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Effect of bio-fertilizers on growth and flower quality of China Aster (*Callistephus chinensis* (L.) Nees.) Cv. Arka Kamini at different NPK levels under coastal AP conditions

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Abstract
China Aster (*Callistephus chinensis* (L.) NEES.) was a hardy winter annual, originated in China and belongs to plants family Asteraceae was one of the commercially cultivated flowering annual. China Aster can be used as cut flower, potted plant and as flowering borders in landscape gardening. Despite of its importance the productivity of the flowers was not upto the mark and to reach the needs very high doses of chemical fertilizers has to be used. Due to high usage of inorganic fertilizers the soil properties are deteriorated greatly and to mitigate this negative effect an experiment was conducted to know the best combination of Inorganic fertilizers with Biofertilizers which were known to have a positive effect on nutrient uptake when contacted with rhizosphere. Different combinations of Recommended Dose of (RDF) with Biofertilizers [*Azospirillum*, Potassium Mobilizing Bacteria (KMB) and Phosphate Solubilizing Bacteria (KMB)] were analysed in the Variety Arka Kamini at Coastal region of Andhra Pradesh. The experimental results revealed that all the vegetative parameters except plant height was superior in the plants those received 100% RDF with *Azospirillum* @ 4 kg acre^{-1} + PSB @ 4 kg acre^{-1} + KMB @ 4 kg acre^{-1}. The quality of the flowers was greater when the plants received 120% RDF with same dose of Biofertilizer but, the yield was more when 100% RDF was given with each biofertilizer @ @ 4 kg per acre.

Keywords: *Azospirillum*, potassium mobilizing bacteria and phosphate solubilizing bacteria

Introduction
China Aster (*Callistephus chinensis* (L.) NEES.) belongs to plant family Asteraceae which was originated in China was a commercially cultivated winter hardy flowering annual used as cut flower, potted plant and as loose flower. The genus *Callistephus* has been derived from two Greek words namely '*Kalistos*' and '*Stephos*' which means 'Beautiful Crown" (Naikwad *et al.*, 2018) [11]. Among the different cultivars of China Aster Arka Kamini was a leading commercially cultivated in the states of Karnataka, Tamil Nadu, Andhra Pradesh and West Bengal. Arka Kamini was a hybrid between two purelines AST6 X AST36 which was released by IIHR, Bengalore possess pink flowers that can be used as loose as well as cut flowers (Sankar *et al.*, 2015) [19]. Among the different factors affecting the plant growth and development nutrition plays a vital role. The recommended dose of fertilizer (RDF) for China Aster was 180:120:60 NPK kg/ha (Munikrishnappa *et al.*, 2011) [10] and sometimes even the higher doses of fertilizers were giving best results and hence an experiment was conducted at College of Horticulture, Dr. YSR Horticultural University, Venkataramannagudem, West Godavari, Andhra Pradesh, India to know the best combination of different levels of RDF with three biofertilizers namely *Azospirillum*, Potassium Mobilizing Bacteria (KMB), Phosphate Solubilizing Bacteria (KMB) at different levels in order to result better growth and development. Biofertilizers are living cells that are known to help the plant in nutrient uptake when they interact with the rhizosphere of the plants (Rajesha and Ray, 2020) [17]. Use of high dose of fertilizers to get good yields impedes the physical, chemical and biological properties of the soil leading to deterioration of soil quality. In the modern farming use of biofertilizers along with the chemical fertilizers helps to mitigate the above mentioned problems and the information on the use of NPK along with biofertilizers as a combination was lacking in the coastal Andhra Pradesh in the crop, China Aster.

