IV. EXPERIMENTAL RESULTS

The present investigation was carried out to study the "Effect of NPK and biofertilizers on growth, yield and quality of china aster (Callistephus chinensis (L.) Nees) cv. Poornima for cut flower purpose" during the year 2013-14, in the experimental field, Floriculture section, Regional Horticultural Research and Extension Centre, College of Horticulture, University of Horticultural Sciences campus, Gandhi Krishi Vignana Kendra (post), Bengaluru, The results obtained are furnished in this chapter under the following subheadings.

4.1 Growth parameters

Vegetative parameters viz., plant height, plant spread, number of branches per plant and leaf area were recorded at different stages of plant growth from 30 days after transplanting up to 90 days at monthly interval. These parameters were analyzed and presented below.

4.1.1 Plant height

The data pertaining to plant height (cm) at different stages of plant growth viz., 30, 60 and 90 days after transplanting in china aster are presented in table-1 and depicted in fig 2.

There was no significant difference in plant height at 30 days after transplanting (DAT) but significant differences were found at 60 and 90 days after transplanting.

The maximum plant height while passing through different stages of growth increased from 19.80 cm at 30 days after transplanting to 54.67 cm at 90 days after transplanting in the treatment 100% NPK + Azospirillum + PSB. This treatment was found to be significantly superior over control (RDF 180:120:60 NPK kg per ha + FYM 15 tons per ha) having the plant height 49.00 cm at 90 days after transplanting.

The treatment receiving 100% NPK + Azospirillum + PSB recorded the highest plant height (38.67 cm) at 60 days after transplanting, which was found on par with 100% NPK + Azospirillum (37.67 cm), 75% N and P + 100% K + Azospirillum + PSB (37.30 cm), 100% NPK + PSB (35.83 cm) and RDF + FYM (33.33 cm).

At 90 DAT, the treatment receiving 100% NPK + Azospirillum + PSB showed the best result (54.67 cm) followed by treatment receiving 100% NPK + Azospirillum. The plant height in control (RDF + FYM) was 49.00 cm.

The treatment receiving Arka microbial consortia alone recorded the lowest plant height 9.20 cm, 24 cm and 40.67 cm at 30, 60 and at 90 days after transplanting respectively.

4.1.2 Plant spread

There was no significant difference observed in plant spread at 30 days after transplanting (DAT). While significant difference noticed among the treatments as influenced by application of NPK and biofertilizers at 60 and 90 days after transplanting (DAT) is presented in Table 2.

At 60 days after transplanting, The plants receiving 100% NPK + Azospirillum + PSB recorded maximum plant spread in N-S and E-W direction (23.00 cm and 22.00 cm respectively), which was found on par with 100% NPK + Azospirillum (21.80 cm), 75% N and P + 100% K + Azospirillum + PSB (20.73 cm), and RDF + FYM (20.70 cm) in N-S and 100% NPK +
Azospirillum (20.00 cm), 100% NPK + PSB (19.70 cm), 75% N and P + 100% K + Azospirillum + PSB (19.40 cm) and RDF + FYM (19.00 cm) in E-W direction. Whereas, plants receiving Arka microbial consortia had minimum plant spread in N-S and E-W direction (17.20 cm and 15.30 cm respectively).

At 90 days after transplanting, the plants receiving 100% NPK + Azospirillum + PSB recorded maximum plant spread in N-S and E-W direction 42.60 cm and 41.00 cm respectively. Whereas, plants receiving Arka microbial consortia had minimum plant spread in N-S and E-W direction (17.20 cm and 15.30 cm respectively).

4.1.3 No. of branches per plant

Number of branches recorded at 60 and 90 days after transplanting was significantly influenced by the application of NPK and biofertilizers. The data on number of branches per plant are presented in the Table 3.

At 60 days after transplanting, the number of branches recorded was significantly higher (11.10) in the treatment which receives 75% N and P + 100% K + Azospirillum + PSB, which was found to be on par with 100% NPK + Azospirillum + PSB (10.17). The lesser number of branches (3.30) was observed in the treatment Arka microbial consortia and the treatment receiving RDF (180:120:60) NPK kg per ha + FYM 15 tonnes per ha (control) which recorded 7.63 branches.

