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Effect of Different INM Packages on Vegetative, Flowering, Yield and Economics of China Aster cv Kamini under High Hill Condition of Uttarakhand

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ABSTRACT

The present investigation was conducted to develop a sustainable INM package for economical production China aster crop under high hill condition of Uttarakhand. The experiment was conducted at Floriculture farm, COH, VCSG, UUHF, Bhrasar from March to September 2022. The treatments were 12, replicate thrice in Randomized Complete Block Design. The results showed that maximum plant spread (22.86 cm), number of leaves plant^{-1} (219.33), leaf area (38.56 cm^2), earliness in days taken to 1st bud appearance and flower opening (68.630 and 82.707days, respectively) and maximum flowering duration (23.430 days) were recorded in T_7 (50% RDF + 25% FYM + 25% Vermicompost + *Azotobacter* (5 mL L^{-1})). However, maximum number of flowers plant^{-1} and plot^{-1} (36.80 and 441.53, respectively), stalk length (38.40 cm), flower diameter (7.26 cm), individual flower weight (3.86 g), flower yield plant^{-1} and bed^{-1} (142.89 g and 1.71 kg), seed yield plant^{-1} (3.330 g) and test weight (2.477 g), shelf and vase life (4.50 and 12.300 days, respectively) and C:B from flowers (1: 2.19) were recorded from the plants grown in plots applied with T_8 (50% RDF + 25% FYM + 25% Neem cake + *Azotobacter* (5 mL L^{-1})). So, from the present investigation it can be concluded that treatment T_8 was found effective in economical production of China aster cv Kamini under high hill condition of Uttarakhand.

Keywords China aster, INM, FYM, Goat manure, Neem cake, Vermicompost.

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INTRODUCTION

China aster (*Callistephus chinensis* (L.) Nees) is one of the most popular annual flower crop grown throughout the world. It belongs to the family Asteraceae and originated from China. The generic name *Callistephus* is derived from two Greek words '*kalistos*' means most beautiful and '*stephos*' means a crown. The flowers are used as cut as well loose flower purposes. Beside use of flowers in bouquets, vases, floral arrangements and garlands, it is one of the important plants used for landscaping. The plants are used as bedding purpose and for making herbaceous border. The dwarf cultivars are suitable for planting in pots, edges and window boxes. It is also found suitable for inter-cropping in coconut gardens.

The wider adaptability, ease of cultivation and higher economic returns make the crop popular among growers. But for getting higher returns now-adays farmers are using enormous quantity of chemicals i.e. fertilizers, pesticides, growth promoters, which have an adverse effect on soil structure as well as available micro flora and fauna. One can get higher yield with the use of chemical fertilizers but they are not economical as well as unsafe and also cause water, air and soil pollution (Bohra *et al.* 2019). Therefore, there is a need of eco-friendly, environment safely and sustainable strategy i.e. Integrated Nutrient Management (INM). Sharma *et al.* (2017) stated that INM not only reduced the cost of cultivation but also give quality assurance along with maintain soil fertility. The combined application of organic and inorganic nutrient sources is the sustainable as well as cost effective management of soil fertility.

The manures have the advantage of supplying secondary and micro nutrient along with NPK, which is important for sustained production (Kumar and Chaudhary 2018). Among the manures FYM is more preferred by the farmers as it easily available as well as easy to prepare. After application of FYM in soil it breaks down and igives off organic acids and carbon dioxide, which helps in dissolving the minerals and makes them more accessible to plants (Singh *et al.* 2022). Vermicompost is an excellent base for establishment of free living and symbiotic microbes. Ruangjanda *et al.* (2022) stated that vermicompost contain plant hormones such as cytokinins, gibberellins and auxins and enzymes (alkaline phosphatase, cellulase, urease). Goat manure is an excellent source of soil conditioner. Neem seed cake is the by-product obtained in the process of cold pressing of neem tree fruits and karnels, and the solvent extraction process for neem oil cake. It not only provides nutrition to the plant but increase the population of earthworms and produces organic acids. Nitrogen fertilizer can be reduced up to 50% through the application of *Azotobacter* inoculation with FYM (Gauri *et al*. 2012). INM is a cost effective, sustainable and commercially viable approach. Therefore, keeping in view the above point, the present study was conducted to develop a sustainable INM package for China aster production under high hill condition of Uttarakhand.

