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Influence of biostimulants on growth and yield of China aster (*Callistephus chinensis*) cv. Poornima

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Abstract
China aster (*Callistephus chinensis* L. Nees.) is an important commercial ornamental annual flower plant. A field experiment was conducted to study the efficacy of biostimulants on performance and flower quality of China aster cv. Poornima at Department of Horticulture, College of Agriculture, University of Agricultural Sciences, GKVK, Bengaluru. The experiment was laid out in randomized complete block design (RCBD) with three biostimulants *via*., Boron, Humicil and Azospirillum at two different concentrations all together as treatments and was replicated thrice. The plants sprayed with FYM + RDF + humic acid at 1.0 per cent recorded maximum plant height (61.50 cm), number of leaves (164.81), leaf area (18.53 cm^2), stem girth (12.01 mm), number of primary branches (17.28) and secondary branches per plant (32.95), internodal length (7.04 cm), days to first flowering (59.44 days), days taken for 50 per cent flowering (67.22) and duration of flowering (70.33 days). With respect to number of buds per plant (43.67), number of flowers per plant (40.00), flower yield per plant (160g/plant), flower yield per square meter (1777.6 g/plant) and flower yield per hectare (17.7kg/ha).

Keywords: China aster, biostimulants, growth parameters, yield etc.

Introduction
Appreciation of the potential of commercial floriculture has resulted within the growth, this field into a viable agri-business possibility. Availability of natural resources under various agro-climatic conditions allow production of a good range of temperate and tropical flowers, nearly throughout year in some a part of the country or different. The enterprise of production and promoting of floricultural product is additionally a supply of paying and quality employment to attain the individuals.

China aster (*Callistephus chinensis* L. Nees.) is a semi-hardy, annual and commercial free blooming flower crop belonging to the family Asteraceae. Somatic chromosome number of plant is (2n=18). It is a significant yearly bloom harvest of our nation and developed all through the world. The harvest is local to China and spread to European nations and other tropical nations during 1731 Advertisement (Desai, 1967) [6]. The sort *Callistephus* is derived from two Greek words Kalistos signifying 'most beautiful' and Stephos 'a crown' alluding to the blossom head.

The current day China aster has been created from a solitary wild species *Callistephus chinensis.* The advancement of China aster was a background marked by surprising variety. As per Emsweller *et al.* (1937) [8], the first plant had single blossom with two to four columns of blue, violet or white beam florets. The principal change in the bloom type had been the prolongation or advancement of focal florets and the creation of quilled blossoms. Germans grew two fold structures during eighteenth century. Subsequently, the asters are additionally alluded as German aster. This was a direct result of the progression of the aster advancement and huge scope for seed creation by Germans. Presentation of expanding types, including tall, medium tall and dwarf sorts made the incredible advancement in the improvement of aster. Spreading types were present in USA, which was primary focus of advancement of this plant just as for the creation of seeds.

Its wide range of shadings, extended vase life, variation in height and growth habit of the plant, exceptionally hardy nature, relative ease of growing all year round and versatility of application all contribute to its popularity. The species includes a diverse range of forms, kinds, and shade ranges. In China aster, erect growth and spreading growth tendencies are common, and there are several cultivars available in colours such as blue, pink, white, purple and red.

It is filled effectively in open conditions for all year creation in kharif, rabi and summer to have continuous supply of flowers to the market. The blossoms have long vase life and are utilized for different purposes. It's used to make festoons, fill flower bundles, and make floral arrangements for flower displays and exhibitions. It is mainstream as a sheet material plant and furthermore utilized in herbaceous boundaries in gardens. It is developed as a potted plant and its dwarf cultivars are reasonable for edges. It is commercially cultivated in Karnataka, Tamil Nadu, Andhra Pradesh, Maharashtra (Pune and Nashik) and West Bengal in India. It is mostly established in Karnataka near Bengaluru, Tumkur, Kolar and Belagavi. The specific measurements on region and creation of this harvest in India isn't accessible. It is assessed to be filled in around 450 ha in Pune area alone. In Karnataka it is assessed to be developed in a space of 1790 hectare with the creation of around 16898 MT and efficiency of 10.50 tons per ha (Anon, 2020) [4]. More than two third of this large area is devoted for the produce of traditional flowers such as marigold, jasmine, roses, chrysanthemum, China aster, and others occupy more than two-thirds of this vast region. There aren't many indigenous improved cultivars of this crop accessible right now. Breeding work was done at the Indian Institute of Horticulture Research (IIHR) in Bangalore to generate improved cultivars (Karnataka). As a result, a better pure white line, known as Poornima, was developed and released for commercial cultivation. Poornima variety was derived by crossing of two pure lines (AST- 29 X AST- 3) which was developed with objective of obtaining white coloured flowering variety for cut flower and loose flower purpose. It is a powdery puff type flower, it takes 105 days to flower and having a vase life of 8 days.

The chemical fertilizers have some adverse impact on physical, chemical and organic properties of soil and furthermore ponders straight forwardly expanded expense of production, which is an approaching cataclysm looked by the agriculturists. Further, the non stop utilization of chemical fertilizer will in general degrade the soil structure. In this specific circumstances, biostimulants are the material other than the chemical fertilizers that advance the plant development, yield and quality when applied in minute amounts and are additionally alluded as metabolic enhancers. In this way, it is significant region to be worried to work on the yield and nature of blossoms with no effect on climate. Plant biostimulant is any substance or microorganism, in the form in which is supplied to the users, applied to plants, seeds or the root environment with the intension to stimulate natural processes of plants benefiting nutrient use efficiency, tolerance to abiotic stress regardless of its nutrient content, or any combination of such substances or microorganisms intended for this use (Troan *et al*., 2014).