At 90 days after transplanting, the treatment receiving 75% N and P + 100% K + Azospirillum + PSB showed the highest number of branches (18.17) followed by 100% NPK + Azospirillum + PSB (18.00), RDF + FYM (control) (17.00) and 100% NPK + Azospirillum (16.33) and the treatment (Arka microbial consortia) showed the least number of branches (14.67).

4.1.4 Leaf area

The data on leaf area (cm$^2$) as influenced by different combinations of nutrients and biofertilizers are presented in Table 4.

Non significant difference was observed among the treatments with respect to leaf area at 30 days after transplanting. At 60 and 90 days after transplanting the leaf area of different treatments varied significantly.

At 60 DAT, the plants receiving 50 % N and P + 100% K + Azospirillum + PSB registered significantly maximum leaf area (12.50 cm$^2$) which was found to be on par with 100% NPK + Azospirillum + PSB (11.67 cm$^2$), 75% N and P + 100% K + Azospirillum + PSB (11.53 cm$^2$), 100% NPK + Azospirillum (11.40 cm$^2$), 100% NPK + PSB (11.33 cm$^2$) and RDF + FYM (11.00 cm$^2$).

At 90 DAT, Significantly higher leaf area (17.67 cm$^2$) was recorded in the treatment 50 % N and P + 100% K + Azospirillum + PSB which was found to be on par with 100% NPK + Azospirillum + PSB (17.17 cm$^2$), 100% NPK + Azospirillum (16.63 cm$^2$), 100% NPK + PSB (16.43 cm$^2$), RDF + FYM (control) (16.37 cm$^2$) and 75% N and P + 100% K + Azospirillum + PSB (15.67 cm$^2$).

The lower leaf area (3.67 cm$^2$), (8.67 cm$^2$) and (13.67 cm$^2$) was observed in the plant receiving Arka microbial consortia at 30, 60 and 90 days after transplanting.
4.1.5 Fresh and dry weights

4.1.5.1 Fresh and dry weights of leaves per plant

The data on fresh and dry weights of leaves per plant as influenced by different combinations of nutrients and biofertilizers are presented in Table 5.

The fresh weight of leaves varied significantly due to different treatments. Among different treatments, application of 100% NPK + *Azospirillum* + PSB recorded significantly higher fresh weight of leaves (20.53 g) per plant and it was on par with 100% NPK + *Azospirillum* (20.33 g), 75% N and P + 100% K + *Azospirillum* + PSB(20.00 g), RDF + FYM (18.00 g) and 50% N and P + 100% K + *Azospirillum* + PSB(17.67 g). While, the plants receiving Arka microbial has recorded lower fresh weight of leaves (13 g) per plant.

The plants receiving 100% NPK + *Azospirillum* + PSB registered significantly maximum dry weight of leaves 11.33 g per plant and on par with treatment (RDF (180:120:60) NPK kg per ha +FYM 15 tonnes per ha) 9.36 g. However, minimum dry weight of leaf 6.70 g per plant was recorded in plants receiving Arka microbial consortia.

4.1.5.2 Fresh and dry weight of stem per plant

The data on fresh and dry weight of stem per plant as influenced by different combinations of nutrients and biofertilizers are presented in Table 5.

The fresh weight of stem varied significantly due to different treatments. The application of 100 % NPK + *Azospirillum* + PSB recorded significantly highest fresh weight of stem (107.33 g) per plant and it was on par with 100% NPK + *Azospirillum* (102.67 g), 75% N and P + 100% K + *Azospirillum* + PSB(100.23 g), 50% N and P + 100% K + *Azospirillum* + PSB (96.33 g), 100% NPK + PSB(95.00 g) and RDF + FYM (94.00 g). And the plants receiving Arka microbial consortia has recorded lowest fresh weight of stem (68.33 g) per plant.

The plants receiving 100 % NPK + *Azospirillum* + PSB registered significantly maximum dry weight of stem (50.0 g) per plant. Which was significantly superior over control (RDF (180:120:60) NPK kg per ha +FYM 15 tonnes per ha) with dry weight 40.46 g. The minimum dry weight of stem (33.17 g) per plant was recorded in plants receiving Arka microbial consortia.

