RESPONSE OF CHINA ASTER (*CALLISTEPHUS CHINENSIS* L.) GENOTYPES TOWARDS FOLIAR APPLICATION OF GA₃

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ABSTRACT

China Aster is one of the most popular flower that are used in ornamental garden. The demand for cut flowers of China aster is increasing day by day, but it has not been possible to supply the adequate amount of flowers especially during the festival season. The area under flower production is increasing year after year but farmers are not getting quality seeds in adequate quantity as very few farmers are taking up seed production because flower seeds loose their viability earlier than crop seeds. So, production of adequate quantity of quality seeds is essential to meet the demand. The present investigation was undertaken in Horticulture Research Station, Mondouri, B.C.K.V., Mohanpur, Nadia, West Bengal during Rabi season of 2018-19 and 2019-20. Over two consecutive years, six genotypes were evaluated the potentiality of for its growth and flowering, as well as to estimate the influence of GA₃ through foliar application at pre-flowering stage on its seed production. In field three treatments were considered viz. T₁ (control i.e.no application of GA₃), T₂ (GA₃@50ppm), T₃ (GA₃@100ppm). According to the size of

flowers, highest was recorded in Local Mix (G_6). So, it could be considered as the best performer genotype considering flower diameter. Seed yield plant^{-1} was recorded highest in Local White (G_5), it could be considered as the best performer genotype considering its higher number of flowers plant^{-1} and number of seeds flower^{-1}. GA_3 (100 ppm) could be utilized in a better way for greater enhancement in all those important parameters as overall influence of GA_3 has been found to improve seed yield plant^{-1} and all the important attributes. Concomitant consideration of seed yield and its important attributes may indicate to recommend foliar application of 100 ppm GA_3 for enhancement in seed yield in all the genotypes. Similar to the seed yield and its attributes, plant growth and development have been noticed to be positively influenced by GA_3 concentrations with a higher side after 100 ppm, may lead to recommend foliar application of 100 ppm GA_3 for commercial cultivation of this crop irrespective of the genotypes.

Keywords: China Aster, GA_3, Seed Yield.

INTRODUCTION

Indian culture is a pleasing mingling of various subcultures. The culture shows a close connection with flowers from ancient era. However, the social and economic aspects of flower growing were recognized much later. The offering and exchange of flowers on all social occasions apart from use of flowers in worshipping and use of flowers in home decoration and hair adornment of women have made more opportunity for commercial cultivation of flowers. Among the various types of flowers, asters are one of the most beautiful and diverse flowers. The name of Aster comes from Greek word 'aster', which means star. According to Greek mythology, the goddess Asterea looked at the sky to watch the stars but she couldn't see any stars. This incident made her sad and she started weeping, where her tears fell on the ground, asters began to grow there. In Victorian England, floriography i.e. coded communication through the exchange of flowers, was all the rage and asters, with their wide range of colors act as the perfect medium. Purple asters represented wisdom and royalty, and were most popular aster. White aster stood for purity, perfection, and innocence. Red asters stood for devotion whereas pink asters stood for love. These days floriography is not in fashion yet, but asters still have an active symbolic life. China Aster is a monotypic genus of flowering plants in the family Asteraceae which contains the single species. Cassini described China aster as Callistephus hortensis but Linnaeus named it as Aster chinensis. Then, Nees changed its name to Callistephus chinensis. The genus Callistephus is evolved from Greek word 'Kalistos' meaning 'most beautiful' and 'Stephos' which means 'a crown' referring to the flower head. Plants of china aster are erect, alternate bearing. It has broadly ovate or triangular ovate, irregularly toothed leaves. Flowers are solitary, contains two types of florets: ray florets and disc florets. The discs are ray florets are long and short. They have daisy like or star like flower heads with a yellow center. The most suitable character for the classification of China aster is by the shape of ray florets (Janakiram & Rao, 2002). The wide spectrum of colour ranges available in China aster are pink, bluish violet, purple and white. Their attractive colour and long shelf life have made them a popular cut flower. Flower quality is primarily a varietal trait. It is influenced by climatic conditions of growing period. Optimum temperature and requisite photoperiod helps in obtaining better blooms of good size and high quality (Nagaraju et al., 2004). The advantages of growing aster are short duration, suitable as intercrop in coconut and it has good seed setting. It is normally winter season flowering annual which is adapted to wide range of agroclimatic regions. The flower colour is well developed in the temperature range of 20-30^{0}C during day and 15-17^{0}C

