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Effect of plant density and calcium nitrate spray on yield and quality of China aster

Anuradha A Watane, Sudhir R Dalal, Apeksha A Gorivale and Pravina N Satpute

Abstract
A field investigation entitled "Effect of plant density and calcium nitrate spray on growth, flowering and yield of China aster" was carried out during the years 2019-20 and 2020-21 at Department of Floriculture and Landscape Architecture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola with the objectives to study the effect of plant density and calcium nitrate spray on yield of China aster cv. Phule Ganesh White and to find out the suitable plant density and dose of calcium nitrate for quality production of China aster. The result of the present investigation indicated that, among the plant density treatment, significantly superior result in respect of flower yield plot^{-1} (11.25 kg), flower yield ha^{-1} (44.61 q), stalk length of flower (26.75 cm), vase life of cut flower (8.76 days) and shelf life of loose flower (6.08 days) were recorded in the 30 x 20 cm plant spacing. However, plant spaced at 30 x 30 cm recorded significantly maximum number of flowers plant^{-1} (42.47), flower yield plant^{-1} (371.41 g), diameter of fully opened flower (8.29 cm), stalk diameter of flower (0.50 cm) and weight of flower (8.73 g). Among the calcium nitrate treatment, significantly superior results for maximum number of flowers plant^{-1} (40.22), flower yield plant^{-1} (387.49 g), flower yield plot^{-1} (11.47 kg), flower yield ha^{-1}(45.51 q), diameter of fully opened flower (8.80 cm), stalk length of flower (25.97 cm), stalk diameter of flower (0.55 cm), weight of flower (9.60 g), vase life of cut flower (9.61 days) and shelf life of loose flower (7.06 days) were recorded in 1.0% calcium nitrate spray. Among the interaction effect (between plant density and calcium nitrate) the plant spaced at 30 x 20 cm and sprayed with 1.0 percent calcium nitrate was found better for maximum flower yield plot^{-1} (15.09 kg) and flower yield ha^{-1} (59.88 q) and stalk length (30.29 cm). Whereas, the treatment combination 30 x 30 cm with 1.0% calcium nitrate spray recorded maximum number of flowers plant^{-1} (46.26), flower yield plant^{-1} (472.74 g), stalk diameter (0.62 cm) and weight of flower (10.21 g).

Keywords: China aster, plant density, calcium nitrate, flower yield

Introduction
China aster (*Callistephus chinensis*) is a very popular annual flower crop and is mainly cultivated for production of cut flowers, loose flowers, as pot plant and for bedding plant purposes in landscape. The practice of spacing varies with the habit of the cultivars and also regions. The economic yield is largely affected when plants are not planted at appropriate planting distance. High plant density brings out various modifications in the growth of plants. Plant population has a pronounced effect on the vegetative growth and yield of flowers. Closer spacing leads to the production of flowers of small size due to greater competition among the plants. Planting distance should be regarded for massing sufficient production of flowers with good quality in China aster. Optimum spacing regulates the proper utilization of solar energy, avoids competition in the uptake of nutrients caused by the collision of root systems, facilitates proper intercultural operations. Though quality of cut flower is primarily a vertical trait, it is greatly influenced by climatic, geographical, nutritional and plant density factors. Calcium nitrate fertilizer is a water-soluble chemical solution that provides plants with supplemental calcium and nitrogen. These elements are the physiological building blocks for strong, disease-resistant plants. Calcium nitrate doesn't occur in nature, it's made by mixing inorganic calcium and nitrogen. This is done by combining limestone and nitric acid, followed by ammonia. Plant population per unit area and nitrate spray has a significant bearing on vegetative and final seed yield in flowering annuals. Several worker in different annuals resulting in enhanced returns per unit area. Numerous studies have shown that nutrient sprays have reported improved vegetative growth through micronutrient sprays thus results in a significant increase in quantity and quality of herbal plant yields. Hence, it is necessary to identify the suitable plant geometry for commercial cultivation in Vidarbha region and even it is felt necessary to find out suitable dose of calcium nitrate spray for China aster to get better yields.

