.4) compared to control.

Dongre (1984) in marigold indicated that, application of nitrogen and phosphorus each at 40 g per square metre recorded higher plant height (128.8 cm) and maximum number of branches per plant (4.05).

Jayanthi and Gowda (1988) observed significant increase in plant height (47.9 cm) and number of branches (7.30) per plant in chrysanthemum with the application of 300:400:200 kg NPK per ha.

Mantur (1988) found that application of 240 kg N, 120 kg P_2O_5 and 75 kg K_2O per ha recorded maximum plant height, number of branches, dry matter production and higher leaf area index in china aster

Mokashi (1988) reported that plant height and number of branches per plant did not respond well with the application of higher doses of nitrogen (150 to 250 kg/ha) and phosphorus (80 to 120 kg/ha) in giallardia.

In marigold, Arulmozhiyan and Pappaiah (1989) found significant increase in the plant height and number of branches per plant with the application of 120 kg N and 90 kg P_2O_5 per ha. Similarly, Yassin and Pappiah (1990) stated that application of 75 kg nitrogen per ha along with sheep manure recorded maximum plant height (72.6 cm) and more number of branches (23.7) per plant in chrysanthemum.

Jana and Pal (1991) reported in cosmos, that among the nutrient elements nitrogen and phosphorus deficiency showed maximum reduction in growth. Maximum growth of plants were obtained with combined application of 20 g nitrogen, 10 g phosphorus and 10 g potash per m^2.

In calendula, application of NPK at the rate of 100:50:25 kg per ha increased the height of plant, number of branches and leaves per plant (Sigedar *et al.*, 1991). Similarly, Rao *et al.* (1992) noticed the increase in the number of lateral branches per plant with higher level of nitrogen (200 kg/ha) in chrysanthemum.

Field experiment conducted by Ramesh kumar and Kiranjeet Kaur (1996) in balsam found increased number of secondary branches per plant and plant height with the application of nitrogen and phosphorus at 20 and 10 gram per m^2 respectively.

Baboo and Sharma (1997) in chrysanthemum indicated that plants receiving 300:200:120 kg NPK per ha recorded maximum plant height and more number of branches.

In gaillardia, Hugar (1997) reported increased plant height (43.0 and 39.3 cm), leaf area index (4.83 and 4.62) and dry matter production (29.92 and 28.12 g) with the application of 75 kg N per ha in rabi and summer, respectively. Whereas, increase in number of branches (34.7 and 34.2) and leaves (343 and 327) was recorded at 100 kg N per ha in rabi and summer respectively.

De and Dhiman (1998) reported that maximum plant height (65 cm) was recorded with combined application of 200 kg N and 400 kg K_2O per ha when compared to control (33 cm) in chrysanthemum.

Ravindra (1998) reported in china aster that all the growth parameters like plant height, number of leaves, stems, diameter *etc.,* were influenced by nitrogen and phosphorus applications, but the effect of potassium was minimum.

In gaillardia, the application of 30 g of nitrogen per square metre recorded significantly maximum plant height of 80.8 cm over the lower doses of nitrogen (Mishra, 1998).

Doddagoudar *et al.* (2002) reported maximum plant height (47.3 cm), number of branches (9.13) and leaves (42.7) per plant with maximum dry weight (34.25 g) with application of 240:180:80 kg NPK per ha in china aster.

Agarwal *et al.* (2002) obtained significantly maximum plant height (69.6 cm) and number of branches (21.9) with application of 200 kg N per ha, compared to control (52.5 cm and 12.8 respectively) in marigold.

Kumar *et al.* (2003) reported that plant height (34.80 cm) and number of branches (4.43) increased significantly with application of nitrogen @ 300 kg per ha as compared to 26.34 cm plant height and 3.3 branches without any nitrogen application. Similarly, phosphorus increased plant height and number of branches by plants receiving higher dose of phosphorus in china aster.

Saud and Ramchandra (2004) reported that higher dose of fertilizer (150:150:150 kg NPK/ha) resulted in maximum number of primary and secondary branches in french marigold.

Acharya and Dashora (2004) reported that application of 200 kg per ha each of nitrogen and phosphorus produced maximum plant height (95.92 cm), plant spread (49.31) and branches (14.2) when compared to other levels of nitrogen, phosphorus and control in African marigold.

Grawal *et al.* (2004) reported that the application of 40 g per m^2 nitrogen significantly took more number of days (123.00) to bud break than all other treatments, irrespective of pinching in chrysanthemum.

2.2.2 Flowering, seed yield and yield parameters

In safflower, Singh and Kushal (1974) recorded maximum number of capitula per plant, number of seeds per capitulum, 1000 seed weight, and seed yield per ha with the application of 20 kg N and 40 kg P_2O_5 per ha.

In china aster, flower number and size was enhanced by NPK when applied at the rate of 120:180:120 kg per ha (Chernewa, 1976). Similarly, Maheshwar (1977) obtained more number of flowers by applying N and P_2O_5 at 120:120 kg per ha respectively in china aster.

The maximum number of seeds per head, 1000 seed weight, seed yield per plant, seed yield per ha was obtained with 40 kg of N, 60 kg of P_2O_5 and 60 kg of K_2O in sunflower (Tripathi and Kalra, 1981).

Nalwadi (1982) found that application of 225 kg N, 120 kg P_2O_5 with 60 kg K_2O per ha resulted in significantly higher number of plant and seed yield per plant in all the eight varieties of marigold.

Venkatesh (1983) recorded significantly higher number of flowers in china aster with the application of 100:60:60 kg NPK per ha and he could not observe any influence of fertilizers on flower diameter, however he obtained increased dry weight of flowers only with potash levels. Similar results were observed in chrysanthemum with the application of 250:150:100 kg NPK per ha by Rachayanavar (1983).

Dongre (1984) reported that application of 40 g of N and 40 g of P_2O_5 per square metre gave maximum number of flowers per plant and seed yield per plant in marigold.

Narayanagowda (1985) obtained higher number of large sized flowers by application of 180:120:100 kg NPK per ha in china aster.

Jayanthi and Gowda (1988) in chrysanthemum reported that flowerdiameter and flower yield were increased significantly with the application of 30:40:20 kg NPK per square metre (300:400:200 kg NPK/ha).

Mantur (1988) noticed delayed flowering with higher number of flowers per plant (36.85), flower yield (83.92 g/plant), large size flowers (5.78 cm) and higher seed yield per plant (6.72 g/plant) with the application of 180:120:100 kg NPK per ha in china aster.

According to Anuradha *et al*. (1990) the number of days taken for 50 per cent flowering were reduced with increased levels of N and P_2O_5 (each from 0 to 90 kg N and P_2O_5/ha) in marigold.

On the contrary Sharanabasappa (1990), reported that application of higher dose of N and P_2O_5 at 150 and 100 kg per ha respectively delayed the days to first flowering by 6 days and 50 per cent flowering by 7.37 days over the control in everlasting flower.

Jana and Pal (1991) reported that higher dose of nitrogen and phosphorus resulted in maximum reduction in flowers and seed yield in cosomos while maximum number of flowers and seed yield were obtained with a combined application of 20 g N, 10 g P and 10 g K per m^2.

Yadav and Bose (1993) stated that application of 300:100 kg N and P_2O_5 per ha significantly increased the seed yield in African marigold but further increase in nitrogen (400 kg) and phosphorus (400 kg) levels reduced the seed yield.

In a gaillardia, the application of 75 kg nitrogen per ha significantly increased the number of flowers per plant, 10 flower weight and seed yield except breadth of flower (Hugar, 1997). He further reported that, increase in N level to 125 kg per ha did not affect the flower and seed yield as compared to 75 kg per ha.

Ravindra (1998) reported in china aster, that time taken for flowering increased with the application of higher doses of nitrogen while phosphorus reduced the time taken for flowering. Flowering duration was increased with increased nitrogen and phosphorus application. While, potassium had no influence on both flowering time and duration of flowering. The flower yield was maximum with the application of 200:100:100 kg NPK per ha.

De and Dhiman (1998) reported in chrysanthemum that number of flowers per plant were maximum (32) with the combination of 600 kg N_2 and 200 kg K_2O per ha followed by 400 kg N_2 and 200 kg K_2O per ha.

Yadav *et al*. (1998) concluded that application of 80 kg nitrogen per ha significantly increased the diameter of head, 1000 seed weight and seed yield over 40 and 60 kg N per ha in sunflower.

Rupinder Kaur and Ramesh Kumar (1998) noticed that number of flowers per plant (65.42) and seed yield per plant (0.59 g) were significantly influenced by the application of N and P and found to be maximum at 30 g of N and 20 g of P_2O_5 per square metre in pansy.

According to Shivakumar (2000), application of 315:84:84 kg NPK per ha significantly increased the number of capitula harvested per plant (25.2), number of seeds per capitula (216), seed yield per plant (7.88 kg) and ha (437 kg). Thousand seed weight did not differ significantly although it was higher at higher fertilizer level (315:84:84 kg NPK/ha) in marigold.

Singh and Sangama (2000) reported in china aster that significantly maximum length of flower stalk (27.27 cm) and number of flowers per plant (35.22) were obtained with higher levels of N (300 kg/ha) but number of days taken for 100 per cent flowering, diameter of flower and weight of 5 flowers were not significantly influenced by graded levels of nitrogen.

Mohanty *et al*. (2002) noticed in marigold that the days taken for flowering was prolonged from 68.03 days in (control) to 71.29 days with application of nitrogen (30 g/m^2). Further, more number of flowers and the highest yield of flower was obtained with 30 g N per m^2.

Doddagoudar *et al.* (2002) recorded more number of capitula (24.2) per plant, higher weight of capitulum (1.77 g), larger diameter of capitulum (5.10 cm), higher seed weight (0.33 g) per capitulum, filled seed weight (0.26 g) per capitulum, filled seed percentage (78.7), thousand seed weight (1.86 g) and harvest index (16.5) with the application of 240:180:80 kg NPK per ha in china aster.

Maximum flower production in chrysanthemum cv. Jayanthi could be assured with the application of 20 g N and 16 g K per pot. It may be more advantageous when chrysanthemum plants were pinched at 20 days after transplanting (Singh and Baboo, 2003).

Baboo and Singh (2003) reported in marigold that application nitrogen @ 375 kg per ha gave highest flower yield (329.7 q/ha). Such boosting effect was ascribed to higher accumulation of carbohydrates in flower heads and increased flower size. Plants received with higher dose of phosphorus took less time to first flower appearance (50.2 days) as compared to control (58.2 days). The higher dose of P (210 kg/ha) also produced maximum flower yield (317.21 q/ha) than lower levels of phosphorus and control.

Kumar *et al*. (2003) reported in china aster that maximum number of flowers per plant (35.22) flower diameter (5.13 cm) and flowering duration (37.45 days) were observed with the higher dose of nitrogen with 300 kg per ha followed by 250 kg per ha and plants receiving higher dose of phosphorus took less time to produce first flower bud (54.05 days) as compared to other levels of fertilizer.

Acharya and Dashora (2004) reported in African marigold that by application of 200 kg of N and P fertilizers per ha recorded the increased diameter of flower, number of flowers per plant and flower yield per plant and per ha when compared to other levels of N and P.

2.2.3 Seed quality parameters

Thousand seed weight was increased significantly as the level of N and P increased from 75 kg per ha (Gaur *et al*., 1973) in sunflower.

Maheshwarappa *et al*. (1985) reported an increase in hundred seed weight and germination percentage with increased level of nitrogen and phosphorus in sunflower (up to 120 and 90 kg/ha, respectively)

Mantur (1988) noticed an increase in germination percentage, root length, shoot length and vigour index with increase in NPK (up to 180:120:100 kg/ha) in china aster.

Hugar (1997) recorded higher germination percentage, root length, shoot length and vigour index in gailardia with 100 kg nitrogen per ha.

Devidayala and Agarwal (1998) noticed significant improvement in thousand seed weight with application of N and P_2O_5 (up to 120 and 60 kg/ha respectively) in sunflower.

Shivakumar (2000) reported that seed quality parameters like root length, shoot length and seedling dry weight except germination percentage and vigour index were not influenced by different fertilizer levels. However, all these parameters recorded higher values at higher fertilizer doses (315:84:84 kg NPK/ha) in marigold.

Higher germination percentage (90.4), shoot length (3.54 cm), root length (1.40 cm), speed of germination (36.6), seedling dry weight (115.9 mg) and seedling vigour index (1449) were recorded with the application of 240:180:180 kg NPK per ha in china aster (Doddagoudar *et al*., 2004).

2.3 INFLUENCE OF MALIC HYDRAZIDE ON PLANT GROWTH, FLOWERING AND SEED YIELD AND QUALITY PARAMETERS

2.3.1 Growth parameters

Beach and Leopold (1963) reported that loss of apical dominance and production of increased number of laterals in chrysanthemum occurred due to foliar application of maleic hydrazide at concentrations ranging from 100 to 1000 ppm.

In carnation, the suppression of height of the main shoot and length of laterals were obtained with spraying MH (2000 ppm) at 65 days after sowing (Dubey, 1972). He further reported that lateral numbers were increased by MH @ 500 ppm and 1000 ppm.

Shanmugam *et al*. (1973) observed the suppression of growth in chrysanthemum by spraying 3 times (30^{th}, 40^{th} and 60^{th} days) after planting with 1000 ppm and 2000 ppm of MH. Dry weight of shoot was increased with 500 ppm of MH but it was reduced with higher concentrations.

Sen and Naik (1977) noticed maximum reduction in growth of chrysanthemum with 200 ppm maleic hydrazide followed by cycocel at 1000 ppm.

Narayan Reddy (1978) noticed that foliar application of MH at 750 and 1000 ppm resulted in significant reduction in internodal length and increase in number of leaves and branches in china aster. Similarly, spraying of MH at 500 ppm reduced the plant height but increased the number of branches compared to control in china aster (Reddy and Sulladmath, 1983) in marigold and china aster (Lal and Mishra, 1986).

Foliar spraying of MH at 500 ppm significantly reduced the plant height and increased the number of branches and leaves compared to control in marigold (Kumar, 1987).

Syamal *et al*. (1990) reported in decrease the height of plants, increase in number of branches, number of leaves with increase in the concentration of MH from 200 ppm to 400 ppm in china aster.

Narayanagouda and Jayanthi (1991) reported in marigold that maleic hydrazide significantly reduced the plant height and increased number of branches, number of internodes and dry weight of plant.

Aswath *et al*. (1994) reported that MH (1500 ppm) resulted in the reduction of plant height (38.52) number of leaves (45.59) number of branches (18.28), branch length (19.94) and internodal length (1.09) when compared to control *i.e.* (47.56, 51.37, 15.82, 24.47 and 2.26) respectively in china aster.

Mitalisaikia and Talukdar (1997) reported in chrysanthemum that in both pinched and unpinched plants, plant height was reduced by spraying MH 500 and 1000 ppm. While, number of leaves and branches decreased with increase in concentration of MH. Further, they reported delay in flowering with increase of MH concentration.

In marigold, Singh (2004a) reported maximum (9.89) number of branches per plant and reduction in plant height (62.13 cm) with MH (400 ppm) treatment. Further, he reported increase in number of leaves and leaf area index.

2.3.2 Flowering, seed yield and yield parameters

Sen and Maharana (1972) found increased flower yield by spraying 250 ppm MH to chrysanthemum plants. But, MH 500 ppm and 1000 ppm spray reduced flower yield. All the treatments of MH delayed flowering by 13 to 23 days.

Flower numbers were increased by spraying MH at 500 and 1000 ppm while flowering was delayed by 8 to 18 days depending on the concentration (Dubey, 1972).

Narayan Reddy (1978) reported that spraying of MH at 500 750 and 1000 ppm thrice after transplanting in china aster delayed flowering. Further, noticed that all the concentrations reduced the diameter of flowers and flowers thickness in winter as well as in summer crops.

Significantly more number of flowers per plant was obtained by spraying of china aster plants with MH at 500 ppm (Reddy and Sulladmath, 1983). Similarly, Parmar and Singh (1983) observed more number of flowers per plant by application of MH 500 ppm compared to control in marigold. Significantly, more number of flowers per plant was obtained in china aster by spraying MH at 500 ppm compared to control (Lal and Mishra, 1986).

Application of MH at 500 ppm significantly increased the number of flowers per plant compared to control in china aster. Further, there was decrease in flower diameter compared to control with 500 ppm but it was non-significant (Aswath, 1991).

Aswath *et al.* (1994) in china aster noticed that spraying of MH 500 ppm significantly increased the number of flowers per plant and also reduced the flower diameter as compared to control.

Mitalicaikia and Talukdar (1997) reported increase in number of flowers and decrease in flower diameter with MH (500 ppm) compared to other treatments in chrysanthemum.

Mantur (1988) reported that flowering was delayed by nitrogen and phosphorus application. The maximum flower yield and quality seeds were recorded with 180:120:75 kg NPK per ha in china aster.

Hugar (1997) in gaillardia, noticed significantly delayed flowering leading to significant increase in weight of 10 flowers, number of flowers per plant, seed weight of 100 capitula seed recovery per cent, seed yield per plant and per ha and total dry matter accumulation.

Jitendrakumar and Sanjeevkumar (2004) reported that number of days taken to first flower bud opening was more with higher concentration of MH (700 ppm) compared to lower concentrations (250 ppm) MH. Further, they reported that more number of flowers per plant were recorded with 250 ppm of MH and less with 700 ppm of MH in balsam.

Singh (2004a) reported in marigold maximum number of flowers, seeds per flower and seed yield per plant and per metre with MH (400 ppm) treatment.

2.3.3 Seed quality parameters

Spraying of MH at 500 ppm, significantly increased the germination percentage and vigour index in gailardia but it did not influence the shoot and root length of the seedling (Hugar, 1977).

Doddagoudar *et al.* (2004) reported increased 1000 seed weight, germinability, shoot and root length, seedling vigour index and seedling dry weight with MH 500 ppm spray in china aster.

Singh (2004a) reported in marigold increased 1000 seed weight with spraying of MH (400 ppm) treatment compared to control and other treatment.

2.4 INFLUENCE OF CCC ON PLANT GROWTH, FLOWERING, SEED YIELD AND QUALITY PARAMETERS

2.4.1 Growth parameters

Shanmugam and Muthuswamy (1974) reported the marked suppression of plant growth at all concentrations (500, 1000 and 2000 ppm) of CCC in chrysanthemum compared to control.

Sen and Naik (1977) noticed marked reduction in plant height over control with foliar spray of cycocel (1000 ppm) in both pinched and unpinched *Chrysanthemum mozifolium* cv. Early white.

Narayanagowda (1985) reported that CCC at 1000 ppm increased the number of branches, nodes and leaves in china aster. In contrast to this, a reduction in internodal length was recorded when the concentrations were increased compared to control.

Narayanagowda and Jayanthi (1991) reported in marigold that cycocel (200 ppm) foliar spray successfully reduced the plant height and at all concentrations (1000, 1500 and 2000 ppm), increased the number of branches at pre bloom stage (26.20 and 26.80 plant) at post blooming stage (53.40 and 52.90 plant) in first and second season respectively.

Shreedhar (1993) in his studies on gaillardia noticed higher number of branches, leaves and dry matter production and reduced plant height with CCC (2000 ppm) as compared to CCC (3000 ppm). With spraying of CCC (1000 ppm) on gaillardia significantly increased number of branches, leaves, leaf area index and total dry matter production were recorded compared to control (Hugar, 1977).

Aswath *et al*. (1994) noticed a decrease in plant height, branches length and internodal length with increase in the concentrations of cycocel in china aster. While, maximum number of branches and leaves were recorded in CCC 1500 ppm.

Khandelwal *et al*. (2003) reported that spraying of 1000, 2000 and 3000 ppm of CCC significantly reduced the plant height, but increased the number of branches and leaves at all concentration compared to control in African marigold.

Singh (2004b) reported that CCC at 2000 ppm exhibited maximum number of leaves and secondary shoots and significantly reduced plant height in rose.

2.4.2 Flowering, seed yield and yield parameters

Parmar and Singh (1983) noticed more flower per plant and flower yield with foliar spray of CCC (500 and 750 ppm) compared to control.

Narayangouda (1985) reported in china aster that application of CCC (1000 ppm) increased the number of days to 50 per cent flowering, number of flower per plant and flower yield compared to control.

Shreedhar (1993) in his studies on growth retardants in gaillardia noticed higher number of flowers (with better size) and flower yield with CCC (2000 ppm) as compared to CCC (3000 ppm).

Aswath *et al*. (1994) reported in china aster that application of cycocel (1000 ppm) delayed the flower bud appearance by 12.40 days. Higher number of flowers per plant were obtained due to the spray of 1500 ppm cycocel followed by alar (1500 ppm). Flower production decreased with 1500 ppm MH compared to control, further they noticed that diameter of flower was not much influenced by growth retardants.

Narayanagouda *et al*. (1996) reported that cycocel treated plants of Guadmullige flowered early with longer duration of flowering and increase in number and flower yield per plant (120.59).

Hugar (1997) reported that spraying of CCC (1000 ppm) to gaillardia plants significantly increased the days to 50 per cent flowering, number of flowers per plant, seed yield per plant, seed recovery percentage, 1000 seed weight, but decreased capitulum diameter compared to control.

Khandelwal *et al*. (2003) observed significantly increased number of flowers, number of days to first flowering and decreased diameter of flowers and decreased diameter of flowers with increase in the concentration of CCC (1000, 2000 and 3000 ppm) compared to control.

Singh (2004b) reported in rose that CCC (2000 ppm) recorded maximum diameter of flower, early induction of flower bud and flowering compared to CCC (1000 ppm).

2.4.3 Seed quality parameters

Mantur (1988) reported that germination percentage, vigour index, shoot and root length of seedling were significantly increased by spraying CCC at 1000 ppm compared to control in china aster.

Hugar (1997) reported that significantly higher 1000 seed weight, seed germination percentage and seedling vigour index with spraying of CCC 1000 ppm on gaillardia compared to other treatment and control.

Akkannavar (2001) reported higher germination percentage, root length and shoot length, speed of germination, seedling dry weight, seedling vigour index with CCC (500 ppm) in ageratum compared to control.

2.5 EFFECT OF GENOTYPES AND CONTAINERS ON STORAGE POTENTIAL

Storage potential of seed is mainly dependent on genotypes and is heritable and is modified by the environment in which it is stored (Delouche, 1973). Further, storage containers are also known to influence seed storage potential in several field and horticultural crops including flower crops. The literature on these aspects in flower crops and especially in china aster is very much limited. As such reviews on other crops have also been presented in this chapter.

2.5.1 Effect of genotypes on storage potential and seed quality

Vanangamudi (1988) reported that among soybean cultivars, Hill, Co-1, Nimsoy 7, DS7437 and PB-1 had better storage potential. Whereas, Bragg showed poor storability after 16 months of storage.

Singh and Gill (1996) observed that the cultivar PK 472 of soybean had a short storability while the cultivars SL 107, SL 144 and SL 129 stored better even after 16 months of storage in cloth bags under ambient conditions of storage.

Danej and Dumbre (1996) reported in tomato that the difference due to genotypes on germination and vigour index was significant. Cultivar Dhanashree recorded highest germination (92.6%) and vigour index (1639) compared to Bhagyashree and Pusa early dwarf which recorded 88.1 and 89.8 per cent germination and 1500 and 1466 vigour index respectively.

Kumar *et al*. (1997) reported that germination and seedling vigour decreased in all the varieties of peas with increased duration of storage.

Kharb *et al*. (1998) reported that the soybean genotypes, T49, MO 40, PK 262, PK 416 and Durya deteriorated at faster rate and considered them as poor storer whereas Kalitur, JS 8021, JS 87 59, JS 89 18, Punjab 1 KB 92, NRC 2, MACS 335 and Pusa 20 were considered as good storer as these genotypes maintained the germination percentage above the certification standard (70%) after nine months of storage.

Singh *et al*. (1998) reported that under ambient storage conditions, vigour and viability of 12 genotypes of rice bean declined gradually during 3 to 3½ years of storage.

Kumbar (1999) reported in chickpea that the seed quality decreased with increase in storage period in all cultivars. However, significantly higher germination (64%), speed of germination (13.5), root length (4.42 cm), shoot length (4.7 cm), vigour index (1338), seedling dry weight (170 mg/seedling) and lowest moisture content (10.7%) and EC (0.950 dsm^{-1}) were recorded in BG-256 compared to Annigeri-1, ICCV-10 and ICCV-2.

Hunje (2002) reported in chilli that Byadagi kaddi showed significantly higher seed quality parameters during storage period compared to Dyavanur local.

2.5.2 Effect of storage containers on storability and seed quality

Miyagi (1966) dried the seeds of onion, carrot, cabbage, lettuce, cucumber and tomato in desiccator and stored in moisture vapour proof resistant and impervious containers. The seed stored in moisture resistant containers retained higher viability and vigour for longer period followed by moisture proof container and impervious containers.

Harington (1973) found that storage of seeds in moisture proof or moisture resistant package would be more valuable in prolonging seed germination and vigour.

The physical properties and storage potential of seed are influenced to a vary great extent by moisture content, relative humidity and temperature of the atmosphere surrounding the seed. In general, seed stored in moisture impervious sealed containers provide suitable environment for storage, protection against contamination and also act as a effective barrier against the escape of seed treatment chemicals than in moisture pervious container (Thomson, 1979).

Viability of pepper seeds dropped to 59 per cent when stored in polythene bag and to zero per cent in cloth bag at the end of 7 year of storage under ambient conditions (Popovska *et al*., 1981).

Vadivelu and Ramaswamy (1983) stored tomato seed at 7 per cent moisture content in cloth bag and aluminium polythene laminated pouches for 30 months. The seed stored in aluminium polythene laminated pouches showed higher germination compared to cloth bag.

Gupta and Murthy (1985) reported that seeds of *Tagetes erecta* stored in open mouth bottle covered with cheese cloth, brown paper bag and polythene bag at room temperature, lost viability completely by the end of 13 months, 16 months and 18 months, respectively.

Gupta and Murthy (1986) stored weed seeds of 12 species of Asteraceae for 24 months in open mouth bottle, paper bag and polythene bag at room temperature. Seed stored in polythene bag maintained viability for longer period followed by paper bag and open mouth bottle.

