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Effect of different doses of chemical fertilizer and different formulations of bio- fertilizer on growth parameters of China aster (*Callistephus chinensis* (L.) Nees) var. Arka Archana

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Abstract
The present study entitled **"**Effect of different dose of chemical fertilizer with different formulation of bio- fertilizer on growth parameters of China aster (*Callistephus chinensis* (L.) Nees) var. Arka Archana" was carried out to study the effect of integrated nutrient management on growth parameters of China aster. The experiment comprises thirteen treatment combinations i.e. 100%, 75%, and 50% RDF along with vermicompost and different formulations of biofertilizer (*Azotobecter* + PSB). Observations on various growth, parameters *viz*., plant height at 45 DAT, 75 DAT, 105 DAT, plant spread at 45 DAT, 75 DAT, 105 DAT, number of primary branches plant $^{-1}$ at 45 DAT, 75 DAT, 105 DAT and stem girth were recorded. In the present investigation the maximum value for plant height at 45 DAT, 75 DAT, 105 DAT, plant spread at 45 DAT, 75 DAT, 105 DAT, number of primary branches plant $^{-1}$ at 45 DAT, 75 DAT, 105 DAT and stem girth were found in treatment T_4 (75% RDF +VC + *Azotobacter* +PSB) and the minimum value for plant height, plant spread, and stem girth was observed in treatment getting 50% RDF + VC + liquid PSB (T_{11}) moreover, in number of primary branches the lower value was observed in treatment T_{12} (50% RDF + VC + liquid *Azotobacter*).

Keywords: China aster, Biofertilizer, *Azotobacter*, Vermicompost, PSB

Introduction
China aster (*Callistephus chinensis* (L.) Nees) belongs to the family Asteraceae and native to China. In importance China aster ranks next to chrysanthemum and marigold among the traditional flowers. It is a winter season half hardy annual flower crop. The genus *Callistephus* is derived from two Greek words *Kalistos* meaning 'most beautiful' and *Stephus*, 'a crown' referring to the flower head. It was first named by Linnaeus as *Aster chinensis* and later Nees changed this name to *Callistephus chinensis* (Janakiram, 2006) [4]. The plants are erect; leaves are arranged alternately on branches and bear solitary type of flowers. It is one of most popular, showy annual crop of our country and grown throughout the world. The flowers have wide range of type, size and shape with very good keeping quality. The flowers assumed economic importance on account of their varied uses such as cut flowers for making garlands and religious functions. In garden, plants are used as bedding plants, making mixed herbaceous border and as a pot plants. Arka archana is white coloured variety with early flowering and spreading growth habit. It was developed through Individual Plant Selection from selfed population of Line No. 15. It is generally used for bedding and loose flower. The Flowers are white coloured and semi-double type.

Materials and Methods
The experiment was carried out at the Govt. Horticultural Nursery, Baghamuda, Mungeli (C.G.). The experiment was conducted during Rabi season of 2019-2020 and 2020-2021. The study was laid out in Randomized Block Design with 13 treatments and three replications. The experiment comprises thirteen treatment combinations i.e. 100%, 75%, and 50% RDF along with vermicompost and different formulations of biofertilizer (*Azotobecter* + PSB) *viz*., T_1 (100% RDF (NPK) Control, T_2 (75% RDF + VC + PSB), T_3 (75% RDF + VC + Azotobacter), T_4 (75% RDF + VC+ Azotobacter + PSB), T_5 (50% RDF + VC+ PSB), T_6 (50% RDF + VC+ Azotobacter), T_7 (50% RDF + VC+ Azotobacter + PSB), T_8 (75% RDF + VC + Liquid PSB), T_9 (75% RDF + VC + Liquid Azotobacter), T_{10} (75% RDF + VC+ Liquid Azotobacter + Liquid PSB), T_{11} (50% RDF + VC+ Liquid PSB), T_{12} (50% RDF + VC+ Liquid Azotobacter), T_{13} (50% RDF + VC+ Liquid Azotobacter + Liquid PSB). The variety Arka Archana was used