Material and Methods

The present investigation was carried out at College of Horticulture, Dr. Y.S.R. Horticultural University, Venkataramannagudem, West Godavari District, Andhra Pradesh. The experiment was laid out in a Factorial Randomized Block Design (FRBD) with two replications. The treatments in each replication were allotted randomly. The experiment consists of two factors, one was RDF with five levels and the other was Biofertilizers with three levels and the details of factors are as follows- FACTOR- I : NPK– 5 levels: F_1-80% NPK (144 : 96 : 48 Kg ha^{-1}) F_2- 90% NPK (162 : 108 : 54 Kg ha^{-1}) F_3- 100% NPK (180 : 120 : 60 Kg ha^{-1}) F_4- 110% NPK (198 : 132 : 66 Kg ha^{-1}) and F_5- 120% NPK (216 : 144 : 72 Kg ha^{-1}). FACTOR-II : Bio-fertilizer– 3 levels : B_1- *Azospirillum* @ 2 kg $acre^{-1}$ + PSB @ 2 kg $acre^{-1}$ + KMB @ 2 kg $acre^{-1}$, B_2- *Azospirillum* @ 3 kg acre-1 + PSB @ 3 kg $acre^{-1}$ + KMB @ 3 kg $acre^{-1}$ and B_3-*Azospirillum* @ 4 kg $acre^{-1}$ + PSB @ 4 kg $acre^{-1}$ + KMB @ 4 kg $acre^{-1}$. All the biofertilizers were inoculated in well rotten FYM and incubated for a month and applied to the plant at the root zone 7 days after transplanting along with FYM @ 50 g $plant^{-1}$ and covered with soil to avoid direct sunlight interference. Adequate moisture was maintained in the field for favourable growth of micro-organisms.

Results and Discussion

The data recorded on various vegetative, floral and soil parameters are subjected to statistical analysis. The results are presented in following subheads with appropriate discussion where ever necessary.

Vegetative parameters

Significant differences were observed among different RDF levels in all vegetative parameters. 120% RDF recorded highest plant height (64.69 cm) and except plant height remaining all vegetative parameters viz., number of branches $plant^{-1}$ (20.95), plant spread (832.37 cm^2), total chlorophyll content (54.87 SPAD units) and Dry weight of the plant (28.80 g) recorded maximum in plants treated with 100% RDF. It was evident from the data that the maximum plant height was recorded in 120% RDF. It might be due to synergistic activities of all the growth nutrients which played active role in enlarging plants cells and tissues, consequently increased plant height at higher dose of fertilizers. The variation in number of branches $plant^{-1}$ among the RDF levels could be attributed to the increased levels of cytokinin in plants due to nitrogen application at optimum dosage at effective root zone resulted in well distribution to above ground parts and promoted the lateral buds to sprout producing more number of lateral branches and thereby increasing plan spread. At optimum dose of RDF the nutrient absorption was more resulting higher chlorophyll content in leaves. Due to high chlorophyll content the at 100% RDF photosynthetic rate was more and accumulated more dry matter. The results are in conformity with the findings of Mohit *et al.*, (2008) [9] in China Aster, Pal and Ghosh (2010) [13] in Marigold, Dorajeerao *et al.*, (2012) [5] in Chrysanthemum and Pooja *et al.*, (2016) [15] in China Aster.

All the Bio-fertilizer levels had shown significant differences with respect to vegetative parameters. The treatment *Azospirillum* @ 4 kg $acre^{-1}$ + PSB @ 4 kg $acre^{-1}$ + KMB @ 4 kg $acre^{-1}$ recorded maximum plant height (54.02 cm), number of branches $plant^{-1}$ (18.38), plant spread (764.73 cm^2), total chlorophyll content (52.74 SPAD units) and Dry weight of the plant (26.56 g). The increased plant height might be due to synergistic effect of all bio-fertilizers. *Azospirillum* is an aerobic free living bacterium and has specific role in fixing atmospheric nitrogen in soil, PSB enhances availability of phosphorus and promote root growth and KMB enhance availability of potash and promote stem growth. Increased number of branches might be due to production of auxin and gibberellins type of plant growth regulators. The high chlorophyll content might be due to higher fixation of nitrogen which was main constituent of chlorophyll pigment by *Azospirillum* resulting increased total chlorophyll content in leaves. The applied bio-fertilizers might have produced GA_3 which increased the photosynthetic activity in leaves by activating the Rubisco enzyme in leaves thereby increased the dry matter accumulation in plant as well as dry weight $plant^{-1}$. Similar findings were also reported by Abhinav and Ashok (2017) [1] and Kulveer *et al.*, (2018) [6] in Marigold and Divya *et al.*, (2019) [4] in Zinnia.

