




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

S. Pathania , B. S. Ditta and A. Kumar

Dept. of Floriculture and Landscape Architecture, Dr Y S Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh (173 230), India



Corresponding  sabhyapathania209@gmail.com

 0009-0007-2282-4480

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

Citation (VANCOUVER): Pathania et al., Response of Biostimulants on Growth, Flowering, Seed Yield and Quality of China Aster (*Callistephus chinensis* (L.) Nees). *International Journal of Bio-resource and Stress Management*, 2023; 14(8), 1108-1115. [HTTPS://DOI.ORG/10.23910/1.2023.3552](https://doi.org/10.23910/1.2023.3552).

Copyright: © 2023 Pathania et al. This is an open access article that permits unrestricted use, distribution and reproduction in any medium after the author(s) and source are credited.

Data Availability Statement: Legal restrictions are imposed on the public sharing of raw data. However, authors have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

Conflict of interests: The authors have declared that no conflict of interest exists.



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; Tiyyagi 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; Khangjarakpam et al.,

2014). Cassini described the China aster as *Callistephus hortensis*. 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; Vijayakumar 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 procured 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 beejamrit. The experiment consist of 14 treatments [T₁: Without Jeevamrit, T₂: Jeevamrit @ 2.5% (Drench)+Foliar application of Jeevamrit @ 5%, T₃: Jeevamrit @ 2.5% (Drench)+Foliar application of Jeevamrit @ 10%, T₄: Jeevamrit @ 2.5% (Drench)+Foliar application of Jeevamrit @ 15%, T₅: Jeevamrit @ 5% (Drench)+Foliar application of Jeevamrit @ 5%, T₆: Jeevamrit @ 5% (Drench)+Foliar application of Jeevamrit @ 10%, T₇: Jeevamrit @ 5% (Drench)+Foliar application of Jeevamrit @ 15%, T₈: Jeevamrit @ 7.5% (Drench)+Foliar application of Jeevamrit @ 5%, T₉: Jeevamrit @ 7.5% (Drench)+Foliar application of Jeevamrit @ 10%, T₁₀: Jeevamrit @ 7.5% (Drench)+Foliar application of Jeevamrit @ 15%, T₁₁: Jeevamrit @ 10% (Drench)+Foliar application of Jeevamrit @ 5%, T₁₂: Jeevamrit @ 10% (Drench)+Foliar application of Jeevamrit @ 10%, T₁₃: Jeevamrit @ 10% (Drench)+Foliar application of Jeevamrit @ 15%, T₁₄: 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], 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 T₁ to T₁₂. 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 2nd, 2018. The seedlings were planted in raised beds with row to row and plant to plant spacing of 30×30 cm² and thus, accommodating 12 plants plot⁻¹ (1.5×1.0 m²). 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% (T₅) resulted in maximum plant height (47.88 cm), plant spread (28.47 cm), number of flowers plant⁻¹ (23.87) and number of flowers plot⁻¹ (286.47) whereas, minimum plant height (39.75 cm), plant spread (18.54 cm), number

Table 1: Effect of biostimulants on vegetative, flowering and seed yield parameters of China aster cv. 'Kamini'