Materials and Methods

The experiment was conducted at Department of Horticulture, College of Agriculture, Gandhi Krishi Vigyana Kendra Campus, University of Agricultural Sciences, Bangalore with eight treatments which were applied as soil application.

Plant Material

The study was conducted using cv. Poornima. The seeds are collected from Indian Institute of Horticultural Research, Hessaraghatta, Bengaluru, Karnataka. The seeds were sown in portrays, in the nursery and were transplanted to main field after 3-4 leaves stage that is after 45 days of sowing. Breeding work was done at the Indian Institute of Horticulture Research (IIHR) in Bangalore to generate improved cultivars (Karnataka). As a result, a better pure white line, known as Poornima variety was derived by crossing of two pure lines (AST- 29 X AST- 3). It is a powdery puff type flower, it takes 105 days to flower and having a vase life of 9 days and flower diameter of 5cm, flower weight of 3.5g with a stalk length of 35cm.

Experimental Details

Design and experimental layout
Crop/ cultivar: China aster cv. Poornima
Season: December-2020 to April-2021
Design: Randomized Complete Block Design (RCBD)
Number of treatments: 08
Number of replications: 03
Total experimental area: 75 m^2
Spacing: 30 cm X 30 cm
FYM: 15 t/ ha
Recommended dose of fertilizers: 180 N: 120 P_2O_5: 60 K_2O kg per ha.

Treatment details

T1 - Absolute Control
T2 - FYM+ RDF
T3 – FYM+ RDF+ Boric acid 0.2%
T4 – FYM + RDF+ Boric acid 0.3%
T5 – FYM + RDF + Humic acid 0.5%
T6 – FYM+ RDF + Humic acid 1.0%
T7 – FYM + RDF+ Azospirillum 4.0%
T8 – FYM + RDF+ Azospirillum 8.0%
RDF - Recommended dose of fertilizer.
FYM - Farm yard manure
Note: FYM + RDF are common for all the treatments.

Observations Recorded

The resulting outcome are collected on growth, reproductive & superiority traits of China aster flower. To observe various outcomes, five (5) plants were randomly chosen from each replication and in each treatment.

Observations on vegetative parameter

Plant height (cm)

The plant height was noted by choosing the five (5) plants randomly in each replication in all the treatments after the fourty five (45) days of transplanting of China aster seedlings. The plant height was measured from ground level to the tip of the plant with the help of meter scale, at an interval of 60, 75, 90 and 105 days after transplanting (DAT).

Number of leaves per plant

The total number of leaves per plant was counted in each treatment from the selected five plants at 60, 75, 90 and 105 DAT and expressed in number.

Leaf area per plant (cm^2)

Leaf area was measured at 50% flowering stage by using leaf area meter. Five leaves were collected from five tagged plants from each treatment treated plot and fed to leaf area meter and observation were recorded and mean was worked out. Leaf area is expressed in cm^2.

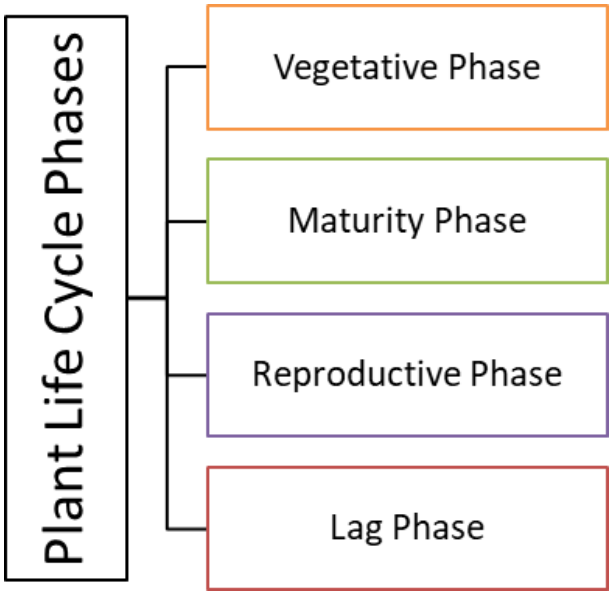
Stem girth (mm)
Stem girth of tagged plants was measured at 60, 75, 90 and 105 DAT by using vernier calipers and expressed in millimeters.

Number of branches per plant
The total number of branches arising from the main stem of each plant were tallied & documented at an interval of 60, 75, 90 and 105 days after transplanting (DAT) in each replication under each treatment and stated in number of branches/plant.

Internodal length (cm)
The internodal distance was measured between two nodes on the main shoot of the plant at an interval of 60, 75, 90 and 105 days after transplanting (DAT) in each replication under each treatment.

Number of buds per plant
The number of axillary and lateral buds were counted at an interval of sixty (60), seventy five (75), ninety (90) and one hundred & five (105) days after transplanting (DAT) in each replication under each treatment.

Observation on reproductive parameters
Every Plant has a life cycle of log phase to lag phase, in that it has various type of phases. They are depicted in the below chart:



Days taken for first flower bud initiation
Plant has life cycle of three stages that are of:
1. Primarily vegetative growth
2. Reproductive growth
3. Quality aspects

After the vegetative phase, plants are transferred to next phase named reproductive phase in which bud initiation / Flower bud appearance is the major component. Number of days taken to produce first flower bud was recorded in days, from the date of transplanting to the stage where the first flower bud was visible on the tagged plants in each replication under each treatment.

