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Effect of NPK, Biofertilizers and Biostimulants on flowering, flower quality and yield of China aster Cv. 'Arka Kamini'

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Abstract
The present study entitled "Effect of NPK, Biofertilizers and Biostimulants on flowering, flower quality and yield of China aster (*Callistephus chinensis* L.) Cv. Arka Kamini" was carried at Floricultural Research Station, (Agricultural Research Institute) Rajendranagar, Hyderabad during October 2020 to April 2021. The experiment was laid out in Completely Randomized Design with three replications and seven treatments. Among different treatments of flowering, flower quality and yield parameters T_3 - RDF 75% + Azotobacter + PSB + KSB + Seaweed extract (0.5%) recorded least number of days taken for flower bud initiation (50.64 days), minimum number of days taken for bud opening (18.33 days), minimum number of days for 50% flowering (60.97 days), maximum duration of flowering (48.37 days), maximum flower longevity on plant (15.22 days), maximum number of flowers per plant (21.98) and maximum flower yield per plant (50.16 g). Whereas, all the flowering parameters are at par with treatment T_6 - RDF 50% + Azotobacter + PSB + KSB + Seaweed extract (0.5%) flower bud initiation (51.82 days), number of days taken for bud opening (18.50 days), number of days for 50% flowering (61.28 days), duration of flowering (48.00 days). Therefore, it is concluded that T_3 - RDF 75% + Azotobacter + PSB + KSB + Seaweed extract (0.5%) is the better treatment for flowering and yield parameters when compared with other treatments. The highest benefit cost ratio of 2.37 was obtained in the treatment T_3 - RDF 75% + Azotobacter + PSB + KSB + Seaweed extract (0.5%).

Keywords: China aster, Azotobacter, PSB, KSB, Seaweed extract

Introduction
Among loose flowers China aster is one of the important flower crops due to its varied range of colours and ease of cultivation. China aster (*Callistephus chinensis* L.) is a member of Asteraceae family. It is one of the most important commercial annual flower crops grown in most parts of the world. Among annual flowers, it ranks third next to chrysanthemum and marigold. (Janakiram, 1997) [9]. China aster name indicates a star and the flower is no less than a star in its appearance and vibrance. It is native to China and has spread to Europe and other tropical countries during 1731 AD (Desai, 1967) [7]. The colour range is so great that today China aster is one of the most valuable garden flowers. In all the different colours, pure white, many shades of pink, pale blue, purple, dark blue and scarlet are widely cultivated. The pure yellow colour is not found in aster (Randhawa and Mukhopadhyay, 2000) [21].

Biofertilizers are formulations of organic origin which are easily available, cost effective and eco-friendly. They can improve soil health and provide protection against drought and some soil borne diseases (Sowmya and Prasad, 2017) [23]. Use of biofertilizers reduces per unit of consumption of inorganic fertilizers and increase the quality and quantity of flowers (Syamal *et al*., 2006) [26]. Biofertilizers have been found helpful in proliferation and survival of beneficial micro-organisms and improves soil properties leading to sustained soil fertility (Harris *et al*, 1966) [8].

Biostimulants are the materials other than the fertilizers that promote the plant growth when applied in minute quantities and are also referred as metabolic enhancers. Further, they promote the plant growth besides improving yield and quality. The use of biostimulants, which has the capacity to beneficially modify plant growth, has grown dramatically over the past decade (Vinutha *et al*, 2017) [29]. However, the research related to use of biostimulants and biofertilizers in combination with inorganic fertilizers in China aster is meagre.

