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Studies on influence of plant density and calcium nitrate spray on growth, flowering and yield of China aster

Anuradha A Watane, Sudhir R Dalal, Ashvini Gaidhani and Nitin S Gupta

Abstract
A field investigation entitled "Studies on influence 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 plant height, days for emergence of first flower bud, days required for full opening of flower from bud initiation, days for 50% flowering, days to first harvesting, duration of flowering, flower yield plot $^{-1}$ and flower yield ha^{-1} were recorded in the 30 x 20 cm plant spacing. However, plant spaced at 30 x 30 cm recorded significantly maximum number of branches per plant, plant spread at 50% flowering and leaf area. Among the calcium nitrate treatment, significantly superior results for maximum plant height, number of branches per plant, plant spread at 50% flowering, leaf area, days for emergence of first flower bud, days required for full opening of flower from bud initiation, days for 50% flowering, days to first harvesting and duration of flowering were recorded in 1.0 percent 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 plant height and yield of China aster.

Keywords: China aster, plant density, calcium nitrate, plant growth

Introduction
Today, floriculture is recognised as most remunerative profession with a much higher potential for returns per unit area than most fields and even some other horticultural crops. The major flower crops cultivated in India included roses, carnation, orchids, gerbera, gladiolus, tuberose, marigold, China aster and chrysanthemum. China asters can be grown successfully in open condition. It is gaining fast popularity in India because of its easy cultural practices, diversity of colours and varied uses. Evolution of aster flowers brought a new range of colours starting from white, pink, red, lavender, magenta and blue to their innumerable variations (Desai, 1967) [6]. Suitable spacing is essential to obtain better plant growth, spread and flower as well as seed yield per hectare. The cultural practices *viz*. the suitable plant spacing and pinching play an important role in influencing the growth, yield and quality of flowers. One of the factors affecting the productivity of most of the floricultural crops is improper use of nutrients. To improve the productivity, adequate amount of fertilizers in balanced proportion should be used which has been given less attention by the flower growers or floriculturists. Calcium nitrate fertilizer can be used to prevent a calcium deficiency or replenish a plant's calcium levels. The boosting of calcium improves leaf strength, fruit and roots. Calcium nitrate will give plants a dose of usable nitrogen to improve energy production. Calcium content in the tissue affects many processes during plant growth, at all stages of development (Ferguson and Drobak 1988) [9]. 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. Keeping in view, the increasing yield potential and increasing demand of China aster for various purposes, there is a good scope for increasing the better quality flower production by adopting some improved agro techniques like plant spacing and fertilizer application.

Considering the economic importance of the crop, the present work was designed to study the "Studies on influence of plant density and calcium nitrate spray on growth, flowering and yield of China aster". The study will helpful to increase branches plant^{-1}, plant spread and yield of flower.

Material and Methods

The investigation entitled "Studies on influence 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) Growth parameter

Effect of Plant Density

The experimental findings indicated that different plant densities were significantly influenced the growth parameters (Table 1 and 2).

The treatment 30 x 20 cm recorded maximum plant height at 90 DAT, (86.27 cm) which was significantly superior than rest of all the treatments. However, significantly minimum plant height (76.82 cm) was recorded with treatment 30 x 45 cm. This might be due to intra plant competition for light, moisture, space, nutrients and aeration. The obtained results could be due to elongation of cells and the number of cells from cell division which increase vertical growth. Similar observation were also been reported by Dhemre *et al*. (1995) [7] in China aster, Chaudhary *et al*. (2008) [5] in gaillardia, Ahirwar *et al*. (2012) [1] in African marigold, Khobragade *et al*. (2012) [11] and Bhargav *et al*. (2016) [4] in China aster, Singh *et al.* (2018) [22] in marigold and Wani *et al.* (2018) [24] in China aster. The treatment 30 x 30 cm plant spacing recorded significantly maximum number of branches per plant (24.80), maximum plant spread at 50% flowering (37.90 cm) and leaf area (123.09 cm^2) which was significantly superior than rest of all the treatments. Whereas, significantly minimum number of branches per plant (20.34), plant spread at 50% flowering (29.29 cm) and leaf area (92.03 cm^2) were recorded with the treatment 30 x 20 cm. This increase in growth characters might be due to the availability of more space which provided better penetration of light, more aeration, well spread of plant utilizing proper carbohydrate, sunlight and ultimately increased photosynthetic activity resulting into significant effect on different growth characters. Similar findings were also reported by Dhemre *et al.* (1995) [7] in China aster, Chaudhary *et al*. (2008) [5] in gaillardia, Kaur *et al*. (2012) [1] in marigold, Khobragade *et al.* (2012) [11] in China aster, Nagdeve *et al.* (2018) [16] in Annual chrysanthemum and Wani *et al*. (2018) [24] in China aster.