Days taken to first flower bud appearance
This observation was recorded in the visual scrutiny of plants by counting the number of days taken from the date of transplanting to the stage at which the first flower bloomed in each plot with tagged plants and the same was expressed in number of days taken for the first flower bud appearance.

Days taken to 50 per cent flowering
Number of days taken for 50 per cent flowering in a labelled plant in each replication and each treatment was recorded by counting days from the date of transplanting to the date at which 50 per cent of the plant flowered.

Duration of flowering (days)
Number of days taken from the first flowering to the last harvest of flowers from five randomly selected plants per replication was recorded as total duration of flowering in each treatment. The mean was computed and expressed in days.

Flower Quality parameters
Stalk length (cm)
The stalk length of the flower was measured from the origin of the stalk from the main stem to the neck of the flower and expressed in centimeter.

Flower diameter (cm)
One of the main quality parameters in deciding flower yield is diameter of flower, which is measured by Vernier caliper at the point of maximum breadth of flower. The measurements were recorded in each treatment and the average diameter was considered (cm).

Shelf life (days)
Shelf life was observed by harvesting the fully developed flowers from each treatment and kept immediately in laboratory condition. The flowers were then observed daily for their shelf life till they were found unfit for display/decoration. The shelf life was expressed in terms of days from the date of harvest to the final observation of wilting of flowers.

Vase life of flowers (days)
The vase life of five China aster stems harvested from each treatment plot was recorded and average was worked out. The average vase life was assessed to be terminated when 80 per cent flowers had senesced, which was characterized by loss of turgor followed by petal wilting. It was worked out in terms of days.

Yield Parameters
Total number of flowers per plant
The total number of healthy flowers per plant was counted for five tagged plants and averages were worked out and presented as total number of flowers per plant.

Flower yield per plant (g/plant)
Total weight of fresh flowers was recorded separately from the five tagged plants and their mean values were worked out and expressed in grams.

Flower yield per plot (kg/plot)
Flower yield per plot was computed on the basis of pooled fresh weight of flowers plucked from plants of the plot at different times and expressed in kilograms.

Flower yield per hectare (t/ha)
Sum of flowers produced per hactare is calculated by

multiplying average number of flowers produced per plant into total number of plants per hectare.

Cost economics
The prices of all the inputs and the labour cost that were prevailing at the time of their use were considered to work out the cost of cultivation.

Gross income
The gross income was worked out based on the prevailing market price when the product was ready to market

Net income
Net income per hectare was calculated by the given formula
Net income = Gross income – Cost of cultivation

Benefit: cost ratio
The benefit: cost ratio was calculated by using the given formula.

$$\text{Benefit: cost ratio} = \frac{\text{Net return (Rs/ha)}}{\text{Cost of cultivation}}$$

Statistical analysis
The experimental data collected on various growth and yield parameters was statistically analysed using RCBD (Randomized Complete Block Design). The significance of treatment mean was tested using F-test at 5% level of significance. The critical difference (C.D.) values were calculated at 5% level of significance for comparing the significance difference among the treatment means. Standard error of mean (S.Em±) and co-efficient of variance were also calculated.…

Results and Discussion
Effect of biostimulants on plant growth and yield of China aster cv. Poornima
Plant height (cm)
With the increase in the age of the plant from 60th to105th day after transplanting there was a corresponding increase in the plant height. At 60 days after transplanting, the maximum plant height (42.08cm) was recorded in the treatment with FYM +RDF + humic acid at 1.0% (T6) followed by T5 (FYM +RDF + humic acid at 0.5%) (41.83cm). The least plant height of 31.83 cm was recorded in T1 treatment *i.e.* Absolute control. At 75 DAT, the maximum plant height (49.33 cm) was recorded in the T6 (FYM +RDF + humic acid at 1.0%) followed by T5 (FYM +RDF + humic acid at 0.5%) (48.50 cm).The least plant height of 40.75 cm was noticed in absolute control (T1) treatment. Similar trend was noticed for 90 and 105 DAT (Table 1). The plant height was influenced significantly by different concentrations of humic acid. Maximum plant height was recorded by T6 (FYM +RDF + humic acid at 1.0%) than all other treatments, this might be due to humic acid application, which is a naturally occurring polymeric organic compound. It is potential natural resource that can be utilized to increase nutrient availability and growth of plant. Similar results were also reported by Ahmad *et al.* (2014) [1] in gladiolus, Esringu *et al*. (2015) [9] *Impatients walleriana*, Memon *et al*. (2014) [13, 14, 15, 16] in zinnia, Manda *et al.* (2014) [12] in *Spathiphyllum wallisi* and Memon *et al*. (2014) [13, 14, 15, 16] in petunia.