during night with relative humidity of 50- 60% and 500-700mm rainfall. Flowers of china asters are used for various purposes like flower decoration, preparation of bouquets, garlands, landscape gardening for aesthetic purpose. It is commercially cultivated in various countries like India, France, Germany, Netherlands, U.K., Siberia, Russia, Japan, North America, Switzerland and England (Raghava, 1984). In India, China aster is largely grown on commercial scale in southern states mainly in Karnataka, Tamil Nadu, Andhra Pradesh, Maharashtra and also some eastern state like West Bengal. In Karnataka, the cultivated area is over an area of 775 lakh ha with an annual production of 6206 tonnes of flowers (Anonymous, 2000). Increased flower production, quality of flowers and perfection in the form of plants are important objectives to be followed in commercial flower production. So, it is essential to meet the demand of adequate quantity of quality seeds for flower as well as seed production. Application of GA_3 is an effective plant growth hormone which stimulates the cells elongation. GA_3 is a lead to produce high seed production. It has ability to regulate plant height, enhance branches, increase productive (Gavino et al., 2008; Yuan et al., 2003). With the above view, present investigation has been carried out to evaluate China aster flower crop by applying GA_3 treatment and record its various seed quality parameters during 2018-2019 and 2019-2020 at Horticulture Research Station, Mondouri, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, India with the main objective of assessment of the effect of GA_3 on growth, development flowering and seed production of different genotypes of China Aster.

MATERIALS AND METHODS

The field experiment was conducted in new alluvial zone at Horticulture Research station, Mondouri, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, India during rabi season of 2018-19 and 2019-20. Soil pH of experimental site was 6.6-6.7, containing organic carbon 0.74%, sandy loam in texture, total available Nitrogen 0.07%, Phosphorus 28.50 kg ha^{-1} and potassium 78 kg ha^{-1}. Seeds of six China aster genotypes viz. Arka Kamini (G_1), Arka Archana (G_2), Arka Adya (G_3), Local pink (G_4), Local White (G_5) and Local Mix (G_6) were sown in the experimental plots. Standard agronomic practices and intercultural operations were followed for raising seedlings in individual plots. Forty days old healthy and uniformly grown seedlings were used for transplanting with a spacing of 40 cm x 40 cm with three replications following Randomised Block Design. A spacing of 45cm between two replications and 45cm between two plots was given to design of water system channels and bunds, individually. The whole exploratory land was separated into plots estimating 2.5 m x 2.5 m. with 54 plots altogether. Farm yard manure was applied @ 2kg plot^{-1}. Fertilizer dose of 10:26:26 (N:P: K mixed fertilizer) @ 150g plot^{-1} was applied as basal portion and another 50g plot^{-1} at 20 days after transplanting. Foliar application of both the doses of Gibberellic acid (i.e. 50 ppm and 100 ppm) was made on plants at three weeks after transplanting and the non-sprayed plants were treated as control. Five plants were randomly tagged at the early crop growth stage and observations on different traits were recorded by a specific method, like plant height (cm), days to bud initiation, days 50% flowering, flower diameter (cm), head diameter (cm), number of flower plant^{-1}, number of seed flower^{-1}, test weight (g) and seed yield plant^{-1} (g).

RESULTS AND DISCUSSION

Different agronomic characters excepting test weight for which it was made during 2018-19 and 2019-20 along with the quality parameters (physiological) of the produced seeds by considerations of effect of GA_3 as foliar application was made over two consecutive years.

Significant variation among the performance of the genotypes, influence of doses of GA_3 as well as its interaction effects observed for all agronomic characters. Gibberellic acid (GA) is a tetracyclic di-terpenoid compound. It is a plant hormone stimulating plant growth and development. It influences seed germination, trigger transitions from meristem to shoot growth, vegetative to flowering and seed development along with an interaction of different environmental factors viz., water, light and temperature. GA_3 is sometime act as paracrine signals; it is still a mystery to understand the GA_3 biosynthesis and its movement. It has not yet established the significant site of bioactive GA_3 in plants or which tissues earmarked by bioactive GA_3 to commence their action.

Plant Height (cm)

Significantly tallest plants were observed for G_4 (Local pink) followed by G_6 (Local Mix), when average was made over the treatments, while most dwarf plants were recognized for G_5 (Local White) (50.277cm) preceded by G_1 (Arka Kamini) and G_2 (Arka Archana), significant difference could be noticed among genotypes during 2018-19 (Table 1). Average influence of 100 ppm GA_3 was significantly superior to that of 50 ppm GA_3 over control for exhibition of plant height at 50% flowering stage. While considering the interaction between genotypes and treatments, significantly maximum plant height was recorded for G_4 after application of 100 ppm GA_3 followed by same genotype after application with 50 ppm of GA_3. Similar to the average influence of GA_3 doses, high GA_3 dose exerted greater influence than that of lower dose for almost all the genotypes for which significant difference between influences of both the doses of GA_3 was recognized.

