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EFFECT OF BIOAGENTS ON GROWTH, FLOWERING AND YIELD OF CHINA ASTER (*CALLISTEPHUS CHINENSIS* (L.) NEES.) CV. ARKA KAMINI

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Abstract – A field experiment was conducted to know the effect of bioagents on growth and flowering of China aster cv. Arka Kamini at the department of Floriculture and Landscape Architecture, College of Horticulture, Mudigere, during 2018-19. The experiment was laid out in Randomized Completely Block Design (RCBD) with six bioagents were evaluated to know the influence on growth and flowering of China aster *viz.*, *Trichoderma asperellum, Pseudomonas fluorescens*, Arka Microbial Consortium (AMC), *Azorhizophilus* sp. (K solubilising bacteria), *Bacillus subtilis*, *Trichoderma harzianum* along with control as treatment and experiment was replicated thrice. Plant height (60.38 cm), number of branches (12.67), plant spread (568.82 cm^2), minimum days to first flower (65.33 days), flower head diameter (5.75 cm), vase life (8.60 days), number of flowers per plant (48.60), flower yield per plant (119.56 g) and flower yield per hectare (13.28 tons) were observed maximum in *Trichoderma harzianum* and which was on par with *Trichoderma asperellum* and *Bacillus subtilis* recorded poor performance with respect to growth and flowering compared to other bioagents. While the maximum number of colonies at 90 days of application was observed in Arka Microbial Consortium of about 92.5 CFU and 62.5 CFU at 10^{-1} and 10^{-2} dilutions respectively, this was on par with *Trichoderma harzianum* of about 85 CFU and 53 CFU at 10^{-1} and 10^{-2} dilutions respectively. The studies have conclusively proved that *Trichoderma harzianum* significantly increased the number of flowers per plant and flower yield of China aster.

INTRODUCTION

China aster [*Callistephus chinensis* (L.) Nees.] is an important winter annual flower and ornamental plant, belonging to the family Asteraceae with the diploid chromosome number of 2n = 18. The crop is native to China, spread to Europe and other tropical countries in 1731 A.D (Desai, 1967). The genus *Callistephus* is derived from two Greek words *Kalistos* meaning 'most beautiful' and *Stephos* 'a crown' referring to the flower head. It was first named by Linnaeus as *Aster chinensis* and Nees changed to *Callistephus chinensis* (Janakiram, 2006). Among annual flowers, China aster ranks next to chrysanthemum and marigold (Chaitra and Patil, 2007). The crop is cultivated throughout the world for cut flower, loose flower, in garden as flower beds and borders. It is a commercial flower crop of Russia, Japan, Europe, Switzerland and North America. In India, China aster is commercially grown in the states of Karnataka, Tamilnadu, Maharashtra, Telangana, Andhra Pradesh and West Bengal (Ramya *et al*., 2019). In Karnataka, it is widely cultivated in Bengaluru, Chitradurga, Tumkur,

Belagavi, Gadag, Bagalkot and Kolar districts in an area of 2,194 hectares with total production of 20,646 MT and the productivity of 9.41 t/ ha (Anon, 2015). It is grown successfully in an open condition during *kharif, rabi* and summer seasons for year around supply of flowers.

Fusarium wilt is the important soil borne disease in hilly area drastically reduces the yield of China aster. Biological control method invokes using a living organism to control another living organism which causes diseases in crop plants. The bioagents includes *Trichoderma viridae*, *Pseudomonas fluorescens* and *Bacillus subtilis.* Among these *Trichoderma viridae* is a saprophytic fungus used generally as potential biological control agent against a wide range of economically important soil-borne plant pathogens. Bioagents influences plant development by several mechanisms, such as production of growth hormones (Windham *et al*., 1986), solubilisation of insoluble minor nutrients in soil (Altomare *et al*., 1999) and increased uptake and translocation of less-available minerals (Kleifield and Chet, 1992). Uptake of P, K and N is of key importance considering their role in plant growth (Johansen, 1999). Use of bioagents will reduce the cost of cultivation, effective and organic way of management of *Fusarium* sp. Keeping these points in view, the present study was conducted to test the efficacy of bioagents on the growth, flowering and yield of China aster.

MATERIALS AND METHODS

The research was carried out in the Department of Floriculture and Landscape architecture, College of Horticulture, Mudigere, during 2018-19 in a Randomized Complete Block Design (RCBD) with seven treatments in three replicates for the statistical analysis. The China aster seedlings were transplanted after 45 days at a spacing of 30 cm × 30 cm.