Saxena *et al*. (1987) stored the seeds of onion, cabbage, radish, cauliflower, okra and peas in polythene and cloth bag at room temperature for 24 months. The decrease in germination, seedling root length, shoot length and vigour index with the increase in storage period was greatest in the seed stored in cloth bag and was least in polythene bag.

Onion seed stored in sealed polythene bag (700 gauge) maintained higher germination (70%) and vigour index. Whereas, untreated seeds stored in cloth bag showed reduced germination (35%) and vigour index at the end of 10 months storage period (Vijayakumar *et al*., 1991).

Verma *et al*. (1991) reported that cauliflower and tomato seeds stored in laminated bags recorded higher germination (65.3 and 67.6%, respectively) compared to unsealed polythene bag (52% and 43% respectively) at the end of 11 months. Onion seed stored in sealed polythene bag (700 gauge) maintained higher germination (65.3 and 67.3%, respectively) compared to unsealed polythene bag (52% and 43%, respectively) at the end of 11 months.

Onion seed stored with 4 to 5 per cent moisture content maintained satisfactory germination above the minimum seed certification standards for 360 days in aluminium foil pouches (71%) and plastic bags (70%) whereas, in cloth bag and paper bag seeds maintained for 300 days (Shelar *et al*., 1992).

Shelar and Patil (1993) reported that seeds of brinjal and tomato maintained satisfactory germination above the minimum seed certification standards (70%) for 540 days when stored in moisture impervious containers like polythene bag and aluminium foil packs whereas, seed stored in moisture pervious containers maintained viability above 70 per cent for 420 days.

Panday *et al*. (1994) reported that onion seed stored in cloth bag and polythene bag (750 gauge) at room temperature maintained satisfactory germination as per minimum seed certification standards (70%) up to 9 and 24 months respectively.

Saxena (1994) stored vegetable seeds like onion, tomato, okra and cabbage at different moisture content in different packing materials. He reported that seeds with 6 to 8 per cent moisture content could be stored for a longer period in polythene bags (700 gauge).

Palanisamy *et al.* (1995) reported that tomato seed stored in polythene bag (700 gauge) maintained higher seed viability (60%) even after 12 months of storage than in cloth bag.

Carpenter *et al.* (1995) noticed that total per cent germination generally declined as seed moisture content increased during storage of Ageratum, Impatiens, Tagetes, Phlox and Saliva when stored in polythene pouches.

Singh and Singh (1990) dried onion seeds to 4.1 per cent moisture content and stored in cloth bag (CB), sealed in single (SP), double (DP) and triple (TP) layer polythene pouches and sealed glass bottle (GB). Seeds stored in GB retained viability (79%) at the end of 24 months of storage and seed stored in CB, SP, DP, TP gave 40, 70, 72 and 73 per cent germination respectively.

Marigold seeds with 7 ± 0.5 per cent moisture content maintained viability up to 6 months when stored in cloth bags and for a longer period when stored in polythene bag (Selvaraju *et al.,* 1999).

Kumbar (1999) reported in chickpea that, the seed quality decreased with increase in storage period in all the cultivars. Among the storage containers, polythene lined gunny bag recorded significantly higher germination (76.30%), speed of germination (16.01), root length (16.28 cm), shoot length (6.35 cm), vigour index (1723), dry weight (171 mg/seedling) and lowest moisture content compared to other containers at the end of storage period.

Patil (2000) reported that chickpea seeds stored in polythene bag maintained higher quality parameters with lesser quantitative losses than the seeds stored in cloth bag. Annigeri–1 stored in polythene bag recorded higher germination (67.68%), vigour index (1504) with less moisture content (9.27%) and electrical conductivity (1.30 dSm^{-1}) at the end of fourteen month of storage period.

Hunje (2002) reported seeds stored in sealed aluminium foil pouches recorded significantly higher germination (89.67%), root length (9.77 cm), shoot length (8.55 cm), vigour index (1643) and lower EC (0.808 dSm^{-1}) at the end of 20 months of storage period compared to seed stored in fruit form in chilli.

Sharanamma (2002) noticed in chilli that among the containers, seeds stored in 700 guage polythene bag recorded higher seed quality parameters compared paper bag.

Bharathi (2002) reported in gaillardia that, the seed quality decreased with increase in the storage period. However, significantly higher germination (69.33%), root length (3.1 cm), shoot length (3.48 cm), vigour index (456), dry weight (20.45 mg), germination rate index (13.95) and lower electrical conductivity of seed leachate (0.690 dSm^{-1}) were recorded in seeds stored in two layer polythene packet (400 gauge) with silicagel at the end of storage period compared to other combination.

MATERIAL AND METHODS

A field experiment was conducted at the Main Agricultural Research Station, University of Agricultural Sciences, Dharwad during *kharif* 2005 to study the "Effect of pinching, fertilizer levels and growth retardants on seed yield, quality and storage potential of China aster. The details of the materials used and experimental techniques adopted during the course of investigation are presented in this chapter.

3.1 GEOGRAPHICAL LOCATION OF EXPERIMENTAL SITE

Dharwad is situated in the Agroclimatic Zone–8 (Northern transitional tract) of Karnataka State. Dharwad is located between 15^0 26' North latitude and 76^0 27' East longitude and at an altitude of 678 m above mean sea level.

3.2 CLIMATIC CONDITIONS

Dharwad has the benefit of Southwest and Northeast monsoons. The rainfall is confined to the monsoon period from May to November with occasional showers in pre-monsoon months of April and May. During the period of experimentation, the total rainfall received was 321.9 mm (September to December, 2005-06) with highest rainfall during September (194.5 mm). The mean maximum temperature during the period of experimentation ranged between 27.5^0C (September) to 28.9^0C (December). The minimum temperature during the said period of experimentation ranged between 20.3^0C (September) to 13.1^0C (December).

The mean relative humidity ranged between 85 per cent (September) to 53 per cent (December).

3.3 SOIL CHARACTERISTICS

The experiment was conducted in black soil. The physical and chemical composition of the field experimental soil is presented in Appendix – II.

3.4 PREVIOUS CROP ON THE EXPERIMENTAL SITE

Cowpea was grown on the experimental site during previous rabi season of 2004-05.

3.5 EXPERIMENT – I : EFFECT OF PINCHING, FERTILIZER LEVELS AND GROWTH RETARDANTS ON SEED YIELD AND QUALITY OF CHINA ASTER CV. PHULE GANESH WHITE

3.5.1 Treatment details

Factor – I : Pinching (P)

P_1 - Pinching

P_2 : No pinching

Factor – II : Fertilizer levels (F)

F_1 – 180:120:100 kg $N:P_2O_5:K_2O$ per ha (RDF)

F_2 : 225:150:125 kg $N:P_2O_5:K_2O$ per ha (25% increase)

F_3 : 270:180:150 kg $N:P_2O_5:K_2O$ per ha (50% increase)

Plate 1: General view of experimental plot of china aster

Plate 1. General view of experimental plot of china aster

Factor – III : Growth retardants spray (S)

S_1 – CCC 100 ppm

S_2 – CCC 200 ppm

S_3 – MH 500 ppm

S_4 – MH 1000 ppm

S_5 – Water (control)

3.5.2 Treatment combination

The field experiment consisted of totally 30 treatment combinations involving pinching and no pinching, three levels of fertilizer and five chemicals spray as follows.

3.5.3 Design and layout

The experiment was laid in RCBD with factorial concept with three replications. The plan of layout of experiment is given in Fig. I.

3.5.4 Plot size

Gross plot : 3.6 x 3.0 m

Net plot : 2.7 x 2.4 m

3.6 SEED SOURCE

The seeds of china aster cv. Phule ganesh white was obtained from the Indian Institute of Horticulture Research (IIHR), Hessarghatta, Bangalore.

3.7 SEED TREATMENT

The seeds were treated with captan at the rate of 2 g per kg of seeds and used for sowing in the nursery.

3.8 CULTURAL OPERATIONS

The details of cultural operations carried out during the course of investigation including the nursery operations are furnished below.

3.8.1 Nursery operation

Raised nursery beds of size 7.0 x 1.2 m were first prepared and drenched with captan (0.01%) before sowing the seeds. The nursery beds were watered twice for first 10 days and daily once for the remaining period. Hand weedings were done at 20 and 30 days after sowing. The seedlings were ready for transplanting 40 days after sowing.

3.8.2 Preparation of experimental plot

The experimental plot was brought to fine tilth by once ploughing and repeated harrowings. The experimental plots were laidout as per the treatment requirements.

3.8.3 Transplanting

The treatments were distributed randomly in the main experimental plot and 40 days old seedlings were transplanted with a spacing of 45 cm between rows and 30 cm between plants. Transplanting was done at the rate of two seedling per hill. Light irrigation was given soon after transplanting.

LEGEND

Factor – I Pinching (P)

P_1 : Pinching

P_2 : No pinching

Factor – II : Fertilizer levels (F)

F_1 : 180: 120 : 100 kg $N:P_2O:K_2O$ per ha (RDF)

F_2 : 225: 150: 125 kg $N:P_2O5:K_2O$ per ha (25%increase)

F_3 : 270: 180: 150 kg $N:P_2O5:K_2O$ per ha (50% increase)

Factor – III : Growth retardants spray (S)

S_1 : CCC 100 ppm

S_2 : CCC 200 ppm

S_3 : MH 500 ppm

S_4 : MH 1000 ppm

S_5 : Water (Control)

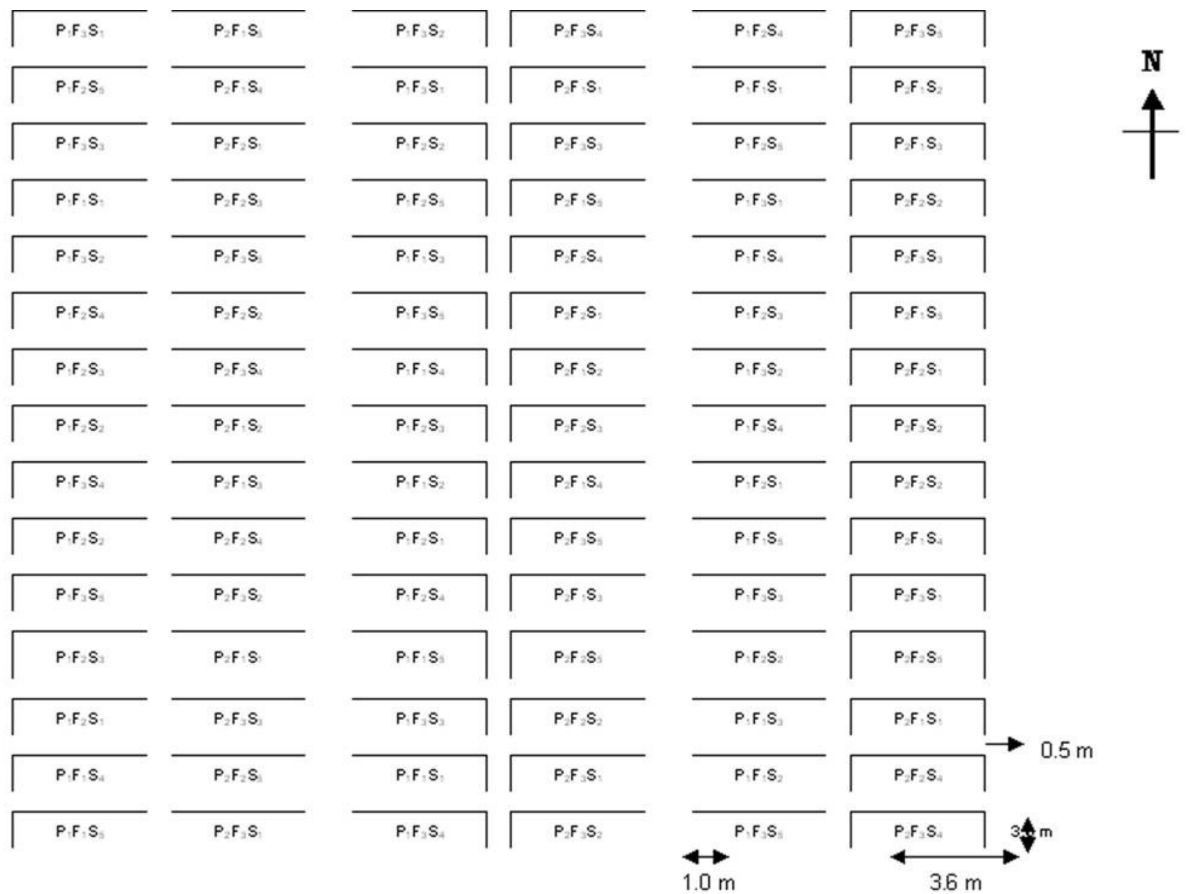

Fig. 1 : Plan of layout of the experimental site

Fig. 1: Plan of layout of the experimental site

3.8.4 Application of fertilizers

The recommended quantity of N, P_2O_5 and K_2O fertilizers in the form Urea, DAP and MOP respectively was calculated as per the treatments. At the time of transplanting, half dose of N and full dose of P_2O_5 and K_2O were applied in a circular band of about 3-4 cm away from each plant. The crop was top dressed with remaining half dose of nitrogen at 30 days after transplanting.

3.8.5 Preparation of chemical solutions

Chloro- Chlorine Chloride (CCC) 100 ppm

One hundred milligram of CCC was dissolved in two to three millilitre of alcohol and the final volume was made up to 1000 ml of distilled water.

Chloro- Chlorine Chloride (CCC) 200 ppm

Two hundred milligram of CCC was dissolved in two to three millilitre of alcohol and the final volume was made up to 1000 ml of distilled water.

Maliec hydrazide (MH) 500 ppm

Half millilitre of MH was dissolved in two to three millilitre of alcohol and the volume was made up to 1000 ml of distilled water.

Maliec hydrazide (MH) 1000 ppm

One millilitre of MH was dissolved in two to three millilitre of alcohol and the volume was made up to 1000 ml of distilled water.

3.8.6 Time of pinching and spray of growth retardants chemicals

The pinching operation was done after 15 days after transplanting (DAT) in the main field and on the same day growth retardants were sprayed. In the similar way water was sprayed as control.

3.8.7 Inter cultivation

Hand weeding was carriedout as and when required during the crop period, irrigation was given at an interval of 7 days depending upon the soil moisture status and climatic conditions. Inter cultivation was taken up within 2-3 days after every irrigation.

3.8.8 Plant protection

Need based plant protection measures were taken so as to protect the crop from pest and diseases. The crop was sprayed with endosulfan 35 EC at the rate of 2 ml per litre of water as prophylactic measures against leaf hopper, aphids, thrips and mites at 30 DAT. Soil drenching was also taken up with Bavistin at the rate of 2 ml per litre of water against *Fusarium* wilt at 60 DAT.

3.8.9 Harvesting

Harvesting of capitula for seed purpose was done at 120 DAT. The fully dried flowers were harvested treatmentwise and sun dried for three days. The dried flowers were threshed, cleaned and filled seeds were separated from chaffy seeds, further filled seeds were used for assessing the seed quality parameters.

3.9 COLLECTION OF DATA

3.9.1 Sampling procedure

The observations on growth parameters were recorded at three stages of plant growth *viz.,* 20 and 50 days after transplanting and at harvest. For recording various biometric observations, five plants at random from net plot area were selected and tagged in each plot.

The observations were made on plant height, number of leaves, number of branches per plant, number of flower per plant, flower diameter, number of seeds per flower, test weight, seed yield per plant and per hectare.

3.9.2 Observations on growth parameters

3.9.2.1 Plant height

The height of the five randomly tagged plants were measured at 20, 50 DAT and at harvest from the ground level to the tip of the plant and average was worked out and expressed in centimetre.

3.9.2.2 Number of branches per plant

The number of primary branches arising from the main stem of five tagged plants were counted and recorded at 50 DAT and at harvest and average was worked out.

3.9.2.3 Number of leaves per plant

The number of fully opened leaves were counted from the five tagged plants at 20 and 50 DAT and the average value was recorded as number of leaves per plant.

3.9.3 Observations on flowering, seed yield and yield components

3.9.3.1 Days to 50 per cent flowering

The number of days taken for 50 per cent of the plants to produce first flower in each plot was recorded by counting the days from the date of transplanting.

3.9.3.2 Number of flower per plant

The number of flowers harvested from the five tagged plants was averaged and recorded as the number of flowers per plant.

3.9.3.3 Flower diameter

The diameter of five randomly selected flowers in each treatment was measured at the point of maximum breadth. This was measured by using Varnier callipers and average was worked out and expressed in centimetre.

3.9.3.4 Number of seeds per flower

After separating the filled seeds from 5 randomly selected flowers from each treatment, the filled seeds were counted from each flower and average was counted as number of seeds per flower.

3.9.3.5 Seed yield per plant and per ha

For the purpose of determination of seed yield per plant, five earlier tagged plants were harvested separately and seeds were separated, cleaned, weighed and average seed yield per plant was estimated and expressed in grams. The seed yield per hectare was computed based on the seed yield per plant and expressed in kilograms.

3.9.4 Seed quality parameters

3.9.4.1 Thousand seed weight

One thousand seeds were manually counted from seeds of five plants in each treatment and 1000 seed weight was recorded by adopting ISTA procedure (Anon., 1996) and was expressed in grams.

3.9.4.2 Germination percentage

The seeds obtained from different treatments were tested for germination by adopting paper towel roll method kept at optimum conditions of temperature (25^0C + 1^0C) and relative humidity (95 $\pm$ 1% RH) in four replications of 100 seeds each (Anon., 1996). The number of normal seedlings were counted at the end of 14 days (II count) and the germination percentage was calculated.

3.9.4.3 Seedling length

Ten normal seedlings from each of the replication from the germination test were carefully removed on 14th day and used for measuring seedling length. The seedling length from tip of shoot to tip of root was measured in centimetre and the average length of the seedling was worked out and expressed in centimetre.

3.9.4.4 Seedling vigour index (SVI)

Seedling vigour index was calculated by using the formula suggested by Abdu-Baki and Anderson (1973).

SVI = Germination (%) x Seedling length (cm)

3.9.4.5 Seedling dry weight

The same ten seedlings used for measuring seedling length were kept in a butter paper packet and dried in hot air oven maintained at 70^{0}C for 48 hours. Then the seedlings were cooled in desiccator for 1 hour before recording the weight. The seedling dry weight was measured with the electronic balance and was expressed in milligram per seedling.

3.9.4.6 Electrical conductivity of seed

Five gram of seeds in four replications were washed in acetone for half a minute and later thoroughly washed in distilled water for five minutes. The seeds were soaked in 25 ml of distilled water and kept in an incubator maintained at 25^{0}C $\pm$ 1^{0}C for 24 hours. The seed leachate was collected and volume was made up to 25 ml by adding distilled water. The electrical conductivity of seed leachate was measured by using the bridge (ELICO) with a cell constant 1.0 and the leachate values were expressed in desi Simans per metre (dSm^{-1}).

3.10 EXPERIMENT – II : STORAGE POTENTIAL OF CHINA ASTER VARIETIES

The storage studies were conducted on four china aster varieties using four storage containers kept under ambient conditions of Department of Seed Science and Technology, College of Agriculture, University of Agricultural Sciences, Dharwad. The details of the materials used and experimental techniques adopted during the course of investigation are presented in this chapter as below.

3.10.1 Treatment details

Factor – I : Varieties (V)

- V_1 – Kamini
- V_2 – Phule ganesh white (PG white)
- V_3 - Phule ganesh purple (PG purple)
- V_4 - Phule ganesh voilet (PG voilet)

Factor – II : Containers (C)

- C_1 – Aluminium foil
- C_2 – Polythene bag
- C_3 – Paper packet
- C_4 – Cloth bag

3.10.2 Treatment combination

There were 16 treatment combinations involving four varieties and four storage containers as detailed below.

C_1V_1	C_2V_1	C_3V_1	C_4V_1
C_1V_2	C_2V_2	C_3V_2	C_4V_2
C_1V_3	C_3V_3	C_3V_3	C_4V_3
C_1V_4	C_4V_4	C_3V_4	C_4V_4

3.10.3 Seed source

Fresh seeds of four varieties (Kamini, PG white, PG purple and PG voilet) were collected from separated raised seed plots during *kharif* season 2005-06. The seed crop was harvested during December 2005 and the initial seed quality parameters were ascertained before conducting storage studies. The initial observations on seed quality parameters are presented below.

Varieties	Germination (%)	Speed of germination	Seedling length (cm)	Seedling vigour index	Seedling dry weight	EC (dSm^{-1})	Moisture content (%)
Kamini	92	16.20	5.0	456	17.6	1.30	8.10
PG white	89	15.90	4.82	428	17.5	1.40	8.15
PG purple	88	15.80	4.85	420	17.35	1.56	8.20
PG violet	90	16.00	4.85	440	7.45	1.38	8.20

3.10.4 Observation

Monthly observations were made on various seed quality parameters from January to June 2006 as detailed below.

3.10.5 Germination percentage

The germination test was determined as per the procedure detailed in section 3.9.4.2.

3.10.6 Speed of germination

Hundred seeds in four replication per treatment were placed in rolled towel and incubated at 25+1^{0}C. Daily count on germinated seeds was made up to 14th day. The speed of germination was calculated by using formula (Haydecker, 1969).

$$\text{Speed of germination} = \frac{N_1}{D_1} + \frac{N_2}{D_2} + \text{---------} + \frac{Nn}{Dn}$$

Where,

N_1, N_2 ------ Nn : Number of emerged seedlings on 1st, 2nd and nth day after sowing

D_1, D_2 ------ Dn : Number of days after sowing

3.10.7 Seedling length

The seedling length was determined as per the procedure detailed in section 3.9.4.3.

3.10.8 Seedling vigour index (SVI)

The seedling vigour index was determined as per the procedure detailed in section 3.9.4.4.

3.10.9 Seedling dry weight (mg)

The seedling dry weight was determined as per the procedure detailed in section 3.9.4.5.

3.10.10 Electrical conductivity of seed (dSm^{-1})

The electrical conductivity was determined as per the procedure detailed in section 3.9.4.6.

3.10.11 Moisture content

The moisture content of seeds was determined by the oven dry method as per ISTA Rules (Anon., 1996). Five grams of seeds were taken in aluminum boxes and dried in the oven at 103 ± 2^0C for 17 ± 1 hours. After oven drying, the metal boxes along with seeds were cooled in a desiccator for 30 minutes and the weight was recorded. The moisture content was expressed on wet basis using the following formula.

$$\text{Moisture content (\%)} = \frac{M_2 - M_3}{M_2 - M_1} \times 100$$

Where,

M_1 = Weight of the empty aluminum box (g)

M_2 = Weight of the aluminum box + seed material before drying (g)

M_3 = Weight of the aluminum box + seed material after drying (g)

3.11 STATISTICAL ANALYSIS

The data collected from the experiment were analysed statistically by the procedure described by Sundararajan *et al.* (1972). Critical differences were calculated at 5 per cent level, wherever 'F' test was significant. The data on percentage of germination are transformed in to arcsine square root percentage values (Snedecor and Cochran, 1967).

EXPERIMENTAL RESULTS

The results of the present investigation on effect of pinching, fertilizer levels and growth retardants on seed yield and quality and storage potential in china aster are presented in this chapter.

4.1 EXPERIMENT – I : INFLUENCE OF PINCHING, FERTILIZER LEVELS AND GROWTH RETARDANTS ON SEED YIELD AND QUALITY IN CHINA ASTER

4.1.1 Growth parameters

4.1.1.1 Plant height

The data on plant height at 20 days after transplanting (DAT), 50 DAT and at harvest as influenced by pinching, fertilizer levels and growth retardants and their interaction effects are presented in Table 1 and depicted in Fig. 2.

Irrespective of pinching, fertilizer levels and growth retardants spray, the mean plant height increased from 13.08 cm (at 20 DAT) to 46.46 (at harvest).

Due to pinching

At 20 DAT plant height differed significantly due to pinching treatments. It was significantly more (13.50 cm) with no pinching (P_2) and less (12.66 cm) with pinching (P_1) treatment (Plate 2).

Similarly at harvest, plant height was significantly more (48.38 cm) with no pinching (P_2) and less (44.54 cm) with pinching (P_1) treatment.

Due to fertilizer levels (F)

The plant height differed significantly at all the stages of crop growth due to fertilizer levels (Plate 3).

At 20 DAT significantly more (14.13 cm) plant height was recorded with F_3 followed by F_2 (13.02 cm) and was less (12.09 cm) with F_1.

At 50 DAT, significantly maximum (40.19 cm) plant height was recorded with F_3 followed by F_2 (38.41 cm) and was less (36.78 cm) with F_1. Similarly at harvest plant height was significantly more (49.52 cm) with F_3 followed by F_2 (46.51 cm) and less (43.36 cm) with F_1.

Due to growth retardants (S)

The plant height at 20 DAT was significantly more (14.25 cm) with control (S_5) and less (11.90 cm) with MH @ 1000 ppm (S_4) (Plate 4).

At 50 DAT, plant height was significantly more (43.21 cm) with control (S_5) followed by S_1 (41.05) and was significantly less (33.52 cm) with MH @ 1000 ppm (S_4).

Significant differences on plant height among all the growth retardants sprays were noticed at harvest. Plant height was significantly more (52.62 cm) with control (S_5) and significantly less (40.41 cm) with MH @ 1000 ppm (S_4).

Due to pinching and fertilizer levels (PxF)

The plant height did not differ significantly due to interaction effects of pinching and fertilizer levels at all the stages of crop growth.

At 20 DAT, plant height was relatively more (14.40 cm) with P_2F_3 than P_1F_1 (11.74 cm).