Average plant height at 50% flowering of G_4 (i.e., Local pink) was also found to be maximum (69.452 cm) followed by that of G_6 (i.e., Local Mix) when average was made over the treatments during 2018-19 as was observed in second year; same like first year, G_5 (Local White) produced dwarf plants of average 50.154cm height preceded by those of G_1, significant difference could be noticed in 2018-19. Significantly enhanced average plant height over control (without application of GA_3) could also be recorded after application of GA_3 and plant height increased with the increased concentration of GA_3 (Table 1). The trend in enhancement in plant height of individual genotypes also followed the similar pattern as was recorded for average influence of GA_3 concentration and significant difference between influence of 50 and 100 ppm GA_3 could be noticed. Plant height was recorded to be as maximum as 75.963cm for G_4 after application of 100 ppm GA_3 followed by that of same genotype after application of 50 ppm of GA_3. Similar type of result in plant height on marigold was also documented previously by (Rai & Bordolui, 2020).

Table 1. Variation in plant height (cm) of different China Aster genotypes

	G_1	G_2	G_3	G_4	G_5	G_6	**Mean T**
2018-2019							
T_1	49.630	50.293	55.663	63.510	44.307	59.220	53.771
T_2	53.530	55.923	59.743	69.437	50.080	64.147	58.810
T_3	58.327	59.563	65.850	76.017	56.443	68.113	64.052
Mean G	53.829	55.260	60.419	69.654	50.277	63.827	
	T	**G**	**T X G**				
SEm(±)	**0.269**	**0.381**	**0.659**				

LSD (0.05)	0.777	1.099	1.924				
2019-2020							
T_1	49.200	50.250	55.577	63.250	44.233	58.890	53.567
T_2	53.407	55.850	59.627	69.143	49.830	64.020	58.646
T_3	57.997	59.510	65.610	75.963	56.400	67.860	63.890
Mean G	53.534	55.203	60.271	69.452	50.154	63.590	
	T	**G**	**T X G**				
SEm(±)	0.264	0.373	0.647				
LSD (0.05)	0.762	1.078	1.867				
Note: T = Treatment, T_1 = Control, T_2 = 50 ppm GA_3, T_3 = 100 ppm GA_3, **G** = Genotypes, G_1 = Arka Kamini, G_2 =Arka Archana, G_3 = Arka Adya, G_4 = Local pink, G_5 =Local White, G_6 = Local Mix							

Days to Flower Bud Initiation

Among the genotypes over treatments, longest duration to flower bud initiation was noted for G_1 i.e. Arka Kamini (88.511days) during the year 2018-19 followed by G_2 i.e. Arka Archana (81.487days), while it was minimum for G_5i.e. local white(71.756 days) preceded by G_4Local pink (72.433days).Among the treatments over the genotypes, maximum duration to bud initiation was observed for T_1 (80.607 days) i.e., in control condition and it was minimum for T_3 (75.071days) i.e., 100 ppm GA_3.It has been observed that days required for bud initiation was reduced with the application of GA_3.The interaction between GA_3 treatment and genotype is noted overall significant though the influence of GA_3 concentration on individual genotypes was varied non significantly in genotype G_4 for both the doses of GA_3 treatments and where no significant difference in days to flower bud initiation was observed. Non-significant difference was observed between the genotype G_3 and G_6 for the treatment T_2 and for the treatment T_3 i.e. 100ppm GA_3 dose; also in case of genotype G_4 and G_5 non-significant difference was observed in days to flower bud initiation in control as well as in T_2.However, maximum days (80.607days) taken to bud initiation was recorded in the control plot i.e. without application of GA_3.

The average performance of the genotypes and influence of GA_3 concentration in 2019-20 was almost similar to that observed in 2018-19, except minimum time taken for flower bud initiation was observed in G_4 i.e. Local pink (70.557days) preceded by G_5i.e Local white, (71.567days),which may be due to the variation in climatic conditions during experimentation over the years (Table 2).When considering interaction between treatments and genotypes, overall it was significant. But it was varied non-significantly among the genotypes G_5 and G_6 for both doses of GA_3, between G_4, G_5 for both the treatments and for control and G_5, G_6 for control. In the year 2019-20; still maximum number of days (90.357days) taken to bud in initiation was recorded for without GA_3 application and consistent reduction in days to flower bud initiation was noticed for all the genotypes with enhancement in GA_3 concentration. Similar type of result in days to flower to bud initiation was also documented previously by (Mahato et al., 2017).