Table 1: Effect of biostimulants on plant height (cm) of China aster cv. Poornima

Treatment Details	60 DAT	75 DAT	90 DAT	105 DAT
T1 - Absolute control	31.83	40.75	45.68	53.92
T2 - FYM+ RDF	33.00	42.50	48.58	58.50
T3 - FYM+ RDF+ Boric acid 0.2%	34.50	42.58	51.25	59.75
T4 - FYM + RDF+ Boric acid 0.3%	34.08	43.33	52.08	56.92
T5 - FYM + RDF + Humic acid 0.5%	41.83	48.50	60.63	66.58
T6 - FYM+ RDF + Humic acid 1.0%	42.08	49.33	62.92	75.92
T7 - FYM + RDF+ Azospirillum 4.0%	38.00	47.42	56.83	65.67
T8 - FYM + RDF+ Azospirillum 8.0%	39.13	46.75	54.00	61.50
F-test	*	*	*	*
S.Em±	0.348	0.430	0.567	1.452
C.D. at 5%	1.055	1.305	1.719	4.405

*significant at 5% confidence level,
DAT -Days After Transplanting
RDF -Recommended Dose of Fertilizer (180:120:60 kg /ha N: P: K)
FYM -Farm Yard Manure (15t/ha)

Number of leaves per plant
The application of biostimulants in addition to RDF and FYM showed marked increase in number of leaves per plant. The number of leaves per plant was significantly increased by different biostimulants with different concentrations at 60, 75, 90 and 105 DAT are presented in Table-2. At 60 DAT maximum number of leaves of 58.21 was recorded in T6 (FYM +RDF + humic acid at 1.0%) which is on par with T5 (FYM +RDF + humic acid at 0.5%) 55.86. Whereas, minimum number of leaves per plant 32.72 was noticed in T1 Absolute control. There was a similar trend noticed at 75, 90 and 105 DAT. Where, maximum number of leaves per plant was observed in T6 (FYM +RDF + humic acid at 1.0%) (106.48, 126.67, 164.81, respectively) followed by T5 (FYM +RDF + humic acid at 0.5%) (102.32, 124.17, 161.07, respectively) and least in T1 Absolute control (74.76, 89.33, 126.85, respectively). The increase in vegetative growth might be due to increase in plasticity of cell wall and formation of energy rich phosphates which stimulates cell division and cell elongation. Another possibility for improved growth could be due to greater osmotic uptake of water and nutrients under the effect of biostimulants, which would improve the nutrient metabolism. These findings corroborates the results reported by Ahmad *et al.* (2014) [1] in gladiolus, Esringu *et al*. (2015) [9] *Impatients walleriana*, Memon *et al*. (2014) [13, 14, 15, 16] in zinnia and Manda *et al.* (2014) [12] in *Spathiphyllum wallisi*.

Leaf area (cm^2)
The leaf area was recorded at 60, 75, 90 and 105 DAT of China aster. The results showed significant differences among the different biostimulants and the data are presented in Table 3. At 60 DAT the highest leaf area (9.16 cm^2) was recorded with T6 (FYM +RDF + humic acid at 1.0%) followed by T5 (FYM +RDF + humic acid at 0.5%) 8.69 cm^2. While the lowest leaf area (6.93 cm^2) was noticed in T1 Absolute control. There was a similar trend noticed at 75, 90 and 105 DAT. Where, maximum leaf area was observed in T6 (FYM + RDF + humic acid 1.0%) (13.12, 15.23, 18.53, respectively) followed by T5 (FYM +RDF + humic acid at 0.5%) (11.51, 14.14, 16.51, respectively) and least in T1 Absolute control (7.53, 9.50, 10.79, respectively). Humic acid increased the chlorophyll content and improved the structure of the thylakoids, which accelerated the rate of photon to be absorbed,

transferred and converted in the chloroplast. Thus, promoted the photosynthesis (Fan *et al.*, 2014) [10]. Foliar spraying of HA is an effective way to supply nutrients and beneficial organic compounds to plant through leaf absorption. The availability of humic acid easily and for longer periods might be responsible for increasing photosynthetic activity, which caused increased leaf area (Ahmad *et al*., 2013) [2].

Similar results were reported by (Fan *et al*., 2014) [10] in chrysanthemum, Ahmad *et al.* (2014) [1] in gladiolus, Esringu *et al*. (2015) [9] *Impatients walleriana*, Memon *et al*. (2014) [13, 14, 15, 16] in zinnia, Manda *et al.* (2014) [12] in *Spathiphyllum wallisi* and Memon *et al*. (2014) [13, 14, 15, 16] in petunia.

Table 2: Effect of biostimulants on number of leaves per plant of China aster cv. Poornima

Treatment Details	60 DAT	75 DAT	90 DAT	105 DAT
T1- Absolute control	32.72	74.76	89.33	126.85
T2 - FYM+ RDF	44.15	83.08	114.76	139.64
T3 - FYM+ RDF+ Boric acid 0.2%	47.86	86.74	118.59	140.99
T4 - FYM + RDF+ Boric acid 0.3%	51.31	90.11	119.67	141.03
T5 - FYM + RDF + Humic acid 0.5%	55.86	102.32	124.17	161.07
T6 - FYM+ RDF + Humic acid 1.0%	58.21	106.48	126.67	164.81
T7 - FYM + RDF+ Azospirillum 4.0%	53.89	95.91	121.88	156.38
T8 - FYM + RDF+ Azospirillum 8.0%	52.82	93.77	120.74	153.10
F- test	*	*	*	*
S.Em±	0.534	0.453	0.573	0.616
C.D. at 5%	1.619	1.374	1.739	1.867

*significant at 5% confidence level,
DAT -Days After Transplanting
RDF -Recommended Dose of Fertilizer (180:120:60 kg /ha N: P: K)
FYM -Farm Yard Manure (15t/ha)