All the interaction effects shown significant differences among them. The treatment combination 120% RDF + *Azospirillum* @ 4 kg $acre^{-1}$ + PSB @ 4 kg $acre^{-1}$ + KMB @ 4 kg $acre^{-1}$ (F_5B_3) recorded maximum plant height (65.22 cm). The treatment combination 100% RDF + *Azospirillum* @ 4 kg $acre^{-1}$+ PSB @ 4 kg $acre^{-1}$ + KMB @ 4 kg $acre^{-1}$ (F_3B_3) recorded highest in number of branches $plant^{-1}$ (22.74), plant spread (847.84 cm^2), total chlorophyll content (55.35 SPAD units) and Dry weight of the plant (29.11 g). The increased plant height with F_5B_3 might be due to the combined application of bio-fertilizers with NPK at this dose resulted in better nutrition leading to increased photosynthetic activity, enhanced cell division and enlargement as nitrogen is important constituent of nucleic acid and it might have increased the synthesis of carbohydrate, amino acids etc. from which the phytohormones like auxins and gibberellins have been synthesized. Similar findings were earlier reported by Maninderpal *et al.*, (2017) [7] and Subash *et al.*, (2018) [22] in China Aster and Manoj *et al.*, (2017) [8] in Marigold.

Table 1: Effect of RDF, bio-fertilizer levels and their interaction on vegetative parameters

Treatments	Plant height (cm)	No of branches plant^{-1}	Plant spread (cm^2)	Total chlorophyll content (SPAD units)	Dry weight of the plant above the ground (g)
F_1	41.32	13.16	674.44	47.60	22.88
F_2	45.09	15.46	708.77	50.74	25.17
F_3	53.31	20.95	832.37	54.87	28.80
F_4	59.30	19.18	790.10	53.21	27.21
F_5	64.69	17.43	749.69	52.55	26.13
S Em	1.48	0.36	8.81	1.88	1.76
CD at 5%	4.50	1.10	26.72	5.70	5.33
B_1	51.19	16.30	737.52	51.18	25.36
B_2	53.01	17.03	750.98	51.47	26.18
B_3	54.02	18.38	764.73	52.74	26.56
S Em	1.15	0.28	6.82	1.46	1.36
CD at 5%	3.49	0.85	20.69	4.41	4.13
F_1 B_1	40.05	11.38	664.70	46.27	20.85
F_1 B_2	41.70	13.51	673.14	46.90	23.67
F_1 B_3	42.20	14.58	685.48	49.64	24.11
F_2 B_1	42.98	14.78	693.34	49.93	24.88
F_2 B_2	45.97	14.98	710.85	50.18	25.14
F_2 B_3	46.32	16.62	722.11	52.10	25.48
F_3 B_1	51.58	19.61	817.50	54.41	28.41
F_3 B_2	53.04	20.51	831.77	54.85	28.87
F_3 B_3	55.30	22.74	847.84	55.35	29.11
F_4 B_1	57.44	18.93	776.86	52.90	26.80
F_4 B_2	59.37	19.22	789.90	52.82	27.15
F_4 B_3	61.08	19.39	803.53	53.90	27.67
F_5 B_1	63.89	16.78	735.18	52.37	25.87
F_5 B_2	64.96	16.92	749.22	52.58	26.09
F_5 B_3	65.22	18.59	764.67	52.71	26.43
S Em	2.57	0.63	15.26	3.25	3.04
CD at 5%	7.79	1.91	46.27	9.87	9.23

Floral Parameters

Significant differences were observed among the different RDF levels in different floral parameters. The plants treated with 100% RDF took less number of days to flower bud initiation (58.92 d) and has long duration of flowering (31.21 d) and recorded maximum number of cut flowers plant^{-1} (33.64). Quality parameters like flower stalk length (29.88 cm), flower diameter (7.48 cm) and vase life (13.46 d) recorded highest in 120% RDF. The delayed flower bud initiation might be at higher nitrogen levels have favoured the amino acid metabolism of expenses of carbohydrate metabolism resulting in delayed flowering. The highest duration of flowering might be due to the synergistic effects of most of essential growth elements which increased the plant growth and contributing attributes to synthesis of more photoassimilates and their translocation to sink. Higher levels of nitrogen, phosphorus and potassium seemed to have increased the synthesis of peptide bond, protein and carbohydrate metabolism that are essential for flower development and might have increased stalk length. The increased flower diameter at highest level of RDF might be due to translocation of available photoassimilates to the formed floral meristems which are in less number, due to this availability of photoassimilates per floral primordial might have increased. At 120% RDF availability of more potassium which increases the rate of photosynthesis and mobilization of sucrose to the shoots which have positive influence in flower initiation (Stockman *et al*., 1983) [24], helps in the protein synthesis and increases resistance against stress which might have improved growth and development of the plant which ultimately increased vase life of the flower. The results are in accordance with Mohit *et al*., (2008) [9], Pooja *et al*., and Tembhare *et al*., (2016) [23] in China Aster and Anupam *et al*., (2018) [2] in zinnia.