Table 2. Variation in days to flower bud initiation (cm) of different China Aster genotypes

	G_1	G_2	G_3	G_4	G_5	G_6	**Mean T**
2018-2019							
T_1	90.357	85.343	81.150	74.377	75.197	77.217	80.607
T_2	88.820	81.073	75.723	71.923	72.143	75.373	77.509

T_3	86.357	78.043	73.433	71.000	67.927	73.667	75.071
Mean G	88.511	81.487	76.769	72.433	71.756	75.419	
	T	**G**	**T X G**				
SEm(±)	**0.251**	**0.355**	**0.615**				
LSD (0.05)	**0.725**	**1.025**	**1.775**				
2019-2020							
T_1	90.433	84.400	81.057	74.597	75.200	76.467	80.359
T_2	88.980	81.203	76.960	70.930	71.963	75.707	77.624
T_3	86.690	78.110	74.043	66.143	67.537	74.000	74.421
Mean G	88.701	81.238	77.353	70.557	71.567	75.391	
	T	**G**	**T X G**				
SEm(±)	**0.234**	**0.330**	**0.572**				
LSD (0.05)	**0.674**	**0.953**	**1.651**				
Note: T = Treatment, **T_1** = Control, **T_2** = 50 ppm GA_3, **T_3** = 100 ppm GA_3, **G** = Genotypes, **G_1** = Arka Kamini, **G_2** =Arka Archana, **G_3** = Arka Adya, **G_4** = Local pink, **G_5** =Local White, **G_6** = Local Mix							

Days to 50% flowering

Significant difference was observed among the genotypes over treatments both the years; highest days to 50% flowering was recorded in G_1 i.e. Arka Kamini (108.778days for first year and 108.520days for second year), followed by genotype G_2 i.e. Arka Archana (96.808daysfor first year and 96.922 days for second year) and lowest days to 50% flowering was recorded in genotype G_4i.e Local Pink (87.254daysfor first year and 87.150 days for second year) preceded by G_5, G_6 and G_3. Among the treatment over genotypes significant difference was observed. Maximum duration of 50% flowering was recorded in T_0 (97.615 days) and it was consistently reduced with the enhancement in GA_3 concentration in both the years. In case of interaction between genotypes and foliar application of GA_3 non-significant difference was recorded. Though change in magnitudes for this parameter of individual genotypes after foliar application of $GA_3$was recorded non-significant in both years, G_1 took the maximum number of days to 50% flowering without application of GA_3 irrespective of the years of experimentation followed by that of G_2, G_3 and G_6. Similar type of result in days to 50% flowering on rice was also documented previously by (Biswas et al., 2020).

Table 3. Variation in days to 50% flowering of different China Aster genotypes after GA_3 application

	G_1	**G_2**	**G_3**	**G_4**	**G_5**	**G_6**	**Mean T**
2018-2019							
T_1	112.187	100.067	97.267	90.173	91.967	94.030	97.615
T_2	107.947	96.323	93.187	87.323	89.037	91.483	94.217
T_3	106.200	94.033	91.133	84.267	86.933	89.000	91.928
Mean G	108.778	96.808	93.862	87.254	89.312	91.504	
	T	**G**	**T X G**				
SEm(±)	**0.175**	**0.247**	**0.428**				
LSD (0.05)	**0.505**	**0.714**	**NS**				
2019-2020							

T_1	112.023	100.550	97.373	90.117	92.090	94.037	97.698
T_2	107.337	96.200	93.150	87.240	89.063	91.493	94.081
T_3	106.200	94.017	91.267	84.093	86.807	89.300	91.947
Mean G	108.520	96.922	93.930	87.150	89.320	91.610	
	T	**G**	**T X G**				
SEm(±)	**0.160**	**0.226**	**0.391**				
LSD (0.05)	**0.461**	**0.652**	**NS**				
Note: T = Treatment, **T₁** = Control, **T₂** = 50 ppm GA₃, **T₃** = 100 ppm GA₃, **G** = Genotypes, **G₁** = Arka Kamini, **G₂** =Arka Archana, **G₃** = Arka Adya, **G₄** = Local pink, **G₅** =Local White, **G₆** = Local Mix							

Flower Diameter (cm)

Flower diameter is enhanced with increased dose of foliar application of GA_3 over control. Average potentiality of individual genotypes with respect to flower diameter of genotypes over treatments was significantly varied among it selves. During first year (2018-2019), genotype G_6 i.e. local mix secured largest average flower diameter (6.552cm) followed by genotype G_4 i.e. Local pink (6.456cm) and G_5 i.e. Local white (6.201cm) respectively. Beside this, smallest average flower diameter was recorded in the genotype G_1 i.e. Arka Kamini (5.459cm) proceeded by G_2 i.e. Arka Archana and G_3 i.e. Arka Adya respectively (Table 4).Among the treatment over genotypes significant difference was observed when considered as average. Largest flower diameter (6.354cm) was recorded under T_3 i.e. 100ppm GA_3 treatment and it is reduced towards lower dose application and in control respectively. In case of interaction, change in magnitudes for this parameter of individual genotypes after foliar application of $GA_3$was recorded significant; maximum flower diameter was noted in genotype G_6 i.e. Local mix (6.823cm). The interaction between treatments and genotypes significantly varied in first year. Highest value was recorded in T_3G_6 and lowest in T_3G_6.