Effect of calcium nitrate

The data presented in Table 1 and 2 exhibited significant differences among the treatments. Maximum plant height at 90 DAT was recorded with the 1.0% calcium nitrate treatment (88.73 cm). However, significantly minimum plant height was recorded with the water spray treatment (73.46 cm). At all the stage of crop growth significantly maximum plant height of aster plant was obtained in an application of calcium nitrate @ 1.0% which supplied the nitrogen in the form of nitrate. The increased plant growth might be attributed to increased cell division and cell elongation induced by calcium nitrate at high concentration**.** This result can be correlated to previous finding in which plant growth and yield were improved due to foliar application of calcium compounds. Nitrogen is a major constituent of chlorophyll and protein and its adequate supply through fertilizer encouraged the photosynthesis, thereby resulting in stem elongation. Similar result were also found by Supanjani *et al*. (2005) [23] in annual chrysanthemum, Indira (2011) [10] in chrysanthemum, Seyedi *et al*. (2013) [20] in lilium and Raj and Mallick (2017) [18] in yellow sarson. Maximum number of branches per plant (24.46), plant spread at 50% flowering (36.11 cm) and leaf area (119.95 cm^2) were recorded in 1.0% calcium nitrate spray. However, minimum number of branches per plant (20.52), plant spread at 50% flowering (31.49 cm) and leaf area (96.36 cm^2) were recorded in water spray. This increase might be due to presence of nitrogen in calcium nitrate. Without nitrogen, plants cannot process sunlight into sugars for growth. The role of intra- and extracellular calcium in altering cell metabolism is often attributed to its influence on cell-wall and membrane structure and function. Calcium is involved in cell membrane stability and permeability in addition to its involvement in cell division and elongation. Similar result was also obsereved by Indira (2011) [10] in chrysanthemum and Shafeek *et al.* (2013) in cucumber and the leaf area of the plant is one of the most important criteria for the nutritional response of the plant, which increase the efficiency of photosynthesis and the production of carbon compounds. It contributes in maintenance of cell membrane stability and wall structure. Similar findings were also reported by Raj and Mallick (2017) [18] in yellow sarson and Mohammed and Abood (2020) [15] in gerbera.

Interaction effect

Interaction effect of different plant densities and calcium nitrate spray on plant height were found to be significant during experimentations (Table 1). The treatment combination 30 x 20 cm with 1.0% calcium nitrate recorded significantly maximum plant height (95.35 cm) at 90 DAT. However, significantly minimum plant height (68.28 cm) at 90 DAT was recorded with the treatment 30 x 45 cm with water spray. This might be due to the closer spacing with high concentration of calcium nitrate spray resulted in highest plant

height. In closer spacing there is a higher plant population, which might have maximized the use of applied nutrients better than the wider spacing.

B) Flowering parameter

Effect of Plant Density

The experimental findings indicated that different plant densities were significantly influenced the flowering parameters (Table 3). The data revealed significant differences among the treatments, in respect of flowering parameter. Minimum days for emergence of first flower bud (69.26 days), days required for full opening of flower from bud initiation (15.83 days), days for 50% flowering (76.30 days), days to first harvesting (78.34 days) and maximum duration of flowering (24.31 days) were recorded in 30 x 20 cm. However, maximum days for emergence of first flower bud (76.93 days), days required for full opening of flower from bud initiation (17.73 days), days for 50% flowering (90.67 days), days to first harvesting (95.25 days) and minimum duration of flowering (22.17 days) were recorded in 30 x 45 cm. Thus, it is noticed that the flower bud appearance delayed successively as the planting distances were increased. This might be due to more competition among plants in closer spacing for space, light, air and nutrition, hence the closer spaced plants tended to grow vertically and led to early physiological maturity as a result of their taller growth. The wider spacing had taken more number of days to first flowering due to the more vegetative growth so the closer spacing showed that early flowering. The result of this investigation is in agreement with Yadram *et al.* (2015) [25] in African marigold, Bhargav *et al*. (2016) [4] in China aster, Mali *et al*. (2017) [14] in chrysanthemum and Shruthi *et al.* (2016) [21] in African marigold and more duration might be due to optimum space for growth of the plant. Similar findings were also reported by Kour *et al*. (2012) [12] in marigold and Kumar *et al*. (2016) [13] in gladiolus.

