Response of Biostimulants on Growth, Flowering, Seed Yield and Quality of China Aster (*Callistephus chinensis* (L.) Nees)

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**ABSTRACT**

A field experiment was conducted to evaluate the effect of different concentrations of Jeevamrit applied both as drench and foliar spray and *Trichoderma* spp @ 1 kg q⁻¹ FYM+Foliar application of Neem seed kernel extract and Garlic extract @ 5% each at 15 days interval on growth and flowering parameters in China aster cv. ‘Kamini’. Findings revealed that maximum plant height (47.38 cm), plant spread (28.47 cm), number of flowers plant⁻¹ (23.87), number of flowers plot⁻¹ (286.44), number of seeds flower⁻¹ (160.27), seed yield plant⁻¹ (8.03 g), seed yield plot⁻¹ (96.40 g), were recorded with treatment application of Jeevamrit @ 5% (Drench)+foliar application of Jeevamrit @ 10%. Maximum flower diameter (5.81 cm), individual flower weight (3.91 g), 100 flower weight (393.31 g), 1000 seed weight (2.20 g), were recorded with Jeevamrit @ 7.5% (Drench)+Foliar application of Jeevamrit @ 10% application. Soil treatment with *Trichoderma* spp @ 1 kg q⁻¹ FYM+Foliar application of Neem seed kernel extract and Garlic extract @ 5% each at 15 days interval, alternatively proved best for seed quality parameters viz., EC (60.25 ds m⁻¹), germination percentage (84.75%), seedling length (6.22 cm), seedling dry weight (4.18 mg), seed vigour index-I (527.15), seed vigour index-II (354.26).

**KEYWORDS:** Biostimulants, China aster, jeevamrit, organic farming, trichoderma
1. INTRODUCTION

In an endeavor to foundations with adoption of natural means of farming to preserve ecosystem, to subside cost of production (Safadi et al., 2021) and to attain the target of doubling farmers’ income, the profundity for Zero Budget Natural Farming (ZBNF) has been realized from the incorporation of this concept in the India’s budget 2019–20 (Anonymous, 2020). The philosophy of the natural farming is to nurture the growth of these beneficial microorganisms without using external manure and chemical pesticides (Srutek and Urban, 2008). Inconsequent use of chemicals in horticulture resulted in several health hazards and environmental problems (Aktar et al., 2009; Dubey and Dat, 2014; Gopinath et al., 2016; Shahane and Shivay, 2021). There is an indiscriminate use of chemical based inputs in the agriculture sector to maximize the production and quality which has been ultimately resulted in environment and soil pollution (Tudi et al., 2021; Shahane and Shivay, 2022). Biostimulants are among the natural preparations that improve the general health, vitality and growth of plants and protect them against infections (Drobek et al., 2019; Kumar et al., 2021). Biostimulants are a good substitute as these are economical and unbounded sources of plant nutrients for sustainable production (Calvo et al., 2014; Tiyagi et al., 2015).

Due to urbanization, the demand of flowers are increasing (Anonymous, 2021), as they are considered as a high value crops. The valuable and blooming business of flowers has led to unrestricted and non-selective use of chemical fertilizers, insecticides and fungicides (Swathi et al., 2017). The use of chemical fertilizers also possess a major threat to sustain soil health and crop productivity. To minimize the use of these inputs without affecting the overall production and the ecosystem, it is necessary to use ecofriendly, economical and easily available biostimulants for the development of more efficient fertility management programme. These are cost effective and a renewable resource of plant nutrients to supplement the chemical fertilizers for sustainable floriculture. In this context, sustainable crop production using biostimulants is an important step towards successful horticulture which in turn will ensure profitable crop production in a cost effective and eco-friendly manner (Xu and Geelen, 2018; Chatterjee and Bandyopadhyay, 2014).

China aster (Callistephus chinensis L. Nees.) is a half hardy annual (Chakraborty et al., 2019) and commercial flower crop belonging to the family Asteraceae (Veluru et al., 2018; Biswas, 2021). It is an important annual crop of our country and grown throughout the world. The genus Callistephus is derived from two Greek words Kalistos meaning ‘most beautiful’ and Stephos, ‘a crown’ referring to the flower head (Munikrishnappa et al., 2013; Khangiarakpam et al., 2014). Cassini described the China aster as Callistephus bortensis. It was first named by Linnaeus as Aster chinensis and Nees changed this name to Callistephus chinensis. It can successfully be grown under different agro-climatic conditions. Among annual flower crops, it ranks next to chrysanthemum and marigold (Kumar et al., 2015; Vijayarukumar et al., 2017). It is gaining popularity because of its easy cultural practices and diversity of colours. Productivity and quality of the loose flowers of China aster can be improved by using high yielding cultivars through improved nutrition (Marak et al., 2020; Padmini et al., 2013; Kaushal et al., 2014). Since there is no scientific information has been available so far. Keeping in view the benefits of biostimulants and owing to the importance of this flower crops, present investigation has been carried out which has both economical and ecological benefits.