4.1.5.3 Fresh and dry weights of roots per plant

The fresh weights of roots per plant ranged from 6.63 g to 9.73 g (Table 5). Significant differences were observed in fresh weights of roots per plant. The plants receiving 100 % NPK + *Azospirillum* + PSB registered highest fresh weight of roots (9.73 g) per plant and it was on par with 100% NPK + *Azospirillum* (9.07 g), 75% N and P + 100% K + *Azospirillum* + PSB (8.97 g), RDF + FYM (control) (8.50) and 75% N and P + 100% K + *Azospirillum* (8.0 g) while, the plants receiving Arka microbial consortia (T10) have recorded lower fresh weights of roots (6.63 g) per plant.

The influence of different combinations of NPK and biofertilizers on dry weights of roots per plant varied significantly. The plants receiving 100 % NPK + *Azospirillum* + PSB recorded significantly maximum roots dry weight (4.87 g) per plant and it was on par with the 100% NPK + *Azospirillum* (4.67 g), RDF + FYM (control) (4.57 g), 100% NPK + PSB (4.33 g), 75% N and P + 100% K + *Azospirillum* (3.67 g) and 50% N and P + 100% K + *Azospirillum* (3.67 g). However, minimum dry weight of roots (2.93 g) per plant was recorded in plants receiving Arka microbial consortia.
4.1.5.4 Total fresh and dry weight per plant

The data on total fresh and dry weights (g) per plant was significantly influenced by the application of different combinations of NPK and biofertilizers presented in Table 5.

Data revealed that the maximum and higher total fresh weight of china aster was recorded in the plant receiving 100 % NPK + Azospirillum + PSB (137 g) followed by 100% NPK + Azospirillum (131.63 g) and 75% N and P + 100% K + Azospirillum + PSB (129.20 g). Whereas, the plant receiving Arka microbial consortia registered minimum total fresh weight per plant (87.60 g). The treatment receiving RDF (180:120:60) NPK kg / ha + FYM 15 tons / ha (control) recorded 120.57 g fresh weight per plant. Which was significantly lower than the treatment 100% NPK + Azospirillum + PSB (137.58 g).

Total dry weight varied significantly among various treatments. The plants receiving 100 % NPK + Azospirillum + PSB registered higher total dry weight (65.80 g) which was found on par with 100% NPK + Azospirillum (63.00 g) and 75% N and P + 100% K + Azospirillum + PSB(62.50 g). However, the treatment Arka microbial consortia had lower total dry weight per plant (42.80 g) and in control RDF (180:120:60) NPK kg per ha +FYM 15 tonnes per ha (control) it was recorded (54.60 g).

4.2 Flower characters

The data on the number of days to first flowering and 50 per cent flowering is presented in Table 6.

4.2.1 Days taken for first flowering

Significant differences were observed among different treatments for the days to first flowering.

The treatments with 50% N and P + 100% K + Azospirillum + PSB recorded early flowering 64.00 days after transplanting. However, treatments 100% NPK + Azospirillum + PSB (64.38), 100% NPK + Azospirillum (64.67), 100% NPK + PSB (64.93), RDF + FYM (control) (65.00) and 75% N and P + 100% K + Azospirillum + PSB (68.73) were on par with 50% N and P + 100% K + Azospirillum + PSB (64.00) treatment. While, the late flowering (74.27 days) was recorded by plants in the treatment which receiving Arka microbial consortia.

4.2.2 Days taken for 50 per cent flowering

The treatment with biofertilizers and 50 per cent RDF had significant effect on the number of days taken for 50 per cent flowering (Table 6). Among all the treatments, 50 per cent flowering (67.00 days after transplanting) was earliest flowering in plants receiving 50% N and P + 100% K + Azospirillum + PSB and on par with 100% NPK + Azospirillum + PSB(67.33), 100% NPK + Azospirillum(67.73), 100% NPK + PSB (68.33) RDF + FYM (68.67), 75% N and P + 100% K + Azospirillum + PSB(71.72), 75% N and P + 100% K + Azospirillum(72.99) and 75% N and P + 100% K + PSB (73.67) Whereas, the treatment with Arka microbial consortia took maximum number of days for 50 per cent flowering (76 days after transplanting).