Hence, in view of the above facts the present study was formulated to study the influence of NPK, biofertilizers and biostimulants on flowering, flower quality and yield of China aster Cv. 'Arka Kamini'

Materials and Methods

The present investigation, was carried out at Floricultural Research Station (Agricultural Research Institute), Sri Konda Laxman Telangana State Horticultural University, Rajendranagar, Hyderabad during October 2020 to April 2021. The experiment was laid out in Completely Randomized Block Design (CRD) with seven treatment combinations. The treatment details of experiment are T_1- Recommended Dose of Fertilizers (RDF) 100%, T_2- RDF 75% + Azotobacter + Phosphate Solubilizing Bacteria (PSB) + Potassium Solubilizing Bacteria (KSB), T_3- RDF 75% + Azotobacter + PSB + KSB + Seaweed extract (0.5%), T_4- RDF 75% + Azotobacter + PSB + KSB + Humic acid (0.5%), T_5- RDF 50% + Azotobacter + PSB + KSB, T_6- RDF 50% + Azotobacter + PSB + KSB + Seaweed extract (0.5%), T_7- RDF 50% + Azotobacter + PSB + KSB + Humic acid (0.5%). The RDF of China aster was 36 kg N: 48 kg P: 24 kg K acre^{-1} at the time of planting + 36 kg N acre^{-1} split 40 Days after planting.

Fifty days old seedlings at four to five leaf stages were transplanted in pots on 23rd November 2020. Before transplanting the roots were dipped in Azotobacter, PSB and KSB in form of liquid formulations at 2.5 ml/l each for half an hour. Again, second application was given at 45 days after planting after pinching Azotobacter at 3 ml/land KSB at 3ml/l as drenching. Biostimulants were sprayed at 3 intervals *viz*., 30, 60 and 90 days after transplanting (DAT). The data collected from the month January 2021 to March 2021 was statistically analyzed using the method given by Panse and Sukhatme (1967) [19].

Results and Discussion

The data pertaining to flowering parameters are presented in Table 1 and flower quality and yield parameters are presented in Table 2.

Number of days taken for flower bud initiation

Significant differences were noticed among the treatments in China aster for number of days taken for flower bud initiation and presented in Table 1. Among the seven treatments T_3- RDF 75% + Azotobacter + PSB + KSB + Seaweed extract (0.5%) was earliest to show visible flower bud (50.64 DAT) and was found to be at par with treatment T_6 - RDF 50% + Azotobacter + PSB + KSB + Seaweed extract (0.5%) (51.82 DAT). The flower bud initiation was recorded late (68.22 days) in T_1 – RDF 100%.

The earliest in flower bud initiation in T_3 (RDF 75% + Azotobacter + PSB + KSB + Seaweed extract (0.5%)) might be due to the early change of vegetative primordia to reproductive primordia by the production of growth promoting substances with the application of biofertilizers and bio stimulants, which might have promoted sufficient vegetative growth required for flower bud formation (Anuradha *et al.*, 1990) [2]. Similar results were also observed by Thane *et al.* (2009) [28] in gerbera. Seaweed extracts decreased the number of days to first flower bud initiation in cucumber (Taha and Salih 2014) [27].

Number of days taken for bud opening

Minimum number of days taken for bud opening (18.33 days) was observed in T_3 - RDF 75% + Azotobacter + PSB + KSB + Seaweed extract (0.5%) which was found to be at par with (18.50 days) in T_6 - RDF 50% + Azotobacter + PSB + KSB + Seaweed extract (0.5%). Maximum number of days taken for bud opening (20.50 days) was observed in T_1 – RDF 100%.

The reason for earliness in flowering might be due to proper uptake of nutrients and production of growth promoting substances like auxins, gibberellins, vitamins and organic acids by the biofertilizers. Further, phosphorus is an important element and essential for the initiation of flowering and PSB is known to increase the availability of phosphorus resulting in early flowering (Anuradha *et al.*, 1990) [2]. Similar results of earlier flowering by combined application of NPK and biofertilizers were reported by Chaitra and Patil (2007) [5] and Kirar *et al.* (2014) [10] in China aster.

Number of days for 50% flowering

Minimum number of days for 50 per cent flowering (60.97 days) was observed in T_3- RDF 75% + Azotobacter + PSB + KSB + Seaweed extract (0.5%) which was found to be at par with T_6 - RDF 50% + Azotobacter + PSB + KSB + Seaweed extract (0.5%) (61.28 days). Maximum number of days for 50 per cent flowering (79.67 days) was observed in T_1 – RDF 100%.