2. MATERIALS AND METHODS

The present investigation was carried out in the Department of Floriculture and Landscape Architecture, Dr Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan, HP during (July, 2018–March, 2019). The experimental site is located 14 km away from Solan city i.e. on Solan-Rajgarh Road, at a latitude of 30°51’0” North and longitude of 77°11’30” East with an elevation of 1276 m above mean sea level. The area falls in the mid zone of Himachal Pradesh. Seeds of China aster cv. ‘Kamini’ were procurred from IIHR, Bangalore. Firstly, the experiment was conducted in the field based on Randomized Block Design (RBD). The healthy, bold and disease free seeds of China aster cv. ‘Kamini’ were sown in 15–20 cm raised beds of 1.2 m wide with convenient length containing a mixture of sand+soil+FYM (2:1:1) on July 1st, 2018. The seeds prior to sowing were treated with bjejamrit. The experiment consist of 14 treatments [T:

- Without Jeevamrit, T;
- Jeevamrit @ 5%
- Jeevamrit @ 10%
- Jeevamrit @ 15%
- Jeevamrit @ 2.5%
- Jeevamrit @ 7.5%
- Jeevamrit @ 10% (Drench)+Foliar application of Jeevamrit @ 5%
- Jeevamrit @ 5% (Drench)+Foliar application of Jeevamrit @ 10%
- Jeevamrit @ 7.5% (Drench)+Foliar application of Jeevamrit @ 15%
- Jeevamrit @ 15% (Drench)+Foliar application of Jeevamrit @ 10% ]
extract and Garlic extract @ 5% each at 15 days interval, alternatively], replicated thrice. Treatment combinations were applied at 15 days interval, alternatively. For controlling insect pests, regular spray with Neemastra @ 2.5% and Bramhastra @ 2.5% at 7 days intervals, alternatively will be followed from T<sub>1</sub> to T<sub>13</sub>. The healthy and disease free seedlings of uniform size and vigour at 4–5 leaf stage were selected and transplanted during evening time on August 2<sup>nd</sup>, 2018. The seedlings were planted in raised beds with row to row and plant to plant spacing of 30×30 cm<sup>2</sup> and thus, accommodating 12 plants plot<sup>-1</sup> (1.5×1.0 m<sup>2</sup>). The standard cultural practices viz. weeding, hoeing, irrigation etc. were followed throughout the experiment from planting till termination. To raise healthy crop, field was irrigated twice a week. The harvested seeds were brought to the laboratory and observations on seed yield and quality parameters were taken following completely randomized design with four replication of each treatment and statistically analyzed with the procedure suggested by Gomez and Gomez (1984).

3. RESULTS AND DISCUSSION

3.1. Growth and flowering parameters

Response of biostimulants at different concentrations resulted in significant influence on vegetative and flowering parameters is presented in Table 1. Plants supplied with Jeevamrit @ 5% (Drench)+Foliar application of Jeevamrit @ 10% (T<sub>10</sub>) resulted in maximum plant height (47.88 cm), plant spread (28.47 cm), number of flowers plant<sup>-1</sup> (23.87) and number of flowers plot<sup>-1</sup> (286.47) whereas, minimum plant height (39.75 cm), plant spread (18.54 cm), number

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SEm± | 0.67 | 0.25 | 0.269 | 0.561 | 0.713 | 168.082 | 0.006 | 0.02 | 224.573 | 7.845 | 0.198 | 28.459 | 0.004

CD | 1.38 | 0.64 | 0.88 | 1.26 | 1.43 | 17.10 | 0.13 | 0.24 | 25.29 | 4.72 | 0.75 | 9.00 | 0.11

PH: Plant height (cm); PS: Plant spread (cm); NDTVBF: No. of days taken for visible bud formation; NDTOF: Number of days taken for opening of flower; NFP: No. of flowers plant<sup>-1</sup>; NFPP: Number of flowers plot<sup>-1</sup>; IFW: Individual flower weight (g); FW: 100 flower weight (g); NSF: No. of seeds flower<sup>-1</sup>; SYP: Seed yield plant<sup>-1</sup> (g); SYP*: Seed yield plant<sup>-1</sup> (g); SW: 1000 seed weight (g); SYP: Seed yield plant<sup>-1</sup> (g); SYP*: Seed yield plant<sup>-1</sup> (g).
of flowers per plant (12.33) and number of flowers per plot (148.00) was recorded in treatment $T_0$ i.e. control.