MATERIALS AND METHODS

The study was conducted at Floiculture Farm, COH, VCSG, Uttarakhand University of Horticulture and Forestry, Bharsar, Pauri Garhwal from March- September 2022. The study site is situated at the Shivalik mountain range hills of Himalayas at 29º20’- 29º75’ N latitude and 78º10’–78º80’ E longitude. The altitude of the place is 1900 meter above the mean sea level, summer (21–30^{O}C) and winter (1 to -4^{O}C) and highest RH (92–97%) during rainy season. The soil comes under order inceptisols with pH 5.5, EC (0.33 dS m^{-1}) available nitrogen (482.85 kg ha^{-1}), available phosphorus (90.17 kg ha^{-1}) and available potassium (101.18 kg ha^{-1}). The uniform size of seedlings of China aster cv Kamini transplanted at a spacing of 30 cm × 20 cm accommodating 20 plants per bed of size 1.2 m × 1.0 m. The study consists of 12 treatments which replicated thrice in Randomized Complete Block Design. The details of treatments were T_1: Control, T_2 : 100 % RDF, T_3 : 75% RDF + 25% FYM + *Azotobacter* (5 mL L^{-1}), T_4 : 75% RDF + 25% Vermicompost + *Azotobacter* (5 mL L^{-1}), T_5 : 75% RDF + 25% Neem cake + *Azotobacter* (5 mL L^{-1}), T_6 : 75% RDF + 25% Goat manure + *Azotobacter* (5 mL L^{-1}), T_7 : 50% RDF + 25% FYM + 25% Vermicompost + *Azotobacter* (5 mL L^{-1}), T_8 : 50% RDF + 25% FYM + 25% Neem cake + *Azotobacter* (5 mL L^{-1}), T_9 : 50% RDF + 25% FYM + 25 % Goat manure + *Azotobacter* (5 mL L^{-1}), T_{10} : 50% RDF + 25% Vermicompost + 25% Neem cake + *Azotobacter* (5 mL L^{-1}), T_{11} : 50% RDF + 25% Vermicompost + 25% Goat manure + *Azotobacter* (5 mL L^{-1}) and T_{12} : 50% RDF + 25% Neem cake + 25% Goat manure + *Azotobacter* (5 mL L^{-1}). Inorganic fertilizers were applied form the source urea, DAP and MOP. The RDF NPK used was 180:120: 60 kg ha^{-1}. Half dose of nitrogen was given at the time of planting of seedlings and remaining half after one month as per the treatment basis. Organic manures FYM, Vermicompost, Neem cake and goat manure were applied as per treatment allocation to the plots and incorporated into the soil 10 days prior to transplanting of seedlings. The treatments were replicated thrice in Randomized Complete Block Design. *Azotobacter* was applied by seedlings dipped method. The roots of seedlings were dipped in solution for 30 minutes as per the treatments and treated seedlings were transplanted in the field. The entire experimental data for different vegetative, floral attributes and yield were statistically analyzed by ANOVA to test the significance of overall difference among treatments by F test and conclusions were drawn at 5% probability level (Gomez and Gomez 1984).

RESULTS AND DISCUSSION

The data depicted that vegetative parameters are significantly influenced by the application of different INM packages (Table 1). The tallest plants (80.74 cm) were recorded from T_5 followed by T_7 (77.53 cm). However, maximum number of primary branches and leaves plant^{-1} (18.63 and 219.33, respectively) were recorded from the plant grown in plots applied with (50% RDF + 25% Vermicompost + 25% Neem cake + *Azotobacter* (5 mL L^{-1})) i.e., T_{10}. This might be due to the optimum availability of nutrients with the use of inorganic fertilizers. Beside this vermicompost act as the source of macro (N, P, K) at micro nutrients (Zn, Fe, Cu and Mn), enzymes and growth hormones in the early growth phase which leads to vigorous vegetative growth. Vermicompost not only provides NPK, but also a good source of micronutrients and various enzymes (Singh *et al.* 2015). *Azotobacter* plays an important role in nitrogen fixation and also involved in the production of IAA, GA_3, cytokinins like substances which enhance the growth of plants (Ali *et al*. 2014). Eifediyi *et al.* (2017) stated that neem cake on decomposition promotes an increase in soil microbial communities and directly influence the vegetative growth of plants. Similarly, plant spread was also recorded maximum (22.867 cm) under the same treatment i.e.T_{10}. It could be attributed due to maximum number of primary branches and leaves per plant were registered under the same treatment which leads to photosynthesis and translocation of photosynthates to other parts of plants and resulted in more plant spread. These findings are in close conformity with the findings of Ranjan and Bohra (2023) in African marigold, Arha *et al.* (2021) in gaillardia and Bohra *et al.* (2019) in China aster.