Minimum number of days for 50% flowering was due to increased uptake of NPK might have resulted in rapid acceleration in development of vegetative growth, leading to early cessation of the vegetative growth (Omi Tayeng, 2010) [17]. This might have further enabled the plants to produce more photosynthates and supply for the early floral primordial development which consequently led to early flower initiation and 50% flowering. The results are in agreement with the finding of Chaitra and Patil (2007) [5].

Duration of flowering (days)

The treatment T_3- RDF 75% + Azotobacter + PSB + KSB + Seaweed extract (0.5%) recorded significantly longer flowering duration of (48.37 days) and it was at par with T_6 - RDF 50% + Azotobacter + PSB + KSB + Seaweed extract (0.5%) (48.00 days). The treatment T_1 recorded the minimum duration of flowering (42.67 days).

Flowers remained presentable for maximum time on the plants due to RDF 75% + Azotobacter + PSB + KSB + Seaweed extract (0.5%) (T_3) might be the role of NPK, bio fertilizers and seaweed extract in increasing growth parameters and translocation and accumulation of more photosynthates might be the reason for increased flowering duration. These results are in accordance with Airadevi (2012) in annual chrysanthemum who recorded maximum flowering duration with Azospirillum + PSB + 50% vermicompost equivalent to recommended dose of N + 50% NPK. Srikrishna and Sutharsan (2018) [25] found that, foliar application of seaweed extract increased growth and flowering in Anthurium.

Flower diameter (cm)

The maximum flower diameter (5.53 cm) was recorded in T_6 - RDF 50% + Azotobacter + PSB + KSB + Seaweed extract (0.5%) which was at par with T_7 - RDF 50% + Azotobacter + PSB + KSB + Humic acid (0.5%) (5.21 cm). Whereas, the minimum diameter of flower (4.74 cm) was observed in T_1 – RDF 100%.

This might be ascribed to the proper uptake of nutrients by plants with inoculation of biofertilizers, biostimulants and their better translocation to the flowers (Omi Tayeng, 2010) [17]. The result is in agreement with the findings of Kirar *et al.*

(2014) [10] in China aster who reported maximum length and width of floral head with 50% NPK + VC + Azotobacter + PSB. Sridhar and Rangasamy (2010) [24], reported that seaweed extract can improve accumulation of total carbohydrate, total protein and total lipid contents in *Tagetes erecta.*

Flower longevity on plant (days)

Among the treatments studied the treatment T_3- RDF 75% + Azotobacter + PSB + KSB + Seaweed extract (0.5%) showed maximum flower longevity on plant (15.22 days) which was significantly followed by treatment T_6 - RDF 50% + Azotobacter + PSB + KSB + Seaweed extract (0.5%) (12.39 days). Whereas, treatment T_2 - RDF 75% + Azotobacter + PSB + KSB registered minimum flower longevity on plant (10.50 days) and was at par with T_4 - RDF 75% + Azotobacter + PSB + KSB + Humic acid (0.5%) (10.58 days).

Number of flowers per plant

The maximum number of flowers per plant (21.98) were observed in T_3- RDF 75% + Azotobacter + PSB + KSB + Seaweed extract (0.5%) which was at par with T_7 - RDF 50% + Azotobacter + PSB + KSB + Humic acid (0.5%) (20.91) number of flowers per plant, respectively. The minimum number of flowers per plant (10.56) was observed in the treatment T_5 - RDF 50% + Azotobacter + PSB + KSB.

The significant increase in number of flowers might be due to proper nitrogen, phosphorus and potassium assimilation from the 75% NPK in association with more nitrogen fixing and phosphorus solubilizing proficiency and secretion of hormones by the biofertilizers. Application of humic substances tends to increase the respiration rate, metabolism rate and growth of plants as reported by Schnitzer and Khan (1972) [22]. Further, these results got support from Mittal *et al*. (2010) and Kumar *et al*. (2009) [11] in African marigold; Meshram *et al*. (2008) [15] in annual chrysanthemum; Chougala *et al*. (2014) [6] in double daisy.