Treat-ments	PH	PS	NDTVBF	NDTOF	NFP	NFPP	FD	IFW	FW	NSF	SYP	SYP*	SW
T ₀	39.75	18.54	49.89	60.60	12.33	148.00	4.06	3.18	297.33	150.73	4.05	48.64	1.80
T ₁	40.91	22.70	50.42	60.87	15.91	190.96	4.99	3.33	315.00	152.13	4.86	58.32	1.87
T ₂	44.08	24.84	52.16	63.60	18.91	226.92	5.09	3.48	329.67	153.47	5.36	64.32	1.89
T ₃	44.17	24.52	54.60	65.00	19.50	234.00	5.30	3.60	345.67	154.93	6.21	74.48	2.03
T ₄	47.59	26.70	56.09	66.93	22.25	267.00	5.47	3.64	369.33	157.93	7.16	85.92	2.06
T ₅	47.88	28.47	57.89	68.13	23.87	286.44	5.75	3.79	381.77	160.27	8.03	96.40	2.10
T ₆	47.85	27.55	56.04	67.13	22.36	268.28	5.49	3.82	383.64	159.93	7.48	89.76	2.12
T ₇	47.39	26.36	55.36	66.47	22.12	265.44	5.77	3.85	388.24	158.74	7.58	90.96	2.15
T ₈	46.33	25.73	55.82	66.20	21.48	257.80	5.81	3.91	393.31	156.87	7.24	86.88	2.20
T ₉	46.31	25.47	55.96	65.80	20.22	242.60	5.67	3.89	391.64	155.60	6.82	81.84	2.13
T ₁₀	44.69	25.51	53.29	63.53	20.18	242.20	5.51	3.67	378.00	156.90	6.57	78.80	2.10
T ₁₁	45.35	25.59	52.06	62.67	20.39	244.68	5.60	3.72	380.00	157.25	6.61	79.28	2.07
T ₁₂	44.28	24.63	50.82	61.20	20.15	241.80	5.45	3.63	369.00	156.75	6.46	77.52	2.13
T ₁₃	45.12	25.67	54.31	64.93	21.24	254.88	5.49	3.81	392.00	155.75	6.97	83.68	2.17
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 (p=0.05)	1.38	0.84	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⁻¹; NFPP: Number of flowers plot⁻¹; FD: Flower diameter (cm); IFW: Individual flower weight (g); FW: 100 flower weight (g); NSF: No. of seeds flower⁻¹; SYP: Seed yield plant⁻¹ (g); SYP*: Seed yield plant⁻¹ (g); SW: 1000 seed weight (g); T₀: Control; T₁: Jeevamrit @ 2.5% (Drench)+Foliar application of Jeevamrit @ 5%; T₂: Jeevamrit @ 2.5% (Drench)+Foliar application of Jeevamrit @ 10%; T₃: Jeevamrit @ 2.5% (Drench)+Foliar application of Jeevamrit @ 15%; T₄: Jeevamrit @ 5% (Drench) +Foliar application of Jeevamrit @ 5%; T₅: Jeevamrit @ 5% (Drench) +Foliar application of Jeevamrit @ 10%; T₆: Jeevamrit @ 5% (Drench)+Foliar application of Jeevamrit @ 15%; T₇: Jeevamrit @ 7.5% (Drench)+Foliar application of Jeevamrit @ 5%; T₈: Jeevamrit @ 7.5% (Drench)+Foliar application of Jeevamrit @ 10%; T₉: Jeevamrit @ 7.5% (Drench)+Foliar application of Jeevamrit @ 15%; T₁₀: Jeevamrit @ 10% (Drench)+Foliar application of Jeevamrit @ 5%; T₁₁: Jeevamrit @ 10% (Drench)+Foliar application of Jeevamrit @ 10%; T₁₂: Jeevamrit @ 10% (Drench)+Foliar application of Jeevamrit @ 15%; T₁₃: 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

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_5 (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 result 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

intensity 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_8) 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_8 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_5 (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 T₈ i.e. Jeevamrit @ 7.5% (Drench)+Foliar application of Jeevamrit @ 10% which was at par with treatment T₅. In contrast, minimum 1000 seed weight was found in treatment T₀ (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 T₈ 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 T₀ (Control) it was (60.25 ds m⁻¹) minimum in treatment T₁₃ 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 T₁₃ 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 T₁₃ 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 T₀ (Control). The increased germination percentage of China aster seeds was found in treatment T₁₃ 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

Table 2: Effect of biostimulants on seed quality parameters of China aster cv. 'Kamini'

Treatments	EC (ds m ⁻¹)	Germination percentage (%)	Seedling length (cm)	Seedling dry weight (mg)	Seed vigour index-I (Length)	Seed vigour index-II (Mass)
T ₀	77.25	70.75	4.37	3.41	309.18	241.26
T ₁	74.75	75.55	5.58	3.58	421.57	270.47
T ₂	71.25	79.49	5.72	3.61	454.68	286.96
T ₃	69.09	79.93	5.75	3.68	459.59	294.14
T ₄	66.50	80.49	5.92	3.85	476.50	309.89
T ₅	62.75	83.63	6.19	4.12	517.67	344.56
T ₆	65.25	82.24	6.04	4.06	496.73	333.89
T ₇	67.29	80.34	5.85	3.92	469.99	314.93
T ₈	67.50	80.30	5.76	3.77	462.53	302.73
T ₉	70.05	79.85	5.74	3.69	458.34	294.65
T ₁₀	73.08	79.19	5.52	3.62	437.13	286.67
T ₁₁	73.75	77.41	5.45	3.60	421.88	278.43
T ₁₂	73.72	76.74	5.23	3.59	401.35	275.49
T ₁₃	60.25	84.75	6.22	4.18	527.15	354.26
SEm±	3.971	2.074	0.056	0.03	79.464	71.37
CD (p=0.05)	2.86	2.07	0.34	0.25	12.80	12.13

