Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; SP1: 3106-3112

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Effect of different planting times and mulching materials on Seed quality and yield of China aster cultivars

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Abstract

The present investigations were carried out at the experimental farm of Department of Floriculture and Landscape Architecture, Dr Y S Parmar University of Horticulture and Forestry, Nauni, Solan, HP during 2015 and 2016. The experiment was laid out in a Randomized Block Design (factorial) consisting of 48 treatment combinations of four planting dates *viz*., D_1- mid March, D_2-mid April, D_3-mid May and D_4-mid June and two cultivars namely V_1- Kamini and V_2 -Poornima with six mulching materials M_0-without mulch, M_1- Black plastic mulch (100 µ), M_2- Silver plastic mulch (100 µ), M_3- Transparent plastic mulch (100 µ), M_3-Transparent plastic mulch (100 µ), M_4- Pine needle (100 µ) and M_5- Grass (1 inch layer). Among different planting times, D_4 *i.e.* mid June planting obtained best results for number of seed per flower (179.38), germination per cent (83.92 %), electrical conductivity (0.97 ds/m), seedling dry weight (7.09 mg), seedling vigour index I (763.79), moisture content (7.83 %) and 1000 seed weight (1.94 g). However, seed yield per plant (14.30 g) were recorded to be maximum in mid of March. Among the cultivars, cv. 'Poornima' gave best results for number of seed per plant (187.30). However, cv. 'Kamini' recorded the best result for seed yield per plant (12.55), electrical conductivity (1.11 ds/m), germination per cent (80.47 %), seedling dry weight (5.11 mg), seedling vigour index I (649.49), moisture content (9.28 %) and 1000 seed weight (1.70 g). Silver plastic obtained best results for number of seed per flower (170.10), seed yield per plant (11.98 g), germination per cent (80.17 %), electrical conductivity (1.26 ds/m), seedling dry weight (4.46 mg), seedling vigour index I (616.78), Moisture content (9.35 %) and 1000 seed weight (1.75 g).

Keywords: cultivars, mulch materials, planting times, flowers

Introduction

China aster [*Callistephus chinensis* (L.) Nees.] Belongs to the family 'Asteraceae' and is a native of China and Europe. The blooms are used as cut flower, loose flower, bedding plant, for flower decoration, bouquets, and garlands and also in landscape gardening to provide mass aesthetic effect. In India China aster is grown on a large scale in Karnataka, Tamil Nadu, Andhra Pradesh, Maharashtra and West Bengal. Productivity and quality of flowers and seed crop can be improved by using high yielding cultivars and improved horticultural practices like date of planting and mulching. Mulching prevents rapid evaporation from the soil surface and reduces rapid drying thereby conserving soil moisture. It also suppresses weed infestation successfully and is also used as a means of successful crop production mainly in place where irrigation facilities are scanty. It is important to produce flower in different ways through which maximum benefits can be obtained from the limited available resources such as water which is main limited factor now a days. The area under flower production is increasing every year but the farmers are not getting quality seeds in adequate quantities as very few farmers are taking up seed production. Further, there is no comprehensive agronomic package for raising seed production crop to obtain higher seed yield and quality in China aster. There is need to standardize production technology under local climatic and edaphic condition so that the farmers get maximum benefits from flower production within limited resources. Hence, the present investigation was designed to determine the effect of various mulches and planting dates on quality of China aster with objective to identify suitable mulch material for China aster and to find out the appropriate planting date for China aster under Nauni (Solan) condition of Himachal Pradesh.

Materials and Methods

The present investigation was carried out at the research farm of the Department of Floriculture and Landscape Architecture, Dr. Y.S. Parmar, University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh during 2015 and 2016. The experimental field was prepared by ploughing the soil thoroughly up to a depth of 30-35 cm. Well rotten farm yard manure (FYM) was added @ 5 kg per meter square before transplanting of seedlings and mixed thoroughly in the soil. Then, the raised beds of required size 1 m x 1 m x 30 cm (L x B x H) were prepared and levelled properly. The healthy, disease free and stocky seedlings of uniform size and vigour at 5-6 leaf stage were selected and transplanted during evening time. The seedlings of two cultivars of China aster namely, 'Kamini' (V_1) and 'Poornima' (V_2) were planted in raised beds with spacing of 30 x 25 cm (Row x Plant) to accommodate 12 plants/m^2 with six mulching materials (M_0) without mulch, (M_1) Black plastic mulch (100 µ), **(**M_2) Silver plastic mulch (100 µ), **(**M_3) Transparent plastic mulch (100 µ), **(**M_3) Transparent plastic mulch (100 µ), **(**M_4) Pine needle (100 µ) and (M_5) Grass (1 inch layer) and four planting dates viz., (D_1) Mid of March, (D_2) Mid of April, (D_3) Mid of May and (D_4) Mid of June. Experiment was laid out in RBD with factorial concept. The observations to recorded number of seeds per flowers, seed yield per plant (g), seed yield per plot (g), electrical conductivity (ds/m), Germination per cent (%), seedling length (cm), seedling dry weight (mg), seedling vigour index I, moisture content (%) and 1000 seed weight (g).