Table 1. Effect of pinching, fertilizer levels and growth retardants on plant height of china aster

Treatments	Plant height (cm)		
	20 DAT	**50 DAT**	**At harvest**
Pinching (P)			
P_1 – Pinching	12.66	37.80	44.54
P_2 - No pinching	13.50	39.12	48.38
S.Em$\pm$	0.18	0.36	0.47
CD at 5%	0.51	1.01	1.33
Fertilizer (F)			
F_1-180:120:100 kg NPK per ha	12.09	36.78	43.36
F_2-225:150:125 kg NPK per ha	13.02	38.41	46.51
F_3-270:180:150 kg NPK per ha	14.13	40.19	49.52
S.Em$\pm$	0.23	0.44	0.58
CD at 5%	0.65	1.24	1.64
Growth retardants sprays (S)			
S_1 – CCC 100 ppm	13.65	41.05	49.61
S_2 – CCC 200 ppm	13.11	38.15	45.84
S_3 – MH 500 ppm	12.49	36.37	43.83
S_4 – MH 1000 ppm	11.90	33.52	40.41
S_5 – Water (control)	14.25	43.21	52.62
S.Em$\pm$	0.29	0.57	0.74
CD at 5%	0.82	1.61	2.10
Interaction (PxF)			
P_1F_1	11.74	35.66	41.50
P_1F_2	12.38	37.78	44.38
P_1F_3	13.86	39.96	47.75
P_2F_1	12.44	37.89	45.23
P_2F_2	13.66	39.05	48.64
P_2F_3	14.40	40.42	51.28
S.Em$\pm$	0.32	0.62	0.81
CD at 5%	NS	NS	NS

NS – Non significant

Contd…..

Treatments	Plant height (cm)		
	20 DAT	**50 DAT**	**At harvest**
Interaction (PxS)			
P_1S_1	13.14	40.05	47.83
P_1S_2	12.75	37.58	44.00
P_1S_3	11.94	36.34	42.02
P_1S_4	11.56	32.92	38.33
P_1S_5	13.90	42.11	50.54
P_2S_1	14.16	42.04	51.40
P_2S_2	13.47	38.72	47.68
P_2S_3	13.04	36.41	45.65
P_2S_4	12.23	34.12	42.48
P_2S_5	14.60	44.32	54.71
S.Em$\pm$	0.41	0.80	1.05
CD at 5%	NS	NS	NS
Interaction (FxS)			
F_1S_1	12.83	39.41	46.96
F_1S_2	12.35	36.58	42.68
F_1S_3	11.48	34.75	40.31
F_1S_4	10.85	31.71	37.30
F_1S_5	12.95	41.43	49.56
F_2S_1	13.28	40.95	49.66
F_2S_2	13.01	37.95	45.95
F_2S_3	12.61	35.48	44.25
F_2S_4	11.78	34.00	40.40
F_2S_5	14.43	43.70	52.31
F_3S_1	14.85	42.78	52.21
F_3S_2	13.98	39.93	48.90
F_3S_3	13.38	38.90	46.95
F_3S_4	13.06	34.85	43.53
F_3S_5	15.36	44.51	56.00
S.Em$\pm$	0.51	0.98	1.29
CD at 5%	NS	NS	NS

NS – Non significant

Contd…..

Treatments	Plant height (cm)		
	20 DAT	**50 DAT**	**At harvest**
Interaction (PxFxS)			
$P_1F_1S_1$	12.36	37.66	45.50
$P_1F_1S_2$	11.96	35.50	40.86
$P_1F_1S_3$	11.03	33.90	38.33
$P_1F_1S_4$	10.83	30.80	34.97
$P_1F_1S_5$	12.50	40.46	47.83
$P_1F_2S_1$	12.53	40.16	47.56
$P_1F_2S_2$	12.43	37.16	43.83
$P_1F_2S_3$	11.96	35.80	42.16
$P_1F_2S_4$	10.96	32.96	38.23
$P_1F_2S_5$	14.03	42.80	50.13
$P_1F_3S_1$	14.53	42.33	50.43
$P_1F_3S_2$	13.86	40.10	47.30
$P_1F_3S_3$	12.83	39.33	45.56
$P_1F_3S_4$	12.90	35.00	41.80
$P_1F_3S_5$	15.16	43.06	53.66
$P_2F_1S_1$	13.30	41.16	48.43
$P_2F_1S_2$	12.73	37.66	44.50
$P_2F_1S_3$	11.93	35.60	42.30
$P_2F_1S_4$	10.86	32.63	39.63
$P_2F_1S_5$	13.40	42.40	51.30
$P_2F_2S_1$	14.03	41.73	51.76
$P_2F_2S_2$	13.60	38.73	48.06
$P_2F_2S_3$	13.26	35.16	46.33
$P_2F_2S_4$	12.60	35.03	42.56
$P_2F_2S_5$	14.83	44.60	54.50
$P_2F_3S_1$	15.16	43.23	54.00
$P_2F_3S_2$	14.10	39.76	50.50
$P_2F_3S_3$	13.93	38.46	48.33
$P_2F_3S_4$	13.23	34.70	45.26
$P_2F_3S_5$	15.56	45.96	58.33
Mean	13.08	38.46	46.46
S.Em$\pm$	0.72	1.35	1.82
CD at 5%	NS	NS	NS

NS – Non significant

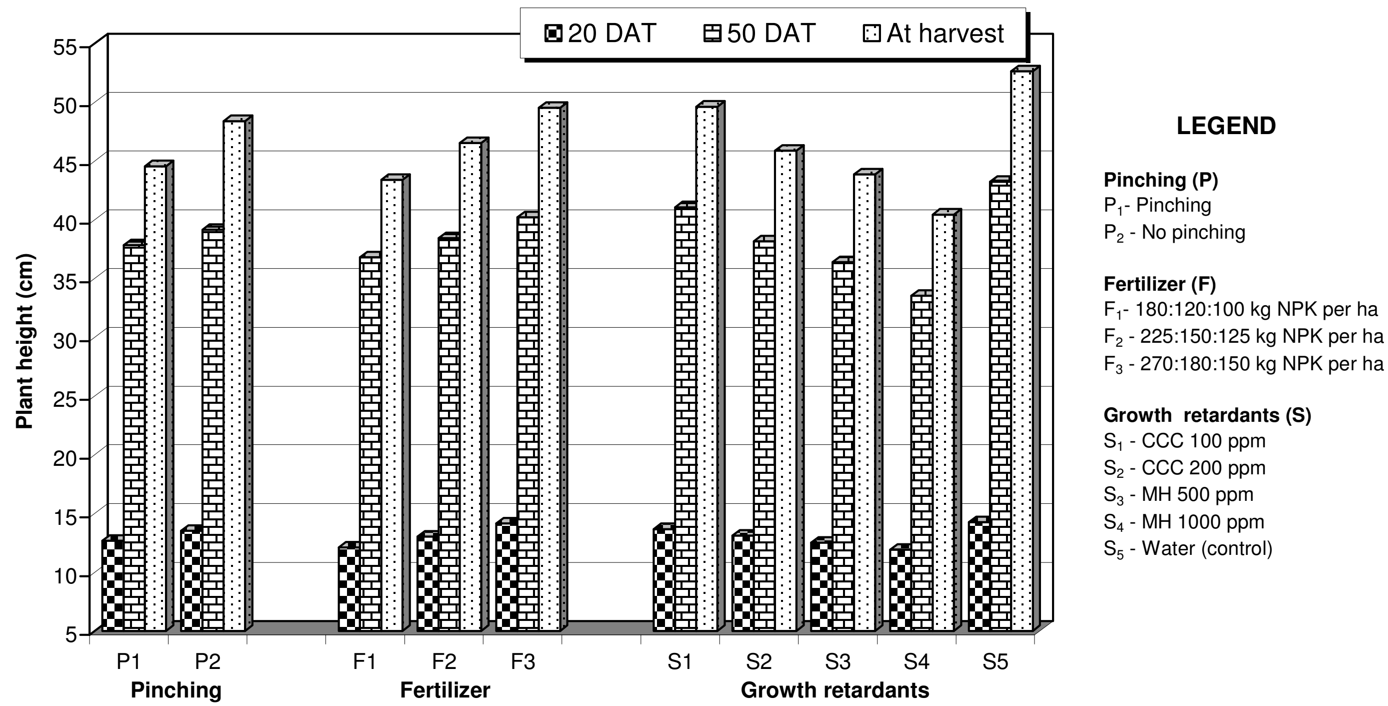

Fig. 2 : Influence of pinching, fertilizer levels and growth retardant sprays on plant height at 20, 50 DAT and at harvest in china aster

Fig. 2. Influence of pinching, fertilizer levels and growth retardant sprays on plant height at 20, 50 DAT and harvest in china aster

Plate 2: Influence of pinching on plant height and number of flower bearing branches in China aster

Plate 3: Influence of nutrition on plant height and number of flower bearing branches in China aster

Plate 4: Influence of growth retardants on plant height and number of flower bearing branching in China aster

AT 50 DAT, less (35.66 cm) plant height was noticed with P_1F_1 and more (40.42 cm) with P_2F_3.

Similarly, at harvest plant height was less (41.50 cm) with P_1F_1 and more (51.28 cm) with P_2F_3.

Due to pinching and growth retardants (PxS)

The interaction between pinching and growth retardants showed non significant differences on plant height at all the stages of the crop growth.

At 20 DAT, plant height was relatively more (14.60 cm) with P_2S_5 followed by P_2S_1 (14.16 cm) and less (11.56 cm) with P_1S_4.

The plant height at 50 DAT was more (44.32 cm) with P_2S_5 and less (32.92 cm) with P_1S_4.

Similarly at harvest, plant height was maximum (54.71 cm) with P_2S_5 and minimum (38.33 cm) with P_1S_4.

Due to fertilizer levels and growth retardants sprays (FxS)

The interaction between fertilizer levels and growth retardants showed non-significant differences on plant height at all the stages of the crop growth.

At 20 DAT, plant height was relatively more (15.36 cm) with F_3S_5 followed by F_3S_1 (42.78 cm) and less (10.85 cm) with F_1S_4.

At 50 DAT, plant height was more (44.51 cm) with F_3S_5 followed by F_3S_1 (14.85 cm) and less (31.71 cm) with F_1S_4.

At harvest, plant height was maximum (56.00 cm) with F_3S_5 and was less (37.30 cm) with F_1S_4.

Due to pinching fertilizer levels and growth retardants spray (PxFxS)

The plant height due to interaction of pinching, fertilizer levels and growth retardants was not significant at all the stages of crop growth.

At 20 DAT, plant height was relatively more (15.56 cm) with $P_2F_3S_5$ followed by $P_2F_3S_1$ (15.16 cm) and less (10.83 cm) with $P_1F_1S_4$.

At 50 DAT, plant height was more (45.96 cm) with $P_2F_3S_5$ followed by $P_2F_2S_1$ (14.73 cm) and less (30.80 cm) with P_1 F_1S_4.

The plant height at harvest was relatively highest (58.33 cm) with $P_2F_3S_5$ followed by $P_2F_2S_5$ (54.50 cm) and lowest (34.97 cm) with $P_1F_1S_4$.

4.1.1.2 Number of branches

The data on number of branches at 50 DAT and at harvest as influenced by pinching, fertilizer levels and growth retardants and their interaction effects are presented in Table 2 and depicted in Fig. 3.

Irrespective of pinching, fertilizer levels and growth retardants spray, the mean number of branches increased from 9.65 (50 DAT) to 10.65 (at harvest).

Due to pinching (P)

Number of branches differed significantly due to pinching treatment at 50 DAT and at harvest (Plate 2).

Significantly more (10.72) number of branches were recorded with pinching (P_1) and less (8.57) with no pinching (P_2) treatment at 50 DAT.

At harvest, number of branches were significantly more (11.60) with pinching (P_1) and less (9.71) with no pinching (P_2) treatment.

Table 2. Effect of pinching, fertilizer levels and growth retardants on number branches and number of leaves of china aster

Treatments	Number of branches		Number of leaves	
	50 DAT	At harvest	20 DAT	50 DAT
Pinching (P)				
P_1 – Pinching	10.72	11.60	11.54	40.29
P_2 - No pinching	8.57	9.71	13.27	37.16
S.Em$\pm$	0.23	0.19	0.23	0.44
CD at 5%	0.65	0.53	0.65	1.24
Fertilizer (F)				
F_1-180:120:100 kg NPK per ha	8.92	9.72	11.10	36.53
F_2-225:150:125 kg NPK per ha	9.25	10.59	12.24	39.04
F_3-270:180:150 kg NPK per ha	10.78	11.66	13.88	40.61
S.Em$\pm$	0.28	0.23	0.28	0.54
CD at 5%	0.78	0.65	0.79	1.52
Growth retardants sprays (S)				
S_1 – CCC 100 ppm	10.23	10.83	12.15	39.78
S_2 – CCC 200 ppm	10.33	11.18	12.62	40.17
S_3 – MH 500 ppm	10.81	12.12	13.15	42.20
S_4 – MH 1000 ppm	9.06	10.08	12.63	37.11
S_5 – Water (control)	7.80	9.05	11.47	34.37
S.Em$\pm$	0.36	0.29	0.36	0.69
CD at 5%	1.01	0.82	1.02	1.95
Interaction (PxF)				
P_1F_1	9.84	10.40	9.91	37.88
P_1F_2	10.68	11.70	11.52	40.66
P_1F_3	11.66	12.68	13.18	42.34
P_2F_1	8.00	9.03	12.30	35.18
P_2F_2	8.82	9.47	12.96	37.43
P_2F_3	9.90	10.64	14.57	38.87
S.Em$\pm$	0.39	0.32	0.40	0.76
CD at 5%	NS	NS	NS	NS

NS – Non significant

Contd…..

Treatments	Number of branches		Number of leaves	
	50 DAT	At harvest	20 DAT	50 DAT
Interaction (PxS)				
P_1S_1	11.38	11.93	11.23	41.61
P_1S_2	11.35	12.20	11.50	41.31
P_1S_3	12.30	13.00	12.42	43.68
P_1S_4	9.93	10.93	11.77	38.75
P_1S_5	8.65	9.93	10.76	36.12
P_2S_1	9.08	9.73	13.07	37.96
P_2S_2	9.32	10.17	13.74	39.03
P_2S_3	9.32	11.25	13.87	40.71
P_2S_4	8.18	9.24	13.50	35.46
P_2S_5	6.95	8.16	12.18	32.63
S.Em$\pm$	0.51	0.42	0.51	0.98
CD at 5%	NS	NS	NS	NS
Interaction (FxS)				
F_1S_1	9.18	9.78	10.90	37.61
F_1S_2	9.48	10.30	11.33	38.41
F_1S_3	10.25	11.16	12.01	40.08
F_1S_4	8.53	9.11	11.53	35.01
F_1S_5	7.16	8.23	9.75	31.53
F_2S_1	10.06	10.88	12.03	39.98
F_2S_2	9.95	10.98	12.20	40.45
F_2S_3	9.76	11.96	12.70	42.46
F_2S_4	8.90	10.00	12.43	36.98
F_2S_5	7.56	9.11	11.83	35.35
F_3S_1	11.46	11.83	13.53	41.76
F_3S_2	11.58	12.28	14.33	41.65
F_3S_3	12.41	13.25	14.73	44.05
F_3S_4	9.75	11.15	13.95	39.33
F_3S_5	8.68	9.80	12.85	36.25
S.Em$\pm$	0.62	0.51	0.63	1.20
CD at 5%	NS	NS	NS	NS

NS – Non significant

Contd…..

Treatments	Number of branches		Number of leaves	
	50 DAT	At harvest	20 DAT	50 DAT
Interaction (PxFxS)				
$P_1F_1S_1$	10.00	10.46	9.56	38.86
$P_1F_1S_2$	10.36	10.66	10.03	39.60
$P_1F_1S_3$	11.23	11.66	10.81	41.63
$P_1F_1S_4$	9.56	9.93	10.40	36.26
$P_1F_1S_5$	8.03	9.30	8.76	33.06
$P_1F_2S_1$	11.46	12.26	11.23	41.76
$P_1F_2S_2$	10.93	12.60	11.33	41.66
$P_1F_2S_3$	12.56	13.33	12.00	44.03
$P_1F_2S_4$	9.90	10.43	11.60	38.93
$P_1F_2S_5$	8.53	9.90	11.43	36.90
$P_1F_3S_1$	12.7	13.06	12.90	44.20
$P_1F_3S_2$	12.76	13.33	13.13	42.66
$P_1F_3S_3$	13.10	14.00	14.46	45.40
$P_1F_3S_4$	10.33	12.43	13.33	41.06
$P_1F_3S_5$	9.40	10.60	12.10	38.40
$P_2F_1S_1$	8.36	9.10	12.23	36.36
$P_2F_1S_2$	8.60	9.93	12.63	37.23
$P_2F_1S_3$	9.26	10.66	13.23	38.53
$P_2F_1S_4$	7.50	8.30	12.66	33.76
$P_2F_1S_5$	6.30	7.16	10.73	30.00
$P_2F_2S_1$	8.66	9.50	12.83	38.20
$P_2F_2S_2$	8.96	9.36	13.06	39.23
$P_2F_2S_3$	6.96	10.60	13.40	40.90
$P_2F_2S_4$	7.90	9.56	13.26	35.03
$P_2F_2S_5$	6.60	8.33	12.23	33.80
$P_2F_3S_1$	10.23	10.60	14.16	39.33
$P_2F_3S_2$	10.40	11.23	15.53	40.63
$P_2F_3S_3$	11.73	12.50	15.00	42.70
$P_2F_3S_4$	9.16	9.86	14.56	37.60
$P_2F_3S_5$	7.96	9.00	13.60	34.10
Mean	9.65	10.65	12.40	38.73
S.Em$\pm$	0.88	0.72	0.89	1.70
CD at 5%	NS	NS	NS	NS

NS – Non significant

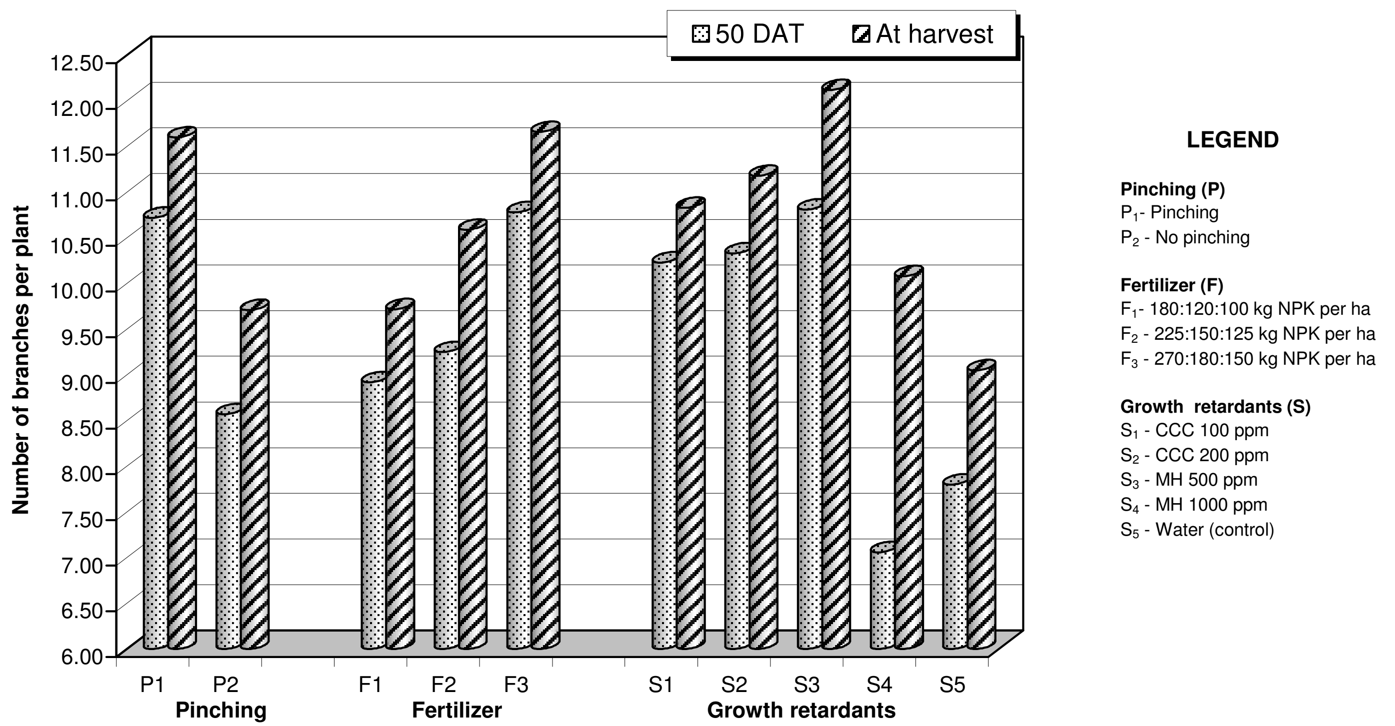

Fig. 3 : Influence of pinching, fertilizer levels and growth retardant sprays on number of branches per plant at 50 DAT and at harvest in china aster

Fig. 3: Influence of pinching, fertilizer levels and growth retardant sprays on number of branches per plant at 50 DAT and at harvest in china aster

Due to fertilizer levels (F)

Number of branches differed significantly due to fertilizer treatment at 50 DAT and at harvest (Plate 3).

Among the fertilizer levels, number of branches were significantly more (10.78) with F_3 followed by F_2 (9.25) and were less (8.92) with F_1 at 50 DAT.

Similarly at harvest, number of branches were markedly more (11.66) with F_3 followed by F_2 (10.59) and significantly less (9.72) with F_1.

Due to growth retardants (S)

Number of branches found to differ significantly due to growth retardant sprays at 50 DAT and at harvest (Plate 4).

Among growth retardants, MH 500 ppm recorded significantly more (10.81) branches and was less (7.80) with S_5 at 50 DAT.

Similarly at harvest, number of branches were significantly more (12.12) and less (9.05) with MH 500 and water spray (S_5) respectively.

Due to pinching and fertilizer levels (PxF)

The number of branches did not differ significantly due to interaction effect of pinching and fertilizer levels at 50 DAT and at harvest.

Number of branches at 50 DAT were relatively more (11.66) with P_1F_3 followed by P_1F_2 (10.68) and less (8.00) with P_2F_1.

At harvest, number of branches were numerically maximum (12.68) with P_1F_3 and minimum (9.03) with P_2F_1.

Due to pinching and growth retardants sprays (PxS)

The interaction between pinching and growth retardants showed non-significant differences on number of branches at 50 DAT and at harvest.

At 50 DAT, relatively maximum (12.30) number of branches with P_1S_3 followed by P_1S_1 (11.38) and minimum (6.95) with P_2S_5.

Similarly at harvest, number of branches were numerically more (13.00) with P_1S_3 followed by P_1S_2 (12.20) and less (8.16) with P_2S_5.

Due to fertilizer levels and growth retardants sprays (FxS)

The number of branches were non-significant due to interaction effect of fertilizer levels and growth retardants sprays at 50 DAT and at harvest.

The number of branches at 50 DAT were numerically maximum (12.41) with F_3S_3 followed by F_3S_2 (11.58) and less (7.16) with F_1S_5.

Similarly at harvest, number of branches were numerically maximum (13.25) with F_3S_3 followed by F_3S_2 (12.28) and less (8.23) with F_1S_5.

Due to pinching, fertilizer levels and growth retardants sprays (PxFxS)

The interaction effect of pinching, fertilizer levels and growth retardants spray was not significant on number of branches at 50 DAT and at harvest.

At 50 DAT, number of branches did not differ significantly but were more (13.10) with $P_1F_3S_3$ followed by $P_1F_3S_2$ (12.76) and $P_1F_2S_3$ (12.56) and were less (6.30) with $P_2F_1S_5$.

At harvest, also number of branches were numerically maximum (14.00) with $P_1F_3S_3$ followed by $P_1F_2S_3$ (13.33) and minimum (7.16) with $P_2F_1S_5$.

4.1.1.3 Number of leaves

The results on number of leaves at 20 and 50 DAT as influenced by pinching, fertilizer levels and growth retardants and their interaction effects are presented in Table 2.

Irrespective of pinching, fertilizer levels and growth retardants spray, the mean number of leaves increased from 12.40 (20 DAT) to 38.73 (50 DAT).

Due to pinching (P)

Number of leaves differed significantly due to pinching treatment at 20 and 50 DAT.

At 20 DAT, significantly more (13.27) number of leaves were recorded with no pinching (P_2) and less (11.54) with pinching (P_1).

At 50 DAT, number of leaves were markedly less (37.16) and more (40.29) with no pinching (P_2) and pinching (P_1) respectively.

Due to fertilizer levels (F)

Number of leaves differed significantly due to fertilizer treatment at 20 and 50 DAT.

Among the fertilizer levels, number of leaves were significantly more (13.88) with F_3 followed by F_2 (12.24) and were less (11.10) with F_1 at 20 DAT. F_1, F_2 and F_3 differed among themselves.

Similarly, at 50 DAT number of leaves were markedly more (40.61) with F_3 followed by F_2 (39.04) and were less (36.53) with F_1.

Due to growth retardants spray (S)

Number of leaves differed significantly due to growth retardant sprays at 20 and 50 DAT.

Among the growth retardants sprays, number of leaves were significantly more (13.15) with S_3 and less (11.47) with S_5. No significant differences were noticed among S_1, S_2, S_3 and S_4 treatment at 20 DAT.

At 50 DAT, number of leaves significantly more (42.20) with S_3 followed by S_2 (40.17) and less (34.37) with S_5 treatment.

Due to pinching and fertilizer levels (PxF)

The number of leaves did not differ significantly due to interaction effects of pinching and fertilizer levels at 20 and 50 DAT.

At 20 DAT, number of leaves were numerically more (14.57) with P_2F_3 and less (9.91) with P_1F_1.

At 50 DAT also number leaves were numerically more (42.34) with P_1F_3 followed by P_1F_2 (40.66) and less (35.18) with P_2F_1.

Due to pinching and growth retardants (PxS)

The interaction between pinching and growth retardants showed non-significant differences on number of leaves at 20 and 50 DAT.

At 20 DAT, number of leaves were relatively more (13.87) with P_2S_3 followed by P_2S_2 (13.74) and were less (10.76) wit P_1S_5.

At 50 DAT, number of leaves were relatively maximum (43.68) with P_1S_3 followed by P_1S_1 (41.61) and minimum (32.63) with P_2S_5.

Due to fertilizer levels and growth retardants spray (FxS)

The number of leaves did not differ significantly due to interaction effects of fertilizer levels and growth retardants spray at 20 and 50 DAT.