Application of different Bio-fertilizer levels had shown significant differences. The plants treated with *Azospirillum* @ 4 kg acre^{-1} + PSB @ 4 kg acre^{-1} + KMB @ 4 kg acre^{-1} had taken minimum number of days to flower bud initiation (61.60), maximum duration of flowering (28.22), flower stalk length (27.92 cm), diameter of the flower (6.42 cm), vase life (11.80) and number of cut flowers plant^{-1} (30.65). It might be due to application of biofertilizers, *Azospirillum* has specific role in fixing atmospheric nitrogen in soil. It also synthesizes and secretes plant growth substances like, thiamin, riboflavin, pyridoxine, nicotinic acid, IAA (Indole Acetic Acid), gibberellins and vitamin B in addition to the production of antifungal antibiotics, which inhibit harmful fungi and have beneficial effect on crop growth. It also increases water uptake by plant. On the other hand, PSB enhances availability of phosphorus and promote root growth. It also secretes organic acids viz., formic, acetic, propionic, lactic, glycolic, fumaric and succinic acids, vitamins and growth promoting substances like IAA and gibberellins which might helped in better plant growth. KSB enhance availability of potash and promote stem growth. The results are in accordance with Rajesh *et al*., (2016) [17] in China Aster, Satish *et al*., (2017) [20] in Dahlia and Pansuriya *et al*. (2018) [14] in Gladiolus.

The interaction effect between NPK and bio-fertilizer levels had shown significant influence with respect to floral parameters. The treatment combination 100% RDF + *Azospirillum* @ 4 kg acre^{-1}+ PSB @ 4 kg acre^{-1} + KMB @ 4 kg acre^{-1} (F_3B_3) took less number of days to flower bud initiation (58.37) and maximum duration of flowering (31.68) and maximum number of cut flowers plant^{-1} (33.74). The quality parameters flower stalk length (30.11 cm), flower diameter (7.63 cm) and vase life (13.83) were recorded highest with treatment of 120% RDF + *Azospirillum* @ 4 kg acre^{-1} + PSB @ 4 kg acre^{-1} + KMB @ 4 kg acre^{-1} (F_5B_3). It could be due to better efficiency in combination with inorganic fertilizers and bio-fertilizers, the enhanced photosynthetic activity due to bio-fertilizers inoculation might have favored an increased accumulation of dry matter and also efficient partitioning of photosynthates towards the sink. Similar findings were also reported by Abhinav and Ashok (2017) [1] and Kulveer *et al.*, (2018) [6] in Marigold, Satish *et al.*, (2018) [20] in Chrysanthemum and Subash *et al.*, (2018) [22] in China Aster. The increase in quality parameters with F_5B_3 might be due to the synergistic effect of fertilizers with bio-fertilizers resulted in increased carbohydrate assimilation leading to increased vegetative growth. These carbohydrates when translocated to reproductive organs which are in less number underwent hydrolysis and got converted into the reducing sugars which ultimately helped in increasing flower size. The results are in line with Abhinav *et al.*, (2017) [1] and Kulveer *et al.*, (2018) [6] in Marigold, Sowmya and Prasad (2017) and Pagarharshal (2018) in China Aster.