Early visible flower bud formation (49.89 days) and flowering (57.89 days) was observed in control i.e. $T_0$, while maximum days taken to visible flower bud formation (57.89 days) and days taken to flowering (68.13 days) was found in treatment $T_3$ (Jeevamrit @ 5% (Drench)+Foliar application of Jeevamrit @ 10%). The increase in plant height might be ascertained to the presence of nutrients viz., N (0.16%), P (0.02%) and K (0.123%) in Jeevamrit. Nitrogen is an important constituent of nucleic acids which might have increased the synthesis of carbohydrates and amino acids from which the phyto-hormones like auxins, gibberellins and cytokinins have been synthesized. Similarly, phosphorus being an indispensable component of protoplasm and chlorophyll, besides ensuring turning of photosynthates into phospholipids and top of it as it holds rich bio-formulation having consortia of beneficial microbes ultimately resulted in adequate vegetative growth which results in increased plant height (Chadha et al., 2012; Sreenivasa et al., 2011; Aulakh et al., 2013).

Nitrogen assist in amelioration of structural parameters because, it is a principal constituent of proteins. Phosphorus on the other hand is an important structural component of phospholipids helping in absorbing and translocation of food material which significantly increased root geometry, nutrient access and supply resulting in the occurrence of sound and healthy rhizosphere and thus, increased plant spread (Chadha et al., 2012). These results were in close proximity in marigold by Singh et al. (2015) whose resulted also reported that the application of jeevamrit resulted in improved growth and flowering parameters.

Adequate nitrogen and potash availability to the plants received from Jeevamrit applications might have enhanced vegetative growth due to which the reproductive phase initiation was prolonged and delay in visible bud formation was noticed. Further, it is quite obvious that in general, an increase in nitrogen supply with the application of Jeevamrit resulted in vigorous growth of the plants which delayed the bud formation and opening of the flower (Lawlor et al., 2004).

The significant increase in number of flowers might be due to nitrogen, phosphorus and potassium assimilation from the presence of nutrients available viz., N (0.16%), P (0.02%) and K (0.123%) in Jeevamrit. Among nitrogen, phosphorus and potash, nitrogen is main serving force behind life processes which enhanced flower production, in association with more nitrogen fixing and phosphorus solubilizing proficiency (Chadha et al., 2012).

The beneficial effects of Jeevamrit have been attributed to enormous quantity of microbial load and growth hormones intensify the soil biomass assist the availability and uptake of applied as well as native soil nutrients which resulted in more number of flowers. Further, operative micro-organisms predominately, lactic acid bacteria, yeast and actinomycetes have been proven to help in increasing the flower yield (Nileema and Sreenivasa, 2011). Deshmukh et al. (2010) also reported Jeevamrit application to increase the growth and yield parameters in ashwagandha.

Application of Jeevamrit @ 7.5% (Drench)+Foliar application of Jeevamrit @ 10% ($T_3$) resulted in maximum flower diameter (5.81 cm), individual flower weight (3.91 g) and 100 flower weight (393.31 g) and minimum was found in treatment $T_0$ (control) i.e. 4.06 cm, 3.18 g and 297.33 g, respectively.

The probable reason in increase in size of flower from Jeevamrit may be ascertained to the activities of microbes by solubilization and uptake of nutrients was enhanced. In addition to NPK availability in Jeevamrit, GA$_3$ and IAA is also present which might have helped in increase in flower size. The beneficial results of Jeevamrit are also opined by Aulakh et al. (2013) and Devakumar et al. (2014). 100 flower weight was observed to be maximum in treatment $T_3$ which could be attributed to the possible role of Jeevamrit in fixing atmospheric nitrogen, increase in availability of phosphorus and its higher uptake, better root proliferation and vis-a-vis uptake of nutrients which might have resulted increase in individual flower weight and ultimately resulted in higher 100 flower weight. These results were also corroborated by the findings of Manjunatha et al. (2009) in Sunflower which reported the beneficial effects of jeevamrit on growth and flowering parameters.

The increase in fresh weight of flowers might be due to better nitrogen fixation, phosphorus solubilisation, thus, increased availability of nutrients attributed higher production of growth promoting hormones (GA$_3$, IAA) with Jeevamrit. The presence of GA$_3$ and IAA might have contributed to improve various physiological processes associated with flowering that ultimately improved the weight of individual flower (Choudhary et al., 2019).