Number of leaves were numerically more (14.73 and 44.05) with F_3S_3 followed by F_3S_2 (14.33 and 41.65) and less (9.75 and 31.53) with F_1S_5 at 20 and 50 DAT respectively.

Due to pinching, fertilizer levels and growth retardants (PxFxS)

No significant differences with respect to number of leaves were noticed due to interaction of pinching, fertilizer levels and growth retardants spray at all the stages of crop growth.

At 20 DAT, number of leaves were numerically more (15.53) with $P_2F_3S_2$ followed by $P_2F_3S_3$ (15.00) and less (8.76) with $P_2F_1S_5$.

At 50 DAT, number of leaves were also numerically more (45.06) with $P_1F_3S_3$ followed by $P_1F_2S_3$ (44.03) and less (30.00) with $P_2F_1S_5$.

4.1.1.4 Days to 50 per cent flowering

The data on days to 50 per cent flowering as influenced by pinching, fertilizer levels and growth retardants and their interaction effects are presented in Table 3.

Due to pinching (P)

Days to 50 per cent flowering differed significantly due to pinching treatment and was significantly more (90.06 days) in pinching (P_1) compared to no pinching (84.13 days).

Due to fertilizer levels (F)

Significant differences were noticed on days to 50 per cent flowering due to fertilizer levels. Significantly maximum (90.26) days were taken for 50 per cent flowering in F_3 followed by F_2 (86.93) and minimum (84.10) in F_1 level of fertilizer and F_1, F_2 and F_3 differed significantly among themselves.

Due to growth retardants sprays (S)

Marked differences were noticed among growth retardants sprays on days to 50 per cent flowering. Markedly maximum (91.66) days were taken for days to 50 per cent flowering with S_4 followed by S_3 (88.66) while minimum (82.66) days with S_5.

Due to pinching and fertilizer levels (PxF)

Days to 50 per cent flowering did not differ significantly due to interaction effect of pinching and fertilizer levels. However, numerically more (93.40) days were taken for 50 per cent flowering with P_1F_3 followed by P_1F_2 (90.20) and less (81.60) with P_2F_1.

Due to pinching and growth retardants sprays (PxS)

The interaction effect of pinching and growth retardants sprays showed non-significant differences on days to 50 per cent flowering. However, numerically more (95.00) days for 50 per cent flowering were recorded with P_1S_4 followed by P_1S_3 (92.00) and (90.00) with P_1S_2 and less (80.33) with P_2S_5.

Due to fertilizer levels and growth retardants sprays (FxS)

Days to 50 per cent flowering did not markedly differ due to interaction of fertilizer levels and growth retardants sprays. Relatively more (94.50) days were taken for 50 per cent flowering with F_3S_4 followed by F_3S_2 and F_2S_4 (91.50) and less (78.50) with F_1S_5.

Due to pinching, fertilizer levels and growth retardants sprays (PxFxS)

The interaction effect due to pinching, fertilizer levels and growth retardants sprays showed no significant differences on days to 50 per cent flowering. However, relatively more (98.00) days were taken for 50 pere cent flowering with $P_1F_3S_4$ followed by $P_1F_3S_3$ and $P_1F_2S_4$ (95.00) and less (78.00) with $P_2F_1S_5$.

Table 3. Effect of pinching, fertilizer levels and growth retardants on days to 50 per cent flowering, number of flowers, flower diameter and number of seeds per flower of china aster

Treatments	Days to 50 per cent flowering	Number of flowers per plant	Flower diameter (cm)	Number of seeds per flower
Pinching (P)				
P_1 – Pinching	90.06	30.78	4.86	67.71
P_2 – No pinching	84.13	26.12	5.21	65.66
S.Em$\pm$	0.63	0.28	0.01	0.56
CD at 5%	1.78	0.79	0.03	1.58
Fertilizer (F)				
F_1-180:120:100 kg NPK per ha	84.10	24.91	4.97	64.96
F_2-225:150:125 kg NPK per ha	86.93	28.29	5.04	66.36
F_3-270:180:150 kg NPK per ha	90.26	32.15	5.09	68.73
S.Em$\pm$	0.77	0.34	0.04	0.69
CD at 5%	2.18	0.96	0.11	1.95
Growth retardants sprays (S)				
S_1 – CCC 100 ppm	85.77	29.01	5.03	67.11
S_2 – CCC 200 ppm	86.72	30.15	5.03	69.00
S_3 – MH 500 ppm	88.66	31.57	5.00	72.16
S_4 – MH 1000 ppm	91.66	27.56	4.96	63.72
S_5 – Water (control)	82.66	23.95	5.16	61.44
S.Em$\pm$	1.00	0.44	0.02	0.89
CD at 5%	2.82	1.24	0.05	2.52
Interaction (PxF)				
P_1F_1	86.60	26.75	4.79	65.93
P_1F_2	90.20	31.54	4.86	67.60
P_1F_3	93.40	34.05	4.92	69.60
P_2F_1	81.60	23.06	5.15	64.00
P_2F_2	83.66	25.04	5.23	65.13
P_2F_3	81.13	30.04	5.26	67.86
S.Em$\pm$	1.10	0.48	0.02	0.97
CD at 5%	NS	1.35	NS	NS

NS – Non significant

Contd…..

Treatments	Days to 50 per cent flowering	Number of flowers per plant	Flower diameter (cm)	Number of seeds per flower
Interaction (PxS)				
P_1S_1	88.33	31.62	4.81	68.22
P_1S_2	90.00	32.73	4.84	70.00
P_1S_3	92.00	34.21	4.83	73.33
P_1S_4	95.00	29.61	4.78	64.66
P_1S_5	85.00	25.73	5.02	62.33
P_2S_1	83.22	26.40	5.25	66.00
P_2S_2	83.44	27.57	5.22	68.00
P_2S_3	85.33	28.94	5.16	71.00
P_2S_4	88.33	25.52	5.13	62.77
P_2S_5	80.33	22.17	5.30	60.55
S.Em±	1.41	0.62	0.02	1.25
CD at 5%	NS	NS	0.06	NS
Interaction (FxS)				
F_1S_1	83.00	25.65	4.95	65.50
F_1S_2	84.00	26.51	4.96	67.50
F_1S_3	86.00	27.00	4.95	71.00
F_1S_4	89.00	23.80	4.20	61.50
F_1S_5	78.50	21.58	5.10	59.33
F_2S_1	85.00	28.31	5.04	66.50
F_2S_2	86.66	29.42	5.05	69.00
F_2S_3	88.50	31.66	4.99	71.50
F_2S_4	91.50	28.25	4.99	63.50
F_2S_5	83.00	23.80	5.15	61.33
F_3S_1	89.33	33.06	5.10	69.33
F_3S_2	89.50	34.51	5.07	70.50
F_3S_3	91.50	36.06	5.05	74.00
F_3S_4	94.50	30.65	4.99	66.16
F_3S_5	86.50	26.48	5.24	63.66
S.Em±	1.73	0.76	0.03	1.53
CD at 5%	NS	NS	NS	NS

NS – Non significant

Contd…..

Treatments	Days to 50 per cent flowering	Number of flowers per plant	Flower diameter (cm)	Number of seeds per flower
Interaction (PxFxS)				
$P_1F_1S_1$	86.00	28.23	4.70	66.00
$P_1F_1S_2$	87.00	28.86	4.75	68.00
$P_1F_1S_3$	89.00	29.03	4.83	72.00
$P_1F_1S_4$	92.00	25.06	4.76	63.00
$P_1F_1S_5$	79.00	22.56	4.93	60.66
$P_1F_2S_1$	88.00	31.76	4.83	68.00
$P_1F_2S_2$	90.00	32.86	4.88	70.00
$P_1F_2S_3$	92.00	35.13	4.76	73.00
$P_1F_2S_4$	95.00	31.26	4.81	65.00
$P_1F_2S_5$	86.00	26.66	5.00	62.00
$P_1F_3S_1$	91.00	34.86	4.90	70.66
$P_1F_3S_2$	93.00	36.46	4.90	72.00
$P_1F_3S_3$	95.00	38.46	4.90	75.00
$P_1F_3S_4$	98.00	32.50	4.78	66.00
$P_1F_3S_5$	90.00	27.96	5.15	64.33
$P_2F_1S_1$	80.00	23.06	5.21	65.00
$P_2F_1S_2$	81.00	24.16	5.18	67.00
$P_2F_1S_3$	83.00	24.96	5.06	70.00
$P_2F_1S_4$	86.00	22.53	5.03	60.00
$P_2F_1S_5$	78.00	20.60	5.26	58.00
$P_2F_2S_1$	82.00	24.86	5.25	65.00
$P_2F_2S_2$	83.33	25.98	5.23	68.00
$P_2F_2S_3$	85.00	28.20	5.21	70.00
$P_2F_2S_4$	88.00	25.23	5.16	62.00
$P_2F_2S_5$	80.00	20.93	5.30	60.66
$P_2F_3S_1$	87.66	31.26	5.30	68.00
$P_2F_3S_2$	86.00	32.56	5.25	69.00
$P_2F_3S_3$	88.00	33.66	5.21	73.00
$P_2F_3S_4$	91.00	28.80	5.20	66.33
$P_2F_3S_5$	83.00	25.00	5.33	63.0
Mean	87.10	28.45	5.09	66.86
S.Em$\pm$	2.44	1.07	0.04	2.17
CD at 5%	NS	NS	NS	NS

NS – Non significant

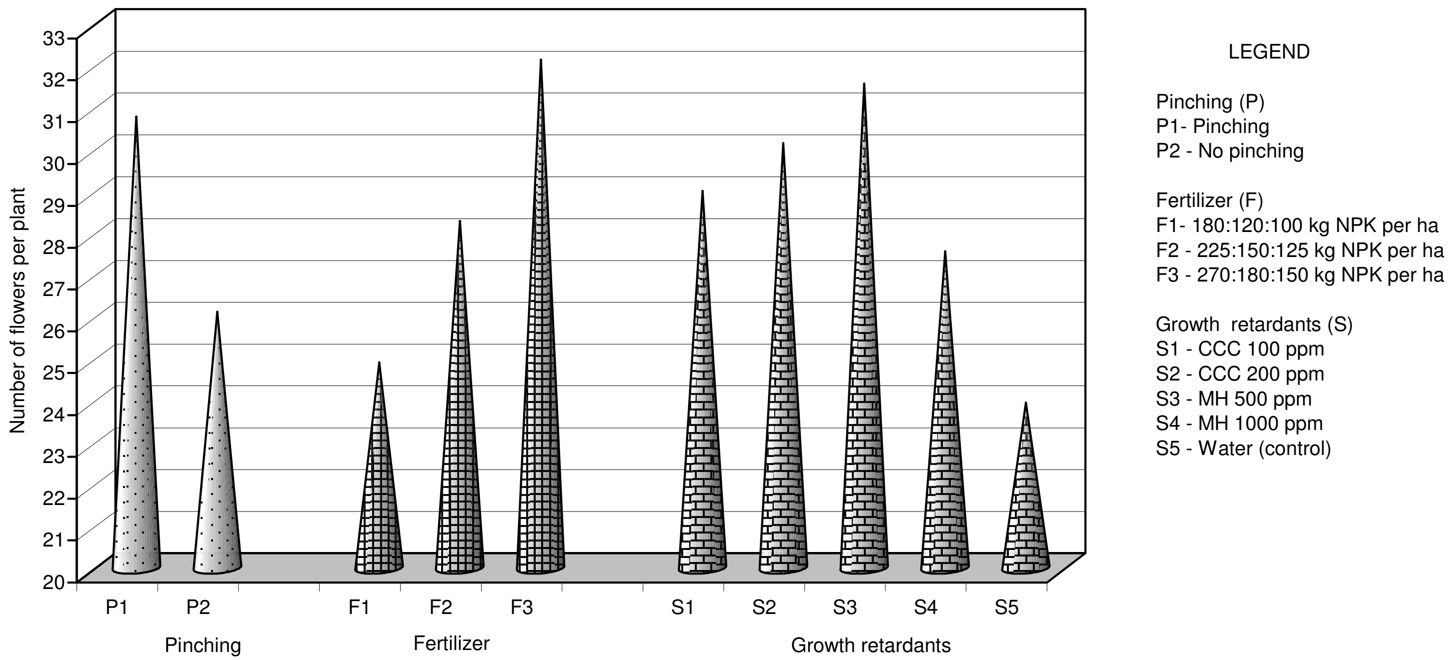

Fig. 4 : Influence of pinching, fertilizer levels and growth retardant sprays on number of flowers per plant at harvest in china aster

Fig. 4: Influence of pinching, fertilizer levels and growth retardant sprays on number of flowers per plant at harvest in china aster

4.1.2 Yield and yield parameters

4.1.2.1 Number of flowers

The data on number of flowers as influenced by pinching, fertilizer levels and growth retardants and their interaction effects are presented in Table 3 and depicted in Fig. 4.

Due to pinching (P)

Number of flowers differed significantly due to pinching treatments and were significantly more (30.78) with pinching (P_1) compared to no pinching (26.12).

Due to fertilizer (F)

Number of flowers differed significantly due to fertilizer levels and were more (32.15) with F_3 followed by F_2 (28.29) and less (24.91) with F_1.

Due to growth retardant sprays (S)

Number of flowers were found to differ significantly among growth retardant sprays. Significantly maximum (31.57) number of flowers were recorded with S_3 followed by S_2 (30.15) and S_1 (29.01) but S_1 and S_2 were non-significant and number of flowers were minimum (23.95) with S_5.

Due to pinching and fertilizer levels (PxF)

Number of flowers differed significantly among different interactions of PxF. Significantly maximum (34.05) number of flowers were recorded with P_1F_3 followed by P_1F_2 (31.54) and P_2F_3 (30.4) and minimum (23.06) with P_2F_1.

Due to pinching and growth retardants sprays (PxS)

The interaction effect of pinching and growth retardants sprays showed non-significant differences on number of flowers. Numerically more (34.21) number of flowers were recorded with P_1S_3 and less (22.17) with P_2S_5.

Due to fertilizer levels and growth retardants sprays (FxS)

Number of flowers per plant did not differ significantly due to interaction effect of fertilizer levels and growth retardant sprays. Relatively number of flowers were maximum (36.06) with F_3S_3 and minimum (21.58) with F_1S_5.

Due to pinching, fertilizer levels and growth retardants sprays (PxFxS)

The interaction effect due to pinching, fertilizer levels and growth retardants sprays showed no significant differences on number of flowers. However, maximum (38.46) number of flowers were recorded with $P_1F_3S_3$ followed by $P_1F_3S_2$ (36.46) and $P_1F_2S_3$ (34.86) and were minimum (20.60) with $P_2F_1S_5$.

4.1.2.2 Flower diameter

The results on flower diameter as influenced by pinching, fertilizer levels and growth retardants and their interaction effects are presented in Table 3.

Due to pinching (P)

Significant differences were noticed on flower diameter due to pinching and significantly maximum (5.21 cm) flower diameter was recorded with no pinching (P_2) when compared to pinching (4.86 cm) (P_1).

Due to fertilizer levels (F)

The flower diameter found to differ significantly among fertilizer levels. It was significantly more (5.09 cm) with F_3 followed by F_2 (5.04) and less (4.97) with F_1. The treatment F_3 and F_2 were at par.

Due to growth retardants sprays (S)

Marked differences were noticed among growth retardants sprays on flower diameter. Significantly maximum (5.16 cm) flower diameter was noticed with S_5 followed by S_1 and S_2 (5.03). while, minimum (4.96 cm) was with S_4.

Due to pinching and fertilizer levels (PxF)

The interaction effect of pinching and fertilizer levels was non-significant with respect to flower diameter. Relatively more (5.26 cm) flower diameter was with P_2F_3 followed by P_2F_2 (5.23 cm) and less (4.79 cm) with P_1F_1.

Due to pinching and growth retardants sprays (PxS)

The interaction effect due to pinching and growth retardants sprays was non-significant with respect to flower diameter. Numerically maximum (5.30 cm) flower diameter was recorded with P_2S_5 followed by P_2S_1 (5.25 cm) and P_2S_2 (5.22 cm) and minimum (4.78 cm) with P_1S_4.

Due to fertilizer levels and growth retardants sprays (FxS)

The interaction effect due to fertilizer levels and growth retardants sprays was found significant with respect to flower diameter. Significantly maximum (5.24 cm) flower diameter was with F_3S_5 followed by F_2S_5 (5.15 cm) and F_3S_1 (5.10 cm) and minimum (4.90 cm) with F_1S_4.

Due to pinching, fertilizer levels and growth retardants sprays (PxFxS)

The interaction effect due to pinching, fertilizer levels and growth retardants sprays was non-significant with respect to flower diameter. However, relatively more (5.33 cm) flower diameter was recorded with $P_2F_3S_5$ followed by $P_2F_2S_5$ and $P_2F_3S_1$ (5.30 cm) and minimum (4.70 cm) with $P_1F_1S_4$.

4.1.2.3 Number of seeds per flower

The data on number of seeds per flower as influenced by pinching, fertilizer levels and growth retardants sprays and their interaction effects are presented in Table 3.

Due to pinching (P)

Number of seeds per flower differed significantly due to pinching treatments and was significantly more (67.71) with pinching (P_1) compared to no pinching (65.66).

Due to fertilizer levels (F)

Number of seeds per flower differed significantly due to fertilizer levels and were more (68.73) with F_3 followed by F_2 (66.36) and less (64.96) with F_1.

Due to growth retardants sprays (S)

Number of seeds per flower were found to differ significantly among the growth retardants sprays. Significantly maximum (72.16) number of seeds per flower were with S_3 followed by S_2 (69.00) and S_1 (67.11) but latter were non-significant and minimum (61.44) was with S_5.

Due to pinching and fertilizer levels (PxF)

The number of seeds per flower did not differ significantly due to interaction effect of pinching and fertilizer levels. However, numerically more (69.60) number of seeds per flower were recorded with P_1F_3 followed by P_1F_2 (67.60) and less (64.00) with P_2F_1.

Due to pinching and growth retardants sprays (PxS)

The interaction effect of pinching and growth retardants sprays showed non-significant differences on number of seeds per flower. However, numerically more (73.33) number of seeds per flower were recorded with P_1S_3 followed by P_2S_2 (71.00) and less (60.55) with P_2S_5.

Due to fertilizer levels and growth retardants sprays (FxS)

The interaction between fertilizer levels and growth retardants showed no significant differences on number of seeds per flower. However, number of seeds per flower were more (74.00) with F_3S_3 followed by F_2S_3 (71.50) and less (59.33) with F_1S_5.

Due to pinching, fertilizer levels and growth retardants sprays (PxFxS)

The number of seeds per flower did not differ significantly due to interaction of pinching, fertilizer levels and growth retardants sprays. Number of seeds per flower were numerically more (75.00) with $P_1F_3S_3$ followed by $P_1F_2S_3$ (73.00) and less (58.00) with $P_2F_1S_5$.

4.1.2.4 Seed yield per plant (g)

The data on seed yield per plant as influenced by pinching, fertilizer levels and growth retardants sprays and their interaction effects are presented in Table 4.

Due to pinching (P)

Significant differences were noticed on seed yield per plant due to pinching. Significantly, more (4.27 g) seed yield per plant was recorded with pinching (P_1) compared to no pinching (3.61 g).

Due to fertilizer levels (F)

The seed yield per plant found to differ significantly among fertilizer levels and was more (4.75 g) with F_3 followed by F_2 (3.88 g) and less (3.20 g) with F_1.

Due to growth retardants sprays (S)

Marked differences were noticed among the growth retardants spray on seed yield per plant. Significantly maximum (5.03 g) seed yield per plant was recorded with MH 500 ppm followed by CCC 500 ppm (4.39 g) and less (2.85 g) with control.

Due to interaction of pinching and fertilizer levels (PxF)

The seed yield per plant due to interaction of pinching and fertilizer levels differed markedly. Significantly maximum (5.03 g) seed yield per plant was recorded with P_1F_3 followed by P_2F_3 (4.47 g) and P_1F_2 (4.37 g) and less (2.98 g) with P_2F_1.

Due to pinching and growth retardants sprays (PxS)

The interaction effect due to pinching and growth retardants spray was significant with respect to seed yield per plant. It was significantly more (5.49 g) with P_1S_3 followed by P_1S_2 (4.74) and P_2S_3 (4.56 g) and less (2.65 g) with P_2S_5.

Due to fertilizer levels and growth retardants sprays (FxS)

The seed yield per plant did not differ significantly due to interaction effect of fertilizer levels and growth retardants sprays. However, more (6.06 g) seed yield per plant was recorded with F_3S_3 followed by F_3S_2 (5.23 g) and less (2.30 g) with F_1S_5.

Due to pinching, fertilizer levels and growth retardants sprays (PxFxS)

The interaction effect due to pinching, fertilizer levels and growth retardants sprays was non-significant with respect to seed yield per pant. Relatively more (6.47 g) seed yield per plant was recorded with $P_1F_3S_3$ followed by $P_2F_3S_3$ (5.65 g) and $P_1F_2S_3$ (5.64 g) and less (2.20 g) with $P_2F_1S_5$.

Table 4. Effect of pinching, fertilizer levels and growth retardants on seed yield per plant, seed yield per ha and 1000 seed weight of china aster

Treatments	Seed yield per plant (g)	Seed yield per ha (kg)	1000 seed weight (mg)
Pinching (P)			
P_1 – Pinching	4.27	308.00	2.08
P_2 - No pinching	3.61	260.50	2.02
S.Em±	0.04	2.95	0.01
CD at 5%	0.11	8.34	0.03
Fertilizer (F)			
F_1-180:120:100 kg NPK per ha	3.20	230.87	1.96
F_2-225:150:125 kg NPK per ha	3.88	279.54	2.06
F_3-270:180:150 kg NPK per ha	4.75	342.23	2.14
S.Em±	0.05	3.61	0.01
CD at 5%	0.14	10.21	0.03
Growth retardants sprays (S)			
S_1 – CCC 100 ppm	3.97	286.48	2.03
S_2 – CCC 200 ppm	4.39	316.15	2.11
S_3 – MH 500 ppm	5.03	362.28	2.20
S_4 – MH 1000 ppm	3.48	250.93	1.98
S_5 – Water (control)	2.85	205.19	1.92
S.Em±	0.06	4.66	0.02
CD at 5%	0.17	13.18	0.06
Interaction (PxF)			
P_1F_1	3.43	246.92	2.00
P_1F_2	4.37	314.66	2.09
P_1F_3	5.03	362.21	2.17
P_2F_1	2.98	214.81	1.91
P_2F_2	3.39	244.41	2.03
P_2F_3	4.47	322.24	2.11
S.Em±	0.07	5.10	0.02
CD at 5%	0.20	14.42	NS

NS – Non significant

Contd…..

Treatments	Seed yield per plant (g)	Seed yield per ha (kg)	1000 seed weight (mg)
Interaction (PxS)			
P_1S_1	4.36	314.13	2.05
P_1S_2	4.74	341.31	2.15
P_1S_3	5.49	395.72	2.23
P_1S_4	3.73	268.96	2.03
P_1S_5	3.05	219.54	1.96
P_2S_1	3.59	258.84	2.01
P_2S_2	4.04	291.00	2.07
P_2S_3	4.56	328.85	2.18
P_2S_4	3.23	232.91	1.93
P_2S_5	2.65	190.84	1.89
S.Em$\pm$	0.10	6.59	0.02
CD at 5%	0.28	18.64	NS
Interaction (FxS)			
F_1S_1	3.30	237.68	1.96
F_1S_2	3.63	261.43	2.03
F_1S_3	4.06	292.41	2.12
F_1S_4	2.73	197.13	1.87
F_1S_5	2.30	165.68	1.81
F_2S_1	3.84	276.93	2.05
F_2S_2	4.30	309.9	2.12
F_2S_3	4.97	358.03	2.22
F_2S_4	3.49	251.76	1.97
F_2S_5	2.79	201.06	1.92
F_3S_1	4.79	344.85	2.10
F_3S_2	5.23	377.13	2.17
F_3S_3	6.06	436.41	2.27
F_3S_4	4.22	303.91	2.10
F_3S_5	3.45	248.83	2.05
S.Em$\pm$	0	8.07	0.03
CD at 5%	NS	NS	NS

NS – Non significant

Contd….