Considering the economic importance of the crop, the present work was designed to study the "Effect of plant density and calcium nitrate spray on growth, flowering and yield of China aster".

Material and Methods

The investigation entitled "Effect of plant density and calcium nitrate spray on growth, flowering and yield of China aster" was carried out at Department of Floriculture and Landscape Architecture, Dr. P.D.K.V., Akola during September, 2019 to January, 2020 and September, 2020 to January, 2021. The experiment was laid out in Factorial Randomized Block Design with three replications and two factors i.e. factor "A" consists of plant density *viz*. 30 x 45 cm, 30 x 30 cm and 30 x 20 cm and factor "B" consists of water spray and 0.5, 1.0 and 1.5% calcium nitrate with 12 treatment combinations. The experimental land was ploughed once. Then criss cross harrowing was done for clod crushing and soil was brought into fine tilth. At the time of land preparation, well rottened FYM @ 10 tonnes ha^{-1} was mixed uniformly in the soil before last harrowing. The ad-hoc recommended dose of fertilizer given by Dr. P.D.K.V., Akola (150: 50: 50 kg NPK ha^{-1}) was applied to all the plots in the form of urea, single super phosphate and muriate of potash. The seedlings of China aster cv. Phule Ganesh White were prepared in polythene bags in polyhouse. The seeds were sown on 15th September and one month old seedlings (i.e. 15th October) were transplanted in experimental plot during the years 2019 and 2020.

Results and Discussion

The results obtained from present investigation are presented below on the basis of pooled mean of two years of experimentation (2019-2020 and 2020-2021).

A) Yield parameters

Effect of Plant Density

The experimental findings indicated that different plant densities were significantly influenced the yield parameters (Table 1). Significantly maximum number of flowers $plant^{-1}$ (42.47) and flower yield $plant^{-1}$ (371.41 g) were recorded in 30 x 30 cm (wider spacing) which was significantly superior than rest of all the treatments. However, significantly minimum number of flowers $plant^{-1}$ (31.09) and flower yield $plant^{-1}$ (251.04 g) were recorded by the treatment 30 x 45 cm. This increase in floral characters might be due to low density planting which provides good conditions for maximum size, weight and number of flowers per plant. Similar results were also reported by Dhemre *et al.* (1995) [8] in China aster, Sharma and Rawat (2007) [19] in chrysanthemum while, under wider spacing, higher yield per plant was achieved and this might be due to less intra competition for light, moisture, space, nutrients and aeration and better growing environment. This result comes in accordance with the results of Khobragade *et al.* (2012) [11] in marigold, Bhargav *et al.* (2016) [4] in China aster and Chaitra and Gopinath (2018) [5] in marigold. However, significantly maximum flower yield $plot^{-1}$ and ha^{-1} were recorded in 30 x 20 cm (closer spacing) i.e. (11.25 kg and 44.61 q, respectively) which was significantly superior than rest of all the treatments. However, significantly minimum flower yield $plot^{-1}$ (4.98 kg) and ha^{-1} (19.75 q) was recorded by the treatment 30 x 45 cm. The higher yield in terms of flowers per unit area can be attributed to the higher population per unit area with closer spacing. It is found that the flower production increases with the increase in plant density per square meter. There by yield increase due to increased plant population per unit area. It was observed that, yield of flowers per unit area was inversely related to the plant spacing i.e. the closer spacing produced the higher yield of flower. Similar findings were reported by Vijaykumar *et al*. 1995 [21] in China aster, Singh and Sangama (2000) [18] in tuberose, Dorajeerao *et al.* (2012) [9] in chrysanthemum, Sharma *et al.* (2014) [20] in chrysanthemum and Kumar *et al*. (2015) [14] in marigold.