for experiment. The weather condition was favorable during the experimental period for growth development and production of China aster. The recommended fertilizer dose of 180:120:60 kg NPK/ha was applied in form of Urea, SSP and Muriate of Potash. As basal dose half dose of nitrogen and full dose of phosphorus and potash were applied in each experimental plot and the remaining half dose of nitrogen was applied in two equal split dose at 30 and 60 days after application of basal dose. Vermicompost, PSB and *Azotobacter* were incorporated in the soil according to the treatments of respective plots. For the application of only one biofertilizer *Azotobacter* or PSB, slurry prepared by mixing 200 g *Azotobacter* or PSB culture in one liter of water and the root portion of seedlings was dipped in this for 30 minutes before transplanting. For application of both *Azotobacter* and PSB biofertilizer in combination, slurry prepared by mixing 100 g each of *Azotobacter* and PSB culture in one liter of water and the root portion of seedlings was dipped in this for 30 minutes before transplanting. From the experimental plot ten plants were randomly selected from each plot and tagged for recording observations.

Results and Discussion

Observations on plant growth parameters were recorded and analyzed statistically. The plant growth parameters showed significant results with effect of different combinations of chemical fertilizer with vermicompost and various formulations of biofertilizers.

Plant Height

Data depicted in Table 1 on plant height clearly indicated that plant height at 45 DAT influenced significantly with different treatment combinations on integrated nutrient management during both the year along with mean basis. Highest plant height at 45 DAT was perceived in treatment T_4 (75% RDF + VC + *Azotobacter* + PSB) during both the year and mean basis, discretely, and found to be *on par* with T_3 (75% RDF + VC + *Azotobacter*), T_9 (75% RDF + VC+ liquid *Azotobacter*) and T_{10} (75% RDF + VC+ Liquid *Azotobacter* + liquid PSB) in first year whereas in second year and mean basis only with T_{10} (75% RDF + VC+ Liquid *Azotobacter* + liquid PSB). However it was showed significant difference with rest of the other treatments. The lowest plant height was recorded in treatment T_{11} (50% RDF + VC + liquid PSB) during both the year as well as pooled mean basis.

Observations on plant height at 75 DAT was recorded maximum in treatment T_4 (75% RDF + VC + *Azotobacter* + PSB) during both the year as well as mean basis, respectively and it was *at par* with treatment T_2 (75% RDF + VC+ PSB), T_8 (75% RDF + VC+ liquid PSB), T_9 (75% RDF + VC + liquid *Azotobacter* +) and T_{10} (75% RDF + VC + liquid *Azotobacter* + liquid PSB) during both the year as well as pooled mean basis. While, significant difference was noted with rest of the other treatments. Treatment T_{11} (50% RDF + VC + liquid PSB) registered minimum plant height in both the year and on pooled mean basis.

Treatment T_4 (75% RDF + VC + *Azotobacter* + PSB) recorded maximum plant height at 105 DAT in both the year as well as mean basis discretely which was *at par* with treatment T_2 (75% RDF + VC+ PSB), T_8 (75% RDF + VC+ liquid PSB), T_9 (75% RDF + VC + liquid *Azotobacter*) and T_{10} (75% RDF + VC + liquid *Azotobacter* + liquid PSB) during both the year as well as pooled mean basis. It showed significant difference with rest of the other treatments. Minimum plant height in both the year and mean basis was observed in treatment T_{11} (50% RDF + VC + liquid PSB).