Table 3: Effect of biostimulants on leaf area (cm^2) of China aster cv. Poornima

Treatment Details	60 DAT	75 DAT	90 DAT	105 DAT
T1 - Absolute control	6.93	7.53	9.50	10.79
T2 - FYM+ RDF	7.45	9.90	10.68	11.50
T3 - FYM+ RDF+ Boric acid 0.2%	7.86	10.58	12.13	14.67
T4 - FYM + RDF+ Boric acid 0.3%	7.94	10.43	11.99	13.90
T5 - FYM + RDF + Humic acid 0.5%	8.69	11.51	14.14	16.51
T6 - FYM+ RDF + Humic acid 1.0%	9.16	13.12	15.23	18.53
T7 - FYM + RDF+ Azospirillum 4.0%	8.15	11.56	13.32	14.67
T8 - FYM + RDF+ Azospirillum 8.0%	8.32	12.02	13.49	15.74
F- test	*	*	*	*
S.Em±	0.173	0.273	0.240	0.234
C.D. at 5%	0.526	0.829	0.728	0.710

*significant at 5% confidence level,
DAT -Days After Transplanting
RDF -Recommended Dose of Fertilizer (180:120:60 kg /ha N: P: K)
FYM -Farm Yard Manure (15t/ha)

Stem girth (mm)

The data on stem girth (mm) as influenced by foliar application of biostimulants recorded at 60, 75, 90 and 105 DAT are shown in Table 4.

While passing through different stages of plant growth, stem girth has been increased from (7.27 mm) at 60 DAT to (12.01mm) at 105 DAT in case of T6 (FYM +RDF + humic acid at 1.0%). Stem girth at 60 DAT increased significantly from a maximum of (7.27mm) in treatment receiving (FYM + RDF + humic acid 1.0%) T6 and was found statistically significant over other treatments under the study. However, minimum stem girth (3.79mm) was recorded in the Absolute control. Stem girth at 75 DAT increased significantly from a maximum of (7.93 mm) in treatment receiving (FYM + RDF + humic acid 1.0%) T6 and was found statistically significant over other treatments under the study. However, minimum stem girth (4.93 mm) was recorded in the Absolute control.

Stem girth at 90 DAT increased significantly from a maximum of (9.12 mm) in treatment receiving (FYM + RDF + humic acid 1.0%) T6 and was found statistically significant over other treatments under the study. However, minimum stem girth (6.39 mm) was recorded in the Absolute control.At 105 DAT, stem girth varied among the treatments studied. The plants sprayed with (FYM + RDF + humic acid 1.0%) T6 recorded significantly the highest stem girth of (12.01 mm) and found statistically significant over other treatments studied. However, Absolute control plants registered the lowest stem girth of (7.06 mm).

According to Swathima (2009) [19] in African marigold the results revealed that ,humic acid helps in promoting growth by decreasing IAA oxidase activity and promoting metabolic activities, due to the subsequent plant growth and accumulation of dry matter, hike of stem girth occurred.

Number of primary and secondary branches per plant

The results of the data pertaining to number of primary branches per plant recorded at 60, 75, 90 and 105 DAT are presented in Table 5. Number of primary branches per plant varied significantly in China aster at 60 DAT. Among the treatments studied, T6 (FYM + RDF + humic acid 1.0%) recorded the maximum number of primary branches per plant (8.31) and also found statistically significant. However, minimum number of primary branches per plant was recorded in Absolute control (4.40).

The number of secondary branches per plant recorded maximum in the treatment T6 (FYM + RDF + humic acid 1.0%) (20.03) and found statistically significant over other treatments studied. However, the least number of secondary branches per plant were recorded in Absolute control (10.11) at 60 DAT. Number of primary branches per plant varied significantly in China aster at 75 DAT. Among the treatments studied, T6 (FYM + RDF + humic acid 1.0%) recorded the maximum number of primary branches per plant (9.37) which was on par with T5 (humic acid 0.5% + FYM+ RDF). However, minimum number of primary branches per plant was recorded in Absolute control (6.36). At 75 DAT, the number of secondary branches recorded maximum in the treatment T6 (FYM + RDF + humic acid 1.0%) (26.21) and was found statistically significant over all other treatments studied. Whereas, Absolute control recorded the minimum number of secondary branches per plant (11.11).There was a similar trend noticed at 90 and 105 DAT. Where, maximum number of primary branches were observed in T6 (FYM + RDF + humic acid 1.0%) (13.86, 17.28 respectively) followed by T5 (humic acid 0.5% + FYM+ RDF) (12.88, 16.17 respectively) and least in T1 Absolute control (8.11, 9.83 respectively).

There was a similar trend noticed at 90 and 105 DAT. Where, maximum number of secondary branches were observed in T6 (FYM + RDF + humic acid 1.0%) (28.21, 32.95 respectively) followed by T5 (FYM +RDF + humic acid at 0.5%) (27.00, 32.00 respectively) and least in T1 Absolute control (15.00, 17.17 respectively).According to Memon *et al*. (2014) [13, 14, 15, 16] in zinnia, Manda *et al.* (2014) [12] in *Spathiphyllum wallis*, Ahmad *et al.* (2014) [1] in gladiolus, Esringu *et al*. (2015) [9] *Impatients walleriana*, and Memon *et al*. (2014) [13, 14, 15, 16] in

petunia. Increase in vegetative growth might be due to increase in plasticity of cell wall and formation of energy rich phosphates which stimulates cell division and cell elongation. Another possibility for improved growth could be due to greater osmotic uptake of water and nutrients under the effect of biostimulants, which would improve the nutrient metabolism of plant system.