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 T₁₃ (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 T₀ (Control). The increase in seedling length found in seeds harvested from plants with treatment T₁₃ 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 GA₃ 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 T₁₃ (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 T₀ (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 T₁₃, the increase in seedling dry weight was also noticed in the same seedlings.

Maximum seed vigour index-I (527.15) was found in treatment T₁₃ (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 T₀ (Control). Seed vigour index-I were recorded to be higher in treatment T₁₃ 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 T₁₃ (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 T₀ (Control). Seed vigour index-II were recorded to be higher in treatment T₁₃ 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 Jeevamrit @ 5% (Drench)+Foliar application of Jeevamrit @ 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

- Aulakh, C.S., Singh, H., Walia, S.S., Phutela, R.P., Singh, G., 2013. Evaluation of microbial culture (Jeevamrutha) preparation and its effect on productivity of field crops. *Indian Journal of Agronomy* 58(2), 182–186.
- Aktar, W., Sengupta, D., Chowdhury, A., 2009. Impact of pesticides use in agriculture: their benefits and hazards. *Interdisciplinary toxicology* 2(1), 1.
- Anonymous, 2020. Economic survey: Volume 2. Government of India Ministry of Finance Department of Economic Affairs Economic Division North Block New Delhi, 320.
- Anonymous, 2021. Floriculture: Impact analysis and way forward, ICAR- Directorate of Floriculture Redearch, College of Agriculture, Shivaji nagar, Pune, 23.
- Asaduzzaman, M., Alam, M.J., Islam, M.M., 2010. Effect of *Trichoderma* on seed germination and seedling parameters of chili. *Journal of Science Foundation* 8, 141–150.
- Biswas, S., 2021. Response of China aster (*Callistephus chinensis* L.) genotypes towards foliar application of GA₃. *American International Journal of Agricultural Studies* 5(1), 1–15.