4.2.3 Stalk length
Treatments differed significantly with respect to stalk length, which ranged from 18.00 cm to 27.87 cm (Table 7).

The plants receiving 50% N and P + 100% K + *Azospirillum* + PSB recorded maximum stalk length of 27.87 cm which was found on par with 100% NPK + *Azospirillum* + PSB (26.63 cm), 75% N and P + 100% K + *Azospirillum* + PSB (26.27 cm), 100% NPK + *Azospirillum* (25.00 cm), 100% NPK + PSB (24.00 cm) and RDF + FYM (control) (23 cm). However, the lower stalk length (18.00 cm) was observed in plants supplied with Arka microbial consortia.

4.2.4 Flower diameter

The data on the flower diameter as influenced by application of different combinations of nutrients and biofertilizers are presented in Table 8. The maximum flower diameter (6.09 cm) was recorded in treatment 50% N and P + 100% K + *Azospirillum* + PSB which was found on par with 100% NPK + *Azospirillum* + PSB (5.80 cm), 100% NPK + *Azospirillum* (5.57 cm), 75% N and P + 100% K + *Azospirillum* + PSB (5.40 cm), 100% NPK + PSB (5.23 cm) and RDF + FYM (control) (4.83 cm). Whereas, the lower flower diameter (3.83 cm) was recorded in plants supplied with Arka microbial consortia.

4.3 Yield parameters

4.3.1 Number of cut flowers per plant

Different treatments significantly influenced the flower production in terms of number of cut flowers produced per plant (Table 9).

Plants treated with 75% N and P + 100% K + *Azospirillum* + PSB registered maximum number of cut flowers (7.33 per plant), which was significantly higher than other treatments and it was on par with 100% NPK + *Azospirillum* + PSB (6.63) and 100% NPK + *Azospirillum* (6.00). Whereas, the least number of flowers per plant (3.50) was observed in Arka microbial consortia.

4.3.2 Number of cut flowers per hectare

The perusal of data presented in table-10 revealed that, the significantly highest (8.13 lakhs/ha) number of cut flowers per hectare recorded in the treatment (75% N and P + 100% K + *Azospirillum* + PSB) and was superior when compared to all other treatments, which was followed by 100% NPK + *Azospirillum* + PSB (4.09 lakhs per ha). Whereas, Arka microbial consortia registered minimum (7.37 lakhs per ha) number of cut flowers per hectare and in control it was 5.92 lakhs per ha.

4.3.3 Weight of cut stems

Treatments significantly influenced the weight of cut stems (g), expressed in the Table 10. Plants treated 100% NPK + *Azospirillum* + PSB registered maximum weight of cut stems (148 g) which was significantly higher than other treatments and it was on par with 75% N and P + 100% K + *Azospirillum* + PSB (138.67 g), 50% N and P + 100% K + *Azospirillum* + PSB (134.00 g). And the treatment receiving RDF (180:120:60) NPK kg per ha + FYM 15 tonnes per ha (control) recorded 131.33g. Whereas, the least weight of cut stem (84.33 g) was observed in Arka microbial consortia.

4.4 Available NPK in soil
The data on available nitrogen, phosphorous and potassium status in soil are recorded after harvest of the crop and presented in Table 11.

4.4.1 Available N

The data on available nitrogen in soil was found to be significantly influenced by different combinations of nutrients and biofertilizers. The highest available nitrogen in the soil (248.00 kg per ha) was recorded in the treatment receiving 100 per cent NPK + *Azospirillum* + PSB. However, lowest available nitrogen in soil (132.50 kg per ha) was recorded in the treatment receiving Arka microbial consortia and the control [RDF (180:120:60) NPK kg per ha + FYM 15 tonnes per ha] recorded 175 kg per ha.