Table 4: Effect of biostimulants on stem girth (mm) of China aster cv. Poornima

Treatment Details	60 DAT	75 DAT	90 DAT	105 DAT
T1 - Absolute control	3.79	4.93	6.39	7.06
T2 - FYM+ RDF	4.76	5.92	7.17	8.05
T3 - FYM+ RDF+ Boric acid 0.2%	5.86	6.65	7.96	9.12
T4 - FYM + RDF+ Boric acid 0.3%	5.79	6.89	8.12	9.44
T5 - FYM + RDF + Humic acid 0.5%	6.39	7.29	8.67	10.93
T6 - FYM+ RDF + Humic acid 1.0%	7.27	7.93	9.12	12.01
T7 -FYM + RDF+ Azospirillum 4.0%	6.25	7.19	8.49	10.67
T8 - FYM + RDF+ Azospirillum 8.0%	6.22	7.15	8.42	10.76
F- test	*	*	*	*
S.Em±	0.176	0.453	0.573	0.616
C.D. at 5%	0.535	1.374	1.739	1.867

*significant at 5% confidence level,
DAT -Days After Transplanting
RDF -Recommended Dose of Fertilizer (180:120:60 kg /ha N: P: K)
FYM -Farm Yard Manure (15t/ha)

Table 5: Effect of biostimulants on number of primary and secondary branches of China aster cv. Poornima

Treatment details	Number of primary branches				Number of secondary branches			
	Days after transplanting							
	60	75	90	105	60	75	90	105
T1 - Absolute control	4.40	6.36	8.11	9.83	10.11	11.11	15.00	17.17
T2 - FYM+ RDF	6.10	7.23	9.33	12.29	15.24	18.16	21.92	24.11
T3 - FYM+ RDF+ Boric acid 0.2%	6.23	8.43	10.03	13.10	15.92	20.92	23.95	28.01
T4 - FYM + RDF+ Boric acid 0.3%	6.24	7.66	10.32	12.90	15.09	20.52	24.08	28.00
T5 - FYM + RDF + Humic acid 0.5%	7.46	8.38	12.88	16.17	18.23	25.03	27.00	32.00
T6 - FYM+ RDF + Humic acid 1.0%	8.31	9.37	13.86	17.28	20.03	26.21	28.21	32.95
T7 -FYM + RDF+ Azospirillum 4.0%	7.02	8.36	11.83	15.37	17.23	23.67	25.87	29.97
T8 - FYM + RDF+ Azospirillum 8.0%	6.52	8.33	11.09	14.28	18.02	25.19	25.91	28.52
F- test	*	*	*	*	*	*	*	*
S.Em±	0.219	0.169	0.268	0.231	0.254	0.302	0.228	0.272
C.D. at 5%	0.663	0.486	0.812	0.700	0.770	0.915	0.691	0.824

*significant at 5% confidence level,
DAT -Days After Transplanting
RDF -Recommended Dose of Fertilizer (180:120:60 kg /ha N: P: K)
FYM -Farm Yard Manure (15t/ha)

Internodal length (cm)

China aster plant internodal length was recorded at different plant growth stages as influenced by different biostimulants with different concentration. The results relating to the effect of different biostimulants on internodal length of China aster cv. Poornima were recorded at an interval of fifteen days are tabulated in Table 6. With the increase in the age of the plant from 60th to105th day after transplanting there was a corresponding increase in internodal length. At 60 days after transplanting, the maximum internodal length (4.49 cm) was reported in the treatment with foliar application of FYM + RDF + humic acid 1.0% (T6) followed by T5 (FYM +RDF + humic acid at 0.5%) (4.22cm). The least internodal length of 3.23 cm was recorded in T1 treatment i.e. Absolute control.

At 75 DAT, the maximum internodal length (6.12 cm) was reported in the T6 (FYM + RDF + humic acid 1.0%) followed by T5 (FYM +RDF + humic acid at 0.5%) (5.02cm).The least internodal length of 3.33 cm was noticed in absolute control (T1) treatment.There was a similar trend noticed at 90 and 105 DAT. Where, maximum internodal length was observed in T6 (FYM + RDF + humic acid 1.0%) (6.29, 7.04, respectively) followed by T5 (FYM +RDF + humic acid at 0.5%) (5.23, 6.55, respectively) and least in T1 Absolute control (3.55, 4.03, respectively).

Maximum internodal length (cm) was recorded by T6 (FYM + RDF + humic acid 1.0%) than all other treatments, this must be due to humic acid application, which is a naturally occurring polymeric organic compound. It is a potential natural resource that can be utilized to increase nutrient availability and growth of plant. Similar results were also reported by Bashir *et al*. (2016) [5] in gladiolus, Menon *et al*. (2014) in phlox, Mohammadipour *et al*. (2012) [17, 18] in pot marigold and Memon *et al*. (2014) [13, 14, 15, 16] in petunia.