### 3.2. Seed yield parameters

Following are the seed yield parameters and are presented in Table 1.

Maximum number of seeds head$^{-1}$ (160.27), seed yield plant$^{-1}$ (8.03 g) and seed yield plot$^{-1}$ (96.40 g) were found with treatment $T_3$ (Jeevamrit @ 5% (Drench)+Foliar application of Jeevamrit @ 10%). In contrast, the minimum number of seeds head$^{-1}$ (150.73) were found to be minimum (4.05 g) in treatment $T_0$ (Control). Various growth promoting substances like Gibberlic Acid (GA$_3$), Indole Acetic Acid (IAA) and other beneficial micro-organisms are present in Jeevamrit (Sreenivasa et al., 2009; Neelima and Sreenivasa, 2011). Due to the presence of these growth
promoting substances in Jeevamrit, which might have contributed for better seed setting and hence resulted in the production of more number of seeds per head. These findings got the support from findings of Manjunatha et al. (2009) in marigold which also observed the higher seed set and seed yield with the application of jeevamrit.

The maximum 1000 seed weight (2.20 g) was recorded in treatment $T_8$, i.e. Jeevamrit @ 7.5% (Drench)+Foliar application of Jeevamrit @ 10% which was at par with treatment $T_5$. In contrast, minimum 1000 seed weight was found in treatment $T_0$ (Control) i.e. 1.80 g. Maximum 1000 seed weight observed might be due to the application of Jeevamrit which improved atmospheric nitrogen fixation, increase in availability of phosphorus and its greater uptake, better root proliferation and further uptake of nutrients. As the flowers produced in treatment $T_8$ are lesser in number with respect to other treatments but it resulted in good quality of flowers (size of flower) which resulted in maximum weight of the individual flower head and ultimately higher 1000 seed weight, as the seeds produced were of good quality. These results were found to be in close proximity with the findings of Manjunatha et al. (2009) in sunflower which stated that application of jeevamrit has improved the seed yield and quality parameters.

3.3. Seed quality parameters: following are the seed quality parameters

Data embodied in Table 2 exhibited the significant effect of treatments w.r.t electrical conductivity. Maximum electrical conductivity (77.25 ds m$^{-1}$) was found in treatment $T_0$ (Control) it was (60.25 ds m$^{-1}$) minimum in treatment $T_{13}$, i.e. Soil treatment with Trichoderma spp @ 1 kg q$^{-1}$ FYM+Foliar application of Neem seed kernel extract and Garlic extract @ 5% each at 15 days interval, alternatively. Electrical conductivity of seeds was reported to be maximum in treatment without Jeevamrit. It could be attributed to the fact that the seeds produced from this treatment might have leaked more solutes in water due to thin seed coat and lower integrity of cell membrane. In contrast, minimum electrical conductivity was reported to be in treatment $T_{13}$ which could be due to the fact that the said seeds are bold and maintain higher integrity of the cell membrane, which resulted in less leakage of solutes from the seeds (Harman et al., 2004).

Maximum germination percentage was recorded in treatment $T_{13}$, i.e. Soil treatment with Trichoderma spp @ 1 kg q$^{-1}$ FYM+Foliar application of Neem seed kernel extract and Garlic extract @ 5% each at 15 days interval, alternatively i.e. (84.75 %) and minimum (70.75 %) in treatment $T_0$ (Control). The increased germination percentage of China aster seeds was found in treatment $T_{13}$ might be ascribed to the fact that root colonization by Trichoderma spp frequently enhances root growth and development and therefore improve crop productivity. Trichoderma spp also increase nutrient uptake and the

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<th>Germination percentage (%)</th>
<th>Seedling length (cm)</th>
<th>Seedling dry weight (mg)</th>
<th>Seed vigour index-I (Length)</th>
<th>Seed vigour index-II (Mass)</th>
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<td>$T_{12}$</td>
<td>73.72</td>
<td>76.74</td>
<td>5.23</td>
<td>3.59</td>
<td>401.35</td>
<td>275.49</td>
</tr>
<tr>
<td>$T_{13}$</td>
<td>60.25</td>
<td>84.75</td>
<td>6.22</td>
<td>4.18</td>
<td>527.15</td>
<td>354.26</td>
</tr>
<tr>
<td>SEm±</td>
<td>3.971</td>
<td>2.074</td>
<td>0.056</td>
<td>0.03</td>
<td>79.464</td>
<td>71.37</td>
</tr>
<tr>
<td>CD (p=0.05)</td>
<td>2.86</td>
<td>2.07</td>
<td>0.34</td>
<td>0.25</td>
<td>12.80</td>
<td>12.13</td>
</tr>
</tbody>
</table>
efficiency of nitrogen use and can solubilize nutrients in the soil, which might have resulted in increase in germination percentage. These findings were found in close proximity with the studies of Harman et al. (2004) and Manka et al. (1997) which reported the beneficial effects of Trichoderma spp. The Trichoderma spp act as a biological control agent which might be the reason to control the seed borne diseases in China aster and ultimately resulted in increased seed germination (Uddin et al., 2015).