The application of biofertilizers add nutrients through the natural processes of nitrogen fixation, solubilising phosphorus, and stimulating plant growth through the synthesis of growth-promoting substances. Moreover, biofertilizer *viz. Azotobacter* and PSB proved to be beneficial as they fix the atmospheric nitrogen and solubilise fixed form of phosphorus in soil also release growth promoting substances like auxin, which stimulate the plant metabolic activities and photosynthetic efficiency leading to better growth of plant. Recommended dose of inorganic fertilizers provides macronutrients and vermicompost supplies the micronutrients. This might be the reason of increase in plant height of China aster. The results are in conformity with findings of Chaitra *et al.* (2007) [3], Pithiya *et al.* (2016) [10], Singh *et al.* (2017) [4] and Bohra *et al.* (2019) [1] in China aster

Table 1: Response of integrated nutrient management on plant height (cm) of China aster

Notation	Plant height (cm)								
	45 DAT			75 DAT			105 DAT		
	2019-20	2020-21	Mean	2019-20	2020-21	Mean	2019-20	2020-21	Mean
T_1	8.72	11.00	9.86	16.12	16.53	16.33	24.38	27.42	25.90
T_2	12.21	11.30	11.76	18.22	19.20	18.71	27.12	29.63	28.38
T_3	12.75	11.74	12.25	18.91	20.06	19.49	28.44	30.20	29.32
T_4	13.85	13.50	13.68	19.75	20.65	20.20	30.26	31.75	31.01
T_5	6.51	9.86	8.19	14.03	14.52	14.28	22.54	25.27	23.91
T_6	7.36	10.35	8.86	14.66	15.00	14.83	23.15	25.85	24.50
T_7	7.86	10.75	9.31	15.20	15.65	15.43	23.78	26.51	25.15
T_8	11.62	11.15	11.39	18.06	18.86	18.46	26.82	29.40	28.11
T_9	12.52	11.52	12.02	18.55	19.80	19.18	27.82	29.85	28.84
T_{10}	13.15	12.06	13.15	19.41	20.30	19.86	29.74	30.65	30.20
T_{11}	6.22	9.26	7.74	13.75	14.21	13.98	21.24	25.05	23.15
T_{12}	7.05	10.17	8.61	14.28	14.85	14.57	22.72	25.62	24.17
T_{13}	7.56	10.55	9.06	14.85	15.14	15.00	23.50	26.35	24.93
S.Em±	0.45	0.53	0.46	0.80	0.83	0.82	1.23	1.34	1.28
CD (P =0.050)	1.33	1.55	1.35	2.33	2.43	2.38	3.58	3.92	3.75

Plant Spread

Two years observation along with pooled mean basis on plant spread at 45, 75 and 105 days after transplanting are depicted in Table 2.

The experimental results on plant spread reveals that there was significant variation in plant spread at 45 DAT, during both the year and on pooled mean basis. Treatment T_4 (75% RDF + VC + *Azotobacter* + PSB) recorded maximum plant spread at 45 DAT in both the year as well as pooled mean basis and it was *at par* with treatment T_2 (75% RDF + VC+ PSB) and T_{10} (75% RDF + VC+ Liquid *Azotobacter* + liquid PSB) during first year and in second year with treatment T_2, T_3 (75% RDF + VC+ *Azotobacter*), T_8 (75% RDF + VC+ liquid PSB), T_9 (75% RDF + VC + liquid *Azotobacter*) and T_{10} (75% RDF + VC + Liquid *Azotobacter* + liquid PSB). With mean basis it was *at pat* with treatments T_2, T_3, T_8 and T_{10}. However it was showed significant difference with rest of the treatments. Even so treatment T_{11} (50% RDF + VC + liquid PSB) recorded minimum plant spread at 45 DAT during both the year as well as on pooled mean basis severally.

From the data presented in Table 2 it was concluded that at 75 DAT the maximum plant spread was noted in treatment T_4 receiving (75% RDF + VC + *Azotobacter* + PSB) during both the year and mean basis which was statically *at par* with treatment T_2 (75% RDF + VC + PSB), T_3 (75% RDF + VC+ *Azotobacter*), T_8 (75% RDF + VC + liquid PSB), T_9 (75% RDF + VC + liquid *Azotobacter*) and T_{10} (75% RDF + VC + Liquid *Azotobacter* + liquid PSB) during first year. During second year and pooled mean basis it was *at par* with treatment T_2, T_3, T_8, T_9 and T_{10}. However, it was showed significant difference with rest of the other treatments. Treatment T_{11} (50% RDF + VC + liquid PSB) recorded minimum plant spread during both the year as well as with pooled mean basis.