Results and Discussion

Number of seed per flower

Pooled data revealed that maximum number of seeds per flower (170.10 g) was recorded with silver plastic mulch (M_2). Whereas, minimum number of seeds per flower (166.81 g) was observed with no mulch (M_0). Maximum number of seeds per flower (179.38 g) were registered in mid-June planting (D_4) and minimum (153.60 g) was recorded in mid-March planting (D_1). Between the cultivars, maximum number of seeds per flower (187.30 g) were recorded in 'Poornima' (V_1) and significantly better than cv. 'Kamini' (V_1) *i.e.* (149.56 g). Pooled data revealed that interaction, cultivars × planting dates also revealed maximum number of seeds per flower (205.33 g) in the interaction ($V_2 \times D_4$) *i.e.* when 'Poornima' was planted on mid-June. However, minimum (146.04 g) was measured for the interaction $V_1 \times D_1$ *i.e.* when 'Kamini' was transplanted on mid-March. In the interaction planting time × mulch materials, maximum (180.49 g) were observed when planting was done in mid-June with silver mulch ($D_4 \times M_2$), while minimum (151.46 g) in mid-March planting with no mulch ($D_1 \times M_0$). In case of cultivars × mulch materials noted that maximum number of seeds per flower (189.47 g) in interaction of $V_2 \times M_{2\ i.e.}$ when 'Poornima' with silver plastic mulch followed by $V_2 \times M_1$ treatment. However, minimum (148.40 g) was measured for the interaction in cultivar 'Kamini' with no mulch ($V_1 \times M_0$). Maximum number of seeds per flower (205.99 g) were recorded in cv. 'Poornima' with mid-March planting and silver plastic mulching ($V_2 \times D_4 \times M_2$) followed by rest of treatment. Whereas, number of seeds per flower was minimum (145.07 g) when cv. 'Kamini' was planted on mid-March without mulch ($V_1 \times D_1 \times M_0$). More seed per plant produced in mid of March planting could be attributed to formation of more number of seed per flower and enhanced plant growth and increased translocation of photosynthesis from vegetative to reproductive parts under favorable climatic conditions. Further the prolonged seed maturation after anthesis is also responsible for better seed filling in turn increasing number of seed. Results are in confirmation with the findings of more yields by Kumar and Kaur (2000) in phlox, Dhatt and Kumar (2010) in larkspur, and Sharma (2012) in pansy obtained with early plantings. Number of seeds per flower is one of the important characters contributing to the seed yield. The present study revealed that maximum number of seeds per flower was recorded with silver plastic mulch (M_2), owing to the bigger and good quality flower resulting in healthier, bolder and increased number of seeds, whereas minimum number of seeds per flower was recorded with no mulch (M_0). 'Poornima' (V_2) took maximum number of seed per flower because due flower diameter large. Its genetical character produces more number of seed per flower. The variation among the varieties with respect to flower yield characters was mainly because of increased flower size with prominent central disc florets and also due to the presence of fairly more number of developed ray florets. Further, being a genetical factor, variations were expected among the varieties of China aster.

Seed yield per plant (g)

Pooled data revealed that maximum seed yield per plant (11.98 g) was recorded with silver plastic mulch (M_2). Whereas, minimum (9.14 g) was observed with no mulch (M_0). Maximum seed yield per plant (14.30 g) were registered in mid-March planting (D_1) and minimum (5.83 g) was recorded in mid-June planting (D_4). Between the cultivars, maximum seed yield per plant (12.55 g) were recorded in 'Kamini' (V_1) and significantly better than cv. 'Poornima' (V_2) i.e. (8.51 g). Interaction V × D and D × M were found to influence significantly the seed yield per plant (Table 1. 4.17). Pooled data revealed that interaction, cultivars × planting dates also revealed maximum seed yield per plant (15.81 g) in the interaction ($V_1 \times D_1$) i.e. when 'Kamini' was planted on mid-March. However, minimum (5.18 g) was measured for the interaction $V_2 \times D_4$ i.e. when 'Poornima' was transplanted on mid-June. In the interaction planting time × mulch materials, maximum seed yield per plant (15.66 g) were observed when planting was done in mid-March with silver mulch ($D_1 \times M_2$) followed by ($D_1 \times M_2$) treatment, while minimum (4.44 g) in mid-June planting with no mulch ($D_4 \times M_0$). Maximum seed yield per plant (17.43 g) were recorded in cv. 'Kamini' with mid-March planting and silver plastic mulching ($V_2 \times D_1 \times M_2$) followed by ($V_2 \times D_1 \times M_1$) and ($V_2 \times D_2 \times M_2$) treatments. Whereas, seed yield per plant was minimum (4.09 g) when cv. 'Poornima' was planted on mid-June without mulch ($V_1 \times D_4 \times M_0$).

Electrical conductivity (ds/m)

Pooled data revealed (Table 1) that minimum electrical conductivity (1.26 ds/m) was recorded with silver plastic mulch (M_2). Whereas, maximum electrical conductivity (1.37 ds/m) was observed with no mulch (M_0). Minimum electrical conductivity (0.97ds/m) were registered in mid-June planting (D_4) and maximum electrical conductivity (1.72ds/m) was recorded in mid-March planting (D_1). Between the cultivars, maximum electrical conductivity (1.11 ds/m) were recorded in 'Kamini' ($V_{1.}$) and significantly better than cv. 'Poornima' (V_1) i.e. (1.53 ds/m). Pooled data revealed that interaction, cultivars × planting dates also revealed minimum electrical conductivity (0.76 ds/m) in the interaction ($V_1 \times D_4$) i.e. when 'Kamini' was planted on mid-June and found to be significantly higher than all other interactions. However, maximum electrical conductivity (1.93 ds/m) was measured for the interaction $V_2 \times D_{1\ i.e.}$ when 'Poornima' was transplanted on mid-March. In the interaction planting time × mulch materials, minimum electrical conductivity (0.91 ds/m) were observed when planting was done in mid-June with silver mulch ($D_4 \times M_2$), while maximum (1.75 ds/m) in mid-March planting with no mulch ($D_1 \times M_0$). Interaction effects of cultivars and mulch materials V × M and V × D × M showed a non-significant effect on electrical conductivity.