Effect of calcium nitrate

The yield parameters included number of flowers $plant^{-1}$, flower yield $plant^{-1}$, flower yield $plot^{-1}$ and flower yield ha^{-1}. The observations recorded on yield parameters are given in Table 1. The data presented in Table 1 exhibited significant differences among the treatments. Maximum number of flowers $plant^{-1}$ (40.22), flower yield $plant^{-1}$ (387.49 g), flower yield $plot^{-1}$ (11.47 kg) and flower yield ha^{-1} (45.51 q) were recorded in 1.0% calcium nitrate which was significantly superior than rest of all the treatments. However, significantly minimum number of flowers $plant^{-1}$ (32.89), flower yield $plant^{-1}$ (207.28 g), flower yield $plot^{-1}$ (6.26 kg) and flower yield ha^{-1} (24.83 q) were recorded by the treatment water spray. Increase in flowers yield might be due to the improvement in nutrient availability influenced by calcium application which helped in enhancing the growth of plants, resulting in higher flower yield per plant. This in turn might have affect flower number. Application of increasing calcium nitrate as a calcium source had positive impact on the morphological parameters. Calcium is involved in cell membrane stability and permeability in addition to its involvement in cell division and elongation. Increasing Ca^{2+} concentration in the nutrient solution increased the flower production. This result can be correlated to previous finding in which plant growth and yield were improved due to foliar application of calcium compounds. Foliar application of calcium nitrate improved the productivity traits and main fertilizers for plants make favourable condition to produce high yield with higher quality. This result comes in accordance with the results of Indira (2011) [10] in chrysanthemum and Nizam *et al*. (2019) [16] in tomato.

Interaction effect

The data presented in Table 1. Exhibited that, the treatment combination 30 x 30 cm with 1.0% calcium nitrate recorded significantly maximum number of flowers $plant^{-1}$ (46.26) and flower yield $plant^{-1}$ (472.74 g). However, significantly maximum flower yield $plot^{-1}$ (15.09 kg) and ha^{-1} (59.88 q) were recorded in treatment combination 30 x 20 cm with 1.0% calcium nitrate. While, significantly minimum flowers $plant^{-1}$ (30.22), flower yield $plant^{-1}$ (182.84 g), flower yield $plot^{-1}$ (3.65 kg) and ha^{-1} (14.49 q) were recorded with the treatment combination 30 x 45 cm with water spray. This increase in flower yield might be due to an increase in the planting distances and improvement in nutrient availability influenced by calcium application which helped in enhancing the growth of plants, resulting in higher flower yield per plant and it is found that the flower production increases with the increase in plant density and increased supply of nutrients which played their unique function in growth and developments.

B) Quality parameters

Effect of Plant Density

The data presented in Table 2 in respect of flower quality exihibited significant differences due to different plant densities. Maximum diameter of fully opened flower (8.29 cm), stalk diameter of flower (0.50 cm) and weight of flower (8.73 g) were recorded with 30 x 30 cm recorded which was significantly superior than rest of all the treatments. However, these were minimum (6.76 cm, 0.44 cm and 6.90 g, respectively) by the treatment 30 x 20 cm. While, maximum stalk length of flower (26.75 cm), vase life of cut flower (8.76 days) and shelf life of loose flower (6.08 days) were recorded in treatment 30 x 20 cm which was significantly superior than rest of all the treatments. However, significantly minimum stalk length of flower (19.26 cm), vase life of cut flower (7.31 days) and shelf life of loose flower (5.52 days) were recorded by the treatment 30 x 45 cm.