Maximum seedling length (6.22 cm) was recorded in treatment $T_{13}$ (Soil treatment with Trichoderma spp @ 1 kg q$^{-1}$ FYM+Foliar application of Neem seed kernel extract and Garlic extract @ 5% each at 15 days interval, alternatively) and Minimum seedling length (4.37 cm) was recorded in treatment $T_0$ (Control). The increase in seedling length found in seeds harvested from plants with treatment $T_{13}$ might be due to the fact that application of Trichoderma helped in growth promotion including control of minor pathogens, enhanced nutrient uptake, increased carbohydrate metabolism and phytohormone synthesis. Trichoderma stimulated growth by influencing the balance of hormones such as IAA and GA$_3$ Harman et al. (2004) and Vinale et al. (2008). This resulted in higher rate of cell division in the root and shoot tips which ultimately resulted in increased seedling length.

Maximum seedling dry weight (4.18 mg) was recorded in treatment $T_{13}$ (Soil treatment with Trichoderma spp @ 1 kg q$^{-1}$ FYM+Foliar application of Neem seed kernel extract and Garlic extract @ 5% each at 15 days interval, alternatively). Whereas, minimum seedling dry weight (3.41 mg) was recorded in treatment $T_0$ (Control). Production of plant growth regulators, solubilization of insoluble minor nutrients in soil, increased availability of micronutrients, increase in nutrient transfer from soil to root, Induced resistance to different pathogens (mostly other fungus) are the main Trichoderma mechanism of action in contact to plants which might have resulted in healthy seedling (Kaveh et al., 2011). The increased seedling dry weight was also found to be positively correlated with the seedling length. As seedling length increased in treatment $T_{13}$, the increase in seedling dry weight was also noticed in the same seedlings.

Maximum seed vigour index-I (527.15) was found in treatment $T_{13}$ (Soil treatment with Trichoderma spp @ 1 kg q$^{-1}$ FYM+Foliar application of Neem seed kernel extract and Garlic extract @ 5% each at 15 days interval, alternatively) and it was minimum (309.18) in treatment $T_0$ (Control). Seed vigour index-I were recorded to be higher in treatment $T_{13}$ which could be attributed to higher germination percentage and seedling length. Owing to the reasons that Seed vigour index-I is product of germination percentage and seedling length, thus, resulted in higher Seed vigour index-I. The results got the support from the findings of Asaduzzaman et al. (2010) which also reported that application of Trichoderma has resulted in improved seed quality parameters in chilli.

Maximum seed vigour index –II (354.26) in treatment $T_{13}$ (Soil treatment with Trichoderma spp @ 1 kg q$^{-1}$ FYM+Foliar application of Neem seed kernel extract and Garlic extract @ 5% each at 15 days interval, alternatively) and it was minimum (241.26) in treatment $T_0$ (Control). Seed vigour index-II were recorded to be higher in treatment $T_{13}$ which could be attributed to higher germination percentage and seedling dry weight. Owing to the reasons that Seed vigour index-II is the product of germination percentage and seedling dry weight, hence, it accounts for higher Seed vigour index-II. These findings got the support from the results of Sisodia and Singh, 2015 who also found the positive effects of Trichoderma application on flowering in gladiolous.

4. CONCLUSION

The application of Jeevanmit @ 5% (Drench)+Foliar application of Jeevanmit @ 10% improved growth, flowering and seed yield parameters whereas, Soil treatment with Trichoderma spp @ 1 kg/q FYM+Foliar application of Neem seed kernel extract and Garlic extract @ 5% each at 15 days interval, alternatively improved the seed quality parameters of China aster cv. ‘Kamini’.

4. REFERENCES


Nileema, S., Sreenivasa, M.N., 2011. Influence of liquid organic manures on growth, nutrient content and yield of tomato (Lycopersicon esculentum Mill.) in...

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