Treatments	Seed yield per plant (g)	Seed yield per ha (kg)	1000 seed weight (mg)
Interaction (PxFxS)			
$P_1F_1S_1$	3.66	263.73	1.97
$P_1F_1S_2$	3.87	278.60	2.10
$P_1F_1S_3$	4.38	315.33	2.15
$P_1F_1S_4$	2.84	204.46	1.95
$P_1F_1S_5$	2.39	172.50	1.85
$P_1F_2S_1$	4.31	310.30	2.10
$P_1F_2S_2$	4.81	346.50	2.15
$P_1F_2S_3$	5.64	406.03	2.25
$P_1F_2S_4$	3.95	284.23	2.00
$P_1F_2S_5$	3.14	226.26	1.95
$P_1F_3S_1$	5.11	368.36	2.10
$P_1F_3S_2$	5.54	398.83	2.20
$P_1F_3S_3$	6.47	465.80	2.30
$P_1F_3S_4$	4.42	318.20	2.15
$P_1F_3S_5$	3.61	259.86	2.10
$P_2F_1S_1$	2.94	211.63	1.95
$P_2F_1S_2$	3.39	244.26	1.97
$P_2F_1S_3$	3.74	269.50	2.10
$P_2F_1S_4$	2.63	189.80	1.80
$P_2F_1S_5$	2.20	158.86	1.77
$P_2F_2S_1$	3.38	243.56	2.00
$P_2F_2S_2$	3.79	273.30	2.10
$P_2F_2S_3$	4.30	310.03	2.20
$P_2F_2S_4$	3.04	219.30	1.95
$P_2F_2S_5$	2.44	175.86	1.90
$P_2F_3S_1$	4.46	321.33	2.10
$P_2F_3S_2$	4.93	355.43	2.15
$P_2F_3S_3$	5.65	407.03	2.25
$P_2F_3S_4$	4.02	289.63	2.06
$P_2F_3S_5$	3.30	237.80	2.00
Mean	3.94	284.21	2.05
S.Em$\pm$	0.16	11.42	0.04
CD at 5%	NS	NS	NS

NS – Non significant

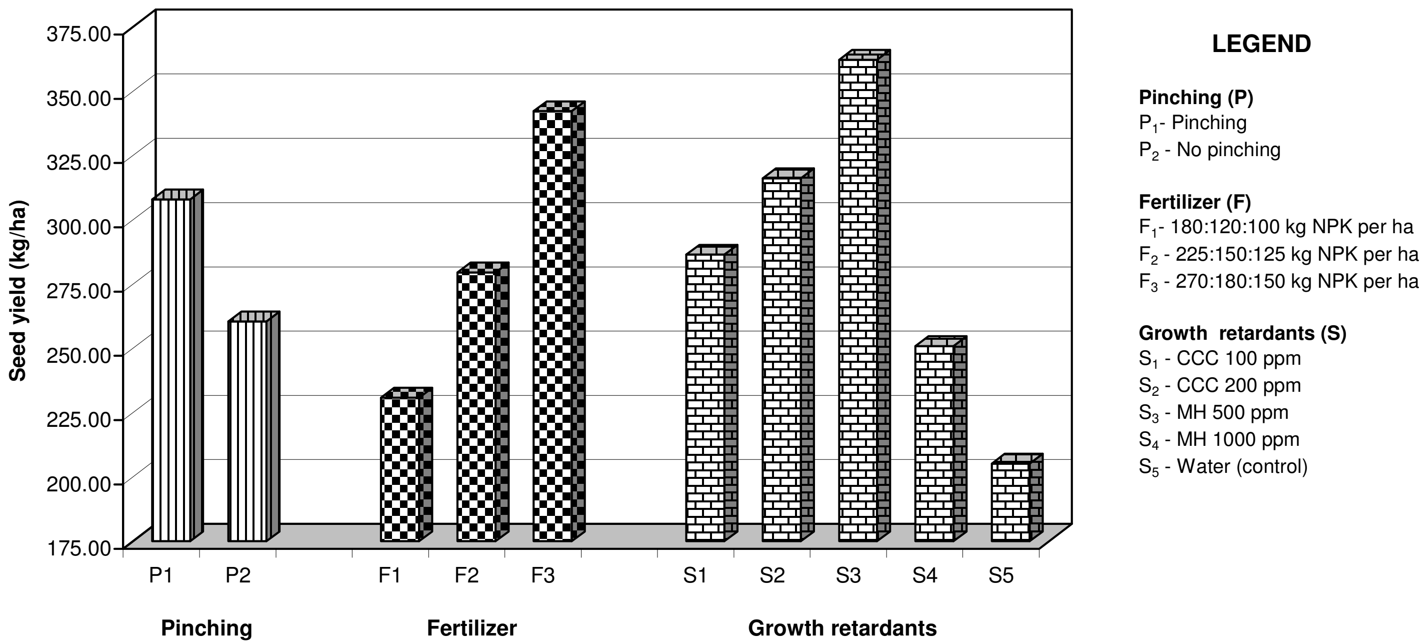

Fig. 5 : Influence of pinching, fertilizer levels and growth retardant sprays on seed yield per ha in china aster

Fig. 5: Influence of pinching, fertilizer levels and growth retardant sprays on seed yield per ha in china aster

4.1.2.5 Seed yield per hectare (kg)

The data on seed yield per ha as influenced by pinching, fertilizer levels and growth retardants sprays and their interaction effects are presented in Table 4 and depicted in Fig. 5.

Due to pinching (P)

Seed yield per ha differed significantly due to pinching treatments and it was significantly more (308.00 kg) with pinching (P_1) compared to no pinching (260.50 kg).

Due to fertilizer levels (F)

Marked differences were noticed among fertilizer levels on seed yield per ha. Markedly maximum (342.23 kg) seed yield per ha was with F_3 followed by F_2 (279.54 kg) and minimum (230.87 kg) with F_1.

Due to growth retardants sprays (S)

Significant differences were noticed on seed yield per ha due to growth retardants sprays. Significantly maximum (362.28 kg) seed yield per ha was recorded with S_3 followed by S_2 (316.15 kg) and S_1 (286.48 kg) and minimum (205.19 kg) with S_5.

Due to pinching and fertilizer levels (PxF)

The seed yield per ha differed significantly due to interaction effect of pinching and fertilizer levels. Significantly more (362.21 kg) seed yield per ha was recorded with P_1F_3 followed by P_2F_3 (322.24 kg) and P_1F_2 (314.66 kg) and less (214.81 kg) with P_2F_1.

Due to pinching and growth retardants sprays (PxS)

The interaction effect of pinching and growth retardants sprays showed marked differences on seed yield per ha. Markedly maximum (395.72 kg) seed yield per ha was with P_1S_3 followed by P_2S_3 (328.85 kg) and P_1S_2 (341.31 kg) and minimum (190.84 kg) with P_2S_5.

Due to fertilizer levels and growth retardants sprays (FxS)

Significant differences were not noticed on seed yield per ha due to interaction of fertilizer levels and growth retardants sprays. However, maximum (436.41 kg) seed yield per ha was recorded with F_3S_3 followed by F_3S_2 (377.13 kg) and F_2S_3 (358 kg) and minimum (165.68 kg) with F_1S_5.

Due to pinching, fertilizer levels and growth retardants sprays (PxFxS)

The interaction effect due to pinching, fertilizer levels and growth retardants sprays showed no significant differences on seed yield per ha. Seed yield per ha was relatively more (465.80 kg) with $P_1F_3S_3$ followed by $P_2F_3S_3$ (407.03) and $P_1F_2S_3$ (406.50 kg) and less (158.86 kg) with $P_2F_1S_5$.

4.1.3 Seed quality parameters

4.1.3.1 Test weight (1000 seed weight)

The data on test weight as influenced by pinching, fertilizer levels and growth retardants sprays and their interaction effects are presented in Table 4.

Due to pinching (P)

Significantly maximum (2.08 g) test weight was recorded with pinching (P_1) compared to no pinching (2.02 g).

Due to fertilizer levels (F)

The test weight found to differ significantly among fertilizer levels. It was significantly more (2.14 g) with F_3 followed by F_2 (2.06 g) and less (1.96 g) with F_1.

Due to growth retardants sprays (S)

The test weight differed significantly due to growth retardants sprays. Significantly maximum (2.20 g) test weight was recorded with S_3 followed by S_2 (2.11 g) and S_1 (2.03 g) and minimum (1.92 g) with S_5 and latter differed significantly between them.

Due to pinching and fertilizer levels (PxF)

The interaction effect of pinching and fertilizer levels showed no marked differences on test weight. However, more (2.17 g) test wieght was recorded with P_1F_3 followed by P_2F_3 (2.11 g) and P_1F_2 (2.09 g) and less (1.91 g) with P_2F_1.

Due to pinching and growth retardants sprays (PxS)

No significant differences were noticed on test weight due to pinching and fertilizer levels. However, maximum (2.23 g) test weight was recorded with P_1S_3 followed by P_2S_3 (2.18 g) and P_1S_2 (2.15 g) and minimum (1.89 g) with P_2S_5.

Due to fertilizer levels and growth retardants sprays (FxS)

The test weight did not differ significantly due to interaction effect of fertilizer levels and growth retardants sprays. However, numerically more (2.27 g) test weight was recorded with F_3S_3 followed by F_2S_3 (2.22 g), F_3S_2 (2.17 g) and F_1S_3 (2.12 g) and less (1.81 g) with F_1S_5.

Due to pinching, fertilizer levels and growth retardants sprays (PxFxS)

No marked differences were noticed among interactions of pinching, fertilizer levels and growth retardants sprays on test weight. However, relatively highest (2.30 g) test weight was noticed with $P_1F_3S_3$ treatment followed by $P_1F_2S_3$ and $P_2F_3S_3$ (2.25 g) and lowest (1.77 g) with $P_2F_1S_5$.

4.1.3.2 Germination percentage

The data on germination percentage as influenced by pinching, fertilizer levels and growth retardants sprays and their interaction effects are presented in Table 5.

Due to pinching (P)

The germination percentage found to differ significantly between pinching treatment. It was significantly more (88.26%) with pinching (P_2) compared to no pinching (86.15%) (P_2).

Due to fertilizer levels (F)

Significant differences were noticed among the fertilizer levels on germination and was maximum (88.90%) was with F_3 treatment, followed by F_2 (87.06%) and minimum (85.66%) with F_1.

Due to growth retardants sprays (S)

Significant differences were noticed among the growth retardants sprays on germination percentage. Significantly highest (90.72%) germination was recorded with S_3 followed by S_2 and S_1 (88.72% and 87.61%, respectively) and lowest (83.16%) with S_5.

Due to pinching and fertilizer levels (PxF)

The interaction effect due to pinching and fertilizer levels showed no marked differences on germination percentage. The germination percentage was comparatively maximum (90.00%) with P_1F_3 followed by P_1F_2 (88.13%) and P_2F_3 (87.80%) and minimum (84.66%) with P_2F_1.

Due to pinching and growth retardants sprays (PxS)

The interaction between pinching and growth retardants showed no significant differences on germination percentage. The germination percentage was relatively more (91.77%) with P_1S_3 followed by P_1S_2 (90.00%) and P_2S_3 (89.66%) and less (82.33%) with P_2S_5.

Table 5. Effect of pinching, fertilizer levels and growth retardants on germination percentage and seedling length of china aster

Treatments	Germination (%)	Seedling length (cm)
Pinching (P)		
P_1 – Pinching	88.26 (69.99)*	4.67
P_2 - No pinching	86.15 (68.18)	4.58
S.Em$\pm$	0.31	0.02
CD at 5%	0.88	0.06
Fertilizer (F)		
F_1-180:120:100 kg NPK per ha	85.66 (67.78)	4.51
F_2-225:150:125 kg NPK per ha	87.06 (68.97)	4.63
F_3-270:180:150 kg NPK per ha	88.90 (70.57)	4.74
S.Em$\pm$	0.38	0.02
CD at 5%	1.07	0.06
Growth retardants sprays (S)		
S_1 – CCC 100 ppm	87.61 (69.42)	4.68
S_2 – CCC 200 ppm	88.72 (70.41)	4.71
S_3 – MH 500 ppm	90.72 (72.30)	4.81
S_4 – MH 1000 ppm	85.83 (67.92)	4.57
S_5 – Water (control)	83.16 (65.80)	4.37
S.Em$\pm$	0.50	0.03
CD at 5%	1.41	0.08
Interaction (PxF)		
P_1F_1	86.66 (68.61)	4.58
P_1F_2	88.13 (69.88)	4.68
P_1F_3	90.00 (71.60)	4.80
P_2F_1	84.66 (66.97)	4.47
P_2F_2	86.00 (68.06)	4.58
P_2F_3	87.80 (69.59)	4.69
S.Em$\pm$	0.54	0.03
CD at 5%	NS	NS

NS – Non Significant * Figures in the parenthesis are arcsine transformed values

Contd…..

Treatments	Germination (%)	Seedling length (cm)
Interaction (PxS)		
P_1S_1	88.88 (70.57)*	4.73
P_1S_2	90.00 (71.60)	4.77
P_1S_3	91.77 (73.36)	4.86
P_1S_4	86.66 (68.67)	4.61
P_1S_5	84.00 (66.45)	4.25
P_2S_1	86.33 (68.23)	4.62
P_2S_2	87.44 (69.27)	4.66
P_2S_3	89.66 (71.27)	4.78
P_2S_4	85.00 (67.24)	4.53
P_2S_5	82.33 (65.17)	4.34
S.Em$\pm$	0.70	0.03
CD at 5%	NS	NS
Interaction (FxS)		
F_1S_1	86.16 (68.19)	4.55
F_1S_2	86.66 (68.61)	4.59
F_1S_3	89.00 (70.66)	4.70
F_1S_4	85.00 (67.24)	4.75
F_1S_5	81.50 (64.45)	4.20
F_2S_1	87.66 (69.46)	4.69
F_2S_2	88.50 (70.21)	4.70
F_2S_3	90.66 (72.24)	4.78
F_2S_4	85.40 (67.65)	4.60
F_2S_5	83.00 (65.68)	4.37
F_3S_1	89.00 (70.66)	4.80
F_3S_2	91.00 (72.57)	4.85
F_3S_3	92.50 (74.14)	4.95
F_3S_4	87.00 (68.90)	4.65
F_3S_5	85.00 (67.24)	4.48
S.Em$\pm$	0.86	0.04
CD at 5%	NS	NS

NS – Non Significant * Figures in the parenthesis are arcsine transformed values

Contd….

Treatments	Germination (%)	Seedling length (cm)
Interaction (PxFxS)		
$P_1F_1S_1$	87.33 (69.18)*	4.60
$P_1F_1S_2$	88.00 (69.76)	4.60
$P_1F_1S_3$	90.00 (71.60)	4.75
$P_1F_1S_4$	86.00 (68.06)	4.50
$P_1F_1S_5$	82.00 (64.92)	4.30
$P_1F_2S_1$	89.33 (70.97)	4.75
$P_1F_2S_2$	90.33 (71.60)	4.76
$P_1F_2S_3$	91.33 (72.91)	4.85
$P_1F_2S_4$	86.00 (68.06)	4.65
$P_1F_2S_5$	84.30 (66.45)	4.40
$P_1F_3S_1$	90.00 (71.60)	4.85
$P_1F_3S_2$	92.00 (73.60)	4.95
$P_1F_3S_3$	94.00 (75.85)	5.00
$P_1F_3S_4$	88.00 (69.76)	4.70
$P_1F_3S_5$	86.00 (68.06)	4.50
$P_2F_1S_1$	85.00 (67.24)	4.50
$P_2F_1S_2$	85.33 (67.51)	4.58
$P_2F_1S_3$	88.00 (69.76)	4.65
$P_2F_1S_4$	84.00 (66.45)	4.45
$P_2F_1S_5$	81.00 (64.19)	4.20
$P_2F_2S_1$	86.00 (68.01)	4.63
$P_2F_2S_2$	87.00 (68.90)	4.65
$P_2F_2S_3$	90.00 (71.60)	4.71
$P_2F_2S_4$	85.00 (67.24)	4.55
$P_2F_2S_5$	82.00 (64.92)	4.35
$P_2F_3S_1$	88.00 (69.76)	4.75
$P_2F_3S_2$	90.00 (71.60)	4.75
$P_2F_3S_3$	91.00 (72.57)	4.90
$P_2F_3S_4$	86.00 (68.06)	4.60
$P_2F_3S_5$	84.00 (66.45)	4.47
Mean	87.21 (69.04)	4.48
S.Em$\pm$	1.22	0.06
CD at 5%	NS	NS

NS – Non Significant * Figures in the parenthesis are arcsine transformed values

Due to fertilizer levels and growth retardants sprays (FxS)

No marked differences were noticed on germination percentage due to interaction of fertilizer levels and growth retardants sprays. However, maximum (92.50%) germination was recorded with F_3S_3 followed by F_3S_2 (91.00%) and F_2S_3 (90.66%) and minimum (81.50%) was with F_1S_5.

Due to pinching, fertilizer levels and growth retardants sprays (PxFxS)

The interaction effect of pinching, fertilizer levels and growth retardants sprays showed no significant differences on germination percentage. Relatively maximum (94.00%) germination was recorded with $P_1F_3S_3$ followed by $P_1F_3S_2$ (92.00%) and $P_1F_2S_3$ (91.33%) and minimum (81.00%) with $P_2F_1S_5$.

4.1.3.3 Seedling length (cm)

The data on seedling length as influenced by pinching, fertilizer levels and growth retardants sprays and their interaction effects are presented in Table 5.

Due to pinching (P)

The seedling length found to differ significantly between pinching treatment. It was significantly more (4.67 cm) with pinching (P_1) compared to no pinching (4.58 cm).

Due to fertilizer levels (F)

Seedling length differed significantly due to fertilizer levels and was more (4.74 cm) with F_3 followed by F_2 (4.63 cm) and less (4.51 cm) with F_1.

Due to growth retardants sprays (S)

Significantly maximum (4.81 cm) seedling length was recorded with S_3 followed by S_2 (4.71 cm) and S_1 (4.68 cm) and was minimum (4.37 cm) with S_5. But, S_1 and S_2 were non-significant.

Due to pinching and fertilizer levels (PxF)

The interaction effect of pinching and fertilizer levels showed non-significant differences on seedling length. However, numerically more (4.80 cm) seedling length was recorded with P_1F_3 and less (4.47 cm) with P_2F_1.

Due to pinching and growth retardants sprays (PxS)

Seedling length did not differ significantly due to interaction of pinching and growth retardants sprays. Relatively more (4.86 cm) seedling length was recorded with P_1S_3 followed by P_1S_2 (4.77 cm) and less (4.34 cm) with P_2S_5.

Due to fertilizer levels and growth retardants sprays (FxS)

The interaction effect due to fertilizer levels and growth retardants sprays on seedling length was non-significant. The seedling length was comparatively more (4.95 cm) with F_3S_3 followed by F_3S_2 (4.85 cm) and F_3S_1 (4.80 cm) and less (4.20 cm) with F_1S_5.

Due to pinching, fertilizer levels and growth retardants sprays (PxFxS)

The interaction effect due to pinching, fertilizer levels and growth retardants showed no marked differences on seedling length. The seedling length was comparatively maximum (5.00 cm) with $P_1F_3S_3$ followed by $P_1F_3S_2$ (4.95 cm) and minimum (4.20 cm) with $P_2F_1S_5$.

Table 6. Effect of pinching, fertilizer levels and growth retardants on vigour index, seedling dry weight and electrical conductivity of seed leachate of china aster

Treatments	Vigour index	Seedling dry weight (mg)	EC (dSm^{-1})
Pinching (P)			
P_1 – Pinching	413	16.68	1.51
P_2 - No pinching	396	15.74	1.57
S.Em$\pm$	2.00	0.11	0.01
CD at 5%	6.00	0.31	0.03
Fertilizer (F)			
F_1-180:120:100 kg NPK per ha	388	15.03	1.59
F_2-225:150:125 kg NPK per ha	404	16.29	1.55
F_3-270:180:150 kg NPK per ha	421	17.32	1.47
S.Em$\pm$	2.00	0.14	0.01
CD at 5%	6.00	0.40	0.03
Growth retardants sprays (S)			
S_1 – CCC 100 ppm	413	16.49	1.55
S_2 – CCC 200 ppm	417	16.93	1.47
S_3 – MH 500 ppm	437	17.67	1.45
S_4 – MH 1000 ppm	393	15.91	1.57
S_5 – Water (control)	362	14.06	1.63
S.Em$\pm$	3.00	0.18	0.01
CD at 5%	8.00	0.51	0.03
Interaction (PxF)			
P_1F_1	395	15.33	1.56
P_1F_2	413	16.80	1.53
P_1F_3	431	17.92	1.43
P_2F_1	380	14.73	1.62
P_2F_2	395	15.78	1.58
P_2F_3	411	16.72	1.50
S.Em$\pm$	3.00	0.20	0.01
CD at 5%	NS	NS	NS

NS – Non significant

Contd…

Treatments	Vigour index	Seedling dry weight (mg)	EC (dSm^{-1})
Interaction (PxS)			
P_1S_1	424	16.95	1.51
P_1S_2	426	17.33	1.43
P_1S_3	448	18.23	1.42
P_1S_4	400	16.26	1.54
P_1S_5	368	14.63	1.62
P_2S_1	402	16.03	1.58
P_2S_2	409	16.53	1.50
P_2S_3	426	17.11	1.47
P_2S_4	385	15.55	1.61
P_2S_5	356	13.50	1.67
S.Em$\pm$	4.00	0.26	0.02
CD at 5%	NS	NS	NS
Interaction (FxS)			
F_1S_1	392	15.28	1.61
F_1S_2	399	15.75	1.52
F_1S_3	420	16.40	1.52
F_1S_4	381	14.88	1.62
F_1S_5	346	12.85	1.67
F_2S_1	414	16.60	1.58
F_2S_2	416	17.00	1.46
F_2S_3	433	17.95	1.46
F_2S_4	392	15.90	1.60
F_2S_5	363	14.00	1.66
F_3S_1	432	17.60	1.45
F_3S_2	437	18.05	1.42
F_3S_3	458	18.66	1.35
F_3S_4	403	16.95	1.50
F_3S_5	377	15.35	1.61
S.Em$\pm$	5.00	0.31	0.02
CD at 5%	NS	NS	NS

NS – Non significant

Contd…..

Treatments	Vigour index	Seedling dry weight (mg)	EC (dSm^{-1})
Interaction (PxFxS)			
$P_1F_1S_1$	402	15.66	1.58
$P_1F_1S_2$	405	16.00	1.50
$P_1F_1S_3$	430	16.80	1.50
$P_1F_1S_4$	487	15.00	1.30
$P_1F_1S_5$	353	13.20	1.65
$P_1F_2S_1$	424	17.20	1.55
$P_1F_2S_2$	427	17.50	1.41
$P_1F_2S_3$	443	18.40	1.45
$P_1F_2S_4$	400	16.40	1.58
$P_1F_2S_5$	370	14.50	1.65
$P_1F_3S_1$	446	18.00	1.41
$P_1F_3S_2$	446	18.50	1.40
$P_1F_3S_3$	470	19.50	1.33
$P_1F_3S_4$	413	17.40	1.45
$P_1F_3S_5$	381	16.20	1.58
$P_2F_1S_1$	383	14.90	1.65
$P_2F_1S_2$	394	15.50	1.55
$P_2F_1S_3$	409	16.00	1.55
$P_2F_1S_4$	375	14.76	1.65
$P_2F_1S_5$	340	12.50	1.70
$P_2F_2S_1$	405	16.00	1.61
$P_2F_2S_2$	404	16.50	1.51
$P_2F_2S_3$	423	17.50	1.48
$P_2F_2S_4$	387	15.40	1.63
$P_2F_2S_5$	357	13.50	1.68
$P_2F_3S_1$	418	17.20	1.48
$P_2F_3S_2$	427	17.60	1.45
$P_2F_3S_3$	446	17.83	1.38
$P_2F_3S_4$	393	16.50	1.55
$P_2F_3S_5$	372	14.50	1.65
Mean	404	16.21	1.54
S.Em$\pm$	6.00	0.44	0.03
CD at 5%	NS	NS	NS

NS – Non significant

4.1.3.4 Vigour index

The data on vigour index as influenced by pinching, fertilizer levels and growth retardants sprays and their interaction effects are presented in Table 6.

Due to pinching (P)

Significantly more (413) vigour index was recorded with pinching (P_1) compared to no pinching (396) with no pinching (P_2).

Due to fertilizer levels (F)

Vigour index differed significantly due to fertilizer levels and was more (421) with F_3 followed by F_2 (404) and less (388) with F_1.

Due to growth retardants sprays (S)

The vigour index found to differ markedly between growth retardants sprays. It was markedly maximum (437) with S_3 followed by S_2 (417) and S_1 (413) and minimum (362) with S_5.

Due to pinching and fertilizer levels (PxF)

The interaction effect of pinching and fertilizer levels showed non-significant differences on vigour index. Numerically higher (431) vigour index was recorded with P_1F_3 followed by P_1F_2 (413) and P_2F_3 (411) and lower (380) with P_2F_1.

Due to pinching and growth retardants sprays (PxS)

Vigour index did not differ markedly due to interaction of pinching and growth retardants sprays. It was relatively more (448) with P_1S_3 followed by P_1S_2 (426) and P_2S_3 (426) and less (356) with P_2S_5.

Due to fertilizer levels and growth retardants sprays (FxS)

The interaction effect of fertilizer levels and growth retardants sprays showed non-significant differences on vigour index. However, vigour index was maximum (458) with F_3S_3 followed by F_3S_2 (437) and F_2S_3 (433) and minimum (346) with F_1S_5.

Due to pinching, fertilizer levels and growth retardants sprays (PxFxS)

Significant differences were not noticed on vigour index due to interaction of pinching, fertilizer levels and growth retardants sprays. The vigour index was comparatively maximum (470) with $P_1F_3S_3$ followed by $P_1F_3S_2$ (446), $P_2F_3S_3$ (446) and $P_1F_3S_2$ (446) and minimum (340) with $P_2F_1S_5$.

4.1.3.5 Seedling dry weight (mg)

The results on seedling dry weight as influenced by pinching, fertilizer levels and growth retardants sprays and their interaction effects are presented in Table 6.

Due to pinching (P)

Seedling dry weight differed markedly due to pinching treatment. Markedly highest (16.68 mg) seedling dry weight was recorded with pinching (P_1) compared to no pinching (15.74 mg).

Due to fertilizer levels (F)

Significant difference were noticed on seedling dry weight due to fertilizer levels. Significantly more (17.32 mg) seedling dry weight was with F_3 followed by F_2 (16.29 mg) and less (15.03 mg) with F_1.

Due to growth retardants sprays (S)

The seedling dry weight found to differ markedly between growth retardants sprays. Markedly more (17.67 mg) seedling dry weight was with S_3 followed by S_2 (16.93 mg) and less (14.06 mg) with S_5.

Due to pinching and fertilizer levels (PxF)

The interaction effect of pinching and fertilizer levels showed non-significant differences on seedling dry weight. Numerically maximum (17.92 mg) seedling dry weight was with P_1F_3 followed by P_1F_2 (16.80 mg) and P_2F_3 (16.72 mg) and minimum (14.73 mg) with P_2F_1.

Due to pinching and growth retardants sprays (PxS)

Marked differences were not noticed on seedling dry weight due to interaction of pinching and growth retardants sprays. The seedling dry weight was comparatively more (18.23 mg) with P_1S_3 followed by P_1S_2 (17.33 mg) and P_2S_3 (17.11 mg) and less (13.50 mg) with P_2S_5.

Due to fertilizer levels and growth retardants sprays (FxS)

No significant differences were noticed between interaction of fertilizer levels and growth retardants sprays. Numerically more (18.66 mg) seedling dry weight was with F_3S_3 followed by F_3S_2 (18.05 mg) and less (12.85 mg) with F_1S_5.