- Calvo, P., Nelson, L., Kloepper, J.W., 2014. Agricultural uses of plant biostimulants. *Plant and Soil* 383, 3–41.
- Chadha, S., Saini, J.P., Paul, Y.S., 2012. Vedic Krishi: Sustainable livelihood option for small and marginal farmers. *Indian Journal of Traditional Knowledge* 11, 483–486
- Chakraborty, A., Bordolui, S.K., Mahato, M.K., Sadhukhan, R., Veda, S.D.J.M.S.N.K., 2019. Variation in seed production potential of China aster genotypes in the New Alluvial Zone of West Bengal. *Journal of Crop and Weed* 15(1), 201–204.
- Chatterjee, M., Bandyopadhyay, S., 2014. Studies on effect of organic, inorganic and biofertilizers on plant nutrient status and availability of major nutrients in tomato. *International Journal of Bioresource and Stress Management* 5(1), 093–097.
- Choudhary, S., Kashyap, B., Choudhary, R.C. Jat, M.L. 2021. Effect of Jeevamrit on growth and flowering of marigold. *The Pharma Innovation* 10, 1037–1040.
- Deshmukh, S.B., Gajbhiye, R.P., Chavan, S.P., 2010. Effect of organic manures and biofertilizers on growth and yield of ashwagandha. *Green Farming* 1, 467–469.
- Devakumar, N., Shubha, S., Gouder, S.B., Rao, G.G.E., 2014. Microbial analytical studies of traditional organic preparations beejamrit and jeevamrit. In: Rahmann G., Aksoy, U. (Eds.), *Proceedings of 4th Scientific Conference on Building Organic Bridges*, October 13–15, 2014, Istanbul, Turkey, pp 639–43.
- Drobek, M., Frac, M., Cybulska, J., 2019. Plant biostimulants: Importance of the quality and yield of horticultural crops and the improvement of plant tolerance to abiotic stress-A review. *Agronomy* 9, 335.
- Dubey, Y.P., Dat, N., 2014. Influence of organic, inorganic and integrated use of nutrients on productivity and quality of pea (*Pisum sativum*) vis-a-vis soil properties. *Indian Journal of Agricultural Sciences* 84(10), 1195–1200.
- Gomez, K.A., Gomez, A.A., 1984. *Statistical Procedures for Agricultural Research* (2nd Edn.) J Willey and Sons, Inc., New York, 680.
- Gopinath, K.A., Rao, C.S., Ramanjaneyulu, A.V., Jayalakshmi, M., Ravindrachary, G., Venkatesh, G., 2016. Organic farming research in India: Present status and way forward. *International Journal of Economic Plants* 3(3), 098–101.
- Gore, N.S., Sreenivasa, M.N., 2011. Influence of liquid organic manures on growth, nutrient content and yield of tomato (*Lycopersicon esculentum* Mill.) in the sterilized soil. *Karnataka Journal of Agricultural Sciences* 24, 153–157.
- Harman, G.E., Howell, C.R., Viterbo, A., Chet, I., Lorito, M., 2004. Trichoderma species-opportunistic, a virulent plant symbionts. *Nature Reviews Microbiology* 2, 43.
- Kaushal, S., Dilta, B.S., Chaudhary, S.V.S., Sharma, B.P., Gupta, Y.C., 2014. Effect of planting dates on growth and flowering of China aster [*Callistephus chinensis* (L.) Nees]. *International Journal of Farm Sciences* 4(1), 60–71.
- Kaveh, H., Jartoodeh, S.V., Aruee, H., Mazhabi, M., 2011. Would Trichoderma affect seed germination and seedling quality of two muskmelon cultivars, Khatooni and Qasri and increase their transplanting success. *Journal of Biodiversity and Environmental Sciences* 5, 169–175.
- Khangjarakpam, G., Kumar, R., Seetharamu, G.K., Rao, T.M., Dhananjaya, M.V., Venugopalan, R., Padmini, K., 2014. Genetic variability for quantitative traits in China aster [*Callistephus chinensis* (L.) Nees]. *Journal of Horticultural Sciences* 9(2), 141–144.
- Kumar, K.P., Padmalatha, T., Pratap, M., Reddy, S. N., 2015. Effect of plant bio-regulators on growth, flowering and seed yield in China aster (*Callistephus chinensis* L. Nees) cv. 'Kamini'. *Indian Journal of Agricultural Research* 49(4), 348–352.
- Kumar, S., Kumar, M., Sewhag, A., Neelam, M., Chaudhary, K., 2021. Assessing mungbean productivity under organic management. *Legume Research* 44(3), 349–352.
- Manjunatha, G.S., Upperi, S.N., Pujari, B.T., Yeledahalli, N.A., Kuligoda, V.B., 2009. Effect of farm yard manure treated with jeevamrit on yield attributes and economics of Sunflower (*Helianthus annuus* L.). *Karnataka Journal of Agricultural Sciences* 22, 342–348.
- Manka, M., Fruzynska, J.D., Pokojaska, B.A., Dahm, H., 1997. Promoting effect of *Trichoderma harzianum* on cutting growth in biocontrol of Fusarium carnation wilt. *Folia Horticulturae* 9(2), 3–13.
- Marak, B.S., Kumar, S., Momin, K.C., 2020. Effects of organic manures and bio-fertilizers on growth, flowering and yield of China aster (*Callistephus chinensis* L. Nees) var. 'Kamini'. *Bangladesh Journal of Botany* 49(4), 1111–1117.
- Lawlor, D.W., Mengel, K., Kirkby, E.A., 2004. Principles of plant nutrition. *Annals of Botany* 93(4), 479–480.
- Munikrishnappa, P.M., Patil, A.A., Patil, V.S., Patil, B.N., Channappagoudar, B.B., Alloli, T.B., 2013. Studies on the growth and yield parameters of different genotypes of China aster (*Callistephus chinensis* Nees.). *Karnataka Journal of Agricultural Sciences* 26, 107–110.
- Nileema, S., Sreenivasa, M.N., 2011. Influence of liquid organic manures on growth, nutrient content and yield of tomato (*Lycopersicum esculentum* Mill.) in