Minimum electrical conductivity of seeds has been reported for the seeds which were produced along with the mulching of plants with plastic sheet. This could be due to the reasons that the seeds produced under this treatment were of very high quality in comparison to the seed produced with the augmentation of other treatments. Consequently, the seeds produced with the above mentioned treatment combination might have leaked significantly less amount of solutes in leachate while testing the Ec of seeds in comparison to the seeds produced under other treatments. Thus, producing the most vigorous seeds. However, electrical conductivity of seeds was reported to be maximum in control as the seeds might have leaked more solutes when placed in water and hence less vigorous seed. Phenotype of plant is the product of its generic and environmental factors. The genetic pattern is fixed for a given plant and determines its potential to maximize growth under favourable conditions. The response of different cultivars has been observed during the study on electrical conductivity and the lower electrical conductivity was obtained in cv. 'Kamini'. It could be ascribed to the genetic makeup of this cultivar. These results are also in agreement with the earlier work of Kishanswaroop *et al.* (2004) and Zosiamliana *et al*. (2013) while working with China aster. Production of better quality seed in June planting due to congenial atmospheric condition might have resulted in of quality seedling among under laboratory conditions with higher germination per cent. On June planting may be due to the highest seed size and flower diameter. In, March and April planting China aster produced high flower yield and seed yield but during seed production heavy rainfall occurred which deteriorated the quality of seeds.

Table 1: Effect of different mulch materials, planting time and cultivars on number of seed per flower, seed yield per plant (g) and electrical conductivity (ds/m) of China aster.

Treatment	Number of seed per flower							
	V_1	V_2	Mean	D_1	D_2	D_3	D_4	
M_0	148.40	185.22	166.81	151.46	165.19	172.58	178.00	
M_1	149.72	188.93	169.32	154.94	167.89	175.19	179.28	
M_2	150.73	189.47	170.10	155.67	168.28	175.96	180.49	
M_3	149.08	186.04	167.56	152.74	165.67	172.75	179.08	
M_4	149.56	186.61	168.09	153.00	166.16	173.60	179.60	
M_5	149.89	187.56	168.72	153.78	166.86	174.44	179.82	
Mean	149.56	187.30		153.60	166.67	174.08	179.38	
D_1	146.04	161.16	$CD_{0.05}$					
D_2	147.88	185.47						
D_3	150.91	197.26	V	D	M	V×M	V×D	D×M
D_4	153.43	205.33	0.33	0.47	0.57	0.81	1.14	1.61

Treatment	Seed yield per plant (g)							
	V_1	V_2	Mean	D_1	D_2	D_3	D_4	
M_0	10.97	7.31	9.14	12.91	10.29	8.93	4.44	
M_1	13.60	9.49	11.54	15.46	12.66	11.21	6.84	
M_2	14.24	9.71	11.98	15.66	13.40	11.73	7.11	
M_3	11.59	7.59	9.59	13.36	10.57	9.44	4.99	
M_4	12.22	8.39	10.31	13.91	11.57	10.00	5.75	
M_5	12.69	8.58	10.64	14.47	11.81	10.41	5.85	
Mean	12.55	8.51		14.30	11.72	10.29	5.83	
D_1	15.81	12.78	$CD_{0.05}$					
D_2	14.69	8.74						
D_3	13.22	7.35	V	D	M	V×M	V×D	D ×M
D_4	6.48	5.18	0.32	0.45	0.55	NS	0.68	1.11

Treatment	Electrical conductivity (ds/m)							
	V_1	V_2	Mean	D_1	D_2	D_3	D_4	
M_0	1.16	1.59	1.37	1.75	1.45	1.25	1.05	
M_1	1.07	1.50	1.28	1.71	1.36	1.14	0.93	
M_2	1.05	1.47	1.26	1.69	1.33	1.11	0.91	
M_3	1.14	1.56	1.35	1.74	1.43	1.25	0.99	
M_4	1.12	1.54	1.33	1.74	1.41	1.18	0.99	
M_5	1.10	1.52	1.31	1.71	1.41	1.16	0.96	
Mean	1.11	1.53		1.72	1.40	1.18	0.97	
D_1	1.51	1.93	$CD_{0.05}$					
D_2	1.19	1.61						
D_3	0.97	1.39	V	D	M	V×M	V×D	D×M
D_4	0.76	1.18	0.01	0.02	002	NS	0.03	0.05

Germination per cent (%)