4.4.2 Available P

Application of 100 per cent NPK + *Azospirillum* + PSB recorded highest available phosphorous (50.07 kg per ha) and it was on par with 100% NPK + PSB (49.36 kg per ha), 100% NPK + *Azospirillum* (45.40 kg per ha), 75% N and P + 100% K + *Azospirillum* + PSB (44.33 kg per ha) and 75% N and P + 100% K + PSB (43.33 kg per ha) in the soil. However, lowest available phosphorous in soil (34.30 kg per ha) was registered in the treatment receiving Arka microbial consortia and the control treatment showed the p content 42.60 kg per ha.

4.4.3 Available K

The data (Table-11) revealed that, application of 100 per cent NPK + *Azospirillum* + PSB recorded highest available K in the soil (138.80 kg per ha) after harvest of the crop followed by 100% NPK + *Azospirillum* (136.30 kg per ha), 100% NPK + PSB (135.00 kg per ha), 75% N and P + 100% K + *Azospirillum* + PSB (134.30 kg per ha) and RDF + FYM (control) (128.33 kg per ha). However, the lowest available K in the soil (118.33 kg per ha) was recorded in the treatment receiving Arka microbial consortia.

4.5 NPK content of china aster plant

The observations pertaining to NPK nutrient content in china aster plant due to the application of biofertilizers in combination with NPK are presented in Table 12.

4.5.1 Nitrogen content

Nitrogen content in plant was estimated at 90 DAT. The data revealed that the application of biofertilizers significantly enhanced nitrogen content in leaves.

The treatment receiving 100 per cent NPK + *Azospirillum* + PSB showed the greatest N content (4.15%), and the second highest (3.73%) was recorded in treatment receiving 100 per cent NPK + *Azospirillum*. While the treatment RDF (180:120:60) NPK kg per ha + FYM 15 tonnes per ha (control) showed 2.75% of N content. While the treatment Arka microbial consortia showed the lowest 2.02% nitrogen content in plant.

4.5.2 Phosphorous content

The data on the phosphorous content in plant showed significant differences among the treatments. The treatment 100 per cent NPK + *Azospirillum* + PSB recorded the maximum P content (0.41%) followed by treatment 100 per cent NPK + PSB with 0.40%, whereas the treatment Arka microbial consortia showed the lowest P content 0.19%.
4.5.3 Potassium content

The application of biofertilizers significantly increased the K content of china aster plant. The treatment 100 per cent NPK + *Azospirillum* + PSB showed the highest K content 2.40% which was followed by treatment 100 per cent NPK + *Azospirillum* with 2.36 % and the control [RDF (180:120:60) NPK kg per ha + FYM 15 tonnes per ha] content 2.28 % K. while, the treatment receiving Arka microbial consortia showed the lowest K content 2.11%.

4.6 Post harvest life of china aster cut flower

The application of NPK and biofertilizers showed a significant influence on Vase life of cut flowers.

4.6.1 Water uptake

The data revealed that the highest water uptake (44.00 g, 45.00 g, 44.00 g, 42.00 g, 39.27 g, 38.23 g, 37.20 g and 36.00 g) was noticed in the treatment receiving 75% N and P + 100% K + *Azospirillum* + PSB during the entire period (1st to 8th days) of observation. While the lowest was recorded in treatment receiving Arka microbial consortia during 1st to 6th days of observation (30.83 g, 27.00 g, 24.30 g, 21.48 g, 19.38 g, and 18.00 g). The control [RDF (180:120:60) NPK kg per ha + FYM 15 tonnes per ha] was recorded 41.67g, 38.27g, 35.10g, 33.00g, 29.00g, 27.17g and 26.27g, (Table 13).

4.6.2 Cumulative water uptake

Cumulative water uptake differed significantly due to the application of NPK and biofertilizers (Table-13). Maximum uptake was recorded in the treatment receiving 75% N and P + 100% K + *Azospirillum* + PSB (325.70 g). The lowest cumulative water uptake was recorded in the treatment receiving Arka microbial consortia (141.20 g) and the control [RDF (180:120:60) NPK kg per ha + FYM 15 tonnes per ha] was recorded 230.40g.