Preparation of bioagents

The bioagents were prepared from pure cultures which were collected from College of Horticulture, Mysuru and subcultured in sterilized petriplates on specific media like potato dextrose agar media for fungi and King's B media for bacterial bioagents. Later, bioagents were mass cultured by autoclaving potato dextrose broth and nutrient broth at 121 °C for 15 Psi. The sub culture of bioagents were inoculated separately under aseptic condition in respective media and incubated at 27±1 °C for 10 days. The treatments were given by drenching different bioagents of about 50 mL suspended culture around the root zone of plants within 10 days after transplanting of seedlings. Then the package of practice UHS, Bagalkot was followed to raise the good crop.

Treatment details were T_1- *Trichoderma asperellum,* T_2- *Pseudomonas fluorescens*, T_3- Arka Microbial Consortium (AMC), T_4- *Azorhizophilus* spp. (K solubilising bacteria), T_5- *Bacillus subtilis*, T_6- *Trichoderma harzianum*, T_7- Control (Untreated). The effect of different bioagents was determined by taking observations of morphological parameters like plant height (cm), number of branches per plant, plant spread (cm^2), days to first flowering, duration of flowering (days), flower head diameter (cm), vase life (days), shelf life (hrs), number of flowers per plant, flower yield/ plant (g) and flower yield/ ha (tonnes).

Microbial analysis

The microbial population of the soil with respect to total fungal and bacterial bioagents were assessed by serial dilution method. Soil samples were collected from rhizosphere aseptically and stored in a refrigerator at 5 °C until further use.

Enumeration of soil microorganisms

Soil microbial populations were enumerated from soil samples collected from the rhizosphere of plant. The soil samples collected were mixed thoroughly and subjected to serial dilution. The enumeration of microorganisms was done after culturing these organisms using respective media by standard dilution plate technique and number of colonies after incubation was counted. Nutrient Agar (NA) for bacteria and Martin's Rose Bengal Agar (MRBA) for fungi were used to enumerate the microbial load.

RESULTS AND DISCUSSION

Significant difference for the growth, flowering and yield parameters of seven bioagent treatments were presented in Table 1. Vegetative parameters as influenced by bioagent treatments showed the maximum plant height (60.38 cm), number of branches (12.67) and plant spread (568.82 cm^2) was recorded in *Trichoderma harzianum* which was on par with *Trichoderma asperellum* for plant height (58.27 cm), number of branches per plant (11.46) and plant

spread (567.98 cm^2) while minimum plant height (56.69 cm), number of branches per plant (9.76) and plant spread (524.55 cm^2) was observed in *Bacillus subtilis* compared to other bioagents and over control. The increase in plant height, number of branches per plant might be due to the progressive mineralization of nutrients and supplementation of balanced nutrition for crop growth due to quick and greater availability of plant nutrients, providing a better environment for root growth and proliferation. It also creates more adsorptive surface for uptake of nutrients, which in turn leads to increased rate of meristematic activity. Simultaneously, plant growth regulators like IAA and cytokinins were released by *T. harzianum* and *T. asperellum* might have resulted in breaking of apical dominance and accelerated higher number of branches whereas, the maximum plant spread could be due to the increase in number of branches. These results are in conformity with the findings of Latt *et al*. (2017) in China aster, Karishma *et al*. (2011) in chrysanthemum, Kumari *et al*. (2013) in gladiolus.

Flowering parameters as influenced by bioagents shows that an early flowering was noticed in *T. harzianum* (65.33 days) which were on par with *T. asperellum* (66.10 days) whereas, *B. subtilis* took maximum number of days for flowering (69.20 days). The earliness in flowering due to the number of days the plant took for bud formation may had the effect on the number of days taken for first flower opening *i.e.,* the plant on which the bud formation occurred earlier will have earlier flowering. This might be due to proper uptake of nutrients and production of growth promoting substances. Thereby, plant completed its vegetative growth soon, resulting in early flowering. These finding are in conformity with the findings of Shabnam (2017) in China aster, Bellubbi *et al.* (2015) in gerbera, Nosir (2016) in tuberose.

Among the different treatments, *T. harzianum* had maximum flowering duration 40.07 days followed by Arka Microbial Consortium (38.33 days) and *T. asperellum* (37.93 days). Significantly, minimum flowering duration 35.87 days was recorded in *B. subtilis* (Table 1). Duration of flowering was maximum with *T. harzianum* could be attributed to the release of growth regulator GA_3, which increase in the level of RNA and protein in plant tissues resulting in an increase in total metabolites in plant cells, which probably plays some role in augmenting flowering characteristics. Similar results were observed by Shabnam (2017) in China aster, Bellubbi *et al.* (2015) in gerbera, Kumari *et al*. (2013) in gladiolus.