An inquisition pooled data revealed that maximum germination per cent (80.17 %) was recorded with silver plastic mulch (M_2). Whereas, minimum (77.56 %) was observed with no mulch (M_0). Maximum germination per cent (83.92 %) were registered in mid-June planting (D_4) and minimum (73.05 %) was recorded in mid-March planting (D_1). Between the cultivars, maximum germination per cent (80.47 %) were recorded in 'Kamini' (V_1) and significantly better than cv. 'Poornima' (V_2) i.e. (77.31 %). The interaction, varieties × planting dates also revealed maximum germination per cent (86.73 %) in the interaction $D_4 \times V_1$ *i.e.* when 'Kamini' was planted on mid-June and found to be significantly higher than all other interactions. However, minimum (72.21 %) was measured for the interaction $D_1 \times V_2$ i.e. when 'Poornima' was transplanted on mid-March. In the interaction planting time × mulch materials, maximum germination per cent (85.52 %) were registered when planting was done in mid-June with silver mulch ($D_4 \times M_2$), while minimum (71.82 %) in mid-March planting with no mulch ($D_1 \times M_0$). Pooled data of Table 3 revealed that V × D × M interactions significantly affected the germination per cent. Maximum germination per cent (88.50 %) were recorded in cv. 'Kamini' with mid-June planting and silver plastic mulching ($V_1 \times D_4 \times M_2$).Whereas, minimum was (70.58 %) when cv. 'Poornima' was planted on mid-March without mulch ($V_2 \times D_1 \times M_0$). Germination is one of the key criteria for determining the physiological aspect of seed and gives an idea about the ability of seed to produce normal and healthy seedlings under the field conditions. Amongst mulches maximum seed germination per cent was obtained with silver plastic mulch (M_2). This may be because of seeds obtained from the large flower that have sufficient food reserves produced healthy and bold seeds which ultimately resulting better seed germination, whereas, minimum seed germination per cent was obtained with no mulch (M_0). Sanderson and Fillmore and Sanderson (2012) while investigating the influence of different mulch types on yield and quality of hips in various wild rose species (*Rosa* sp.) have reported production of better quality hips with the application of black plastic mulch. The data show that in the laboratory, large-heavy seeds required 27 hr for radical protrusion in both cultivars, whereas, small-light seeds required only 20 and 22 hr for "germination." Small-light seeds, however, had significantly higher critical moisture content for germination than did large-heavy seeds for both cultivars. This can be attributed to the greater amount of water absorbed per unit weight for germination of the small-light seeds as compared to the large-heavy seeds. The large-heavy seeds also exhibited a higher rate of water absorption than the small-light seeds for both cultivars. While the large-heavy seeds absorbed water at the highest rate (larger contact surface) they took more time to germinate than did small-light seeds. They not only required more water to germinate, but also more time for seed coat saturation and moisture migration to the center of the embryo. In mid-June planting 100 seed weight is higher as compared to the mid of March. So that germination per cent is also higher in June planting as compared to mid of March. The variation in germination per cent might be due to genetic makeup and variation in the environmental factors during production. In cv. 'Kamini' germination was high as compared to cv. 'Poornima'.

Table 2: Effect of different mulch materials, planting time and cultivars on number of seed per flower, seed yield per plant (g) and electrical conductivity (ds/m) of China aster

Treatment	Number of seed per flower								Seed yield per plant (g)								Electrical conductivity (ds/m)							
	V_1				V_2				V_1				V_2				V_1				V_2			
	D_1	D_2	D_3	D_4	D_1	D_2	D_3	D_4	D_1	D_2	D_3	D_4	D_1	D_2	D_3	D_4	D_1	D_2	D_3	D_4	D_1	D_2	D_3	D_4
M_0	145.07	147.08	150.12	151.34	157.86	183.31	195.04	204.66	14.46	13.15	11.48	4.78	11.35	7.43	6.38	4.09	1.53	1.24	1.04	0.84	1.96	1.66	1.46	1.26
M_1	146.61	148.69	150.81	152.78	163.27	187.08	199.57	205.78	17.15	15.57	14.13	7.56	13.77	9.76	8.30	6.13	1.50	1.15	0.93	0.72	1.92	1.57	1.35	1.14
M_2	146.93	148.99	151.99	154.99	164.42	187.56	199.93	205.99	17.43	16.70	14.94	7.91	13.90	10.11	8.53	6.32	1.48	1.12	0.90	0.70	1.90	1.54	1.32	1.12
M_3	145.45	147.20	150.27	153.41	160.04	184.14	195.22	204.75	14.76	13.47	12.37	5.74	11.96	7.67	6.50	4.23	1.53	1.22	1.03	0.78	1.95	1.64	1.46	1.20
M_4	145.99	147.49	150.78	153.98	160.00	184.82	196.41	205.22	15.12	14.45	12.92	6.40	12.70	8.69	7.08	5.11	1.53	1.19	0.97	0.77	1.95	1.62	1.39	1.20
M_5	146.18	147.82	151.48	154.09	161.38	185.90	197.40	205.55	15.96	14.81	13.50	6.51	12.99	8.80	7.31	5.20	1.50	1.20	0.94	0.75	1.92	1.62	1.37	1.17
$CD_{0.05}$	1.61								1.57								NS							

Seedling dry weight (mg)