Production of flowers with greater diameter under wider spacing as compared to closer spacing might be due to more favourable conditions like nutrients, sun light and soil moisture available to individual plant and weight of flower due to availability of more area per plant and less competition for absorption of nutrients and moisture, no shading effect which ultimately increases the rate of net photosynthesis and translocation of assimilates to the storage organs. Similar results were also reported by Dhemre *et al*. (1995) [8] in China aster, Kaur (2001) in chrysanthemum, Chaudhary *et al*. (2008) [6] in gaillardia, Yagi *et al*. (2014) [22] in celosia, Sharma *et al*. (2014) [20] in chrysanthemum, Badawy *et al*. (2015) [2] in straw flower, Nain *et al*. (2017) and Chaitra and Gopinath (2018) [5] in marigold. The decrease in plant height is always associated with increase in stem diameter, because shorter the height thicker the stem and vice versa. Similar result were also reported by Bijimol and Singh (2001) in gladiolus and Khalaj and Edrisi (2012) in tuberose.

Effect of calcium nitrate

Significantly maximum diameter of fully opened flower (8.80 cm), stalk length of flower (25.97 cm), stalk diameter of flower (0.55 cm), weight of flower (9.60 g), vase life of cut flower (9.61 days) and shelf life of loose flower (7.06 days) were recorded in 1.0% calcium nitrate which was significantly superior than rest of all the treatments. However, significantly minimum diameter of fully opened flower (6.33 cm), stalk length of flower (19.65 cm), stalk diameter of flower (0.35 cm), weight of flower (5.67 g), vase life of cut flower (5.46 days) and shelf life of loose flower (3.71 days) were recorded in water spray.

It can be seen that calcium nitrate improved the weight of flower. More amount of calcium during development and flower opening increase its diameter. Calcium provides structural strength to plants' cell walls while nitrogen is a major constituent of chlorophyll and protein and its adequate supply through fertilizer encouraged the photosynthesis, thereby resulting in stem elongation. This results are similar with the findings of Indira *et al*. (2011) [10] in chrysanthemum, Arjenaki *et al*. (2012) [1] in hybrid rose and Bala *et al*. (2019) [3] in lily. Calcium is an essential element affecting the plants' growth and development processes in a way that its accumulation in them facilitates creating the connections among pectin polymers and accordingly it escalates the mechanical strength of stem and lignin production and increase the stem diameter and application of calcium leads to more weight gain of flower. This result is supported by Reddy and Sarkar (2016) [17] in gladiolus and Bala *et al*. (2019) [3] in lily.

Interaction effect

Data presented in Table 3. In respect of interaction effect of different plant densities and calcium nitrate spray on stalk length, stalk diameter and weight of flower were found to be significant during experimentations.

The treatment combination 30 x 20 cm with 1.0% calcium nitrate recorded significantly maximum stalk length of flower (30.29 cm) whereas, 30 x 30 cm with 1.0% calcium nitrate recorded significantly maximum flower stalk diameter (0.62 cm) and weight of flower (10.21 g) and was significantly superior than rest of all the treatments. However, significantly minimum stalk length of flower (14.40 cm) was recorded by the treatment combination 30 x 45 cm with water spray and minimum stalk diameter of flower (0.34 cm) and weight of flower (3.90 g) were recorded with the treatment combination 30 x 20 cm with water spray.

Maximum stalk length due to the closer spacing enhanced the vertical growth and calcium provides structural strength to plants' cell walls, improving most growth traits when sprayed with calcium nitrate could be attributed to the nitrogen that involved in the construction of auxins, thereby increasing activity of cellular division and elongation. However, increasing the stalk diameter and more weight gain of flower due to optimum spacing which regulates the proper utilization of solar energy, water, avoids competition in the uptake of nutrients caused by the collision of root systems, facilitates proper intercultural operations and calcium nitrate which is absorb by plant as a nutrient factor which results in increasing cell division and elongation activity.