All the applied treatment significantly improves earliness in flowering as compared to control (Table

Table 1. Effect of different INM on vegetative and floral attributes of China aster cv Kamini.

Treatments	Plant height (cm)	Number of primary branches plant^{-1}	Plant spread (cm)	Number of leaves plant^{-1}	Number of days taken to bud appearance	Number of days taken to flowering	Flowering duration (days)
T_1 Control	70.66	13.30	16.53	165.93	77.89	94.46	16.45
T_2 100% RDF	75.80	16.00	19.90	200.20	71.68	87.40	21.73
T_3 75% RDF+25%FYM+*Azotobacter*	76.93	16.56	20.16	205.72	74.41	90.81	20.85
T_4 75% RDF+25% VC+*Azotobacter*	75.80	15.26	18.70	185.77	72.07	88.80	21.60
T_5 75% RDF+25% NC+*Azotobacter*	80.74	17.96	21.16	212.23	72.30	89.93	20.66
T_6 75% RDF+25% GM+*Azotobacter*	75.26	17.00	20.50	206.60	71.95	87.73	21.53
T_7 50% RDF+25% FYM+25% VC+ *Azotobacter*	77.53	15.56	18.76	194.56	68.63	82.70	23.43
T_8 50% RDF + 25% FYM + 25% NC + *Azotobacter*	77.20	16.70	20.30	207.22	72.05	88.20	21.26
T_9 50% RDF + 25% FYM + 25% GM + *Azotobacter*	74.00	15.00	18.55	178.72	73.59	89.60	20.933
T_{10} 50% RDF + 25% VC + 25% NC + *Azotobacter*	77.13	18.63	22.86	219.33	69.79	85.40	21.93
T_{11} 50% RDF + 25% VC+ 25% GM + *Azotobacter*	75.06	16.16	19.96	192.58	72.44	89.33	21.06
T_{12} 50% RDF + 25% NC + 25% GM + *Azotobacter*	77.00	17.66	20.96	210.48	72.41	89.06	21.13
SE(d)	1.50	0.75	0.74	4.13	1.32	1.03	0.60
$CD_{(0.05)}$	3.14	1.56	1.55	8.62	2.76	2.15	1.25

Table 2. Effect of different INM on flower quality and yield attributes of China aster cv Kamini.

	Treatments	Flower diameter (cm)	Individual flower weight (g)	Stalk length (cm)	Number of flowers per plant	Number of flowers per plot	Flower yield per plant (g)	Flower yield per plot (kg)
T_1	Control	5.76	2.69	28.46	27.40	328.80	73.04	0.87
T_2	100% RDF	6.74	3.41	36.46	32.40	388.73	111.78	1.34
T_3	75% RDF + 25% FYM + *Azotobacter*	6.61	3.35	36.00	33.66	404.00	113.40	1.36
T_4	75% RDF + 25% VC + *Azotobacter*	6.33	2.90	33.10	32.467	389.60	94.67	1.13
T_5	75% RDF + 25% NC + *Azotobacter*	6.57	3.23	35.86	33.53	402.40	109.29	1.31
T_6	75% RDF + 25% GM + *Azotobacter*	6.45	3.03	34.00	32.06	384.80	97.14	1.16
T_7	50% RDF + 25% FYM + 25% VC+ *Azotobacter*	6.47	3.12	34.73	31.33	376.00	97.74	1.17
T_8	50% RDF + 25% FYM + 25% NC + *Azotobacter*	7.26	3.86	38.40	36.80	441.53	142.89	1.71
T_9	50% RDF + 25% FYM + 25% GM + *Azotobacter*	6.55	3.18	35.60	33.46	401.60	106.18	1.27
T_{10}	50% RDF + 25% VC + 25% NC + *Azotobacter*	6.66	3.37	36.13	33.73	404.80	113.80	1.36
T_{11}	50% RDF + 25% VC+ 25% GM + *Azotobacter*	6.75	3.47	37.06	34.26	411.20	119.05	1.42
T_{12}	50% RDF + 25% NC + 25% GM + *Azotobacter*	6.76	3.53	37.33	34.46	413.60	121.37	1.45
SE(d)		0.28	0.22	0.95	1.032	3.311	1.47	0.01
$CD_{(0.05)}$		0.43	0.46	1.98	2.154	6.911	3.07	0.03

1). The plants grown in plots applied with treatment T_7 (50% RDF + 25% FYM + 25% Vermicompost + *Azotobacter* (5 mL L^{-1})) recorded the earliest days taken to first flower bud appearance and flower opening (68.630 and 82.707 days) followed by T_{10} (69.79 and 85.40 days, respectively). However, delay in number of days taken to first flower bud appearance and flower opening (77.89 and 94.46 days) were found in control (T_1). Similarly, maximum flowering duration (23.43 days) was recorded in T_7, whereas, minimum (16.45

Table 3. Effect of different INM packages on flower keeping quality and seed yield of China aster cv Kamini.