The observations recorded for seedling dry weight as influenced by various mulch materials, cultivars and planting time has been presented in Table 3. An inquisition pooled data revealed that maximum seedling dry weight (4.46 mg) was recorded with silver plastic mulch (M_2) followed by rest of the treatments. Whereas, minimum seedling dry weight (3.91 mg) was observed with no mulch (M_0). Maximum seedling dry weight (7.09 mg) were registered in mid-June planting (D_4) and minimum seedling dry weight (1.34 mg) was recorded in mid-March planting (D_1). Between the cultivars, maximum seedling dry weight (5.11 mg) was recorded in 'Kamini' (V_1) and minimum in cv. 'Poornima' (V_2) i.e. (3.29 mg). The interaction, varieties × planting dates also revealed maximum seedling dry weight (8.53 mg) in the interaction $D_4 \times V_1$ i.e. when 'Kamini' was planted on mid-June and found to be significantly higher than all other interactions. However, minimum seedling dry weight (0.96 mg) was measured for the interaction $D_1 \times V_2$ i.e. when 'Poornima' was transplanted on mid-March. In the interaction planting time × mulch materials, maximum seedling dry weight (7.40 mg) were registered when planting was done in mid-June with silver mulch ($D_4 \times M_2$), while minimum (1.06 mg) in mid-March planting with no mulch ($D_1 \times M_0$). Pooled data of Table 4.34 revealed that V × D × M interactions significantly affected the seedling dry weight. Maximum seedling dry weight (8.95 mg) were recorded in cv. 'Kamini' with mid-June planting and silver plastic mulching ($V_1 \times D_4 \times M_2$).Whereas, seedling dry weight was minimum (0.75 mg) when cv. 'Poornima' was planted on mid-March without mulch ($V_2 \times D_1 \times M_0$). The effect of mulching on seedling dry weight gave the significant results. The plants being mulched with silver plastic sheet might have created congenial conditions for the better growth, flowering as well as production of quality seeds. Consequently, the seeds produced with this particular treatment combination were of very good quality parameters (both physical and physiological quality attributes). Thus, resulted in the production of better quality seedlings and consequently, the seedlings dry weight was significantly higher. Production of better quality seed in June planting due to congenial atmospheric condition might have resulted in production of quality seedling with higher seedling dry weight. The variation in seedling dry weight among cultivars might be due to genetic makeup and variation in the environmental factors during production.

Table 3 Effect of different mulch materials, planting time and cultivars on germination percent (%), seedling length (cm) and seedling dry weight (mg) of China aster.

<table>
<tr><th rowspan="2">Treatment</th><th colspan="8">Germination percentage (%)</th><th colspan="8">Seedling dry weight (mg)</th></tr>
<tr><th>V₁</th><th>V₂</th><th>Mean</th><th>D₁</th><th colspan="2">D₂</th><th>D₃</th><th>D₄</th><th>V₁</th><th>V₂</th><th>Mean</th><th>D₁</th><th colspan="2">D₂</th><th>D₃</th><th>D₄</th></tr>
<tr><td>M₀</td><td>79.51 (8.91)</td><td>75.60 (8.69)</td><td>77.56 (8.80)</td><td>71.82 (8.47)</td><td colspan="2">76.20 (8.73)</td><td>79.58 (8.92)</td><td>82.63 (9.09)</td><td>4.78</td><td>3.04</td><td>3.91</td><td>1.06</td><td colspan="2">2.78</td><td>4.96</td><td>6.82</td></tr>
<tr><td>M₁</td><td>81.18 (9.01)</td><td>78.36 (8.85)</td><td>79.77 (8.93)</td><td>73.83 (8.59)</td><td colspan="2">78.65 (8.87)</td><td>81.70 (9.04)</td><td>84.91 (9.21)</td><td>5.40</td><td>3.41</td><td>4.41</td><td>1.49</td><td colspan="2">3.23</td><td>5.54</td><td>7.37</td></tr>
<tr><td>M₂</td><td>81.59 (9.03)</td><td>78.76 (8.87)</td><td>80.17 (8.95)</td><td>74.08 (8.61)</td><td colspan="2">79.05 (8.89)</td><td>82.05 (9.06)</td><td>85.52 (9.25)</td><td>5.48</td><td>3.44</td><td>4.46</td><td>1.58</td><td colspan="2">3.39</td><td>5.51</td><td>7.40</td></tr>
<tr><td>M₃</td><td>79.85 (8.93)</td><td>76.24 (8.73)</td><td>78.05 (8.83)</td><td>72.46 (8.51)</td><td colspan="2">76.70 (8.76)</td><td>80.04 (8.95)</td><td>82.98 (9.11)</td><td>4.86</td><td>3.13</td><td>3.99</td><td>1.19</td><td colspan="2">3.13</td><td>4.89</td><td>6.75</td></tr>
<tr><td>M₄</td><td>80.08 (8.94)</td><td>76.80 (8.76)</td><td>78.44 (8.85)</td><td>72.55 (8.52)</td><td colspan="2">77.13 (8.78)</td><td>80.78 (8.99)</td><td>83.29 (9.12)</td><td>5.00</td><td>3.25</td><td>4.12</td><td>1.32</td><td colspan="2">3.23</td><td>5.04</td><td>6.90</td></tr>
<tr><td>M₅</td><td>80.62 (8.97)</td><td>78.08 (8.83)</td><td>79.35 (8.90)</td><td>73.57 (8.58)</td><td colspan="2">78.32 (8.85)</td><td>81.30 (9.02)</td><td>84.20 (9.17)</td><td>5.15</td><td>3.45</td><td>4.30</td><td>1.38</td><td colspan="2">3.29</td><td>5.25</td><td>7.28</td></tr>
<tr><td>Mean</td><td>80.47 (8.97)</td><td>77.31 (8.79)</td><td></td><td>73.05 (8.55)</td><td colspan="2">77.67 (8.81)</td><td>80.91 (8.99)</td><td>83.92 (9.16)</td><td>5.11</td><td>3.29</td><td></td><td>1.34</td><td colspan="2">3.17</td><td>5.20</td><td>7.09</td></tr>
<tr><td>D₁</td><td>73.90 (8.60)</td><td>72.21 (8.50)</td><td colspan="6" rowspan="2">CD 0.05</td><td>1.71</td><td>0.96</td><td colspan="6" rowspan="2">CD 0.05</td></tr>
<tr><td>D₂</td><td>78.81 (8.88)</td><td>76.54 (8.75)</td><td>3.</td><td>2.51</td></tr>
<tr><td>D₃</td><td>82.46 (9.08)</td><td>79.36 (8.91)</td><td>V</td><td>D</td><td>M</td><td>V×M</td><td>V×D</td><td>D×M</td><td>6.53</td><td>4.04</td><td>V</td><td>D</td><td>M</td><td>V×M</td><td>V×D</td><td>D ×M</td></tr>
<tr><td>D₄</td><td>86.73 (9.31)</td><td>81.12 (9.01)</td><td>0.05</td><td>0.07</td><td>0.08</td><td>NS</td><td>0.09</td><td>0.23</td><td>8.53</td><td>5.65</td><td>0.69</td><td>0.98</td><td>1.20</td><td>NS</td><td>1.39</td><td>2.40</td></tr>
</table>