Flower yield per plant (g)

The highest flower yield per plant (50.16 g) was observed in T_3- RDF 75% + Azotobacter + PSB + KSB + Seaweed extract (0.5%) which as at par T_7 (48.43 g) flower yield per plant, respectively. The treatment T_5- RDF 50% + Azotobacter + PSB + KSB obtained minimum flower yield per plant (24.01 g).

It might be due to the production of phytohormones by the biofertilizers and seaweed extract or humic acid, which stimulated root growth and induced changes in root morphology, which in turn affected the assimilation of the nutrients (Maninderpal singh, 2016) [13]. The results of the present study are in conformity with those of Patil and Agasimani (2013) [20] and Kirar *et al*. (2014) [10] in China aster; Mittal *et al*. (2010) in African marigold; Meshram *et al*. (2008) [15], Panchal *et al*. (2010) [18] in annual chrysanthemum and Kumari *et al*. (2014) [12] in chrysanthemum.

Soil nutrient status

The data on available nitrogen, phosphorus and potassium in soil after harvest are presented in Table 3.

Available nitrogen in soil (kg/ha).

The highest available nitrogen (208.33 kg/ha) was recorded in treatment T_3 - RDF 75% + Azotobacter + PSB + KSB + Seaweed extract (0.5%) and was found to be significantly followed by T_4 - RDF 75% + Azotobacter + PSB + KSB + humic acid (0.5%) (203.98 kg/ha). The lowest available nitrogen (181.23 kg/ha) was recorded in treatment T_5 - RDF 50% + Azotobacter + PSB + KSB.

Available phosphorus in soil (kg/ha).

The highest available phosphorus (57.91 kg/ha) was recorded in treatment T_3 - RDF 75% + Azotobacter + PSB + KSB + Seaweed extract (0.5%) and was found to be significantly followed by T_4 - RDF 75% + Azotobacter + PSB + KSB + humic acid (0.5%) (54.37 kg/ha). The lowest available phosphorus (39.68 kg/ha) was recorded in treatment T_5 - RDF 50% + Azotobacter + PSB + KSB.

Available potassium in soil (kg/ha).

The highest available potassium (162.56 kg/ha) was recorded in treatment T_3 - RDF 75% + Azotobacter + PSB + KSB + Seaweed extract (0.5%) and was found to be significantly followed by T_4 - RDF 75% + Azotobacter + PSB + KSB + humic acid (0.5%) (160.79 kg/ha). The lowest available potassium (151.92 kg/ha) was recorded in treatment T_5 - RDF 50% + Azotobacter + PSB + KSB.

The available NPK in soil increased with combined application of inorganic fertilizers, biofertilizers and biostimulants over their individual applications. This may be attributed due to the direct addition of adequate supply of inorganic nutrients to the soil and also due to the slow release of nutrients through Azotobacter, PSB, KSB and Seaweed extract in the soil. Biofertilizers and biostimulants plays a major role in increasing the availability of nutrients by enriching the humus (Beaulah *et al*., 2004) [3]. Similar observations were also made by Mashaldi (2000) [14] in marigold and Chaitra (2006) [4] in China aster.

Table 1: Effect of NPK, Biofertilizers and Biostimulants on flowering of China aster (*Callistephus chinensis* L.) Cv. Arka Kamini.