Table 1: Effect of different plant densities and calcium nitrate spray on yield parameter of China aster

Treatments	Number of flowers per plant			Flower yield plant^{-1} (g)			Flower yield plot^{-1} (kg)			Flower yield ha^{-1} (q)		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
Factor A - Plant density(D)												
D_1(30x45cm)	30.63	31.57	31.09	228.71	273.37	251.04	4.57	5.39	4.98	18.12	21.37	19.75
D_2(30x30cm)	41.46	43.48	42.47	335.42	407.39	371.41	9.38	11.72	10.55	36.96	46.09	41.53
D_3(30x20cm)	37.09	38.26	37.67	254.75	307.73	281.24	10.19	12.31	11.25	40.40	48.82	44.61
'F' test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
SE (m)±	0.53	0.54	0.49	2.89	3.30	3.22	0.13	0.32	0.19	0.53	1.29	0.76
CD at 5%	1.52	1.61	1.44	9.12	9.86	9.58	0.39	0.93	0.56	1.57	3.79	2.25
Factor B - Calcium nitrate spray(S)												
S_1(Water spray)	32.34	33.45	32.89	171.23	243.33	207.28	5.01	7.50	6.26	19.89	29.76	24.83
S_2 (0.5%)	36.09	37.94	37.01	273.70	302.60	288.15	8.07	8.89	8.48	32.00	35.29	33.65
S_3(1.0%)	39.49	40.96	40.22	352.56	422.41	387.49	10.41	12.53	11.47	41.30	49.73	45.51
S_4(1.5%)	37.64	38.72	38.18	294.35	349.64	321.99	8.69	10.29	9.49	34.12	40.26	37.19

'F' test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
SE (m)±	0.61	0.63	0.56	2.65	3.43	3.03	0.15	0.36	0.22	0.61	1.49	0.88
CD at 5%	1.80	1.86	1.67	8.03	10.38	9.12	0.46	1.08	0.65	1.81	4.37	2.60
Interaction effect (D X S)												
D_1S_1	29.55	30.89	30.22	146.79	218.88	182.84	2.93	4.37	3.65	11.64	17.35	14.49
D_1S_2	30.05	31.38	30.72	224.96	250.63	237.80	4.49	5.01	4.75	17.83	19.86	18.84
D_1S_3	32.41	32.50	32.45	288.89	335.84	312.37	5.77	6.41	6.09	22.89	25.44	24.17
D_1S_4	30.51	31.51	31.01	254.20	288.13	271.16	5.08	5.76	5.42	20.14	22.84	21.49
D_2S_1	35.67	36.67	36.17	213.02	298.15	255.59	5.96	9.62	7.79	23.65	38.17	30.91
D_2S_2	41.27	44.80	43.03	344.05	383.38	363.72	9.63	10.73	10.18	38.19	42.56	40.38
D_2S_3	45.11	47.41	46.26	440.35	505.12	472.74	12.32	14.14	13.23	48.90	56.10	52.50
D_2S_4	43.80	45.04	44.42	344.26	442.93	393.59	9.61	12.40	11.00	37.11	47.52	42.32
D_3S_1	31.80	32.80	32.30	153.89	212.97	183.43	6.15	8.51	7.33	24.38	33.77	29.08
D_3S_2	36.97	37.64	37.31	252.09	273.79	262.94	10.08	10.95	10.52	39.99	43.44	41.72
D_3S_3	40.97	42.97	41.97	328.45	426.29	377.37	13.13	17.05	15.09	52.11	67.64	59.88
D_3S_4	38.63	39.63	39.13	284.59	317.86	301.23	11.38	12.71	12.05	45.12	50.43	47.77
'F' test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
SE (m)±	1.06	1.09	0.98	3.79	3.60	3.45	0.27	0.64	0.38	1.07	2.58	1.53
CD at 5%	3.12	3.22	2.89	10.91	10.93	10.02	0.79	1.87	1.13	3.14	7.58	4.51

Table 2: Effect of different plant densities and calcium nitrate spray on quality parameter of China aster