Seedling vigour index I

An inquisition pooled data revealed that maximum seedling vigour I (616.78) was recorded with silver plastic mulch (M_2). Whereas, minimum seedling vigour I (570.77) was observed with no mulch (M_0). Maximum seedling vigour I (763.79) were registered in mid-March planting (D_1) and minimum seedling vigour I (367.38) was recorded in mid-June planting (D_4). Between the cultivars, maximum seedling vigour I

(649.49) were recorded in 'Kamini' (V_1) and significantly better than cv. 'Poornima' (V_2) i.e. (538.18). The interaction, varieties × planting dates also revealed maximum seedling vigour I (835.99) in the interaction $V_1 \times D_4$ i.e. when 'Kamini' was planted on mid-June. However, minimum seedling vigour I (325.49) was measured for the interaction $D_1 \times V_2$ i.e. when 'Poornima' was transplanted on mid-March. In the interaction planting time × mulch materials, maximum seedling vigour I (783.74) were registered when planting was done in mid-June with silver mulch ($D_4 \times M_2$) followed by rest of the treatments, while minimum (351.66) in mid-March planting with no mulch ($D_1 \times M_0$). Pooled data of Table 4.36 revealed that V × D × M interactions significantly affected the seedling vigour I. Maximum seedling vigour I (858.56) were recorded in cv. 'Kamini' with mid-June planting and silver plastic mulching ($V_1 \times D_4 \times M_2$).Whereas, seedling vigour I was minimum (306.82) when cv. 'Poornima' was planted on mid-March without mulch ($V_2 \times D_1 \times M_0$). The germination test alone is not enough to provide information about the performance of seed under the field conditions. So the vigour status of the seed becomes an important parameter as it determines the actual germiability and performance of seed under the field conditions. Maximum seed vigour index-I and seed vigour index-II were recorded in silver-black plastic mulch (M_2), which may be because of the fact that silver-black mulch maintained optimum soil moisture and temperature during maturation of seeds and these factors resulted in bold and vigorous seed formation, whereas, minimum seed vigour index-I and seed vigour index-II were recorded in no mulch (M_0). In June planting seed size is more as compared early planting and bolder seed as the more food reserves are available in adequate quantity germinating seeds. Early planting plants seed affected by fungal infection due to rainfall. So delay planting produces good quality seed. In cv. 'Kamini' seed vigour was high as compared to cv. 'Poornima'. The variation in seed vigour I might be due to genetic makeup and variation in the environmental factors during production.

Table 4: Effect of different mulch materials, planting time and cultivars on germination percent (%), seedling length (cm) and seedling dry weight (mg) of China aster.