- the sterilized soil. *Karnataka Journal of Agricultural Sciences* 24, 153–157.
- Padmini, K., Janakiram, T., Naik, L.B., 2013. Effect of nutrients and growth regulators on seed yield in China aster (*Callistephus chinensis*) cv. 'Poornima'. *Indian Journal of Agricultural Sciences* 83(3), 349–351.
- Safadi, M.K., Merlet, M., Marchand, P.A., 2021. Bioresources: Back to the Ancient World? *International Journal of Bioresource and Stress Management* 12(4), 5–7.
- Shahane, A.A., Shivay, Y.S., 2021. In-season nutrient management in arable crops- A key to increased productivity and nutritional security. *Indian Journal of Fertilizers* 17(6), 560–577.
- Shahane, A.A., Shivay, Y.S., 2022. Soil health management in organic production system—a review. *International Journal of Bio-resource and Stress Management* 13(11), 1186–1200.
- Singh, M., Dwivedi, D.H., Kumar, M., 2015. Efficiency of organic and biodynamic manures on growth and flowering in marigold (*Tagetes patula* L.). *Progressive Agriculture* 15(1), 134–137.
- Sisodia, A., Singh, A.K., 2015. Effects of farmyard manure, vermicompost and Trichoderma on flowering and corm attributes in gladiolus. *Bangladesh Journal of Botany* 44, 309–314.
- Sreenivasa, M.N., Naik, N.M., Bhat, S.N., 2009. Beneficial traits of microbial isolates of organic liquid manures. In: *First Asian PGPR Congress for Sustainable Agriculture*, ANGRAU, Hyderabad, 21–24.
- Sreenivasa, M.N., Naik, N.M., Bhat, S.N., 2009. Nutrient status and microbial load of different organic liquid manures. *Karnataka Journal of Agricultural Sciences* 24(2), 583–584.
- Srutek, M., Urban, J., 2008. Organic Farming. In: *Jorgensen, S.E., Fath, B.D. (Eds.), Encyclopedia of Ecology*, Academic Press, 2582–2587.
- Swathi, K., Sarkar, I., Maitra, S., Sharma, S., 2017. Organic manures and bio-inoculants mediated influence on growth and flowering of african marigold (*Tagetes erecta* L.) cv. 'Pusa Narangi Gainda'. *International Journal of Bio-resource and Stress Management* 8(3), 429–432.
- Tiyagi, S.A., Safiuddin, R., Rizvi, I., Mahamood Khan, Z., 2015. Evaluation of organic matter, bio-inoculants and inorganic fertilizers on growth and yield attributes of tomato with to the management of plant parasitic nematodes. *Emirates Journal of Food and Agriculture* 27, 602–609.
- Tudi, M., Daniel Ruan, H., Wang, L., Lyu, J., Sadler, R., Connell, D., Chu, C., Phung, D.T., 2021. Agriculture development, pesticide application and its impact on the environment. *International Journal of Environmental Research and Public Health* 18(3), 1112.
- Uddin, A.F.M.J., Hussain, M.S., Rahman, S.K.S., Ahmad, H., Roni, M.Z.K., 2015. Effect of Trichoderma concentration on the growth and yield of tomato. *Bangladesh Journal of Agricultural Research* 11, 228–232.
- Veluru, B., Rajiv, K., Rao, T.M., Bharathi, T.U., Dhananjaya, M.V., Pratiksha, K., 2018. Characterization of China aster (*Callistephus chinensis*) genotypes by using DUS guidelines. *Indian Journal of Agricultural Sciences* 88(1), 138–144.
- Vijayakumar, S., Rajadurai, K.R., Pandiyaraj, P., 2017. Effect of plant growth regulators on flower quality, yield and post harvest shelflife of China aster (*Callistephus chinensis* L. Nees) cv. 'Local'. *International Journal of Agricultural Science and Research* 7(2), 297–304.
- Vinale, F., Sivasithamparam, K., Ghisalberti, E.L., Marra, R., Woo, S.L., Lorito, M., 2008. Trichoderma–plant–pathogen interactions. *Soil Biology and Biochemistry* 40, 1–10.
- Xu, L., Geelen, D., 2018. Developing biostimulants from agro-food and industrial by-products. *Frontiers in Plant Science* 9, 1567.