The average performance of the genotypes and influence of GA_3 concentration in 2019-20 was almost similar to that observed in 2018-19 with slight change in magnitude which may be due to the variation in climatic conditions during experimentation over the years (Table 4). The interaction between treatments and genotypes, was varied significantly overall though non-significant difference is recorded between the genotype G_4 and G_6 in control for the considered parameter. Largest flower diameter was recorded in genotype G_6 (6.867cm) and smallest flower diameter was recorded in the genotype G_1 (5.492cm) as like in first year.

Table 4. Variation in flower diameter of different China Aster genotypes after GA_3 application

	G₁	**G₂**	**G₃**	**G₄**	**G₅**	**G₆**	**Mean T**
2018-2019							
T_1	5.237	5.360	5.603	6.187	5.770	6.257	5.736
T_2	5.463	5.823	5.970	6.473	6.323	6.577	6.105
T_3	5.677	6.053	6.353	6.707	6.510	6.823	6.354
Mean G	5.459	5.746	5.976	6.456	6.201	6.552	
	T	**G**	**T X G**				

SEm($\pm$)	**0.009**	**0.013**	**0.023**				
LSD (0.05)	**0.027**	**0.039**	**0.067**				
2019-2020							
T_1	5.247	5.373	5.617	6.213	5.823	6.277	5.758
T_2	5.480	5.857	6.027	6.490	6.407	6.603	6.144
T_3	5.750	6.103	6.410	6.787	6.600	6.867	6.419
Mean G	5.492	5.778	6.018	6.497	6.277	6.582	
	T	**G**	**T X G**				
SEm($\pm$)	**0.009**	**0.013**	**0.022**				
LSD (0.05)	**0.026**	**0.037**	**0.065**				
Note: T = Treatment, T_1 = Control, T_2 = 50 ppm GA_3, T_3 = 100 ppm GA_3, G = Genotypes, G_1 = Arka Kamini, G_2 =Arka Archana, G_3 = Arka Adya, G_4 = Local pink, G_5 =Local White, G_6 = Local Mix							

Head Diameter (cm)

Head size was consistently increased among the various genotypes with increasing the dose of foliar application of GA_3compared to control. Overall significant difference was observed when considering average performance of genotypes over treatments as well as in case of treatment over genotypes. Though non-significant differences was observed among the genotypes G_1 and G_2, G_2 and G_3, G_3 and G_4, G_4 and G_5 when considering average performance of the mentioned genotype over the treatments during the year 2018-2019. Highest average head diameter was noted in case of genotype G_5 i.e. local white (2.001cm) followed by genotype G_6 i.e. Local Mix (1.964cm), G_4 i.e. Local pink (1.906cm) respectively. Smallest head diameter is recorded in the genotype G_3 i.e. Arka Adya (1.808cm) preceded by G_2 and G_1 (Table 5).When considering treatments over genotypes, the parameter varied significantly. Highest magnitude in head diameter was noted for T_3 i.e. 100ppm foliar application of GA_3 and lowest is observed in case of control. Overall significant difference is observed in case of interaction between genotypes and treatments; though non-significant difference is observed between genotype G_1, G_2, G_3, G_4, G_5 and G_6 when critically observing the interaction (Table 5). Highest head diameter was recorded for genotype G_1 i.e. Arka Kamini (2.227cm) when foliar application of 100ppm GA_3 was given.

The average performance of the genotypes and influence of GA_3 concentration in 2019-20 was almost similar to that observed in 2018-19.The trend in performance of individual genotypes for head diameter in second year was also similar to that recorded in first year, especially with regard to highest and lowest head size. Interaction between treatments and genotypes, was varied significantly overall though non-significant difference is recorded among the genotype G_1, G_2, G_3 and among G_4, G_5, G_6 over various treatment.

Table 5. Variation in head diameter of different China Aster genotypes after GA_3 application

	G_1	G_2	G_3	G_4	G_5	G_6	Mean T
2018-2019							
T_1	1.620	1.520	1.600	1.760	1.873	1.820	1.698
T_2	1.770	1.930	1.833	1.793	2.010	2.007	1.891
T_3	2.227	2.053	1.990	2.163	2.120	2.067	2.103
Mean G	1.872	1.834	1.808	1.906	2.001	1.964	
	T	**G**	**T X G**				
SEm(±)	**0.030**	**0.043**	**0.074**				
LSD (0.05)	**0.087**	**0.123**	**0.213**				
2019-2020							
T_1	1.640	1.550	1.613	1.807	1.887	1.843	1.753
T_2	1.797	1.920	1.853	1.823	2.050	2.103	1.924
T_3	2.257	2.080	2.017	2.177	2.153	2.107	2.132
Mean G	1.898	1.850	1.828	1.936	2.030	2.018	
	T	**G**	**T X G**				
SEm(±)	**0.027**	**0.038**	**0.065**				
LSD (0.05)	**0.077**	**0.108**	**0.188**				
Note: T = Treatment, T_1 = Control, T_2 = 50 ppm GA_3, T_3 = 100 ppm GA_3, **G** = Genotypes, G_1 = Arka Kamini, G_2 =Arka Archana, G_3 = Arka Adya, G_4 = Local pink, G_5 =Local White, G_6 = Local Mix							