Treatment	**Germination per cent (%)**								**Seedling dry weight (mg)**							
	V_1				**V_2**				**V_1**				**V_2**			
	D_1	**D_2**	**D_3**	**D_4**	**D_1**	**D_2**	**D_3**	**D_4**	**D_1**	**D_2**	**D_3**	**D_4**	**D_1**	**D_2**	**D_3**	**D_4**
M_0	73.06 (8.55)	77.73 (8.82)	81.58 (9.03)	85.69 (9.26)	70.58 (8.40)	74.68 (8.64)	77.58 (8.81)	79.58 (8.92)	1.38	3.41	6.07	8.25	0.75	2.16	3.86	5.40
M_1	74.42 (8.63)	79.39 (8.91)	83.20 (9.12)	87.73 (9.37)	73.24 (8.56)	77.90 (8.83)	80.20 (8.96)	82.09 (9.06)	1.93	4.00	6.74	8.91	1.05	2.45	4.34	5.78
M_2	74.62 (8.64)	79.72 (8.93)	83.54 (9.14)	88.50 (9.41)	73.54 (8.57)	78.38 (8.85)	80.57 (8.98)	82.54 (9.08)	2.04	4.14	6.78	8.95	1.12	2.65	4.23	5.89
M_3	73.73 (8.58)	78.24 (8.85)	81.73 (9.04)	85.73 (9.26)	71.20 (8.44)	75.16 (8.67)	78.35 (8.55)	80.24 (8.96)	1.52	3.74	6.00	8.17	0.87	2.52	3.79	5.33
M_4	73.54 (8.58)	78.73 (8.87)	81.99 (9.05)	86.06 (9.28)	71.57 (8.46)	75.54 (8.69)	79.58 (8.92)	80.53 (8.97)	1.67	3.86	6.15	8.32	0.97	2.60	3.94	5.48
M_5	74.02 (8.60)	79.06 (8.89)	82.73 (9.09)	86.69 (9.31)	73.13 (8.55)	77.58 (8.81)	79.87 (8.94)	81.72 (9.04)	1.75	3.90	6.39	8.56	1.01	2.68	4.12	6.00
$CD_{0.05}$	0.23								3.40							

Moisture content (%)

A cursory glance of data in Table 5 extrapolated that the moisture content were significantly influenced by various mulch materials, planting time and cultivars. A perusal of pooled data revealed that minimum moisture content (9.35 %) was recorded with silver plastic mulch (M_2). Whereas, maximum moisture content (10.15 %) was observed with no mulch (M_0). Minimum moisture content (7.83 %) was found in mid-June planting (D_4) and maximum moisture content (12.57 %) was recorded in mid-March planting (D_1). Between the cultivars, minimum moisture content (9.18 %) were recorded in 'Kamini' (V_1) and significantly better than cv. 'Poornima' (V_2) i.e. (10.28 %).

In case of July planting (D_4) showed the minimum moisture content, which might be due to the moist agro climatic conditions during seed development and maturity phase. Mid of March planting date was more immature seeds. The variation in seed moisture per cent might be due to genetic makeup and variation in the environmental factors during production. In cv. 'Kamini' seed low moisture content as compared to cv. 'Poornima' these findings are in accordance with the work of Kishanswaroop *et al*. (2004) in China aster. The effect of mulching on seed moisture per cent gave the significant results. The plants being mulched with silver plastic sheet might have created congenial conditions for the better growth, flowering as well as production of quality seeds. Consequently, the seeds produced with this particular treatment combination were of very good quality parameters (both physical and physiological quality attributes). Thus, resulted in the production of better quality seedlings and consequently, the low moisture per cent were significantly higher.

Table 5: Effect of different mulch materials, planting time and cultivars on seedling vigour index I, moisture content (%) and 1000 seed weight of China aster.

Treatment	Seedling vigour index I							Moisture content (%)							1000 seed weight						
	V_1	V_2	Mean	D_1	D_2	D_3	D_4	V_1	V_2	Mean	D_1	D_2	D_3	D_4	V_1	V_2	Mean	D_1	D_2	D_3	D_4
M_0	627.29	514.26	570.77	351.66	483.42	701.54	746.48	9.65	10.65	10.15	13.13	10.20	9.09	8.17	1.66	1.62	1.64	1.37	1.53	1.78	1.89
M_1	664.93	551.62	608.27	378.07	552.20	726.77	776.06	9.11	10.11	9.61	12.27	9.83	8.50	7.83	1.73	1.73	1.73	1.46	1.62	1.88	1.96
M_2	673.45	560.12	616.78	383.46	568.50	731.43	783.74	8.85	9.85	9.35	12.12	9.67	8.29	7.32	1.74	1.76	1.75	1.47	1.65	1.89	1.97
M_3	635.15	525.33	580.24	357.51	504.13	706.95	752.37	9.54	10.54	10.04	12.98	10.16	8.97	8.06	1.68	1.67	1.67	1.39	1.56	1.82	1.92
M_4	642.94	531.49	587.21	361.19	515.63	714.24	757.79	9.35	10.35	9.85	12.62	10.02	8.86	7.88	1.70	1.67	1.69	1.41	1.57	1.82	1.94
M_5	653.19	546.25	599.72	372.41	539.93	720.25	766.29	9.18	10.18	9.68	12.32	9.99	8.71	7.71	1.70	1.71	1.70	1.44	1.58	1.86	1.94
Mean	649.49	538.18		367.38	527.30	716.86	763.79	9.28	10.28	10.15	12.57	9.98	8.74	7.83	1.70	1.68		1.42	1.58	1.84	1.94
D_1	409.27	325.49	$CD_{0.05}$					12.07	13.07	$CD_{0.05}$					1.50	1.35	$CD_{0.05}$				
D_2	570.02	484.59						9.48	10.48						1.59	1.58					
D_3	782.68	651.04	V	D M	V×M	V×D	D×M	8.24	9.24	V	D	M V×M	V×D	D ×M	1.82	1.86	V	D M	V×M	V×D	D×M
D_4	835.99	691.59	10.85	15.30 18.74	NS	21.64	37.49	7.33	8.33	0.13	0.18	0.23 NS	NS	NS	1.98	1.90	0.03	0.04 0.05	NS	0.11	0.15

1000 seed weight (g)