Due to pinching, fertilizer levels and growth retardants sprays (PxFxS)

Seedling dry weight did not differ markedly due to interaction of pinching, fertilizer levels and growth retardants sprays. Relatively maximum (19.50 mg) seedling dry weight was recorded with $P_1F_3S_3$ followed by $P_1F_3S_2$ (18.50 mg) and $P_1F_3S_1$ (18.00 mg) and minimum (12.50 mg) with $P_2F_1S_5$.

4.1.3.6 Electrical conductivity (dSm^{-1})

The results on electrical conductivity as influenced by pinching, fertilizer levels and growth retardants sprays and their interaction effects are presented in Table 6.

Due to pinching (P)

The electrical conductivity found to differ significantly between pinching treatments. It was significantly more (1.57 dSm^{-1}) with no pinching (P_2) compared to pinching (1.51 dSm^{-1}).

Due to fertilizer levels (F)

The electrical conductivity found to differ significantly among the fertilizer levels. Significantly more (1.59 dSm^{-1}) electrical conductivity was with F_1 followed by F_2 (1.55 dSm^{-1}) and less (1.47 dSm^{-1}) with F_3.

Due to growth retardants sprays (S)

Electrical conductivity differed significantly due to growth retardants sprays. It was maximum (1.63 dSm^{-1}) with S_5 followed by S_4 (1.57 dSm^{-1}) and minimum (1.45 dSm^{-1}) with S_3.

Due to pinching and fertilizer levels (PxF)

The interaction between pinching and fertilizer levels showed non-significant differences on electrical conductivity. Numerically more (1.62 dSm^{-1}) electrical conductivity was with P_2F_1 followed by P_2F_2 (1.58 dSm^{-1}) and P_1F_1 (1.56 dSm^{-1}) and less (1.43 dSm^{-1}) with P_1F_3.

Due to pinching and growth retardants sprays (PxS)

The interaction effect of pinching and growth retardants sprays was non-significant on electrical conductivity. But was more (1.67 dSm^{-1}) with P_2S_5 followed by P_2S_4 (1.61 dSm^{-1}) and less (1.42 dSm^{-1}) with P_1S_3.

Due to fertilizer levels and growth retardants sprays (FxS)

Electrical conductivity did not differ significantly due to interaction of fertilizer levels and growth retardant sprays. Relatively maxi. (1.67 dSm^{-1}) electrical conductivity was with F_1S_5 followed by F_2S_5 (1.66 dSm^{-1}) and F_1S_4 (1.62 dSm^{-1}) and less (1.35 dSm^{-1}) with F_3S_3.

Due to pinching, fertilizer levels and growth retardants sprays (PxFxS)

The interaction effect due to pinching, fertilizer levels and growth retardants sprays showed no significant differences on electrical conductivity. However, electrical conductivity was maximum (1.70 dSm^{-1}) with $P_2F_1S_5$ followed by $P_2F_2S_5$ (1.68 dSm^{-1}) $P_2F_1S_4$ and $P_2F_1S_1$ (1.65 dSm^{-1}) and minimum (1.33 dSm^{-1}) with $P_1F_3S_3$.

4.2 EXPERIMENT – II : STUDIES ON SEED STORAGE POTENTIAL OF CHINA ASTER VARIETIES

Storage potential of seeds is mainly under genetic control and varies among species, varieties and seed lots (Delouche, 1973). Further, it is also influenced by storage environmental factors such as relative humidity, temperature, seed moisture content, storage containers, hygienic conditions of storage room etc. The results of storage study on china aster varieties is presented below.

4.2.1 Germination percentage

The data on germination percentage as influenced by varieties, containers and their interactions are presented in Table 7 and depicted in Fig. 6.

Due to varieties (V)

Significant variation among varieties were observed for germination percentage at first and subsequent months of storage. The germination of china aster seeds declined progressively with increase in storage period in all the varieties irrespective of containers. The mean germination gradually decreased from 87.28 (first month) to 67.25 per cent at the end of six months of storage.

Significantly highest (90.12%) germination was noticed in Kamini compared to other cultivars (Phule ganesh, violet, PG puple and PG white) and was lowest (84.87%) in PG purple at the first month after storage. This trend was seen in subsequent month of storage. Significantly higher (70.87%) germination was noticed in Kamini and lower (64.37%) in PG purple at the end of six month of storage.

Due to containers (C)

The germination of china aster seeds declined progressively with increase in the storage period, irrespective of storage containers. Significantly more (89.25 and 75.50%) germination was observed in aluminium foil bag followed by polythene bag (87.62 and 71.50%) and low (85.62 and 59.37%) germination was recorded in cloth bag after first and six months of storage period respectively.

Due to interaction of varieties and containers (VxC)

Non-significant differences in seed germination were observed due to interaction between varieties and containers during storage period. Numerically Kamini seeds stored in aluminium foil bag (V_1C_4) recorded higher (91.50 and 79.00%) germination during first and at the end of six month of storage period respectively followed by V_1C_3 (91.00 and 74.50%) and lower (83.00 and 54.50%) in PG purple seeds stored in cloth bag (V_4C_1) at first month and at the end of six month of storage period respectively.

4.2.2 Speed of germination

The data on speed of germination as influenced by varieties, containers and their interactions are presented in Table 8.

Due to varieties (V)

Table 7. Effect of varieties and containers on germination percentage during storage of china aster

Treatment	Storage months					
	January	**February**	**March**	**April**	**May**	**June**
Varieties (V)						
V_1 – Kamini	90.12 (71.71)*	88.00 (69.76)	84.37 (67.47)	81.62 (64.64)	76.50 (61.03)	70.87 (57.36)
V_2 – PG white	86.37 (68.36)	84.37 (66.74)	80.25 (63.64)	76.87 (61.28)	60.87 (57.36)	66.62 (54.73
V_3 – PG voilet	87.75 (69.54)	85.00 (67.24)	80.87 (64.09)	77.25 (61.54)	71.50 (57.76)	67.12 (55.03)
V_4 – PG purple	84.87 (67.14)	81.87 (64.83)	77.37 61.62)	74.50 (59.70)	69.25 (56.35)	64.37 (53.37)
S.Em$\pm$	0.36	0.34	0.43	0.36	0.76	0.47
CD at 5%	1.07	1.02	1.28	1.07	1.38	1.41
Containers (C)						
C_1 – Cloth bag	85.62 (67.74)	81.75 (64.74)	76.62 (61.11)	73.00 (58.72)	65.00 (53.75)	59.37 (50.42)
C_2 – Paper bag	86.62 (68.57)	85.72 (67.85)	79.62 (63.19)	75.37 (60.27)	67.75 (55.42)	62.62 (52.36)
C_3 – Polythene	87.62 (69.43)	85.87 (67.95)	82.25 (65.11)	79.62 (63.19)	76.12 (60.77)	71.50 (57.76)
C_4 – Aluminium foil	89.25 (70.89)	86.87 (68.79)	84.87 (67.14)	82.25 (65.11)	79.25 (62.96)	75.50 (60.36)
S.Em$\pm$	0.36	0.34	0.43	0.36	0.76	0.47
CD at 5%	1.07	1.02	1.28	1.07	1.38	1.41
Interactions (VxC)						
V_1C_1	88.50 (70.21)	84.50 (66.84)	80.50 (63.82)	76.50 (61.03)	69.50 (56.50)	63.50 (52.87)
V_1C_2	89.50 (71.12)	87.50 (69.33)	83.00 (65.68)	79.50 (63.11)	71.50 (57.76)	66.50 (54.66)
V_1C_3	91.00 (72.57)	89.50 (71.12)	87.50 (69.33)	84.50 (66.84)	81.50 (64.55)	74.50 (59.70)
V_1C_4	91.50 (73.08)	90.50 (72.02)	88.50 (70.21)	86.00 (68.06)	83.50 (66.06)	79.00 (62.79)
V_2C_1	85.00 (67.24)	81.50 (64.55)	75.50 (60.36)	72.00 (58.08)	63.00 (52.56)	55.88 (50.21)
V_2C_2	85.50 (67.65)	85.00 (67.24)	80.50 (63.82)	75.50 (60.36)	68.50 (55.88)	62.50 (52.26)
V_2C_3	86.50 (68.47)	85.00 (67.24)	81.00 (64.19)	77.50 (61.71)	73.50 (59.04)	69.50 (56.50)
V_2C_4	88.50 (70.21)	86.00 (68.06)	84.00 (66.45)	82.50 (65.30)	78.50 (62.40)	75.50 (60.36)
V_3C_1	86.00 (68.06)	82.00 (64.92)	77.00 (61.37)	74.00 (59.37)	65.50 (54.05)	60.50 (51.08)
V_3C_2	87.50 (69.33)	86.00 (68.06)	80.50 (63.82)	75.50 (60.36)	67.00 (54.96)	62.00 (51.96)
V_3C_3	87.50 (69.33)	85.50 (67.65)	81.50 (64.55)	79.00 (62.75)	76.00 (60.69)	57.76 (71.50)
V_3C_4	90.00 (71.60)	86.50 (68.47)	84.50 (66.84)	80.50 (63.82)	77.50 (61.71)	74.50 (59.70)
V_4C_1	83.00 (65.68)	79.00 (62.75)	73.50 (59.04)	69.50 (56.50)	62.00 (51.96)	54.50 (47.60)
V_4C_2	84.00 (66.45)	80.50 (63.82)	74.50 (59.70)	71.00 (57.44)	64.00 (53.15)	59.50 (50.50)
V_4C_3	85.50 (67.65)	83.50 (66.06)	79.00 (62.75)	77.50 (61.71)	73.50 (59.04)	70.50 (57.13)
V_4C_4	87.00 (68.90)	84.50 (66.84)	82.50 (65.30)	80.00 (63.46)	77.50 (61.71)	73.00 (58.72)
Mean	87.28 (69.12)	84.01 (67.05)	80.84 (61.01)	77.56 (61.75)	72.03 (58.05)	67.25 (55.06)
S.Em$\pm$	0.72	0.68	0.86	0.73	1.52	0.93
CD at 5%	NS	NS	NS	NS	NS	NS

NS – Non Significant * Figures in the parenthesis are arcsine transformed values

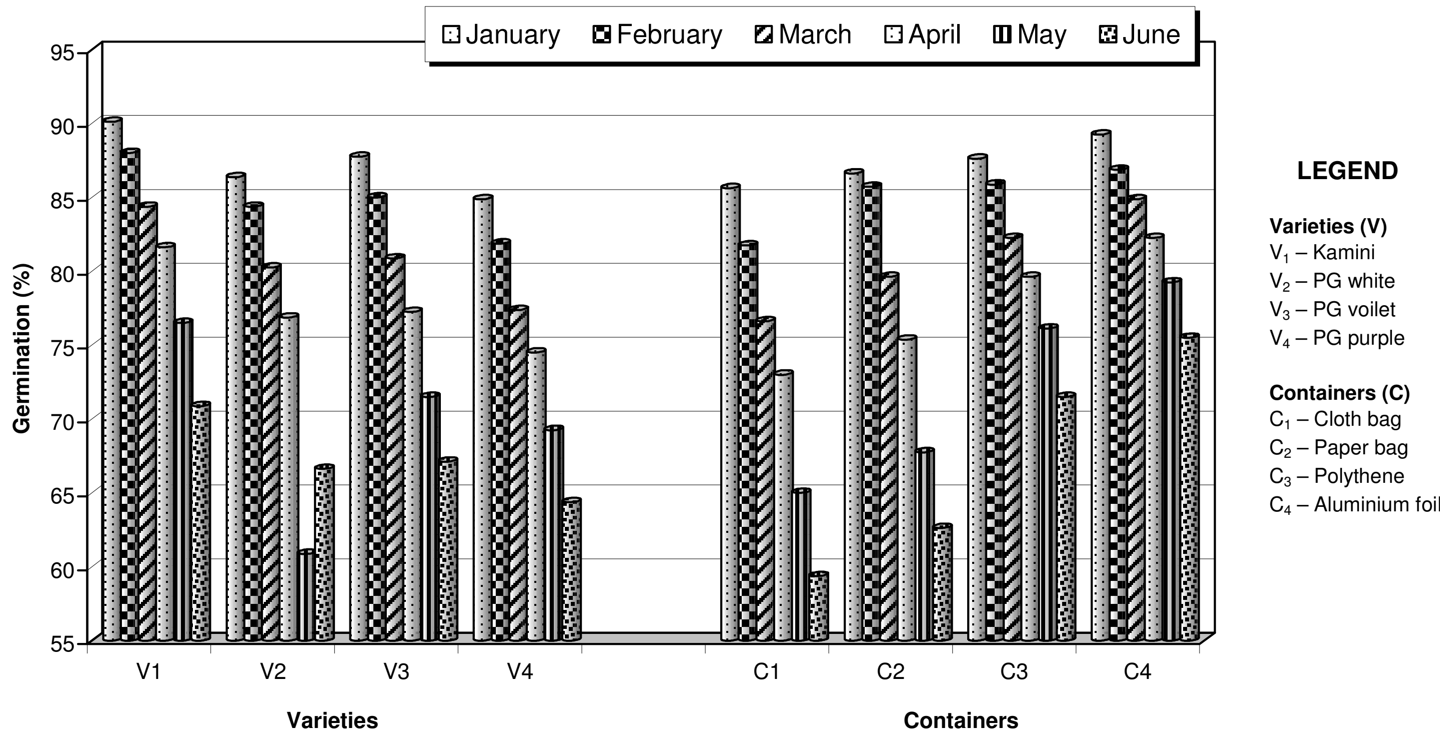

Fig. 6 : Influence of varieties and containers on germination percentage during storage of china aster

Fig. 6 : Influence of varieties and containers on germination percentage during storage of china aster

Table 8. Effect of varieties and containers on speed of germination during storage of china aster

Treatment	Storage months					
	January	February	March	April	May	June
Varieties (V)						
V_1 – Kamini	16.17	15.64	14.92	14.12	13.66	12.45
V_2 – PG white	15.78	15.30	14.66	13.70	12.87	11.94
V_3 – PG voilet	15.93	15.46	14.88	13.86	13.04	12.15
V_4 – PG purple	15.65	15.14	14.44	13.42	12.66	11.70
S.Em$\pm$	0.05	0.04	0.08	0.04	0.12	0.06
CD at 5%	0.14	0.13	0.25	0.12	0.36	0.18
Containers (C)						
C_1 – Cloth bag	15.70	15.06	14.35	13.20	12.63	11.51
C_2 – Paper bag	15.81	15.25	14.52	13.49	12.81	11.77
C_3 – Polythene	16.00	15.58	14.73	14.20	13.31	12.40
C_4 – Aluminium foil	16.03	15.63	15.30	14.23	13.49	12.55
S.Em$\pm$	0.05	0.04	0.08	0.04	0.12	0.06
CD at 5%	0.14	0.13	0.25	0.12	0.36	0.18
Interactions (VxC)						
V_1C_1	16.05	15.37	14.37	13.55	13.80	11.85
V_1C_2	16.15	15.55	14.77	13.85	13.45	12.25
V_1C_3	16.25	15.75	15.05	14.55	13.65	12.80
V_1C_4	16.25	15.90	15.50	14.55	13.75	12.90
V_2C_1	15.55	14.95	14.40	13.15	12.32	11.37
V_2C_2	15.72	14.11	14.42	13.47	12.60	11.65
V_2C_3	15.90	15.55	14.60	14.05	13.17	12.27
V_2C_4	15.95	15.57	15.22	14.15	13.40	12.47
V_3C_1	15.75	15.15	14.60	13.25	12.35	11.65
V_3C_2	15.85	15.35	14.62	13.60	12.75	11.90
V_3C_3	16.05	15.65	14.90	14.30	13.45	12.45
V_3C_4	16.00	15.70	15.42	14.32	13.62	12.60
V_4C_1	15.45	15.80	14.05	12.85	12.05	11.17
V_4C_2	15.55	15.00	14.27	13.05	12.45	11.30
V_4C_3	15.80	15.40	14.40	13.90	12.97	12.07
V_4C_4	15.82	15.37	15.05	13.90	13.20	12.25
Mean	15.88	15.38	14.73	13.78	13.49	12.06
S.Em$\pm$	0.09	0.08	0.17	0.08	0.24	0.12
CD at 5%	NS	NS	NS	NS	NS	NS

NS – Non Significant

Table 9. Effect of varieties and containers on seedling length (cm) during storage of china aster

Treatment	Storage months					
	January	February	March	April	May	June
Varieties (V)						
V_1 – Kamini	4.82	4.80	4.71	4.50	4.42	4.23
V_2 – PG white	4.65	4.61	4.51	4.30	4.17	4.03
V_3 – PG voilet	4.67	4.63	4.57	4.40	4.30	4.10
V_4 – PG purple	4.64	4.53	4.44	4.26	4.16	4.01
S.Em$\pm$	0.03	0.03	0.03	0.03	0.03	0.02
CD at 5%	0.08	0.10	0.08	0.08	0.07	0.07
Containers (C)						
C_1 – Cloth bag	4.50	4.44	4.32	4.09	3.95	3.76
C_2 – Paper bag	4.66	4.56	4.44	4.25	4.10	3.87
C_3 – Polythene	4.75	4.71	4.66	4.44	4.40	4.25
C_4 – Aluminium foil	4.87	4.86	4.81	4.70	4.61	4.49
S.Em$\pm$	0.03	0.03	0.03	0.03	0.03	0.02
CD at 5%	0.08	0.10	0.08	0.08	0.07	0.07
Interactions (VxC)						
V_1C_1	4.72	4.71	4.57	4.22	4.15	3.95
V_1C_2	4.75	4.72	4.62	4.45	4.32	4.05
V_1C_3	4.85	4.82	4.77	4.57	4.47	4.35
V_1C_4	4.97	4.97	4.90	4.77	4.75	4.60
V_2C_1	4.36	4.37	4.17	4.05	3.90	3.75
V_2C_2	4.65	4.52	4.42	4.22	4.00	3.82
V_2C_3	4.77	4.75	4.65	4.30	4.27	4.12
V_2C_4	4.82	4.82	4.80	4.65	4.52	4.45
V_3C_1	4.52	4.47	4.40	4.15	4.00	3.77
V_3C_2	4.62	4.57	4.50	4.27	4.17	3.85
V_3C_3	4.67	4.62	4.60	4.47	4.42	4.27
V_3C_4	4.87	4.85	4.80	4.72	4.60	4.50
V_4C_1	4.40	4.22	4.15	3.95	3.75	3.60
V_4C_2	4.62	4.42	4.22	4.05	3.90	3.77
V_4C_3	4.72	4.67	4.65	4.42	4.42	4.27
V_4C_4	4.82	4.80	4.75	4.65	4.57	4.42
Mean	4.69	4.64	4.56	4.37	4.26	4.09
S.Em$\pm$	0.03	0.07	0.06	0.05	0.05	0.05
CD at 5%	NS	NS	NS	NS	NS	NS

NS – Non Significant

Significantly highest (16.17) speed of germination was noticed in Kamini followed by PG violet (15.93) and lowest (15.65) with PG purple at first month after storage. The similar trend was noticed in subsequent months of storage. Significantly higher (12.45) speed of germination was noticed in Kamini followed by PG violet (12.15) and lower (11.70) in PG purple at the end of six months of storage.

Due to containers (C)

Significantly higher (16.03 and 12.55) speed of germination was observed in seeds stored in aluminium foil bag followed by polythene bag (16.00 and 12.40) and lower (15.70 and 11.51) was recorded in cloth bag after first and six months of storage respectively.

Due to interaction of varieties and containers (VxC)

Non-significant difference in speed of germination were observed due to interaction between varieties and containers during storage period. Kamini seeds stored in aluminium foil bag (V_1C_4) recorded numerically higher (16.25 and 12.90) speed of germination during first and at the end of six month of storage period respectively, followed by V_1C_3 (16.25 and 12.80) and lower (15.45 and 11.17) in PG purple seeds stored in cloth bag at first and at the end of six month of storage period respectively.

4.2.3 Seedling length

The data on seedling length as influenced by varieties, containers and their interactions are presented in Table 9.

Due to varieties (V)

After first month of storage significantly highest (4.82 cm) seedling length was recorded in Kamini followed by PG violet (4.67 cm) and was lowest (4.64 cm) in PG purple. The similar trend was noticed in subsequent months of storage. Significantly higher (4.23 cm) seedling length was noticed in Kamini followed by PG violet (4.10 cm) and lower (4.01 cm) in PG purple at the end of six months of storage.

Due to containers (C)

Significant variation on seedling length was observed due to containers in all the months of storage. It was found to decrease from 4.69 in the first month to 4.09 cm at the end of six month of storage irrespective of containers. Among the containers, seed stored in aluminium foil bag recorded higher (4.49 cm) seedling length followed by polythene bag (4.25 cm) while, seed stored in paper and cloth bag recorded lower (3.87 and 3.76 cm respectively) at the end of six month of storage.

Due to interaction of varieties

There was no significant difference on seedling length due to interaction of varieties and containers in all the months of storage. However, the mean seedling length was found to decrease from 4.69 to 4.09 cm from first month to end of six month of storage. All the varieties stored in aluminium foil and polythene bags maintained higher seedling length in all the months of storage.

4.2.4 Vigour index

The data on seedling vigour index as influenced by varieties, containers and their interactions are presented in Table 10 and depicted in Fig. 7.

Due to varieties (V)

Significant varietal differences on vigour index was noticed in all the months of storage irrespective of containers. The mean vigour index decreased from 412 (first month) to 277 (at the end of six months). Among varieties, Kamini recorded significantly more (434 and 301) vigour index followed by PG violet (410 and 276) and PG white (408 and 270) while, PG purple recorded less (394 and 261) vigour index at the end of first and six months of storage respectively.

Table 10. Effect of varieties and containers on vigour index during storage of china aster

Treatment	Storage months					
	January	February	March	April	May	June
Varieties (V)						
V_1 – Kamini	434	424	400	364	338	301
V_2 – PG white	408	388	362	338	296	270
V_3 – PG voilet	410	394	369	342	310	276
V_4 – PG purple	394	372	343	321	289	261
S.Em$\pm$	2.00	2.00	3.00	3.00	4.00	3.00
CD at 5%	7.00	6.00	8.00	9.00	14.00	8.00
Containers (C)						
C_1 – Cloth bag	391	362	330	300	260	224
C_2 – Paper bag	404	389	353	321	276	242
C_3 – Polythene	416	405	384	361	335	304
C_4 – Aluminium foil	436	421	408	384	361	339
S.Em$\pm$	2.00	2.00	3.00	3.00	4.00	3.00
CD at 5%	7.00	6.00	8.00	9.00	14.00	8.00
Interactions (VxC)						
V_1C_1	418	399	368	323	288	250
V_1C_2	425	415	383	353	303	269
V_1C_3	441	431	417	382	364	324
V_1C_4	455	450	433	397	396	363
V_2C_1	393	351	309	307	247	221
V_2C_2	399	386	357	322	276	239
V_2C_3	410	403	379	353	316	286
V_2C_4	431	412	402	370	346	336
V_3C_1	389	366	338	295	272	228
V_3C_2	404	395	360	320	278	238
V_3C_3	409	395	372	358	336	305
V_3C_4	438	419	405	393	256	335
V_4C_1	365	333	304	274	232	196
V_4C_2	388	358	311	287	350	224
V_4C_3	404	390	367	350	325	301
V_4C_4	419	405	391	374	347	323
Mean	412	394	369	341	308	277
S.Em$\pm$	5.00	4.00	5.00	6.00	9.00	5.00
CD at 5%	NS	NS	NS	NS	NS	NS

NS – Non Significant

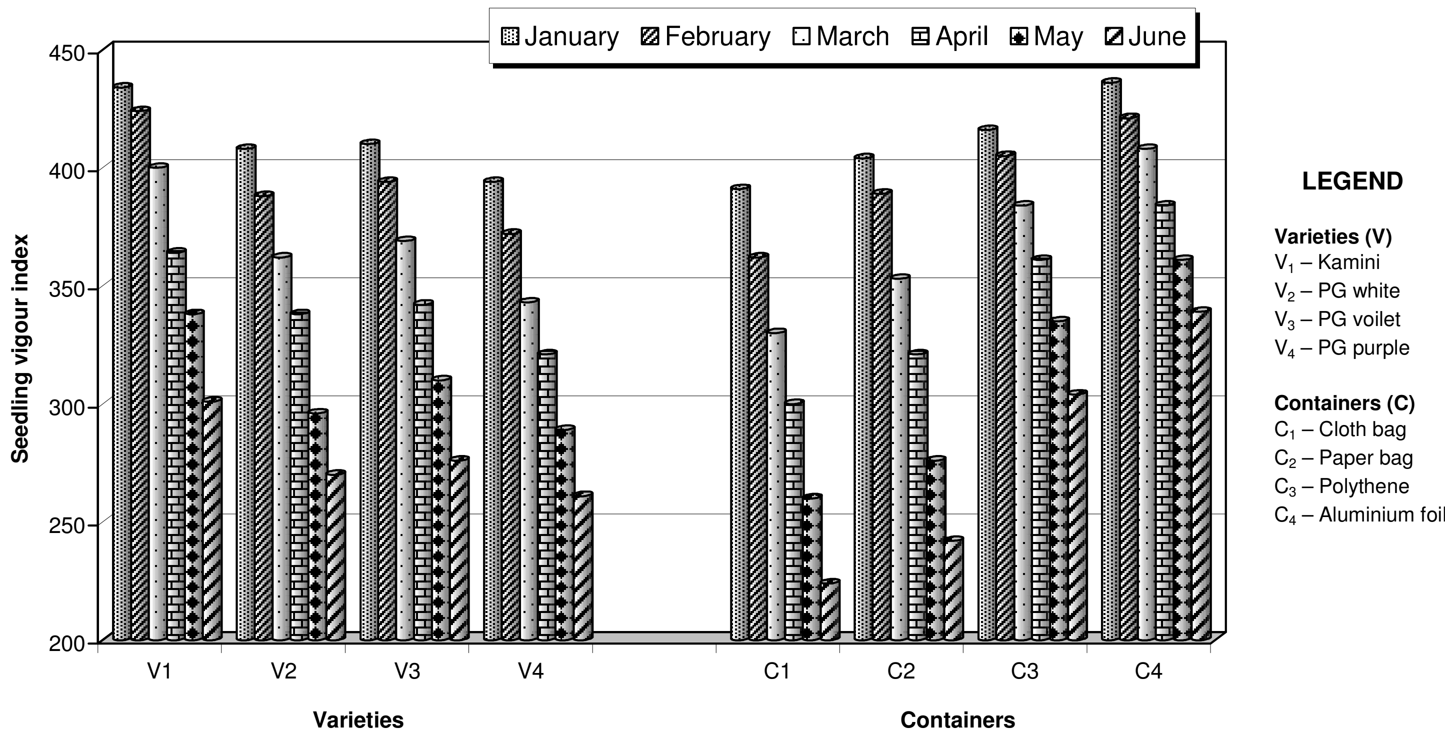

Fig. 7 : Influence of varieties and containers on vigour index during storage of china aster

Fig. 7: Influence of varieties and containers on vigour index during storage of china aster

Due to containers (C)

Irrespective of varieties, the vigour index was found to decrease due to containers on vigour index. Among the containers, seeds stored in aluminium foil and polythene bag recorded more (339 and 304) while seeds stored in cloth bag and paper bag (224 and 242) vigour index respectively at the end of six months of storage.