Number of buds per plant

In China aster, the number of buds per plant was recorded at different plant growth stages as influenced by different biostimulants with different concentration. The results relating to the effect of different biostimulants were recorded at an interval of fifteen days are tabulated in Table 7.At 60 days after transplanting, the maximum number of buds (33.00) was recorded in the treatment with T8 (FYM + RDF+ *Azospirillum* 8.0%), followed by T7 (FYM + RDF+ *Azospirillum* 4.0%) (32.00). The least number of buds of (20.00) was recorded in

T1 treatment i.e. Absolute control. At 75 DAT, the highest number of buds (39.33) was recorded in the T8 (FYM + RDF+ *Azospirillum* 8.0%) followed by T7 (FYM + RDF+ *Azospirillum* 4.0%) (38.67). The number of buds of 25.00 was noticed in absolute control (T1) treatment. There was a similar trend noticed at 90 and 105 DAT. Where, maximum number of buds was observed in T8 (FYM + RDF+ *Azospirillum* 8.0%) (40.67, 43.67, respectively) followed by T7 (FYM + RDF+ *Azospirillum* 4.0%) (40.00, 41.67 respectively) and least in T1 Absolute control (29.00, 33.00 respectively). The application of *Azospirillum* lead to greater dry matter accumulation which shows better photosynthetic activity, other metabolic activities and uptake of nutrients from soil which were probably diverted towards more number of buds production Similar results were also reported by Kamalakannan *et al.* (2017) [11] *Jasminum grandiflorum*, Memon *et al*. (2014) [13, 14, 15, 16] in zinnia, Esringu *et al*. (2015) [9] *Impatients walleriana*, Bashir *et al*. (2016) [5] in gladiolus, Menon *et al*. (2014) in phlox, Mohammadipour *et al*. (2012) [17, 18] in pot marigold and Memon *et al*. (2014) [13, 14, 15, 16] in petunia.

Table 6: Effect of biostimulants on internodal length (cm) of China aster cv. Poornima

Treatment Details	60 DAT	75 DAT	90 DAT	105 DAT
T1 - Absolute control	3.23	3.33	3.55	4.03
T2 - FYM+ RDF	3.76	3.39	4.24	4.77
T3 - FYM+ RDF+ Boric acid 0.2%	3.82	4.22	4.39	4.95
T4 - FYM + RDF+ Boric acid 0.3%	3.96	4.52	4.71	5.18
T5 - FYM + RDF + Humic acid 0.5%	4.22	5.02	5.23	6.55
T6 - FYM+ RDF + Humic acid 1.0%	4.49	6.12	6.29	7.04
T7 - FYM + RDF+ Azospirillum 4.0%	4.01	4.77	5.05	6.05
T8 - FYM + RDF+ Azospirillum 8.0%	4.07	4.85	5.24	6.09
F- test	*	*	*	*
S.Em±	0.157	0.187	0.210	0.231
C.D. at 5%	0.477	0.566	0.637	0.699

*significant at 5% confidence level,
DAT -Days After Transplanting
RDF -Recommended Dose of Fertilizer (180:120:60 kg /ha N: P: K)
FYM -Farm Yard Manure (15t/ha)

Table 7: Effect of biostimulants on number of buds per plant of China aster cv. Poornima

Treatment Details	60 DAT	75 DAT	90 DAT	105 DAT
T1 - Absolute control	20.00	25.00	29.00	33.00
T2 - FYM+ RDF	26.00	30.00	34.00	35.33
T3 - FYM+ RDF+ Boric acid 0.2%	26.33	32.33	35.33	38.33
T4 - FYM + RDF+ Boric acid 0.3%	27.33	32.33	37.00	39.33
T5 - FYM + RDF + Humic acid 0.5%	31.33	35.67	37.33	40.67
T6 - FYM+ RDF + Humic acid 1.0%	31.67	37.00	38.67	41.00
T7 - FYM + RDF+ Azospirillum 4.0%	32.00	38.67	40.00	41.67
T8 - FYM + RDF+ Azospirillum 8.0%	33.00	39.33	40.67	43.67
F- test	*	*	*	*
S.Em±	0.733	0.617	0.786	0.948
C.D. at 5%	2.224	1.872	2.383	2.876

*significant at 5% confidence level,
DAT -Days After Transplanting
RDF -Recommended Dose of Fertilizer (180:120:60 kg /ha N: P: K)
FYM -Farm Yard Manure (15t/ha)

Reproductive parameters

The data on number of days taken for first flower appearance, days to 50 per cent flowering and duration of flowering of China aster as influenced by different biostimulants are presented here under the following sub headings. The data presented in Table 8 indicated that the treatment differences were significant in respect to days taken for first flower initiation, days to 50 per cent flowering and duration of flowering.

Days taken for first flower initiation

The results revealed that, the number of days taken for first flower initiation was early 59.44 days in T6 (FYM + RDF+ humic acid 1.0%) followed by T5 (FYM+ RDF + humic acid 0.5%) (60.00 days). The delay in flower initiation 67.22 days was noticed in T1 Absolute control.

Days taken for 50 per cent flowering

The number of days taken for 50 percent flowering was earlier 72.00 days in treatment T6 (FYM + RDF+ humic acid 1.0%) followed by T5 (FYM+ RDF + humic acid 0.5%) (73.29 days). The delay in 50 per cent flowering (82.78 days) was noticed in T1 Absolute control.

Duration of flowering (days)

The duration of flowering was maximum 70.33 days in treatment T6 (FYM + RDF+ humic acid 1.0%) followed by 68.00 days with treatment T5 (FYM+ RDF + humic acid 0.5%) and less number of 56.00 days was found in T1 Absolute control.