Treatments	Vase life (days)	Shelf life (days)	Seed yield $plant^{-1}$ (g)	Seed yield $plot^{-1}$ (g)	Test weight (g)
T_1 Control	9.06	2.73	1.10	13.22	1.92
T_2 100% RDF	11.00	3.25	1.67	20.053	2.08
T_3 5% RDF + 25% FYM + *Azotobacter*	11.25	3.19	2.60	31.22	2.19
T_4 75% RDF + 25% VC + *Azotobacter*	10.80	2.96	1.84	22.16	2.11
T_5 75% RDF + 25% NC + *Azotobacter*	11.15	3.16	2.18	26.17	2.18
T_6 75% RDF + 25% GM + *Azotobacter*	11.10	3.04	1.64	19.75	2.07
T_7 50% RDF + 25% FYM + 25% VC + *Azotobacter*	10.63	3.14	1.52	18.31	2.05
T_8 50% RDF + 25% FYM + 25% NC + *Azotobacter*	12.30	4.50	3.33	39.96	2.47
T_9 50% RDF + 25% FYM + 25% GM + *Azotobacter*	11.11	3.15	2.16	25.97	2.13
T_{10} 50% RDF + 25% VC + 25% NC + *Azotobacter*	11.38	3.21	2.99	35.97	2.20
T_{11} 50% RDF + 25% VC+ 25% GM + *Azotobacter*	11.41	3.30	3.09	37.17	2.21
T_{12} 50% RDF + 25% NC + 25% GM + *Azotobacter*	12.00	3.59	3.15	37.81	2.25
SE(d)	0.46	0.21	0.065	0.47	0.05
$CD_{(0.05)}$	0.96	0.44	0.136	0.98	0.12

Table 4. Effect of different INM packages of economics of flower cultivation.

Treatments	Estimated flower yield (kg/ha)	Selling rate of flower (₹/kg)	Gross returns (₹/ha)	Cost of cultivation (₹/ha)	Net return (₹/ha)	Cost benefit ratio
T_1 Control	8,120	30	2,43,600	1,18,105	1,25,495	1:1.06
T_2 100% RDF	12,410	30	3,72,300	1,38,306	2,33,994	1:1.69
T_3 75% RDF+25%FYM+*Azotobacter*	12,600	30	3,78,000	1,40,311	2,37,689	1:1.69
T_4 75% RDF+25% VC+*Azotobacter*	10,510	30	3,15,300	1,45,561	1,69,739	1:1.16
T_5 75% RDF+25% NC +*Azotobacter*	12,140	30	3,64,200	1,48,836	2,15,364	1:1.44
T_6 75% RDF+25% GM+*Azotobacter*	10,790	30	3,23,700	1,46,811	1,76,889	1:1.20
T_7 50% RDF+25% FYM+25% VC+ *Azotobacter*	10,860	30	3,25,800	1,44,766	1,81,034	1:1.25
T_8 50% RDF+25% FYM+25% NC + *Azotobacter*	15,780	30	4,73,400	1,48,041	3,25,359	1:2.19
T_9 50% RDF+25% FYM+25% GM+*Azotobacter*	11,790	30	3,53,700	1,46,016	2,07,684	1:1.42
T_{10} 50% RDF+25% VC + 25% NC+ *Azotobacter*	12,640	30	3,79,200	1,53,291	2,25,909	1:1.47
T_{11} 50% RDF+25% VC+ 25% GM+*Azotobacter*	13,230	30	3,96,900	1,51,266	2,45,634	1:1.62
T_{12} 50% RDF+25% NC+25% GM + *Azotobacter*	13,480	30	4,04,400	1,54,541	2,49,859	1:1.61

days) in T_1 (control). The early flowering might be due to the amplification of nutrients from inorganic fertilizers and organic manures. The simultaneous translocation of phytohormones to axillary buds leads to transformation of plant parts from vegetative to reproductive phase. Adhikari *et al.* (2016) stated that vermicompost helps in increase in microbial mass and dehydrogenases activity helps in nitrogen fixation an increase the availability to the crop and boost up the growth. Organic manures slowly decomposed and provide the nutrients throughout the life cycle of plants that helps in preventing leaching losses of nitrogen nutrient. *Azotobacter* might have played an indirect role, in making the nutrients readily available along with the presence of growth promoting substances which led to early flowering. Similar studies have been reported by Vaishali *et al.* (2018) in marigold and Indhumathi *et al.* (2023) in gallardia.