Flower quality parameters as influenced by bioagents shows that maximum flower head diameter (5.75 cm), vase life (8.60 days) and shelf life (39.00 hrs) was recorded in *T. harzianum* which was on par with *T. asperellum* for flower head diameter (5.65 cm), vase life (8.40 days) and shelf life (38.13 hrs) while minimum flower head diameter (5.52 cm), vase life (7.77 days) and shelf life (37.10 hrs) observed in *B. subtilis* compared to other bioagents and over control (Table 2). The increased flower head diameter might be ascribed to the proper uptake of nutrients by plants with inoculation of bioagent and their better translocation to the flowers. While maximum vaselife and shelf life might be increased flower stalk length and which might be due to overall food nutrient status of flowers which influences flower longevity due to the increased nutrient uptake by plants and greater development of water conducting tissue. The result is in agreement with the findings of Saini *et al.* (2019) in chrysanthemum, Bellubbi *et al.* (2015) in gerbera, Muthukumar *et al*. (2006) in tuberose.

Table 1. Effect of bioagents on growth and flowering of China aster cv. Arka Kamini.

Treatments	Plant height (cm)	No. of branches per plant	Plant spread (cm^2)	Days to first flowering	Duration of flowering (days)
T1- *Trichoderma asperellum*	58.27	11.46	567.98	66.10	37.93
T2- *Pseudomonas fluorescens*	57.60	9.93	533.56	69.07	36.33
T3- Arka Microbial Consortium	58.08	11.15	545.61	67.60	38.33
T4- *Azorhizophilus* sp.	57.63	11.03	536.38	67.93	36.67
T5- *Bacillus subtilis*	56.69	9.76	524.55	69.20	35.87
T6- *Trichoderma harzianum*	60.38	12.67	568.82	65.33	40.07
T7- Control (Untreated)	53.33	9.73	517.44	69.47	35.80
S. Em ±	0.71	0.40	0.29	0.26	0.51
CD (5%)	2.20	1.24	0.88	0.81	1.56

Flower yield parameters as influenced by bioagents shows that maximum number of flowers per plant (48.60), flower yield per plant (119.56 g) and flower yield per hectare (13.28 tons) was recorded in *T. harzianum* (Table 2 and plate 1) which was on par with *T. asperellum* for number of flowers per plant (47.67), flower yield per plant (114.40 g) and flower yield per hectare (12.71 tons) while minimum number of flowers per plant (43.33), flower yield per plant (99.66 g) and flower yield per hectare (11.07 tons) observed in *B. subtilis* compared to other bioagents and over control (Table 2 and Fig. 1). The *T. harzianum* had recorded maximum plant height, more number of branches, plant spread, early flowering and number of flowers thus resulted in maximum flower yield. The increased in flower yield might be attributed to the production and accumulation of maximum photosynthates in flowering branches and individual flowers, which ultimately resulting the production of maximum flower yield. Similar findings have been reported by Shabnam (2017) in China aster, Kumari *et al*. (2016) in chrysanthemum.

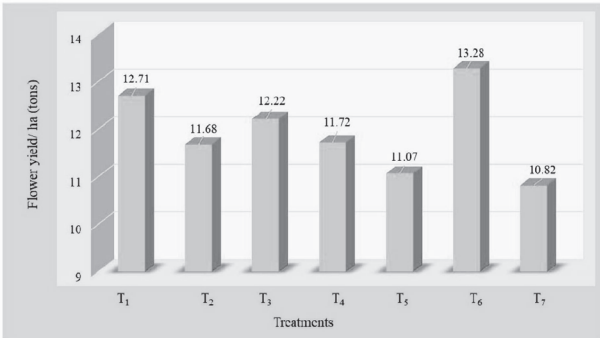


Fig. 1. Effect of different bioagents on flower yield of China aster cv. Arka Kamini.