Treatments	Number of days taken for flower bud initiation	Number of days taken for bud opening	Number of days for 50% flowering	Duration of flowering (days)
T_1- RDF 100%	68.22	20.50	79.67	42.67
T_2- RDF 75% + Azotobacter + PSB + KSB	54.42	18.75	64.49	45.80
T_3- RDF 75% + Azotobacter + PSB + KSB + Seaweed extract (0.5%)	50.64	18.33	60.97	48.37
T_4- RDF 75% + Azotobacter + PSB + KSB + Humic acid (0.5%)	55.08	18.78	65.33	43.84
T_5- RDF 50% + Azotobacter + PSB + KSB	56.85	19.33	65.58	45.60
T_6- RDF 50% + Azotobacter + PSB + KSB + Seaweed extract (0.5%)	51.82	18.50	61.28	48.00
T_7- RDF 50% + Azotobacter + PSB + KSB + Humic acid (0.5%)	60.95	19.67	72.23	46.00
S.Em ±	0.91	0.29	0.69	0.68
CD at 5%	2.77	0.86	2.09	2.07

Table 2: Effect of NPK, Biofertilizers and Biostimulants on flower quality and yield of China aster (*Callistephus chinensis* L.) Cv. Arka Kamini

Treatments	Flower diameter (cm)	Flower longevity on plant (days)	Number of flowers per plant	Flower yield per plant (g)
T_1- RDF 100%	4.74	12.00	17.00	35.72
T_2- RDF 75% + Azotobacter + PSB + KSB	5.03	10.50	16.22	32.13
T_3- RDF 75% + Azotobacter + PSB + KSB + Seaweed extract (0.5%)	5.14	15.22	21.98	50.16
T_4- RDF 75% + Azotobacter + PSB + KSB + Humic acid (0.5%)	5.07	10.58	18.41	45.02
T_5- RDF 50% + Azotobacter + PSB + KSB	4.91	11.64	10.56	24.01
T_6- RDF 50% + Azotobacter + PSB + KSB + Seaweed extract (0.5%)	5.53	12.39	18.34	44.08
T_7- RDF 50% + Azotobacter + PSB + KSB + Humic acid (0.5%)	5.21	11.33	20.91	48.43
S.Em ±	0.11	0.18	0.37	0.65
CD at 5%	0.35	0.55	1.13	1.97

Table 3: Effect of NPK, Biofertilizers and Biostimulants on soil nutrient status after harvest of China aster (*Callistephus chinensis* L.) Cv. Arka Kamini

Treatments	Available N_2 (kg/ha)	Available P_2O_5 (kg/ha)	Available K_2O (kg/ha)	Initial N_2 (kg/ha)	Initial P_2O_5 (kg/ha)	Initial K_2O (kg/ha)
T_1- RDF 100%	186.82	42.56	153.35	165	36	144
T_2- RDF 75% + Azotobacter + PSB + KSB	199.56	52.23	157.29			
T_3- RDF 75% + Azotobacter + PSB + KSB + Seaweed extract (0.5%)	208.33	57.91	162.56			
T_4- RDF 75% + Azotobacter + PSB + KSB + Humic acid (0.5%)	203.98	54.37	160.79			
T_5- RDF 50% + Azotobacter + PSB + KSB	181.23	39.68	151.92			
T_6- RDF 50% + Azotobacter + PSB + KSB + Seaweed extract (0.5%)	190.48	47.19	156.83			
T_7- RDF 50% + Azotobacter + PSB + KSB + Humic acid (0.5%)	187.07	40.86	154.18			
Mean	193.92	47.82	156.70			
S.Em ±	0.38	0.20	0.26			
CD at 5%	1.16	0.62	0.78			

Conclusion

Therefore, it may be concluded that the application of RDF 75% + Azotobacter + PSB + KSB + Seaweed extract (0.5%) T_3 recorded minimum number of days taken to flower bud initiation (50.64 days), number of days taken for bud opening (18.33 days) and 50 per cent flowering (60.97 days). Maximum duration of flowering (48.37 days), flower longevity on plant (15.22 days), number of flowers per plant (21.98) and flower yield per plant (50.16 g). The highest benefit cost ratio of 2.37 was obtained in the treatment T_3 - RDF 75% + Azotobacter + PSB + KSB + Seaweed extract (0.5%).

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