The data presented in Table 2 showed that maximum flower diameter (7.267 cm), individual flower weight (3.867 g) and stalk length (38.40 cm) were observed in treatment containing T_8 (50% RDF + 25% 'N' through FYM + 25% Neem cake + *Azotobacter* (5 mL L^{-1}). FYM and neem cake helps in improving physical, chemical and biological properties of soil. *Azotobacter* possess that the ability to bring nitrates into soluble forms by secreting organic acid which lower soil pH and in turn, bring about dissolution of immobile forms of soil nitrate. The above results are corroborated with the findings of Pansuriya and Chauhan (2015) in gladiolus and Yadav *et al*. (2023) in tuberose. Similarly, maximum numbers of flowers per plant, per plot (36.800 and 441.533 respectively) were recorded in treatment T_8 (50% RDF + 25% 'N' through FYM + 25% Neem cake + *Azotobacter* (5 mL L^{-1})). This might be due to the combination of organic manures might have improved the nitrogen use efficiency, micro and macro nutrient recovery. Kaushik and Singh (2020) reported that increase in number of flowers per plant with the application of *Azotobacter* in marigold. The above results are corroborated with the findings of Bohra *et al.* (2019) in China aster, Bohra and Nautiyal (2019) in tuberose and Sudhagar *et al.* (2020) in tuberose.

The maximum flower yield plant^{-1} and plot^{-1} (142.89 g and 1.71 kg) were recorded from the plants grown in plot applied with T_8 (50% RDF + 25% 'N' through FYM + 25% Neem cake + *Azotobacter* (5 mL L^{-1})) depicted in Table 2. This might be due to maximum number of flowers and individual weights of flower were registered under the same treatment. Similar findings have been reported by Singh *et al.*

(2015) in African marigold, Arha *et al.* (2021) in gaillardia and Abdul *et al.* (2021) in dahlia. The flowers harvested from the plants grown in plots applied with T_8 recorded maximum shelf and vase life of flowers (4.50 and 12.30 days respectively). It might be due to overall food nutrients status of flowers under this treatment. Increased shelf life could be attributed due to optimum nutrients availability from different organic and inorganic sources which might have resulted in greater development of water conducting tissue with high level water retention in the cells of flowers thereby lowering the desiccation. Similar beneficial effects of INM on shelf and vase life have been reported by Bohra *et al.* (2019) in China aster and Ranjan and Bohra (2023) in marigold.

The data presented in Table 3 also showed that all the applied INM treatments had significant effect on seed yield. The maximum seed yield plant^{-1}, seed yield plot^{-1} and test weight (3.33 g, 39.96 g and 2.47 g, respectively) were obtained from treatment T_8 (50% RDF + 25% 'N' through FYM + 25% Neem cake + *Azotobacter* (5 mL L^{-1})). This might be due to maximum number of flowers and individual flower weight registered under the same treatment. Neem cake being total natural, it is easily compatible with soil microbes, improves the rhizosphere micro flora and also enhances the fertility of the soil (Suja *et al.* 2017). These results are in close conformity with the findings of Thumar *et al.* (2013) in marigold and Sharma *et al.* (2009) in China aster which revealed that application of organic manures and bio-fertilizers increased significantly yield per hectare. The treatment wise economics of China aster var. Kamini is depicted in Table 4. The results revealed that maximum gross returns (₹4,73,400/ha), net returns (₹3,25,359/ha) and CB ratio 1: 2.19 were recorded in T_8. The cost benefit ratio directly depends on the flower yield. Similar result was recorded by Kumar *et al.* (2019) in China aster and they reported that application of inorganic fertilizers along with organic manure and biofertilizer recorded highest C:B ratio (1:1.41 and 1:1.45, respectively) in two years (2015-16 and 2016-17).

It can be concluded from the present study that treatment containing 50% RDF + 25% FYM + 25% Neem cake + *Azotobacter* (5 mL L^{-1}) was found effective in economic production of China aster cv Kamini under high condition of Uttarakhand.

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