Number of Flower Plant^{-1}

Overall significant difference was observed when average was made among the genotypes over treatments for both the years; in the year 2018-2019 highest average number of flower per plant was recorded in G_5 i.e. Local White (36.800) followed by genotype $G_2$and G_1(Table 6)and lowest average number of flower was recorded in genotype G_6i.e Local Mix (24.456) preceded by G_3 and G_1 (Table 6). Among the treatment over genotypes significant difference was observed. Maximum number of flowers was recorded in T_3 (36.844) and it was consistently reduced with the lower GA_3 concentration in both the years. In case of interaction, significant difference was observed overall but when observing critically, non- significant difference is observed between the performance of the genotype G_3 and G_4, G_1 and G_2 over control and in case of genotype G_3 and G_6, G_1 and G_2, G_4 and G_1 over T_2 and in between the genotype G_1 and G_2 over T_3. Maximum number of flowers was recorded in T_3 (36.844) and it was consistently reduced with the decrease in GA_3 concentration in both the years

Similar pattern of improvement in flower number was recognized after utilization of GA_3 in second year as like as first year. The performance of individual genotypes for number of flowers per plant in second year was as likewise as that recorded in first year, especially with respect to maximum and minimum number of flower (Table 6). Interaction of genotypes with the treatment was noted overall significant. Though insignificant difference was noticed between the genotype G_3 and G_4 under unsprayed plot, in addition to this non-significant difference was observed among the genotypes G_1, G_2, G_4 and between G_3 and G_6 for application of 50ppm GA_3 when observing critically (Table 6).

Table 6. Variation in number flower plat^{-1} of different China Aster genotypes after GA$_3$ application

	G$_1$	G$_2$	G$_3$	G$_4$	G$_5$	G$_6$	Mean T
2018-2019							
T$_1$	22.533	24.467	20.400	20.533	28.433	17.767	22.356
T$_2$	29.933	30.633	24.500	28.767	34.833	25.633	29.050
T$_3$	37.700	38.467	32.867	34.933	47.133	29.967	36.844
Mean G	30.056	31.189	25.922	28.078	36.800	24.456	
	T	**G**	**T X G**				
SEm(±)	**0.375**	**0.530**	**0.918**				
LSD (0.05)	**1.082**	**1.531**	**2.651**				
2019-2020							
T$_1$	22.500	25.233	20.033	20.667	28.833	16.867	22.356
T$_2$	29.733	30.433	23.967	29.733	34.633	25.367	28.978
T$_3$	37.533	38.500	33.367	35.533	46.300	29.800	36.839
Mean G	29.922	31.389	25.789	28.644	36.589	24.011	
	T	**G**	**T X G**				
SEm(±)	**0.380**	**0.537**	**0.930**				
LSD (0.05)	**1.096**	**1.550**	**2.686**				
Note: **T** = Treatment, **T$_1$** = Control, **T$_2$** = 50 ppm GA$_3$, **T$_3$** = 100 ppm GA$_3$, **G** = Genotypes, **G$_1$** = Arka Kamini, **G$_2$** =Arka Archana, **G$_3$** = Arka Adya, **G$_4$** = Local pink, **G$_5$** =Local White, **G$_6$** = Local Mix							

Number of Seed Flower^{-1}

Significant difference was observed among the average performance of genotypes over treatments for this trait. Highest number of seeds flower^{-1} was recorded for the genotypeG$_4$ (210.751) followed by G$_5$ while smallest number of seeds flower^{-1} was recorded for G$_3$ (100.640) followed by G$_1$ when considering average (Table 7). There was a rise in number of seeds flower^{-1} with enhanced dose of GA$_3$ compared to unsprayed condition. When considering treatments over genotypes, the parameter varied significantly. Highest number of seeds flower^{-1} was recorded for T$_3$ (182.318), and it reduced with decreased dose of GA$_3$ (Table 7).Significant difference was observed in interaction between treatments and genotypes. Highest number of seeds flower^{-1} was recorded for the genotype G$_4$ (218.513) when treated with100ppm GA$_3$ while lowest number of seed per flower head was recorded for the genotype G$_3$ (93.460) in control. It is markable that, potential of producing seeds flower^{-1} was varied genotype to genotype which may conclude that this parameter is genotype specific.