On the basis of data analysis maximum plant spread at 105 DAT was observed in treatment T_4 (75% RDF + VC + *Azotobacter* + PSB) during first and second year and also in pooled mean basis and which was statistically *at par* with treatment T_2 (75% RDF + VC + PSB), T_3 (75% RDF + VC+ *Azotobacter*), T_8 (75% RDF + VC + liquid PSB), T_9 (75% RDF + VC + liquid *Azotobacter*) and T_{10} (75% RDF + VC + Liquid *Azotobacter* + liquid PSB). With rest of the other treatments it exhibited significant difference. However treatment T_{11} (50% RDF + VC + liquid PSB) showed the minimum plant spread during both year as well as mean basis.

The reason for the enhanced plant spread may be due to the increased cell division and enlargement by application of *Azotobacter* and PSB along with vermicompost which might have increased the micro flora and enzymatic activity as it is sufficient source of macro and micro nutrients like Fe and Zn. Maximum plant spread obtained might be due to formation of new cells in meristem and increased in size resulted more production of cells (Barad *et al*. 2015) [12]. Similar findings have been also reported by Pithiya *et al*. (2016) [10] in China aster, Krushaiah *et al.* in Italian aster. (2018), Kirar *et al*. (2009), Bose *et al*. (2016), Singh *et al*. (2017) [4] and Bohra *et al*. (2019) [1] in China aster.

Table 2: Response of integrated nutrient management on plant spread (cm) of China aster

Notation	Plant spread (cm)								
	45 DAT			75 DAT			105 DAT		
	2019-20	2020-21	Mean	2019-20	2020-21	Mean	2019-20	2020-21	Mean
T_1	12.30	14.54	13.42	19.70	22.85	21.28	25.98	28.80	27.39
T_2	15.30	17.62	16.46	23.20	25.86	24.53	28.38	31.88	30.13
T_3	14.74	16.76	15.75	22.20	25.23	23.72	27.55	31.42	29.49
T_4	16.87	18.50	17.69	24.30	26.45	25.38	29.73	32.50	31.12
T_5	9.35	13.04	11.20	17.62	21.65	19.64	22.15	25.45	23.80
T_6	9.80	13.26	11.53	18.06	22.08	20.07	22.82	26.80	24.81
T_7	10.65	13.65	12.15	18.70	22.40	20.55	23.77	27.64	25.71
T_8	14.60	17.25	15.93	22.70	25.67	24.19	27.84	31.65	29.75
T_9	14.45	16.55	15.50	21.50	25.06	23.28	27.12	31.15	29.14
T_{10}	15.70	17.83	16.77	23.60	26.14	24.87	28.87	32.32	30.60
T_{11}	8.82	12.80	10.81	16.50	20.60	18.55	21.32	24.38	22.85
T_{12}	9.65	13.15	11.40	17.75	21.87	19.81	22.65	26.35	24.50
T_{13}	10.05	13.42	11.74	18.40	22.23	20.32	23.52	27.32	25.42
S.Em±	0.61	0.74	0.67	0.98	1.14	1.06	1.22	1.39	1.31
CD (P =0.050)	1.77	2.15	1.98	2.86	3.32	3.09	3.58	4.07	3.83

Number primary branches plant^{-1}

Effect of integrated nutrient management on number of branches plant^{-1} was recorded at 45 DAT, 75 DAT and 105 DAT and the data presented in table 3.

In case of number of primary branches plant^{-1} at 45 days after transplanting treatment T_4 (75% RDF + VC + *Azotobacter* + PSB) exerted significantly maximum number of primary branches plant^{-1} at 45 DAT during both the year as well as pooled mean basis, which was statically similar with treatment T_2 (75% RDF + VC + PSB), T_3 (75% RDF + VC+ *Azotobacter*), T_8 (75% RDF + VC + liquid PSB) and T_{10} (75% RDF + VC + Liquid *Azotobacter* + liquid PSB) during first year, second year and with pooled mean basis. However with rest of the treatments it showed significant difference. While, the plant receiving 50% RDF + VC + liquid PSB (T_{12}) revealed significantly minimum number of primary branches plant^{-1} during both the year and on pooled mean basis.