Effect of calcium nitrate

The data presented in Table 3 exhibited significant differences among the treatments. Minimum days for emergence of first flower bud (66.58 days), days required for full opening of flower from bud initiation (14.09 days), days for 50% flowering (76.22 days), days to first harvesting (79.00 days) and maximum duration of flowering (27.45 days) were recorded in 1.0 percent calcium nitrate spray. However, maximum days for emergence of first flower bud (81.61 days), days required for full opening of flower from bud initiation (19.02 days), days for 50% flowering (91.29 days), days to first harvesting (95.73 days) and minimum duration of flowering (18.85 days) were recorded in water spray. Several findings showed that flowers' petal growth is associated with flower bud opening which results from cell expansion. The role of calcium promotes photosynthesis, cells division and elongation, its effect in cell membrane, the plasma membrane, absorption of other elements and its effects on the process of metabolism. Foliar application of nitrate salts at beginning of reproductive growth of plant involve in number of physiological changes which might be leads to changes in growth parameters and ultimately increased the yield of the crop. Similar results were also reported by Bala *et al.*, (2019) [3] in Lily and Mohammed and Abood (2020) [15] in gerbera and Beauty of flower looks better on the plant itself. Therefore, any treatment which increases the duration of flowering on the plant will always be recognized universally. The spray of calcium was found most effective in prolonging the longevity. The increase in calcium concentration increases the days of senescence. Similar findings were also reported by Arjenaki *et al*. (2012) [2] in hybrid rose.

C) Yield parameters

Effect of Plant Density

The experimental findings indicated that different plant densities were significantly influenced the yield parameters (Table 1). 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. There by yield increased 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 also reported by Vijaykumar *et al*. (1995) in China aster, Dorajeerao *et al.* (2012) [8] in chrysanthemum and Kumar *et al*. (2015) in marigold.

Effect of calcium nitrate

The yield parameters included 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 2 exhibited significant differences among the treatments. Maximum flower yield plot $^{-1}$ (11.47 kg) and ha^{-1}(45.51 q) were recorded in 1% calcium nitrate which was significantly superior than rest of all the treatments. However, significantly minimum flower yield plot $^{-1}$ (6.26 kg) and 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. Increasing Ca^{2+} concentration in the nutrient solution increased the flower production. 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) [17] in tomato.

Interaction effect

The data presented in Table 1. exhibited that, the treatment combination 30 x 20 cm with 1.0% calcium nitrate recorded significantly maximum flower yield plot^{-1} (15.09 kg) and ha^{-1} (59.88 q). However, significantly minimum 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 is might be due to the flower production increases with the increase in plant density per square meter and increased supply of nutrients which played their unique function in growth and developments. This result can be correlated to previous finding in which plant growth and yield were improved due to foliar application of calcium compounds.

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

Treatments	Plant height at 90 DAT			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
Factor A - Plant density(D)									
D_1(30x45cm)	75.55	78.09	76.82	4.57	5.39	4.98	18.12	21.37	19.75
D_2(30x30cm)	80.53	84.41	82.47	9.38	11.72	10.55	36.96	46.09	41.53
D_3(30x20cm)	85.00	87.54	86.27	10.19	12.31	11.25	40.40	48.82	44.61
'F' test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
SE (m)±	0.94	0.98	0.70	0.13	0.32	0.19	0.53	1.29	0.76
CD at 5%	2.74	2.86	2.06	0.39	0.93	0.56	1.57	3.79	2.25
Factor B - Calcium nitrate spray(S)									
S_1(Water spray)	71.17	75.75	73.46	5.01	7.50	6.26	19.89	29.76	24.83
S_2 (0.5%)	78.50	80.98	79.74	8.07	8.89	8.48	32.00	35.29	33.65
S_3(1.0%)	87.93	89.54	88.73	10.41	12.53	11.47	41.30	49.73	45.51
S_4(1.5%)	83.84	87.12	85.48	8.69	10.29	9.49	34.12	40.26	37.19
'F' test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
SE (m)±	1.08	1.13	0.81	0.15	0.36	0.22	0.61	1.49	0.88
CD at 5%	3.17	3.31	2.38	0.46	1.08	0.65	1.81	4.37	2.60
Interaction effect (D X S)									
D_1S_1	65.05	71.51	68.28	2.93	4.37	3.65	11.64	17.35	14.49
D_1S_2	72.74	73.23	72.99	4.49	5.01	4.75	17.83	19.86	18.84
D_1S_3	83.42	84.63	84.03	5.77	6.41	6.09	22.89	25.44	24.17
D_1S_4	81.00	83.00	82.00	5.08	5.76	5.42	20.14	22.84	21.49
D_2S_1	75.30	80.67	77.98	5.96	9.62	7.79	23.65	38.17	30.91
D_2S_2	78.79	81.43	80.11	9.63	10.73	10.18	38.19	42.56	40.38
D_2S_3	84.24	89.41	86.82	12.32	14.14	13.23	48.90	56.10	52.50
D_2S_4	83.79	86.12	84.96	9.61	12.40	11.00	37.11	47.52	42.32
D_3S_1	73.17	75.08	74.12	6.15	8.51	7.33	24.38	33.77	29.08
D_3S_2	83.97	88.27	86.12	10.08	10.95	10.52	39.99	43.44	41.72
D_3S_3	96.13	94.57	95.35	13.13	17.05	15.09	52.11	67.64	59.88
D_3S_4	86.74	92.23	89.49	11.38	12.71	12.05	45.12	50.43	47.77
'F' test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
SE (m)±	1.87	1.95	1.41	0.27	0.64	0.38	1.07	2.58	1.53
CD at 5%	5.49	5.73	4.12	0.79	1.87	1.13	3.14	7.58	4.51