4.6.3 Transpiration loss

During the entire period of observation transpiration loss of water in the flowers was found to be influenced by the application of NPK and biofertilizers. The treatment receiving 75% N and P + 100% K + *Azospirillum* + PSB exhibited significant influence on water loss and recorded minimum (40.53 g, 37.13 g, 35.67 g, 34.00 g, 33.00 g, 31.67 g, 30.20 g and 29.30 g) transpiration rate during 1st to 8th days respectively and the control [RDF (180:120:60) NPK kg per ha + FYM 15 tonnes per ha] was recorded 45.62g, 42.67g, 43.00g, 41.00g, 39.33g, 38.19g and 37.33g, (Table 14).

However it was maximum (54.33 g, 51.00 g, 50.33 g, 48.00 g, 44.33 g and 43.00 g per flower) in the treatment receiving Arka microbial consortia during the entire period (1st to 8th days) of observation.

4.6.4 Fresh weight of cut flower

During the entire period of observations on vase life (viz., 1st to 8th day) the fresh weight of cut flower was found to be maximum in treatment, receiving 75% N and P + 100% K + *Azospirillum* + PSB (87.88 g, 87.93 g, 86.20 g, 85.40 g, 84.20 g, 85.10 g, 84.30 g and 83.12 g respectively) and it was statistically significant over other treatments tried, while the treatment receiving Arka microbial consortia recorded minimum fresh weight (76.53 g, 74.63 g, 71.33 g,
70.00 g, 69.20 g and 68.00 g respectively) at various period of vase life (Table-15). The control was recorded 85.49g, 84.00g, 81.27g, 79.50g, 77.10g, 77.00g, 76.80g and 75.60g.

4.6.5 Vase life of cut flower

Vase life of china aster cut flower differed significantly among the different treatments. The maximum vase life (8.00 days) was noticed in treatment receiving 75% N and P + 100% K + Azospirillum + PSB (Table-18), which was on par with 100% NPK + Azospirillum + PSB (7.67 days), 50% N and P + 100% K + Azospirillum + PSB (7.67 days), 100% NPK + Azospirillum (97.47 days), 100% NPK + PSB (7.33 days) and RDF + FYM (control) (7.00 days), whereas, minimum vase life was noticed in the treatment, receiving Arka microbial consortia alone (5.40 days) in Table 16.

4.7 Microbial population in the rhizosphere of china aster

The effect of biofertilizers in combination with NPK on the rhizosphere microbial population of china aster is presented in Table 17.

4.7.1 Enumeration of microbial population in the rhizosphere of china aster

The highest population (13.40 X 10^6) of Azospirillum was seen in 100% NPK+ Azospirillum + PSB treatment compared to all other treatments followed by 50% N and P + 100% K + Azospirillum + PSB (12.23 X 10^6). Whereas, the lowest population (4.43 X 10^6) of Azospirillum was seen in the rhizosphere of plants which received RDF (180:120:60) NPK kg per ha + FYM 15 tonnes per ha when compared to all other treatments.

The populations of the functionally important microorganisms, inoculated in the rhizosphere, were tremendously varied. Phosphate solubilizing bacterial (PSB) colonization was maximum (12.88 X 10^5) in the treatment 100% NPK + Azospirillum + PSB (100% NPK+ Azospirillum + PSB) treatment compared to all other treatments, which is followed by 50% N and P + 100% K + Azospirillum + PSB (11.96 X 10^5). Whereas, the lowest colonization (3.33 X 10^6) of PSB was seen in the rhizosphere of plants in control treatment [RDF (180:120:60) NPK kg per ha + FYM 15 tonnes per ha] when compared to all other treatments.

The treatment Arka microbial consortia alone showed the highest population (9.67 X 10^5) of Azotobacter when compared to all other treatments. This was lowest (3.00 x 10^6) in the control treatment RDF (180:120:60) NPK kg per ha + FYM 15 tonnes per ha.

4.8 Economics of china aster cultivation

The data on effect of NPK and biofertilizers on economics of china aster crop is presented in Table 18. The maximum benefit cost ratio (1.00:5.83) was recorded in the treatment 75% N and P + 100% K + Azospirillum + PSB. This was followed by the treatments 100% NPK + Azospirillum + PSB (1.00:5.07). The minimum benefit cost ratio (1.00:2.43) was recorded in the treatment Arka microbial consortia alone in Table18.