Table 2: Effect of RDF, bio-fertilizer levels and their interaction on Floral parameters

Treatments	No. of Days taken to flower bud initiation (d)	Duration of flowering (d)	Flower stalk length (cm)	Flower diameter (cm)	Vase life (d)	Number of cut flowers plant^{-1}
F_1	66.81	24.49	23.45	4.55	9.56	20.30
F_2	63.82	26.20	25.91	5.45	10.16	28.16
F_3	58.92	31.21	27.57	6.57	11.66	33.64
F_4	60.21	28.81	29.09	6.98	12.39	33.22
F_5	61.95	27.68	29.88	7.48	13.46	32.65
S Em	3.65	0.51	0.78	0.15	0.48	1.03
CD at 5%	11.07	1.55	2.36	0.47	1.46	3.12
B_1	63.28	26.93	26.52	5.98	11.30	28.57
B_2	62.14	27.89	27.11	6.22	11.51	29.56
B_3	61.60	28.22	27.92	6.42	11.80	30.65
S Em	2.83	0.40	0.60	0.12	0.37	0.80
CD at 5%	8.58	1.20	1.83	0.36	1.13	2.48
F_1 B_1	68.91	22.44	21.65	4.24	9.38	17.90
F_1 B_2	66.29	25.37	23.64	4.59	9.53	19.08
F_1 B_3	65.23	25.66	25.06	4.82	9.78	23.91
F_2 B_1	64.55	25.90	25.53	5.23	10.39	25.70
F_2 B_2	63.72	26.25	25.80	5.39	10.54	29.23
F_2 B_3	63.18	26.45	26.39	5.74	10.89	29.56
F_3 B_1	59.21	30.72	27.14	6.31	11.54	33.55
F_3 B_2	59.18	31.23	27.41	6.59	11.68	33.64
F_3 B_3	58.37	31.68	28.15	6.80	11.77	33.74
F_4 B_1	61.27	28.45	28.56	6.88	12.10	33.11
F_4 B_2	59.70	28.79	28.85	6.95	12.35	33.22
F_4 B_3	59.65	29.18	29.87	7.10	12.71	33.32
F_5 B_1	62.47	27.13	29.70	7.23	13.11	32.58
F_5 B_2	61.83	27.80	29.83	7.58	13.44	32.64
F_5 B_3	61.55	28.11	30.11	7.63	13.83	32.72
S Em	6.32	0.89	1.35	0.27	0.83	1.78
CD at 5%	19.17	2.69	4.09	0.81	2.53	5.41

Plate 1: Vase life study on effect of NPK, bio-fertilizers and their interaction

	Azo + PSB + KMB @ 2 kg acre^{-1}	*Azo* + PSB + KMB @ 3 kg acre^{-1}	*Azo* + PSB + KMB @ 4 kg acre^{-1}
80% RDF			
90% RDF			
100% RDF			
110% RDF			
120% RDF			

Plate 2: Effect of NPK, bio-fertilizers and their interaction on flower diameter (cm)

	Azo + PSB + KMB @ 2 kg $acre^{-1}$	*Azo* + PSB + KMB @ 3 kg $acre^{-1}$	*Azo* + PSB + KMB @ 4 kg $acre^{-1}$
80% RDF			
90% RDF			
100% RDF			
110% RDF			
120% RDF			

Plate 3: Effect of NPK, bio-fertilizers and their interaction on flower weight (g)

Conclusion

From the experiment it could be concluded that treatment combination of 100% RDF with *Azospirillum* @ 4 kg $acre^{-1}$ + PSB @ 4 kg $acre^{-1}$ + KMB @ 4 kg $acre^{-1}$was superior over other treatment combinations with respect to vegetative and floral parameters but, quality parameters were significantly superior in treatment combination of 120% RDF with *Azospirillum* @ 4 kg $acre^{-1}$ + PSB @ 4 kg $acre^{-1}$ + KMB @ 4 kg $acre^{-1}$. Hence it may be recommended to the farmers that application of 100% RDF with *Azospirillum* @ 4 kg $acre^{-1}$ + PSB @ 4 kg $acre^{-1}$ + KMB @ 4 kg $acre^{-1}$ is best practice to get good growth and yield in China Aster for the good flower production, as well as to get quality flowers as cut flower production application of 120% RDF with *Azospirillum* @ 4 kg $acre^{-1}$ + PSB @ 4 kg $acre^{-1}$ + KMB @ 4 kg $acre^{-1}$ is recommended for the prosperous cultivation of China Aster cv. Arka Kamini under coastal AP conditions.

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