Average performance of genotypes in response to various treatments varied significantly in final year. Highest and lowest number of seeds flower^{-1} was recorded for the same genotypes

as was in first year. Similar pattern of improvement in flower number was recognized after utilization of GA_3 in second year as like as first year. The performance of individual genotypes for number seeds flower^{-1} in second year was as likewise as that recorded in first year with a minor change in magnitude. Significant variation was observed when considering interaction between genotypes and treatments. Highest number of seeds flower^{-1} was recorded in genotype G_4 and lowest in case of genotype G_3 as likewise in first year with a slight change in magnitude (Table 7).

Table 7. Variation in number of seed flower^{-1} of different China Aster genotypes after GA_3 application

	G_1	G_2	G_3	G_4	G_5	G_6	Mean T
2018-2019							
T_1	161.133	175.593	93.460	203.293	193.867	171.270	166.436
T_2	168.140	181.783	100.430	210.447	199.523	180.547	173.478
T_3	177.010	190.293	108.030	218.513	209.393	190.667	182.318
Mean G	168.761	182.557	100.640	210.751	200.928	180.828	
	T	**G**	**T X G**				
SEm(±)	**0.326**	**0.461**	**0.798**				
LSD (0.05)	**0.941**	**1.331**	**2.073**				
2019-2020							
T_1	161.300	175.377	93.370	203.223	193.887	171.330	166.415
T_2	168.483	182.243	100.223	210.113	199.857	181.470	173.732
T_3	176.993	190.477	107.533	218.060	209.143	191.013	182.203
Mean G	168.926	182.699	100.376	210.466	200.962	181.271	
	T	**G**	**T X G**				
SEm(±)	**0.291**	**0.412**	**0.714**				
LSD (0.05)	**0.841**	**1.189**	**2.060**				
Note: T = Treatment, **T₁** = Control, **T₂** = 50 ppm GA₃, **T₃** = 100 ppm GA₃, **G** = Genotypes, **G₁** = Arka Kamini, **G₂** =Arka Archana, **G₃** = Arka Adya, **G₄** = Local pink, **G₅** =Local White, **G₆** = Local Mix							

Test Weight (g)

Unlike other parameters, test weight of seeds of different genotypes was recorded for final year only. Significant difference was observed overall when average was made among the genotypes over treatment. Though non-significant difference was observed between average test weight in between G_4 and G_5; highest average test weight was recorded in G_1(1.922) followed by G_6 and G_3 while lowest average test weight was noticed in G_2 preceded by G_5 and G_4.Impact of foliar application of GA_3 on various genotypes recorded significant when considering average where highest test weight was recorded for T_3 (1.944).When considering interaction of treatments with genotypes, overall   significant difference was observed. But when observing critically, some genotypes like G_3, G_4 in T_1 and G_5; G_1 and G_6 in T_1 again G_4, G_5 and G_6 in T_2; G_1, G_5 and G_6 in T_2 showed insignificant difference in their test weight.

Table 8. Variation in test weight of seed different China Aster genotypes after GA_3 application

	G_1	G_2	G_3	G_4	G_5	G_6	Mean T
T_1	1.813	1.673	1.740	1.737	1.720	1.793	1.746
T_2	1.920	1.750	1.840	1.817	1.803	1.903	1.839
T_3	2.033	1.860	1.930	1.900	1.920	2.020	1.944
Mean G	1.922	1.761	1.837	1.818	1.814	1.906	
	T	G	T X G				
SEm(±)	0.003	0.005	0.008				
LSD (0.05)	0.010	0.014	0.024				
Note: T = Treatment, T_1 = Control, T_2 = 50 ppm GA_3, T_3 = 100 ppm GA_3, G = Genotypes, G_1 = Arka Kamini, G_2 =Arka Archana, G_3 = Arka Adya, G_4 = Local pink, G_5 =Local White, G_6 = Local Mix							

Seed Yield Plant^{-1} (g)

Significant difference was observed among the average performance of genotypes over treatments in 1st years. Highest average seed yield plant^{-1} was recorded for the genotype G_5 (3.577g) followed by G_4 (3.183g). Lowest yield plant^{-1} was recorded in G_3 for both the years. When considering treatments over genotypes significant variation was noticed with highest magnitude of seed yield plant^{-1} in T_3 for both the years; concluding that application of GA_3 has a positive impact on seed yield. In case of interaction effect, overall significant variation was observed. Highest seed yield plant^{-1} was recorded in G_5 (3.980 g) when treated with 100ppm GA_3. On the other hand, lowest seed yield plant^{-1} was recorded in G_3 (1.860g) in control.

Average performance of genotypes in response to foliar application of GA_3 varied significantly in final year. Highest and lowest seed yield plant^{-1} was recorded for the same genotypes as noted in first year. Similar pattern of improvement in seed yield was recognized after utilization of GA_3 in second year just like first year. The performance of individual genotypes for seed yield plant^{-1} in second year was as likewise as that recorded in first year with a minor change in magnitude. Significant variation was observed when considering interaction between genotypes and treatments; with highest yield of 3.987g in G_3 when treated by T_3. Similar type of result in seed yield plant^{-1} was also documented previously by (Chakraborty et al., 2019).