Treatments	Diameter of fully opened flower (cm)			Stalk length (cm)			Stalk diameter (cm)			Weight of flower (g)			Vase life of flower (days)			Shelf life of lower (days)		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
Factor A - Plant density(D)																		
D_1(30x45cm)	7.48	8.34	7.91	18.22	20.30	19.26	0.45	0.46	0.46	7.42	8.64	8.03	6.49	8.14	7.31	5.53	5.50	5.52
D_2(30x30cm)	7.70	8.88	8.29	22.46	23.97	23.21	0.49	0.52	0.50	8.05	9.41	8.73	7.94	8.56	8.25	5.62	5.70	5.66
D_3(30x20cm)	6.85	6.68	6.76	26.13	27.37	26.75	0.43	0.45	0.44	6.31	7.49	6.90	8.35	9.17	8.76	6.01	6.14	6.08
'F' test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
SE (m)±	0.12	0.21	0.13	0.33	0.34	0.33	0.01	0.01	0.01	0.14	0.18	0.14	0.24	0.27	0.19	0.12	0.15	0.09
CD at 5%	0.35	0.62	0.39	0.98	1.00	0.98	0.03	0.03	0.03	0.42	0.54	0.42	0.71	0.80	0.58	0.37	0.45	0.26
Factor B - Calcium nitrate spray(S)																		
S_1	6.10	6.56	6.33	18.71	20.59	19.65	0.33	0.36	0.35	4.67	6.65	5.67	5.37	5.55	5.46	3.91	3.50	3.71
S_2	7.21	7.68	7.44	21.40	23.40	22.40	0.48	0.46	0.47	7.45	7.94	7.70	7.46	8.50	7.98	5.26	5.48	5.37
S_3	8.27	9.32	8.80	25.31	26.64	25.97	0.53	0.56	0.55	8.90	10.31	9.60	8.89	10.33	9.61	6.98	7.14	7.06
S_4	7.79	8.29	8.04	23.66	24.88	24.27	0.49	0.53	0.51	8.02	9.16	8.59	8.65	10.11	9.38	6.73	7.01	6.87
'F' test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
SE (m)±	0.13	0.24	0.15	0.38	0.39	0.38	0.01	0.01	0.01	0.16	0.21	0.16	0.28	0.31	0.22	0.14	0.18	0.10
CD at 5%	0.40	0.71	0.45	1.14	1.16	1.13	0.03	0.04	0.03	0.49	0.62	0.48	0.82	0.93	0.67	0.42	0.53	0.30

Table 3: Interaction effect of different plant densities and calcium nitrate spray on quality parameter of China aster

Interaction effect (D X S)									
Treatments	Stalk length (cm)			Stalk diameter (cm)			Weight of flower (g)		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
D_1S_1	13.24	15.56	14.40	0.34	0.36	0.35	4.97	7.07	6.02
D_1S_2	18.50	20.50	19.50	0.48	0.40	0.44	7.49	7.99	7.74
D_1S_3	21.47	23.47	22.47	0.52	0.56	0.54	8.91	10.34	9.63
D_1S_4	19.70	21.70	20.70	0.50	0.54	0.52	8.33	9.14	8.74
D_2S_1	20.20	22.20	21.20	0.35	0.37	0.36	6.01	8.13	7.07
D_2S_2	21.37	23.37	22.37	0.51	0.53	0.51	8.06	8.56	8.31
D_2S_3	24.67	25.67	25.17	0.60	0.63	0.62	9.76	10.66	10.21
D_2S_4	23.60	24.63	24.12	0.53	0.57	0.55	8.35	10.31	9.33
D_3S_1	22.70	24.03	23.37	0.33	0.35	0.34	3.05	4.76	3.90
D_3S_2	24.33	26.33	25.33	0.46	0.48	0.47	6.82	7.27	7.05
D_3S_3	29.79	30.79	30.29	0.49	0.51	0.50	8.02	9.92	8.97
D_3S_4	27.71	28.33	28.02	0.47	0.49	0.48	7.37	8.02	7.69
'F' test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
S.E(m)±	0.67	0.68	0.67	0.02	0.01	0.01	0.28	0.36	0.28
CD at 5%	1.97	2.00	1.96	0.03	0.05	0.04	0.86	1.08	0.97

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