Application of higher levels of humic acid along with FYM and RDF produced early crop, which must be due to the higher nutrient availability extended by humic acid. Humic acid might have stimulated plant metabolic activity and photosynthetic efficiency leading to better growth and development. It may act like a supporting team for insurance of increased cell division and elongation, also enhances food accumulation and diversion of photosynthates towards sink resulting in better growth C:N ratio also helped in balanced management of vegetative and reproductive phases and promote early flowering Prasad, 2018 in marigold. Similar findings have been reported by Memon *et al*. (2014) [13, 14, 15, 16] in zinnia, Memon *et al*., 2014 [13, 14, 15, 16] in petunia and Bashir *et al*., (2016) [5] in gladiolus.

Yield parameters

Number of flowers per plant

The Table 9 depicted the numbers of flowers produced per plant, flower yield per plant, numbers of flowers per square meter and number of flowers per hectare as effected by different biostimulants in China aster cv. poornima.

Significantly higher number of flowers produced per plant was reported in treatment T8 (40.00) compared to all other treatments. However, number of flowers per plant in treatment T7 (38.33) and T6 (37.00) are on par with T5 treatment. T1 resulted into least number of flowers per plant (30.00) among all the other treatments.

Flowers yield per plant (g/ plant)

The highest flowers yield per plant was observed in treatment T8 (160.00) which is significantly superior than other treatments. The flower yield per plant was least (60.00) in T1 (Absolute control).

Number of flowers per square meter

The highest number of flowers per square meter was observed in treatment T8 (1777.6) which is significantly superior than

other treatments. The number of flowers per square meter was least (700) in T1 (Absolute control).

Number of flowers per hectare (t/ha)

China aster plants provided with T8 (FYM + RDF+ Azospirillum 8.0%) registered highest (17.7) number of flowers per hectare which was significantly higher than other treatments. The least number of flowers (7.00) per hectare was recorded for (T1) Absolute control.

The biostimulant produced significant increase in vegetative growth, more photosynthates by changing or altering source / sink rates which had the direct bearing on synthesis of flowering hormone (Florigen) and thus might be responsible for change of plant from vegetative to reproductive phase results in producing more number of flowers per lateral and plant. Greater dry matter accumulation shows better photosynthetic activity, other metabolic activities and uptake of nutrients from soil which were probably diverted towards more flower production. Similar findings were also reported by Verma *et al.* (2012) [21] in chrysanthemum, El-Naggar (2010) [7] *Narcissus tazetta*, Anand *et al.* (2016) [3] in *Cymbidium giganteum* and Vinutha *et al.* (2017) [22] in China aster.

Table 8: Days taken for first flower bud initiation, days taken for 50 per cent flowering and duration of flowering influenced by biostimulants on China aster cv. Poornima

Treatment Details	Days taken for first flower initiation	Days taken for 50% flowering	Duration of flowering
T1 - Absolute Control	67.22	82.78	56.00
T2 - FYM+ RDF	63.33	79.67	61.44
T3 - FYM+ RDF+ Boric acid 0.2%	62.11	78.22	66.89
T4 - FYM + RDF+ Boric acid 0.3%	61.56	79.11	66.33
T5 - FYM + RDF + Humic acid 0.5%	60. 00	73.29	68.00
T6 - FYM+ RDF + Humic acid 1.0%	59.44	72.00	70.33
T7 - FYM + RDF+ Azospirillum 4.0%	61.78	79.67	67.67
T8 - FYM + RDF+ Azospirillum 8.0%	60.77	78.56	68.33
F- test	*	*	*
S.Em ±	0.473	0.243	0.699
C.D. at 5%	1.434	0.738	2.120

*significant at 5% confidence level,
DAT -Days After Transplanting
RDF -Recommended Dose of Fertilizer (180:120:60 kg /ha N: P: K)
FYM -Farm Yard Manure (15t/ha)

Table 9: Effect of biostimulants on number of flowers in China aster cv. Poornima

Treatment Details	Number of flowers/ Plants	Flower yield/ plant (g/plant)	Flower yield /Sq. meter	Flower yield/ Hectare (t/Ha)
T1 - Absolute Control	30.00	60.00	700	7.0
T2 - FYM+ RDF	34.00	77.20	855.47	8.6
T3 - FYM+ RDF+ Boric acid 0.2%	34.67	105.10	1166.6	11.7
T4 - FYM + RDF+ Boric acid 0.3%	35.00	105.10	1166.6	11.7
T5 - FYM + RDF + Humic acid 0.5%	36.67	111.00	1233.2	12.0
T6 - FYM+ RDF + Humic acid 1.0%	37.00	133.20	1479.9	14.8
T7 - FYM + RDF+ Azospirillum 4.0%	38.33	147.57	1644.2	16.0
T8 - FYM + RDF+ Azospirillum 8.0%	40.00	160.00	1777.6	17.7
F- test	*	*	*	*
S.Em ±	0.491	13.843	13.500	0.437
C.D. at 5%	1.490	41.987	40.949	1.327

*significant at 5% confidence level,
DAT -Days After Transplanting
RDF -Recommended Dose of Fertilizer (180:120:60 kg /ha N: P: K)
FYM -Farm Yard Manure (15t/ha)

Conclusion

On the basis of the result obtained in the present investigation it is concluded that, FYM + RDF + humic acid at 1.0 per cent recorded maximum improved growth parameter under open field condition, the present study also confirmed that the use of biostimulants is an eco-friendly technique to enhance crop production. Thus, it may be recommended that the China aster plants treated with humic acid at 1.0 per cent along with FYM and RDF to get maximum flower yield which may ensure us to get maximum net returns.

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