Table 9. Variation in seed yield plant^{-1} (g) of different China Aster genotypes after GA_3 application

	G_1	G_2	G_3	G_4	G_5	G_6	Mean T
2018-2019							
T_1	2.340	2.280	1.860	2.500	2.923	2.007	2.318
T_2	3.337	3.150	2.777	3.463	3.827	3.053	3.268
T_3	3.460	3.353	3.057	3.587	3.980	3.247	3.447
Mean G	3.044	2.928	2.564	3.183	3.577	2.769	
	T	G	T X G				
SEm(±)	0.008	0.011	0.018				

LSD (0.05)	0.022	0.031	0.053				
2019-2020							
T_1	2.361	2.290	1.897	2.513	2.947	2.053	2.343
T_2	3.347	3.153	2.770	3.490	3.860	3.063	3.281
T_3	3.520	3.420	3.060	3.610	3.987	3.347	3.491
Mean G	3.076	2.954	2.576	3.204	3.598	2.821	
	T	G	T X G				
SEm(±)	0.007	0.009	0.016				
LSD (0.05)	0.019	0.027	0.047				

Note: T = Treatment, **T₁** = Control, **T₂** = 50 ppm GA₃, **T₃** = 100 ppm GA₃, **G** = Genotypes, **G₁** = Arka Kamini, **G₂** =Arka Archana, **G₃** = Arka Adya, **G₄** = Local pink, **G₅** =Local White, **G₆** = Local Mix

i)Arka Kamini(V₁)
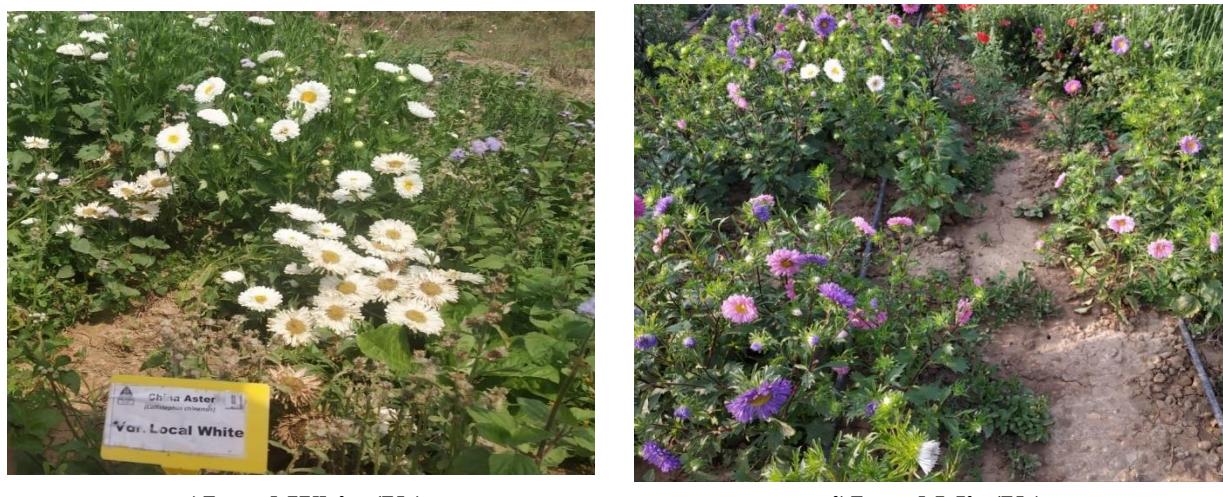
ii)Arka Archana(V₂)

iii)Arka Aadya(V₃)

iv)Local Pink(V₄)

v)Local White(V₅)   **vi)Local Mix(V₆)**

Figure 1. Field performance of different genotypes of China aster

CONCLUSIONS

Among the genotypes, highest flower size was recorded in Local Mix (G_6). So, it could be recommended as the best performer genotype considering flower diameter. Seed yield plant^{-1} was recorded highest in Local White (G_5), it could be considered as the best performer genotype considering its higher number of flowers plant^{-1} and number of seeds flower^{-1}. GA_3(100 ppm) could be utilized in a better way for greater enhancement in all those important parameters as overall influence of GA_3 has been found to enhance seed yield plant^{-1} and all the important attributes. Seed yield is an important attributes may indicate to recommend foliar application of 100 ppm GA_3 for enhancement this trait for all the genotypes. The plant growth and development have been noticed to be positively influenced by GA_3 @ 100 ppm, may lead to recommend foliar application of 100 ppm GA_3 for commercial cultivation of this crop irrespective of the genotypes.

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