Pooled data revealed that maximum 1000 seed weight (1.75 g) was recorded with silver plastic mulch (M_2). Whereas, minimum 1000 seed weight (1.64 g) was observed with no mulch (M_0). Maximum 1000 seed weight (1.94 g) were registered in mid-March planting (D_1) and minimum 1000 seed weight (1.42 g) was recorded in mid-June planting (D_4). Between the cultivars, maximum 1000 seed weight (1.70 g) were recorded in 'Kamini' (V_1) and significantly better than cv. 'Poornima' (V_2) i.e. (1.68 g). Pooled data revealed that interaction, cultivars × planting dates also revealed maximum 1000 seed weight (1.98 g) in the interaction ($V_1 \times D_4$) i.e. when 'Kamini' was planted on mid-June followed by ($V_2 \times D_4$) treatment. However, minimum 1000 seed weight (1.35 g) was measured for the interaction $V_2 \times D_1$ i.e. when 'Poornima' was transplanted on mid-June. In the interaction planting time × mulch materials, maximum 1000 seed weight (1.97 g) were observed when planting was done in mid-June with silver mulch ($D_4 \times M_2$), while minimum (1.37 g) in mid-March planting with no mulch ($D_1 \times M_0$). The variation in seed weight might be due to genetic makeup and variation in the environmental factors during production. In cv. 'Kamini' seed high seed weight as compared to cv. 'Poornima' these findings are in accordance with the work of Kishanswaroop *et al*. (2004) in China aster. The effect of mulching on seed weight gave the significant results. The plants being mulched with silver plastic sheet might have created congenial conditions for the better growth, increase flower diameter, flowering as well as production of quality seeds. Consequently, the seeds produced with this particular treatment combination were of very good quality parameters (both physical and physiological quality attributes). Thus, resulted in the production of better quality seedlings and consequently, the low moisture per cent were significantly higher. Seed weights of rape tended to increase with planting date whereas seed weights. In general, seed weights were higher for the mid of June planting dates suggesting that there were more immature seeds in the March and April planting dates than the June planting dates. These data suggest that seed development was affected by warm temperatures. The seed weights were similar to those reported by Johnson *et al.* (1995) and follow the general trend of *B. napus* seed weights being greater than *B. rapus* seed weights. Planting done in mid of March it's not clear whether this resulted from low pollination rates, which could affect reproductive efficiency, less favorable environmental conditions, or other unknown factors.

Table 6: Effect of different mulch materials, planting time and cultivars on seedling vigour index I, moisture content (%) and 1000 seed weight of China aster

Treatment	Seedling vigour index I							Moisture content (%)							1000 seed weight						
	V_1	V_2	Mean	D_1	D_2	D_3	D_4	V_1	V_2	Mean	D_1	D_2	D_3	D_4	V_1	V_2	Mean	D_1	D_2	D_3	D_4
M_0	627.29	514.26	570.77	351.66	483.42	701.54	746.48	9.65	10.65	10.15	13.13	10.20	9.09	8.17	1.66	1.62	1.64	1.37	1.53	1.78	1.89
M_1	664.93	551.62	608.27	378.07	552.20	726.77	776.06	9.11	10.11	9.61	12.27	9.83	8.50	7.83	1.73	1.73	1.73	1.46	1.62	1.88	1.96
M_2	673.45	560.12	616.78	383.46	568.50	731.43	783.74	8.85	9.85	9.35	12.12	9.67	8.29	7.32	1.74	1.76	1.75	1.47	1.65	1.89	1.97
M_3	635.15	525.33	580.24	357.51	504.13	706.95	752.37	9.54	10.54	10.04	12.98	10.16	8.97	8.06	1.68	1.67	1.67	1.39	1.56	1.82	1.92
M_4	642.94	531.49	587.21	361.19	515.63	714.24	757.79	9.35	10.35	9.85	12.62	10.02	8.86	7.88	1.70	1.67	1.69	1.41	1.57	1.82	1.94
M_5	653.19	546.25	599.72	372.41	539.93	720.25	766.29	9.18	10.18	9.68	12.32	9.99	8.71	7.71	1.70	1.71	1.70	1.44	1.58	1.86	1.94
Mean	649.49	538.18		367.38	527.30	716.86	763.79	9.28	10.28	10.15	12.57	9.98	8.74	7.83	1.70	1.68		1.42	1.58	1.84	1.94
D_1	409.27	325.49	$CD_{0.05}$					12.07	13.07	$CD_{0.05}$					1.50	1.35	$CD_{0.05}$				
D_2	570.02	484.59						9.48	10.48						1.59	1.58					
D_3	782.68	651.04	V	D M	V×M	V×D	D×M	8.24	9.24	V	D	M V×M	V×D	D ×M	1.82	1.86	V	D M	V×M	V×D	D×M
D_4	835.99	691.59	10.85	15.30 18.74	NS	21.64	37.49	7.33	8.33	0.13	0.18	0.23 NS	NS	NS	1.98	1.90	0.03	0.04 0.05	NS	0.11	0.15

Conclusion

Under the present investigation conducted with respect to the use of mulch materials, planting time and cultivars in China aster, it can be concluded that most of the seed yield and seed quality parameters were found to be best in the plants with silver plastic mulch apart of cv. 'Kamini' expects number of seed per flower best in cv. 'Poornima' Mid June planting best for seed quality parameters and mid-March planting for seed yield parameters

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