Due to interaction of varieties and containers (VxC)

The vigour index due to interaction between varieties and containers did not differ significantly in all the months of storage. However, all the varieties stored in aluminium foil and polythene bag found to record numerically higher vigour index compared to those stored in cloth bag and paper bag in all the months of storage.

4.2.5 Seedling dry weight

The data on seedling dry weight as influenced by varieties, containers and their interactions are presented in Table 11.

Due to varieties (V)

The seedling dry weight differed significantly due to varieties and the mean seedling dry weight decreased from 16.10 mg (first month) to 14.75 mg (at the end of six month of storage). Among the varieties, Kamini recorded significantly more (16.89 and 15.65 mg) while PG purple recorded low (15.63 and 14.20 mg) seedling dry weight at first and six months after storage respectively.

Due to containers (C)

Irrespective of varieties, the seedling dry weight was found to decrease due to containers. After first month of storage, seeds stored in aluminium foil bags recorded more (17.43 mg) dry weight and was less (15.14 mg) in cloth bag. At the end of six month of storage, seeds stored in aluminium foil and polythene bag recorded more (16.49 and 15.24 mg) while, seed stored in cloth bag and paper bag (13.53 and 13.72 mg) seedling dry weight respectively.

Due to interaction of varieties and containers (VxC)

No significant differences were noticed on seedling dry weight due to the interactions of varieties and containers. However, seeds stored in aluminium foil and polythene bag in all the varieties recorded numerically higher seedling dry weight compared to those stored in paper and polythene bag in all the months of storage.

4.2.6 Electrical conductivity

The data on electrical conductivity as influenced by varieties, containers and their interactions are presented in Table 12.

Due to varieties (V)

The electrical conductivity differed significantly due to varieties and the mean EC increased from 1.48 (first month) to 2.34 dSm^{-1} (at the end of six month). Among varieties, Kamini recorded significantly lowest (1.38 and 2.17 dSm^{-1}) while, PG purple recorded highest (1.66 and 2.53 dSm^{-1}) EC at first and six months after storage respectively.

Due to containers (C)

Significant variation on electrical conductivity was recorded due to containers in all the months of storage. The mean EC increased from (1.48 dSm^{-1} (in first month) to 2.34 dSm^{-1} (after six months of storage). Among containers, the seeds stored in aluminium and polythene bag recorded significantly less (2.03 and 2.25 dSm^{-1}). While, the seeds stored in paper and cloth bag recorded more (2.48 and 2.62 dSm^{-1}) EC respectively at the end of six month of storage.

Table 11. Effect of varieties and containers on seedling dry weight (mg) during storage of china aster

Treatment	Storage months					
	January	February	March	April	May	June
Varieties (V)						
V_1 – Kamini	16.89	16.75	16.57	16.38	16.01	15.65
V_2 – PG white	15.81	15.61	15.44	15.15	14.73	14.42
V_3 – PG voilet	16.08	15.89	15.75	15.49	15.05	14.71
V_4 – PG purple	15.63	15.35	15.15	14.95	14.58	14.20
S.Em$\pm$	0.06	0.07	0.06	0.06	0.06	0.06
CD at 5%	0.17	0.18	0.19	0.18	0.19	0.18
Containers (C)						
C_1 – Cloth bag	15.14	14.95	14.73	14.47	13.98	13.53
C_2 – Paper bag	15.43	15.16	14.92	14.63	14.12	13.72
C_3 – Polythene	16.40	16.21	16.06	15.84	15.51	15.24
C_4 – Aluminium foil	17.43	17.28	17.18	17.02	16.76	16.49
S.Em$\pm$	0.06	0.06	0.06	0.06	0.06	0.06
CD at 5%	0.17	0.18	0.19	0.18	0.19	0.18
Interactions (VxC)						
V_1C_1	16.33	16.05	15.80	15.55	15.05	14.45
V_1C_2	16.37	16.15	15.85	15.67	15.17	14.70
V_1C_3	17.32	17.32	17.17	17.05	16.85	16.62
V_1C_4	17.52	17.50	17.47	17.25	17.00	16.85
V_2C_1	14.52	14.42	14.25	13.95	13.55	13.25
V_2C_2	15.15	14.90	14.70	14.25	13.67	13.32
V_2C_3	16.10	15.90	15.70	15.45	15.05	14.75
V_2C_4	17.47	17.22	17.12	16.95	16.67	16.37
V_3C_1	15.27	15.15	14.95	14.65	14.05	13.60
V_3C_2	15.55	15.22	15.07	14.75	14.20	13.82
V_3C_3	16.05	15.85	15.75	15.52	15.12	14.85
V_3C_4	17.45	17.35	17.22	17.05	16.82	16.57
V_4C_1	14.45	14.17	13.95	13.75	13.30	12.85
V_4C_2	14.65	14.40	14.07	13.85	13.45	13.05
V_4C_3	16.15	15.80	15.65	15.35	15.05	14.75
V_4C_4	17.30	17.05	16.92	16.85	16.55	16.17
Mean	16.10	15.90	15.73	15.49	15.09	14.75
S.Em$\pm$	0.12	0.12	0.13	0.12	0.13	0.12
CD at 5%	NS	NS	NS	NS	NS	NS

NS – Non Significant

Table 12. Effect of varieties and containers on electrical conductivity (dSm^{-1}) during storage of china aster

Treatment	Storage months					
	January	February	March	April	May	June
Varieties (V)						
V_1 – Kamini	1.38	1.50	1.65	1.83	2.02	2.17
V_2 – PG white	1.46	1.56	1.78	2.04	2.20	2.43
V_3 – PG voilet	1.44	1.55	1.69	1.91	2.10	2.25
V_4 – PG purple	1.66	1.67	1.81	2.13	2.37	2.53
S.Em$\pm$	0.02	0.02	0.02	0.01	0.02	0.03
CD at 5%	0.05	0.06	0.07	0.04	0.06	0.08
Containers (C)						
C_1 – Cloth bag	1.58	1.72	1.93	2.19	2.41	2.62
C_2 – Paper bag	1.52	1.63	1.81	2.06	2.25	2.48
C_3 – Polythene	1.44	1.50	1.66	1.89	2.16	2.25
C_4 – Aluminium foil	1.39	1.44	1.53	1.77	1.87	2.03
S.Em$\pm$	0.02	0.02	0.02	0.01	0.02	0.03
CD at 5%	0.05	0.06	0.07	0.04	0.06	0.08
Interactions (VxC)						
V_1C_1	1.47	1.67	1.87	2.05	2.27	2.47
V_1C_2	1.37	1.55	1.77	1.87	2.10	2.22
V_1C_3	1.37	1.42	1.55	1.77	2.00	2.12
V_1C_4	1.30	1.36	1.43	1.62	1.72	1.87
V_2C_1	1.35	1.72	1.95	2.27	2.45	2.70
V_2C_2	1.50	1.62	1.85	2.15	2.27	2.65
V_2C_3	1.42	1.47	1.75	1.92	2.22	2.27
V_2C_4	1.37	1.45	1.57	1.82	1.87	2.10
V_3C_1	1.57	1.67	1.87	2.12	2.37	2.55
V_3C_2	1.50	1.62	1.77	2.00	2.15	2.35
V_3C_3	1.37	1.50	1.62	1.82	2.12	2.17
V_3C_4	1.32	1.42	1.50	1.72	1.77	1.95
V_4C_1	1.75	1.82	2.02	2.32	2.57	2.77
V_4C_2	1.72	1.75	1.87	2.22	2.47	2.70
V_4C_3	1.60	1.60	1.72	2.05	2.32	2.42
V_4C_4	1.57	1.52	1.62	1.92	2.12	2.22
Mean	1.48	1.57	1.73	1.98	2.17	2.34
S.Em$\pm$	0.04	0.04	0.04	0.03	0.04	0.05
CD at 5%	NS	NS	NS	NS	NS	NS

NS – Non Significant

Table 13. Effect of varieties and containers on moisture content during storage of china aster

Treatment	Storage months					
	January	February	March	April	May	June
Varieties (V)						
V_1 – Kamini	8.08	8.03	7.86	7.79	7.82	8.00
V_2 – PG white	8.10	0.05	7.90	7.80	7.78	8.06
V_3 – PG voilet	8.11	8.10	7.98	7.91	7.85	8.01
V_4 – PG purple	8.18	8.13	8.01	7.91	7.86	8.01
S.Em$\pm$	0.02	0.01	0.02	0.02	0.01	0.02
CD at 5%	0.06	0.03	0.06	0.06	0.03	NS
Containers (C)						
C_1 – Cloth bag	8.22	8.18	7.95	7.85	7.82	8.24
C_2 – Paper bag	8.17	8.09	7.94	7.84	7.83	8.21
C_3 – Polythene	8.06	8.02	7.90	7.83	7.78	7.87
C_4 – Aluminium foil	8.02	8..01	7.96	7.90	7.87	7.80
S.Em$\pm$	0.02	0.01	0.02	0.02	0.01	0.02
CD at 5%	0.06	0.03	NS	NS	0.03	0.06
Interactions (VxC)						
V_1C_1	8.21	8.17	7.87	7.77	7.90	8.25
V_1C_2	8.12	7.99	7.85	7.77	7.85	8.22
V_1C_3	8.00	7.98	7.80	7.72	7.67	7.87
V_1C_4	8.00	8.00	7.95	7.90	7.87	7.89
V_2C_1	8.22	8.17	7.82	7.72	7.67	8.27
V_2C_2	8.15	8.05	7.85	7.77	7.77	8.30
V_2C_3	8.05	7.97	7.92	7.85	7.82	7.88
V_2C_4	8.00	8.00	8.00	7.87	7.85	7.87
V_3C_1	8.20	8.17	8.07	8.00	7.87	8.20
V_3C_2	8.17	8.12	8.00	7.87	7.82	8.15
V_3C_3	8.05	8.05	7.95	7.87	7.82	7.91
V_3C_4	8.05	8.05	7.92	7.90	7.87	7.88
V_4C_1	8.27	8.22	8.06	7.92	7.85	8.25
V_4C_2	8.25	8.0	8.07	7.95	7.90	8.17
V_4C_3	8.15	8.10	7.95	7.85	7.80	7.83
V_4C_4	8.05	8.00	8.00	7.92	7.90	7.90
Mean	8.12	8.07	7.94	7.85	7.83	8.02
S.Em$\pm$	0.04	0.03	0.04	0.04	0.03	0.04
CD at 5%	NS	NS	NS	NS	NS	NS

NS – Non Significant

4.2.7 Moisture content

The results on moisture content as influenced by varieties, containers and their interactions are presented in Table 13.

Due to varieties (V)

The moisture content found to differ significantly in all the varieties in all the months of storage. In initial month moisture content it was 8.12 per cent whereas, it was 8.02 per cent at the end of six months of storage while, during third, fourth and fifty month it was less (7.94, 7.85 and 7.83%, respectively). Among varieties, PG voilet and PG purple recorded more moisture content compared to PG white and Kamini in all the months of storage.

Due to containers

Significant variations were recorded among storage containers on moisture content in all the months of storage irrespective of varieties. Significantly more (8.24 and 8.20%) moisture content was recorded in seeds stored in cloth bag and paper bag respectively at the end of six months of storage. While, it was less in seeds stored in aluminium foil and polythene bag (7.80 and 7.87%, respectively).

Due to interactions

No significant differences on moisture content were noticed due to interactions of varieties and containers. However, in all the varieties seeds stored in aluminium foil bags recorded relatively less moisture content compared to those stored in cloth bag and paper bag.

DISCUSSION

In any seed production programme, the crop growth, seed yield and quality parameters are directly or indirectly controlled by environment in which crops are grown. In addition genotype, soil fertility, nutrition, cultural practices and their interactions exhibit profound influence on growth, flowering and productivity of crop plants. Certain cultural practices like apical bud pinching, nutrition, exogenous application of growth retardants are known to influence seed yield and quality in several field and horticulture crops. Hence, an attempt was made to study the influence of these on seed yield and quality parameters in china aster cv. Phule ganesh white. Further, seed storage is also an important component of seed production as such “seed saved is seed produced” an adage is rightly applicable in modern agriculture as seeds loose viability due to certain internal and external factors. Though seed storability is mainly under genetic control but it is also influenced by other factors including storage containers in which the seeds are stored. Generally, seeds stored in moisture pervious containers retain viability for longer period compared to those stored in moisture impervious container. Hence, an attempt was also made to ascertain the influence of storage containers on viability of china aster varieties. The results obtained in the present investigations have been discussed in this chapter.

5.1 EFFECT OF PINCHING, FERTILIZER LEVELS AND GROWTH RETARDANTS ON SEED YIELD AND QUALITY IN CHINA ASTER

5.1.1 Influence of apical bud pinching

Apical bud pinching is one of the important cultural operation practiced in flower crops and is known to manipulate the plant physiology, plant architect which may eventually lead to enhance number of flower bearing branches, leaves, flower and alter source and sink relationship leading to higher yield.

In the present study, the terminal shoot tip of plant was pinched at 15 DAT in order to restrict the vertical growth and to enhance the horizontal growth. The effect of pinching on plant growth, flowering, seed yield and quality was ascertained.

5.1.1.1 Influence of pinching on growth parameters

Between pinching and no pinching treatments, non pinched plants (P_2) recorded significantly more plant height at 20, 50 DAT and at harvest (13.5, 39.12 and 48.38 cm, respectively) compared to pinched plants. While, pinched plants (P_1) recorded significantly higher number of leaves at 50 DAT (46.29). Similarly, number of branches were also more (10.72 and 11.60) at 50 DAT and at harvest, respectively compared to non pinched plants.

The higher plant height noticed with no pinching (P_2) treatment was mainly due to the fact that plants were not pinched and grew to their original height without reduction. While, number of leaves and branches per plant were more in case of pinched plants. This may be due to pinching effect of apical buds which resulted in production of more secondary branches and leaves owing to cessation of vertical growth. Decrease in plant height with increased number of leaves and branches due to pinching was reported in marigold (Sehrawat *et al.,* 2003 and Tomar *et al*., 2004), in coriander (Iyyanngouda, 2003), in fenugreek (Sudarshan, 2004), in chrysanthemum (Singh and Baboo, 2003 and Grawal *et al*., 2004) and in carnation (Pathania *et al*., 2000 and Kumar and Singh, 2003).

With respect to days to 50 per cent flowering, pinched plants took more (90.06) number of days compared to non pinched plants (84.13). Perhaps, pinching helps in altering the source-sink relationship thereby advancing the reproductive phase. Grawal *et al*. (2004) also noticed delayed flowering in pinched chrysanthemum plants.

5.1.1.2 Influence of pinching on seed yield and yield parameters

In any crop, seed yield is a function of plant growth, number of productive branches, number of flowers per plant, number of seeds per flower, test weight *etc.* Arresting of vertical growth of plants by pinching apical bud always results in production of more number of productive branches. In the present study, plants pinched at 15 DAT (P_1) recorded significantly highest values for all the seed yield parameters. More number of flowers per plant (30.78), number of seeds per flower (67.71), test weight (2.08 g), seed yield per plant (4.27 g) and per ha (307.93 kg) were recorded with pinching. The increase in seed yield and yield attributing parameters noticed with pinching was mainly due to production of more number of productive branches and more number of leaves. The pinching is known to accumulate more photo synthates which are utilized for production of more number of flower bearing branches and more number of seeds per flower (Arora, 1980).

Similar beneficial influence of pinching on seed yield and yield parameters are reported by Kumar and Singh (2003) in carnation. Grawal *et al*. (2004) and Singh and Baboo (2003) in chrysanthemum, Iyyannagouda (2003) in coriander, Tomar *et al*. (2004) in marigold, Sudarshan (2004) in fenugreek.

5.1.1.3 Influence of pinching on seed quality parameters

Plants pinched at 15 DAT (P_1) recorded significantly the highest values for all the seed quality parameters like test weight (2.08 g), germination (88.26%), seedling length (4.67 cm), seedling dry weight (16.68 mg) and vigour index (413). While, electrical conductivity was significantly the lowest (1.51 dSm^{-1}) compared to no pinching treatment. Higher seed quality parameters noticed with pinching at 15 DAT may be due to increase in photosynthetic area leading to higher photosynthetic rate, better assimilation and accumulation of more photosynthates resulting into better seed development as evident with higher test weight which ultimately resulted in higher seed germination and seedling vigour. Similar increase in germination and decrease in electrical conductivity of seed leachate with apical bud pinching was earlier revealed in okra by Venkatreddy *et al*. (1997) and Sajjan *et al*. (2002), in capsicum by Mc. Craw and Greig (1986) and in palak by Phor and Mangal (1991). Increased test weight with removal of herb was reported by Mehta *et al*. (1995) and Gill *et al*. (2001) in fenugreek.

5.1.2 Influence of fertilizer

Application of adequate quantity of fertilizer to seed crop is most essential for realising better crop growth so as to obtain desired benefits interms of higher seed yield and quality. Generally, nitrogen enhances vegetative growth while, phosphorous and potassium are key nutrients involved in various physiological processes, such as flowering and seed development.

5.1.2.1 Influence of fertilizer on growth parameters

All the growth parameters differed significantly among various fertilizer levels (Table 1 and 2). The plant height was significantly increased with application of increased level of fertilizer from F_1 (180:120:100 kg NPK/ha) to F_3 (270:180:150 kg NPK/ha) at all the stages of crop growth. Significantly, higher plant height (14.13, 40.19 and 49.52 cm) at 20, 50 DAT and at harvest stage respectively was recorded at higher level of fertilizer application (F_3). This increase in plant height might be due to greater uptake of nutrients into the plant system which involved in cell division, cell elongation as well as protein synthesis which ultimately enhanced stem length and vegetative growth. Similar increase in plant height with higher fertilizer levels was also noticed in china aster (Singh and Sangama, 2000; Doddagoudar *et al.,* 2002 and Kumar *et al*., 2003), in chrysanthemum (Singh and Baboo, 2003), in marigold (Mohanty *et al*., 2002; Baboo and Singh 2003; Saud and Ramchandra, 2004; Acharya and Dashora, 2004 and Grawal *et al*., 2004) and in gaillardia (Mishra, 1998).

Similarly, number of branches and leaves per plant increased significantly as fertilizer levels increased from F_1 to F_3. The higher level of fertilizer (F_3) recorded maximum number of branches (10.78 and 11.66) at 50 DAT and at harvest respectively compared to lower levels of fertilizer F_1 (8.92 and 9.72) and F_2 (9.25 and 10.59). Number of leaves per plant were also more in F_3 (13.88 and 40.61) compared to F_2 (12.24 and 39.04) and F_1 (11.10 and 36.53) at 20 and 50 DAT respectively. Nitrogen, phosphorus and potassium are the major nutrients known to have a major role in synthesis of amino acids and protein which could increase vertical growth (plant height) and lateral growth in terms of branches and leaves. The results are in conformity with findings of Singh and Sangama (2000), Doddagoudar *et al.* (2002) and

Kumar *et al.* (2003) in china aster, with Shivakumar (2000), Mohanty *et al.* (2002), Agrawal *et al.* (2002), Baboo and Singh (2003), Saud and Ramchandra (2004) and Acharya and Dashora (2004) in marigold and Akkannanavar (2001) in agaratum.

Days to 50 per cent flowering was delayed with the increase in levels of fertilizer owing to increased vegetative growth at higher levels of fertilizer (Grawal *et al.*, 2004) in chrysanthemum, Mantur (1988) in china aster.

5.1.2.2 Influence of fertilizer on seed yield and yield parameters

In many crops it is evident that yield is a function of number of flowers per plant, number of seeds per flower and test weight. The highest number of flowers per plant (32.15) was recorded in F_3 followed by F_2 (28.29). This showed that F_3 levels was optimum to get maximum number of flowers per plant. The increased number of flowers under higher dose of NPK may be attributed to more number of flower bearing branches per plant. Similar increase in flower number with higher fertilizer levels was also noticed by Doddagoudar *et al.* (2002) and Kumar *et al.* (2003) in china aster, Anuradha *et al.* (1990), Shivakumar (2000), Agarwal (2002), Saud and Ramchandra (2004) and Acharya and Dashora (2004) in marigold and Akkannavar (2001) in agaratum.

The flower diameter differed significantly among fertilizer levels. Maximum (5.09 cm) flower diameter was recorded at higher level of fertilizer (F_3). Similar observations were also made by Baboo and Singh (2003) in marigold and Kumar *et al.* (2003) in china aster.

The number of seeds per flower were significantly higher in F_3 (68.73) compared to F_2 (66.36) and F_1 (64.96).

Thousand seed weight is also one of the yield contributing component which differed significantly among the fertilizer levels in the present study. It was maximum (2.14 g) with F_3 followed by F_2 (2.06 g) and F_1 (1.96 g). The results are in conformity with Doddagoudar *et al.* (2002) in china aster.

In the present investigation, significantly higher seed yield per plant (4.75 g) and per ha (342.21 kg) was recorded with F_3 over F_2 and F_1 levels. The higher seed yield obtained at higher fertilizer level (F_3) may be attributed to more number of flowers, more number of filled seeds and 1000 seed weight. This was mainly due to availability of adequate quantity of nutrients for better filling up of seeds which resulted in increased seed weight. These findings are in agreement with the findings of Mantur (1988) and Doddagoudar *et al.* (2002) in china aster, Hugar (1997) in gaillardia, Shivakuamr (2000) in marigold and Akkannavar (2001) in ageratum.

5.1.2.3 Influence of fertilizer on seed quality parameters

Observations of the present investigations indicated that the higher dose of fertilizer (F_3) recorded significantly higher germination percentage (88.90%), seedling length (4.74 cm), vigour index (421) and seedling dry weight (17.32 mg) with lower electrical conductivity (1.47 dSm^{-1}) over lower doses of fertilizer levels (F_2 and F_1). The higher seed quality attributes noticed at higher fertilizer levels (F_3) might be due to proper development of seed and also higher number of filled seed weight per flower which in turn might have supplied adequate food reserves during germination. This kind of improvement in seed quality attributes with increase in fertilizer levels was also reported by Mantur (1988) and Doddagoudar *et al.* (2004) in china aster, Hugar (1997) in gaillardia, Shivakumar (2000) in marigold and Akkannavar (2001) in agaratum.

5.1.3 Influence of growth retardants

Generally, growth retardants are applied exogenously to arrest vertical growth and to enhance horizontal growth. The growth retardants are known to break apical dominance and have inhibitory action on cell division and cell elongation of merestematic tissues by way of counteracting growth harmones and resulting in more number of flower bearing branches and leaves.

5.1.3.1 Influence of growth retardants on growth parameters

In the present study, plant height was markedly reduced with foliar spray of MH 1000 ppm and CCC 200 ppm while, lower concentration of MH (500 ppm) and CCC (200 ppm) significantly increased the number of branches and leaves compared to control. The decrease in plant height may be due to reduction of auxin content in growing tissues due to antagonistic effect and dwarfing properties of growth retardants (Shanmugam and Muthuswamy, 1974) and interference in metabolic activity of plants by interrupting nutrient assimilation and growth. The increase in number of branches and leaves may be related to diversion of photosynthates towards the axillary buds. The results are in conformity with the findings of Aswath *et al.* (1994) and Doddagoudar *et al.* (2002) in china aster, Akkannavar (2001) in ageratum, Hugar (1997) in gaillardia and Khandelwal *et al*. (2003) and Singh (2004a) in marigold.

Number of days taken for 50 per cent flowering with MH (500 and 1000 ppm) and CCC (200 ppm) were more compared to control which may be due to suppression of vegetative growth with subsequent increase in number of flower bearing branches which perhaps need more days for development and initiation of flowering. Similar results were obtained by Narayan Reddy (1978), Narayanagouda (1985) and Jitendrakumar and Sanjeevkumar (2004) in china aster.

Decrease in flower diameter was noticed with spray MH (1000 ppm) which is conformity with the reports of Aswath (1991) in china aster.

5.1.3.2 Influence of growth retardants on seed yield and yield parameters

The seed yield and yield attributing parameters were found significantly influenced by growth retardants spray. Among the growth retardants, seed yield per plant and per ha was significantly more (5.03 g and 362.28 kg, respectively) with MH (500 ppm) spray followed by CCC (200 ppm) compared to other treatments. The increase in seed yield may be due to increase in number of flowers bearing branches, number of flower per plant (31.57), number of seeds per flower (72.16) and test weight (2.20 g). Similar beneficial influence on seed yield and yield attributing parameters were reported by Hugar (1997) in gaillardia with MH and CCC spray, by Doddagoudar *et al.* (2002) in china aster and by Akkannavar (2001) in agaratum.

5.1.3.3 Influence of growth retardants on seed quality parameters

The results of the present study indicated that all the seed quality parameters were significantly influenced by growth retardants. The plants sprayed with MH (500 ppm) recorded markedly higher (90.72%) germination, seedling length (4.81 cm), vigour index (437) and seedling dry weight (17.67 mg) with lower electrical conductivity (1.45 dSm^{-1}). The next best treatment was found to be CCC (200 ppm). The higher seed quality attributes noticed with these growth retardant sprays may be ascribed to better development of seed as evident with higher test weight which inturn supplied adequate food reserves during germination and seedling development. Similar improvement in seed quality attributes with spray of growth retardants was reported by Mantur (1988) and Doddagoudar *et al.* (2004) in china aster and Akkannavar (2001) in agaratum.