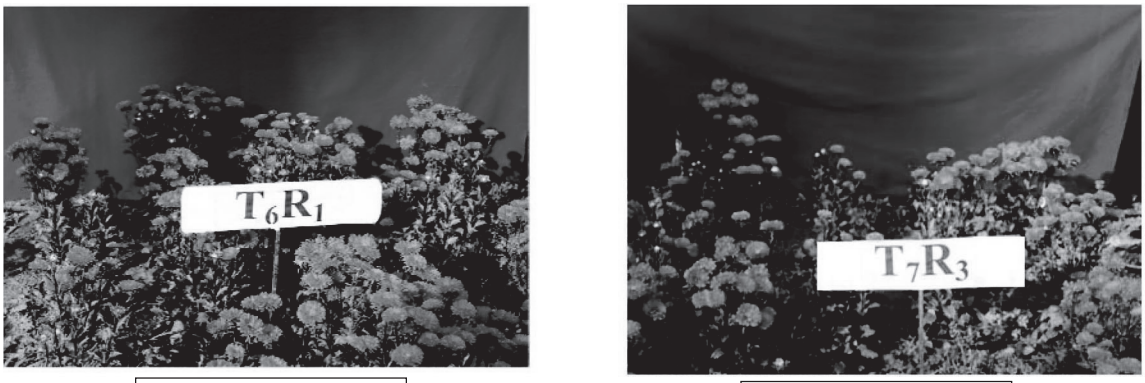
The colonization as influenced by different bioagents were shown in Table 3. At initial stage of application the maximum number of colonies were found in Arka Microbial Consortium of about 44.5 CFU and 21.5 CFU at 10^{-1} and 10^{-2} dilutions respectively, which was on par with *Trichoderma harzianum* of about 43.5 CFU and 21.0 CFU at 10^{-1} and 10^{-2} dilutions respectively. At 90 days of application the maximum number of colonies were observed in Arka Microbial Consortium of about 92.5 CFU and 62.5 CFU at 10^{-1} and 10^{-2} respectively,

Table 2. Effect of bioagents on quality and yield of China aster cv. Arka Kamini.

Treatments	Flower head diameter (cm)	Vase life (days)	Shelf life (hrs)	Number of flowers per plant	Flower yield/ plant (g)	Flower yield/ha (tons)
T1- *Trichoderma asperellum*	5.65	8.40	38.13	47.67	114.40	12.71
T2- *Pseudomonas fluorescens*	5.53	8.10	37.15	44.90	105.11	11.68
T3- Arka Microbial Consortium	5.56	8.33	37.30	46.22	110.00	12.22
T4- *Azorhizophilus* sp.	5.55	8.11	37.19	45.11	105.52	11.72
T5- *Bacillus subtilis*	5.53	7.77	37.10	43.33	99.66	11.07
T6- *Trichoderma harzianum*	5.75	8.60	39.00	48.60	119.56	13.28
T7- Control (Untreated)	5.52	7.60	36.13	42.73	97.42	10.82
S. Em ±	0.05	0.14	0.45	0.69	0.12	0.49
CD (5%)	0.15	0.43	1.38	2.07	0.37	1.59

Table 3. Colonization of different bioagents in root zone of China aster under field condition

Treatments	At initial application (CFU/ g of soil)		At 90 days after application (CFU/ g of soil)	
	10^{-1}	10^{-2}	10^{-1}	10^{-2}
T1- *Trichoderma asperellum*	19.50	6.50	59.50	28.50
T2- *Pseudomonas fluorescens*	30.50	20.50	75.00	40.00
T3- Arka Microbial Consortium	44.50	21.50	92.50	62.50
T4- *Azorhizophilus* sp.	30.00	17.50	75.00	35.50
T5- *Bacillus subtilis*	29.50	15.50	66.00	35.00
T6- *Trichoderma harzianum*	43.50	21.00	85.00	53.00
T7- Control (Untreated)	8.00	5.50	15.00	9.80
S. Em. ±	0.48	0.26	1.08	0.63
CD @ 5%	2.04	1.08	4.56	2.63



Trichoderma harzianum | Control (untreated)

Plate 1. Comparison of *Trichoderma harzianum and control* (untreated) under field condition

which was on par with *T. harzianum* of about 85 cfu and 53 cfu at 10^{-1} and 10^{-2} respectively. The maximum colonies were due to the highly hydrated polysaccharides of the root-secreted mucigel layer and the mono and disaccharides excreted by plant roots into the rhizosphere encourage growth of the fungi. It has been observed that plant-derived sucrose is an important resource provided to *Trichoderma* cells to facilitate root colonization, the coordination of defence mechanisms and increased rate of nutrient solubilisation. This was in-line with Nosir (2016) in tuberose, Kaki *et al*. (2013) in *Calendula officinalis.*

CONCLUSION

The results of the present study conclude that among different bioagent treatments *Trichoderma harzianum* significantly increased the plant growth, flowering, quality and yield parameters of the China aster cv. Arka Kamini followed by *T. asperellum* and least was observed in *Bacillus subtilis*. While colonization was maximum in Arka Microbial Consortium followed by *T. harzianum.*

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