Table 2: Studies on influence of different plant densities and calcium nitrate spray on growth parameter of China aster

Treatments	Number of branches per plant			Plant spread at 50% flowering (cm)			Leaf area (cm^2)		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
Factor A - Plant density(D)									
D_1(30x45cm)	22.06	22.96	22.51	34.15	35.28	34.85	116.95	118.06	117.50
D_2(30x30cm)	24.06	25.54	24.80	36.83	38.97	37.90	122.59	123.59	123.09
D_3(30x20cm)	19.68	21.00	20.34	28.75	29.83	29.29	91.88	92.18	92.03
'F' test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
SE (m)±	0.49	0.41	0.30	0.48	0.51	0.39	1.59	1.83	1.65
CD at 5%	1.44	1.20	0.88	1.42	1.49	1.14	4.69	5.37	4.84
Factor B - Calcium nitrate spray(S)									
S_1(Water spray)	19.86	21.18	20.52	30.74	32.24	31.49	95.86	96.86	96.36
S_2 (0.5%)	22.00	22.41	22.20	33.21	34.28	33.75	111.29	112.40	111.84
S_3(1.0%)	23.42	25.50	24.46	35.27	36.94	36.11	119.74	120.16	119.95
S_4(1.5%)	22.45	23.58	23.01	34.11	35.32	34.71	115.02	115.69	115.36
'F' test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
SE (m)±	0.57	0.47	0.35	0.56	0.59	0.45	1.84	2.11	1.90
CD at 5%	1.66	1.39	1.01	1.64	1.72	1.32	5.41	6.21	5.59

Table 3: Studies on influence of different plant densities and calcium nitrate spray on flowering parameter of China aster

Treatments	Days for emergence of first flower bud (days)			Days required for full opening of flower from bud initiation (days)			Days for 50% flowering (days)			Days to first harvesting (days)			Duration of flowering (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
Factor A - Plant density (D)															
D_1(30x45cm)	78.64	75.21	76.93	18.14	17.32	17.73	90.88	90.46	90.67	96.55	93.96	95.25	21.31	23.02	22.17
D_2(30x30cm)	76.72	73.66	75.19	17.31	16.39	16.85	88.88	82.57	85.73	91.71	86.49	89.10	21.99	24.58	23.28
D_3(30x20cm)	70.13	68.39	69.26	16.59	15.07	15.83	78.54	74.06	76.30	80.54	76.14	78.34	23.62	25.00	24.31
'F' test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
SE (m)±	1.34	1.34	1.07	0.37	0.56	0.28	1.28	1.65	1.23	1.96	1.66	1.39	0.63	0.37	0.37
CD at 5%	3.95	3.93	3.15	1.09	1.64	0.84	3.77	4.85	3.61	5.75	4.88	4.09	1.85	1.09	1.09

Factor B - Calcium nitrate spray(S)															
S_1(Water spray)	81.51	81.69	81.61	19.97	18.07	19.02	89.93	92.65	91.29	95.81	95.65	95.73	16.84	20.86	18.85
S_2 (0.5%)	76.59	75.11	75.86	18.53	17.29	17.91	89.04	86.67	87.86	91.93	89.89	90.91	21.63	22.13	21.88
S_3(1.0%)	70.20	62.96	66.58	14.14	14.02	14.09	81.84	70.60	76.22	84.39	73.60	79.00	27.11	27.79	27.45
S_4(1.5%)	72.35	69.90	71.13	16.74	15.67	16.21	83.60	79.53	81.57	86.26	82.98	84.62	23.66	26.01	24.83
'F' test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
SE (m)±	1.55	1.54	1.24	0.43	0.64	0.33	1.48	1.90	1.42	2.26	1.92	1.69	0.73	0.43	0.43
CD at 5%	4.56	4.53	3.64	1.26	1.90	0.97	4.35	5.60	4.17	6.65	5.63	4.72	2.14	1.26	1.26

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