5.1.4 Interaction between apical bud pinching and fertilizer levels (PxF)

The seed yield and quality during seed production of any crop is a complex phenomenon interacted by various factors. They can be manipulated by taking advantage of their combined actions.

5.1.4.1 Interaction between apical bud pinching and fertilizer levels on growth parameters

The interaction between pinching and fertilizer levels showed no significant differences on all the growth parameters. However, relatively more (14.40, 40.42, 51.28 cm) plant height was noticed at 20, 50 DAT and at harvest, respectively with P_2F_3 followed by P_2F_2 compared to other treatments. Similarly, number of leaves and branches were also more with these treatments. The results are in conformity with the reports of Arora and Khanna (1986), Singh and Baboo (2003) in marigold, Grawal *et al*. (2004) in chryasanthemum who reported that, pinching resulted in suppression of vertical growth while fertilizer helped for better growth of laterals and leaves.

5.1.4.2 Interaction between apical bud pinching and fertilizer levels on seed yield and yield parameters

In the present study, interaction between pinching and fertilizer levels showed significant differences on number of flowers which were more (34.05) with P_1F_3 followed by P_1F_2 (31.54) and less (23.06) with P_2F_1. Significantly higher seed yield per plant and per ha (5.03 g and 362.21 kg, respectively) was recorded with P_1F_3 followed by P_2F_3 (4.47 g/plant and 322.24 kg/ha). The increase in seed yield noticed with P_1F_3 in the present study could be attributed to increase number of branches, number of flowers, number of seeds per flower and test weight, which may be due to increased availability of nutrients for better growth of plants, production of more number of branches, more number of flowers, more number of seeds per flower and better development of seeds. Similar results were reported by Arora and Khanna (1986) in Marigold and Singh and Baboo (2003) and Grawal *et al*. (2004) in chrysanthemum.

5.1.4.3 Interaction between apical bud pinching and fertilizer levels on seed quality parameters

The interaction due to pinching and fertilizer levels did not show any influence on all the seed quality parameters. However, maximum germination (90.00%), vigour index (431) and seedling dry weight (17.92 mg) were recorded in the pinched plant at higher level of fertilizer (P_1F_1) with lower electrical conductivity (1.43 dSm^{-1}). Relatively higher seed quality parameters noticed in present study may be ascribed to higher test weight in pinched plants at higher level of fertilizer.

5.1.5 Interaction between pinching and growth retardants sprays (PxS)

5.1.5.1 Interaction between pinching and growth retardants sprays On growth parameters

In the present study, the interaction of pinching and growth retardants sprays did not show any influence on all the growth parameters. However, plant height was relatively more (14.60, 44.32 and 54.71 cm) at 20, 50 DAT and at harvest respectively with P_2S_5, whereas decreased plant height was noticed with P_1S_4 (11.56, 32.92 and 38.33 cm) at 20, 50 DAT and at harvest respectively.

More plant height noticed with unpinched plants and sprayed with water (control) is due to normal growth of plants. Whereas, decreased plant height noticed with P_1S_4 and P_1S_3 may be due to pinching effect resulting in suppression of vegetative growth and break of apical dominance by maleic hydrazide spray of 1000 ppm. On the contrary, more number of leaves (43.68) at 50 DAT and more number of branches (12.03 and 13.00) at 50 DAT and at harvest respectively were recorded in pinched plants sprayed with MH 500 ppm (P_1S_3). Relative increase in number of leaves and branches observed in pinched plants sprayed with MH (500 ppm) is due to suppression effect of both pinching and MH. MH is known to have antiauxin and dwarfing properties and nullification of apical dominance (Shanmugam and Muthuswamy, 1974).

5.1.5.2 Interaction between pinching and growth retardants sprays on seed yield and yield parameters

The interaction between pinching and growth retardants spray was found to be non-significant with respect to number of flowers. However, number of flowers were less (22.17) in control but were more in pinched plants sprayed with 500 ppm MH (34.21) and CCC (200 ppm). More number of flowers noticed in pinched plants sprayed with MH (500 ppm) followed by CCC (200 ppm) may be due to increased number of flower bearing branches due to combined effect of pinching and growth retardants. Since pinching as well as CCC and MH are known to suppress apical dominance and the photosynthates are utilized for production of more number of axillary buds.

On the contrary, significant differences among pinching and growth retardant sprays were noticed with respect to diameter of flower. In non pinched plants, flower diameter was significantly more with all the growth retardant sprays compared to pinched plants. Maximum flower diameter (5.30 cm) was noticed with P_2S_5 and less (4.81) with P_1S_1. Reduction in size of the flower noticed in pinched plants sprayed with all growth retardants may be attributed increase in number of flowers per plant due to which there may be less supply of photosynthates to each flowers. The results corroborate with findings of Khandelwal *et al*. (2003) in marigold and Mitalisaikia and Talukadar (1997) in chrysanthemum.

In the present study, seed yield per plant (5.49 g) and per ha (395.96 kg) were significantly more in pinched plants sprayed with MH (500 ppm) followed by CCC 200 ppm (4.74 g/plant and 341.31 kg/ha) compared to non pinched plants sprayed with different growth retardants. The beneficial influence of pinching and growth retardants sprays with MH (500 ppm) and CCC (200 ppm) may be due to increase in number of flower bearing branches owing to suppression of apical dominance (Khandelwal *et al*., 2003) in marigold. Leading to increased number of flower bearing branches as a result of succession terminal growth (Narayanagouda and Jayanthi, 1991) in marigold. In the present study, the yield contributing factors like number of seeds per flower, test weight were also higher thus increased seed yield are quite evident in P_1S_3 treatment combination.

5.1.5.3 Interaction between pinching and growth retardants sprays on seed quality parameter

All the seed quality parameters were found to be not influenced by pinching and growth retardants sprays. However, marginal beneficial influence has been noticed on germination, seedling vigour index, seedling length and seedling dry weight with lower electrical conductivity values in pinched plant sprayed with different growth retardants compared to non pinched plants sprayed with various growth retardants.

5.1.6 Interaction between fertilizer levels and growth retardant sprays (FxS)

5.1.6.1 Interaction between fertilizer levels and growth retardant sprays on growth parameters

The interaction between fertilizer levels and growth retardants (FxS) showed no significant difference on all the growth parameters. However, relatively more plant height (15.36, 44.51 and 56.00 cm) was noticed at 20, 50 DAT and at harvest respectively with F_3S_5 followed by F_2S_5. Similarly, number of leaves and branches were also more with this treatment. The results compromise with Arora and Khanna (1986), Singh and Baboo (2003) in chrysanthemum.

5.1.6.2 Interaction between fertilizer levels and growth retardant sprays on seed yield and yield parameters

The interaction due to FxS did not show any influence on seed yield and yield attributes. However, seed yield per plant and per ha were relatively more (6.06 g and 436.41 kg respectively) with application of higher level of fertilizer, sprayed with 500 ppm MH (F_3S_3).

5.1.6.3 Interaction between fertilizer levels and growth retardant sprays on seed quality parameters

All the seed quality parameters were found to be non-significant due to interaction of FxS. However, maximum germination (92.50%), vigour index (458), seedling length (4.85 cm) and seedling dry weight (18.66 mg) was recorded with F_3S_3 with lower electrical conductivity (1.35 dSm^{-1}). Similar results were noticed by Doddagoudar *et al.* (2004) in chin aster.

5.1.7 Interaction among pinching, fertilizer levels and growth retardant sprays (PxFxS)

5.1.7.1 Interaction among pinching, fertilizer levels and growth retardant sprays on growth parameters

The interaction due to pinching, fertilizer levels and growth retardant sprays showed no significant differences on all the growth parameters. However, numerically maximum plant height at all the stages of crop growth was recorded with $P_2F_3S_5$ and minimum with $P_1F_1S_4$. Whereas, number of branches and leaves per plant were also less in $P_2F_1S_5$ and more $P_1F_3S_3$. Relatively more in number of leaves and branches noticed with $P_1F_3S_3$ may be due to combined effect of pinching, higher level of fertilizer and foliar spray with MH 500 ppm. as pinching and growth retardant sprays resulted in suppressing apical dominance whereas, higher level of fertilizer has resulted in production of more number of branches as well as more number of leaves,

5.1.7.2 Interaction among pinching, fertilizer levels and growth retardant sprays on seed yield and yield parameters

In the present study, the seed yield and yield parameters were found to be not influenced due to interaction effect of PxFxS. However, beneficial influence on seed yield and yield parameters have been noticed with $P_1F_3S_3$ treatment owing to combined effect of pinching, fertilizer levels and growth retardants spray with MH (500 ppm).

5.1.7.3 Interaction among pinching, fertilizer levels and growth retardant sprays on seed quality parameters

The interaction of PxFxS showed no significant differences on all the seed quality parameters. However, maximum germination (94.00%), vigour index (470.13), seedling length (5.00 cm) and seedling dry weight (19.50 mg) were noticed in $P_1F_3S_3$ with lower electrical conductivity (1.33 dSm^{-1}). The marginal beneficial influence noticed due to this interaction may be related to combined effect of these three treatments.

5.2 EXPERIMENT – II : STUDIES ON STORAGE POTENTIAL OF CHINA ASTER VARIETIES

Seed a biological entity, is an important basic and crucial agriculture input in enhancing agricultural productivity. Loss of seed viability due to aging, senescence and deterioration are common phenomena leading to death of seed. Seed deterioration leading to loss of viability is invitable, irreversible and inexorable but its rate can be controlled to some extent by modifying the storage environment. Generally, seed stored in moisture impervious containers like aluminium foil and polythene bag store for longer period compared to those stored in moisture pervious containers such as cloth bag, jute bag, paper bag *etc.*

The present storage experiment was conducted involving four varieties of china aster *viz.,* Kamini, PG white, PG violet and PG purple and four containers *viz.,* cloth bag, paper packet, polythene bag and aluminium foil bag under ambient storage conditions. Monthly observations were made on various seed quality parameters for six months and the results obtained are discussed in this chapter.

5.2.1 Influence of varieties

The storage potential of seed generally varies among varieties, species and genera as it is influenced by genetic factor (Delouche, 1973 and Agrawal, 1974).

In the present study, storage potential of seed as judged by germination percentage was found to differ significantly among varieties of china aster seeds in all the months of storage (Table 8). Irrespective of varieties and containers, the mean seed germination was found to decrease from 87.28 to 67.25 per cent from first to the end of six months after storage. Germination was maximum (90.12%) in Kamini, followed by PG voilet (87.75%) and minimum (84.47%) in PG purple in the first month after storage. From second month onwards, germination percentage decreased gradually in all the varieties and at the end of six months of storage also Kamini maintained higher (70.87%) germination followed by PG voilet (67.12%) and was lower (64.30%) in PG purple. The differences noticed in storability as judged by germination values among varieties of china aster seeds may be related to genetic makeup of varieties as storage potential is under genetic control and is heritable (Roberts, 1972; Delouche, 1973 and Agrawal, 1974).

Likewise, the mean speed of germination decreased from initial month (15.88) to the end of six months (12.06) irrespective of varieties. Among varieties, Kamini showed maximum (16.17 and 12.45) speed of germination followed by PG voilet (15.93 and 12.15) and was minimum (15.65 and 11.70) in PG purple after first and six month of storage respectively.

Similarly, seedling length, vigour index, seedling dry weight were found to decrease from first month of storage to end of six month of storage in all the china aster varieties. All these seedling parameters were higher in Kamini followed by PG voilet and lower in PG purple variety in all the months of storage.

The decline in speed of germination, seedling vigour parameters such as seedling length, seedling dry weight, vigour index noticed among the varieties of china aster may be due to their genetic differences and age induced deterioration. With the increase in storage period decline in seed vigour is expected (Delouche, 1973) and is manifested through decrease in seedling vigour parameters. Similar decrease in seedling vigour parameters with increase in storage period are reported by Bharathi (2002) in gaillardia, Doijode (1995) in onion, Sharma *et al*. (1998) and Hunje (2002) in chilli and Palaniswamy and Karivaratharaju (1991) in tomato.

Generally, the electrical conductivity of seed leachate is inversely related to seed quality ; higher the EC lower the seed quality and vice versa. In aged seeds or partly detoriated seed, the EC will be higher owing to decrease in membrane integrity caused by detrimental changes occurring in seeds (Koostra and Harrington 1969).

In the present study, the mean EC was found to increase from 1.48 to 2.34 dSm^{-1} from first month to the end of six month of storage irrespective of varieties. Among varieties, EC was higher (1.66 and 2.53 dSm^{-1}) in PG purple followed by PG white (1.46 and 2.43 dSm^{-1} respectively) and lower (1.38 2.17 dSm^{-1}) in Kamini at first month and after six month of storage respectively. The differential EC values recorded among varieties indicate that though membrane permeability is lost during seed aging, the nature and extent of membrane damage may not be similar for all the varieties and thus differences in EC value are bound to occur (Kurdikeri, 1991).

Seeds are hygroscopic in nature and as such loose or gain moisture content in concomitant with the changes in prevailing atmospheric relative humidity and temperature. In the present study also moisture fluctuation has been noticed in all the varieties during storage from first month to the end of six month of storage. The mean moisture content was found to vary from 8.12 to 8.02 per cent irrespective of varieties from first month to end of six month of storage. The moisture content was less in all the varieties in the month of March, April and May owing to lesser relative humidity and higher temperature in the atmosphere. Similar variation in seed moisture content was reported in gailardia (Bharathi, 2002), in chilli (Sharma *et al*., 1998 and Hunje, 2002), in onion (Doijode, 1995) and in tomato (Palaniswamy and Karivaratharaju, 1991).

5.2.2 Influence of containers

Generally, seeds stored in moisture impervious containers like aluminium foil and polythene bags maintained viability and vigour for longer period compared to those stored in moisture pervious containers like cloth bag, paper bag *etc.* It is mainly attributed to lesser moisture fluctuation in seeds stored in moisture impervious containers.

In the present study, germination percentage differed significantly among containers in all months of storage. Among storage containers, germination was significantly higher in seeds stored in aluminium foil and polythene containers compared to those stored in cloth bag and paper packet in the all months of storage. Maximum (75.50%) germination percentage was observed with seeds stored in aluminium foil followed by polythene bag (71.50%) and was minimum (59.37%) in cloth bag at the end of six month of storage. The beneficial influence of moisture impervious containers in maintaining viability for longer period noticed in the present study may be ascribed to slow deterioration possibly due to lesser fluctuation of seed moisture content compared to those stored in pervious containers. The superiority of aluminium foil as well as polythene bag over cloth bag and paper packet in maintaining viability was also reported by Bharathi (2002) in gaillardia and Hunje (2002) in chilli and Kumbar (1999) and Patil (2000) in chickpea.

The speed of germination was also found to differ significantly among storage containers in all months of storage. However, it was high in seed stored in aluminium foil and polythene bag (12.55 and 12.40, respectively) compared to those stored in cloth bag and paper packet even at the end of six month of storage. The beneficial influence of moisture impervious containers (aluminium foil and polythene bag) noticed may be related to lesser decrease in seed vigour compared to those stored in pervious containers like cloth bag and paper pocket.

Likewise, seedling vigour parameters such as seedling length, vigour index and dry weight also differed significantly among containers in all the months of storage. All the seedling vigour parameters decreased more in seeds stored in paper and cloth bag compared to aluminium foil polythene bag. Similar decrease in seedling vigour parameters due to greater reduction of germination percentage and seedling length in seeds stored in moisture pervious containers has been reported by Bharathi (2002) in gaillardia, Doijode (1998), Sharma *et al*. (1998) and Hunje (2002) in chilli and Vijaykumar *et al*. (1991) in onion.

As pointed out earlier, seed quality is related inversely to leachate values. The EC of seeds stored in impervious containers were found to be lower compared to those stored in pervious containers which indicated beneficial influence by maintaining membrane integrity and thus the higher seed quality. The results are in conformity with the reports of Bharathi (2000) in gaillardia, Sharanamma (2002) and Hunje (2002) in chilli and Vijaykumar *et al*. (1991) in onion.

The fluctuation of seed moisture content was noticed in seeds stored in either moisture pervious or impervious containers in all the month of storage. However, fluctuation of seed moisture content was more in cloth bag and paper containers compared to aluminium and polythene bag. Similar fluctuation in seed moisture content in relation to prevailing atmospheric conditions were reported by Bharathi (2002) in gaillardia, Sharanamma (2002) and Hunje (2002) in chilli. Further, fluctuation of moisture content in seeds stored even in polythene bag were reported by Merlene and Mumford (1986) and opined that polythene bags are not completely moisture proof containers.

5.2.3 Interaction effect influence of varieties and containers (VxC)

The interaction effects due to china aster varieties and containers showed no significant differences on seed germination, speed of germination, seedling length, seedling vigour index, seedling dry weight, moisture content and electrical conductivity. However, decrease in all these parameters and increase in EC with increase in storage period have been noticed in all the china aster varieties and storage containers. However, in seeds of all the varieties stored in moisture impervious containers (aluminium foil and polythene bag), the seed vigour as well as seedling vigour parameters were relatively higher compared to moisture pervious container (cloth bag and paper packet).

RACTICAL APPLICATION OF THE RESULTS

The following practical applications based on the results of the present studies are indicated.

Pinching at 15 DAT may be practiced for obtaining maximum number of flowers with more number of seeds per flower and more seed yield and quality in china aster.

Application of higher level of fertilizer (270:180:150 kg NPK/ha) found optimum to obtain higher seed yield and quality in china aster.

Pinching at 15 DAT with application of 270:180:150 kg NPK per ha may be practiced for obtaining increase number of flowers with higher seed yield and quality in china aster.

Spraying of MH (500 ppm) or CCC (200 ppm) at 15 DAT is found beneficial in arresting plant height and in increasing leaves, branches, number of flowers and seed yield.

The seeds of china aster may be stored in moisture impervious containers like aluminium foil and polythene bag for longer period with higher seed quality.

FUTURE LINE OF WORK

Following future line of work is suggested for obtaining higher seed yield and quality for the benefit of seed growers and traders.

Similar studies on pinching, fertilizer levels and growth retardants in other china aster varieties may be initiated.

The influence of growth retardants at different concentration with MH and CCC and other growth retardants needs to be studied.

The influence of other low cast inputs like organic fertilizers and plant protection measures needs to be studied.

The storage studies may be continued involving seed treatment with botanicals and chemicals.

There is a scope to initiate seed enhancement studies like seed invigoration, seed colouring, pelleting, *etc*.

SUMMARY

The results generated from field studies on influence of pinching, fertilizer levels and growth retardants on seed yield and quality and storage studies in china aster conducted during 2005-06 are summarized below.

A. Pinching

Pinching at 15 DAT resulted in decreased plant height, increased number of branches, leaves and flowers per plant.

Pinching at 15 DAT recorded significantly higher seed yield (4.27 g) per plant and per ha (308 kg) with higher seed quality parameters.

Better seed quality parameters were recorded due to pinching effects.

The pinched plants took more number of days to 50 per cent flowering compared to non pinched plants.

B. Fertilizer levels

With increasing fertilizer level there was significant increase in plant height, number of leaves, number of branches, number of flower and flower diameter.

The seed yield attributes were markedly more and seed yield per plant (4.75 g) and per ha (342.2 kg) were significantly more with application of higher level of fertilizer (270:180:150 kg NPK/ha).

At higher level of fertilizer (270:180:160 kg NPK/ha) seed germination, seedling length, seedling vigour index and seedling dry weight were significantly maximum compared to lower levels of fertilizer application.

C. Growth retardants sprays (S)

Foliar application of MH (500 ppm) and CCC (200 ppm) at 15 DAT decreased plant height and increased the number of flowers.

Seed yield per plant and per ha were significantly maximum with application of MH (500 ppm) followed by CCC (200 ppm) compared to other treatment and control.

Seed quality parameters such as germination, seedling length, seedling vigour index and seedling dry weight were maximum with lower EC with MH (500 ppm) spray followed by CCC (200 ppm).

Interaction effects

Among various interactions, significant differences were noticed only between pinching and fertilizer (PxF) on number of flowers, seed yield per plant and seed yield per ha; between pinching and growth retardants (PxS) on seed yield per plant and seed yield per ha and between fertilizer and growth retardants (FxS) on flower diameter. While, no significant differences were noticed in any of the other interaction effects.

The number of flowers were significantly more (34.05) in pinched at higher level of fertilizer (P_1xF_3).

The pinched plants applied with high level of fertilizer (P_1xF_3) recorded significantly more (5.03 g and 362.21 kg) seed yield per plant and per ha respectively.

The interaction of pinching and growth retardants (PxS) recorded significantly more seed yield per plant (5.49 g) and per ha (395.72 kg).

The interaction of fertilizer levels and growth retardants resulted in increase in flower diameter (5.05 cm) with application of higher level of fertilizer (270:180:150 kg NPK/ha) and spray of MH (500 ppm).

Seed storage

Among the varieties, Kamini followed by PG voile, PG white and PG purple maintained significantly higher germination throughout the storage period of six month with higher speed of germination more seedling length, vigour index, seedling dry weight with lesser EC.

Irrespective of varieties, the seeds stored in moisture impervious containers (aluminium foil and polythene bag) retained significantly more viability compared to those stored in moisture pervious containers (cloth bag and paper packet) besides showing higher speed of germination and higher seedling vigour parameters. Greater fluctuation of moisture content was noticed in seeds stored in moisture pervious containers compared to those in moisture impervious containers.

The interaction of varieties and containers had no significant influence on seed germination and other seedling vigour parameters.

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Appendix I. Monthly meteorological data for 67 years (1938-39 to 2005-06) of Main Agricultural Research Station, University of Agricultural Sciences, Dharwad

Appendix I. Monthly meteorological data for 67 years (1938-39 to 2005-06) of Main Agricultural Research Station, University of Agricultural Sciences, Dharwad

Month	Normal (67 years)		2005-06			Temperature (°C)	
	Rainfall (mm)	No. of rainy days	Rainfall (mm)	No. of rainy days	Relative humidity	Maximum	Minimum
April	29.1	3	75.0	5	53	36.3	21.3
May	82.4	8	29.4	3	55	37.0	21.5
June	104.5	13	151.0	10	76	30.9	21.5
July	137.5	23	290.2	19	83	27.4	21.0
August	92.5	21	138.8	15	81	27.1	20.4
September	108	12	194.5	14	85	27.5	20.3
October	123.1	11	89.4	9	70	29.6	19.1
November	34.0	3	38.0	1	51	29.4	14.9
December	7.1	0.8	Trace	Trace	53	28.9	13.1
January	2.0	0	Trace	0	52	29.9	12.9
February	2.0	0	Trace	0	39	32.4	14.8
March	5.9	0.7	5.2	1	45	34.1	18.1
April	46.4	3	1.5	1	49	37.1	20.3
	773.5	**98.6**	**1013.0**	**78**	-	-	-

Appendix II. Physical and chemical properties of the soil of the experimental site

Appendix II. Physical and chemical properties of the soil of the experimental site

Sl. No.	Particulars	Value obtained	Method employed
I	**Physical properties**		
A	Mechanical composition		
	Course sand (%)	5.80	Hydrometer method (Piper, 1966)
	Fine sand (%)	14.20	Hydrometer method (Piper, 1966)
	Silt (%)	28.00	Hydrometer method (Piper, 1966)
	Clay (%)	51.90	Hydrometer method (Piper, 1966)
	Textural class	Clay loam	Hydrometer method (Piper, 1966)
B	Bulk density ($g\ cm^{-3}$)	1.2	Core sample method (Dastane, 1967)
II	**Chemical properties**		
	Total nitrogen (%)	0.056	Subbaiah and Asija (1956)
	Available phosphorus (kg/ha)	42.00	Olsen's method (Jackson, 1967)
	Available potassium (kg/ha)	325.00	Flame photometer (Jackson, 1967)
	Soil pH (1:2.5 soil : water)	7.5	pH meter (Piper, 1966)
	Organic carbon (%)	0.76	Wet oxidation method (Jackson, 1967)

EFFECT OF PINCHING, PLANT NUTRITION AND GROWTH RETARDANT SPRAYS ON SEED YIELD, QUALITY AND STORAGE STUDIES IN CHINA ASTER [*Callistephus chinensis* (L.) Nees]

ABSTRACT

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The field experiment was conducted to ascertain the influence of pinching, fertilizer levels and growth retardant sprays on seed yield and quality. Storage studies in four china aster varieties stored in four containers was also conducted in the department of Seed Science and Technology, UAS, Dharwad during 2005-06. The results of the field experiment revealed that pinching at 25 DAT showed significant decrease in plant height and increase in number of flower bearing branches, number of flowers per plant, number of seeds per flower, test weight and seed yield per ha (308 kg) with better seed quality parameters. Among fertilizer levels, higher fertilizer level (270:180:150 kg NPK/ha) resulted in more number of branches, flowers, seeds per flower and higher seed yield (342.3 kg/ha) with better seed quality parameters. Among growth retardants, foliar spray at 25 DAT with MH 500 ppm followed by CCC 200 ppm also resulted in more number of branches, flowers, seeds per flower, seed yield per ha (362.28 and 316.85 kg, respectively) and higher seed quality parameters.

The interaction between pinching and fertilizer level (PxF), pinching and growth retardant sprays (PxS), fertilizer levels and growth retardant sprays (FxS) and pinching, fertilizer levels and growth retardants sprays (PxFxS) showed non-significant differences on plant growth, seed yield and seed quality parameters. However, relatively more yield and seed quality parameters were noticed with pinching, higher level of fertilizer and spray of MH 500 ppm.

The storage experiment involving four varieties of china aster and four containers revealed that, among varieties, Kamini followed by Phule Ganesh Voilet found relatively better in storability with high germination and seedling vigour with low EC up to six months of storage. Among containers, seeds stored in aluminium foil and polythene bags were found better in storage with high germination and seedling vigour parameters compared to seeds stored in paper and cloth bags.