Among different treatment applied the maximum number of primary branches plant^{-1} was recorded in treatment T_4 (75% RDF + VC + *Azotobacter* + PSB) at 75 days after transplanting in both the year as well as pooled mean basis which was statically *at par* with treatment T_2 (75% RDF + VC + PSB), T_3 (75% RDF + VC+ *Azotobacter*), T_8 (75% RDF + VC + liquid PSB) T_9 (75% RDF + VC + liquid *Azotobacter*) and T_{10} (75% RDF + VC + Liquid *Azotobacter* + liquid PSB) in first year and in second year and pooled mean basis it was *at par* with treatment T_2, T_8 and T_{10}. However significant difference was observed with remaining treatments. Significantly minimum number of primary branches plant^{-1} was observed in treatment T_{12} (50% RDF + VC + liquid *Azotobacter*) in both the year as well pooled mean basis.

Significantly maximum number of primary branches plant^{-1} at 105 DAT was exhibited by treatment T_4 (75% RDF + VC + *Azotobacter* + PSB) in both the year as well as pooled mean basis which was found statically *at par* with treatment T_2 (75% RDF + VC + PSB), T_3 (75% RDF + VC+ *Azotobacter*), T_8 (75% RDF + VC + liquid PSB) and T_{10} (75% RDF + VC + Liquid *Azotobacter* + liquid PSB) in first year and pooled mean basis, in second year it was *at par* with treatment T_2, T_8 T_{10}. However, it showed significant difference with rest of the other treatments. While, the plant receiving 50% RDF + VC + Liquid *Azotobacter* (T_{12}) revealed significantly minimum number of primary branches plant^{-1} during both the year as well as pooled mean basis.

Highest number of primary branches might be attributed to better flow of various micro and macro nutrients with plant growth substances into the plant system. Moreover the reason for higher number of branches might be the growth hormone NAA and cytokinins released by the *Azotobacter* and PSB which helps in breaking apical dominance and hastened higher number of branches. Highest number of primary branches plant^{-1} by application of 75% NPK + *Azotobacter* + PSB was also noticed by Thumar *et al*, (2013) [12]. The similar results were also reported by Kumar *et al*. (2003) [8], Chaitra *et al*. (2007) [3] and Bose *et al*. (2016) in China aster, and Khan *et al*. (2009) [5] in Tulip.

Table 3: Response of integrated nutrient management on number primary branches plant^{-1} of China aster

Notation	Number of primary branches plant^{-1}								
	45 DAT			75 DAT			105 DAT		
	2019-20	2020-21	Mean	2019-20	2020-21	Mean	2019-20	2020-21	Mean
T_1	16.70	16.80	16.75	18.25	19.65	18.95	21.63	23.65	22.64
T_2	20.25	21.85	21.05	23.30	24.75	24.03	26.01	28.80	27.41
T_3	19.00	20.70	19.85	22.12	23.00	22.56	25.06	27.00	26.03
T_4	21.12	23.80	22.46	24.10	26.80	25.45	27.60	30.50	29.05
T_5	13.54	13.65	13.60	15.43	15.30	15.37	18.25	19.45	18.85
T_6	11.73	13.02	12.38	14.31	14.60	14.46	16.53	17.60	17.07
T_7	14.21	14.74	14.48	16.67	17.40	17.04	19.00	21.20	20.10
T_8	19.34	21.40	20.37	22.75	23.70	23.23	25.86	27.60	26.73
T_9	18.25	19.65	18.95	21.56	22.50	22.03	24.07	26.50	25.29
T_{10}	20.83	22.50	21.67	23.65	25.62	24.64	26.54	29.40	27.97
T_{11}	12.45	13.42	12.94	15.81	15.75	15.78	17.73	18.80	18.27
T_{12}	10.50	12.67	11.59	14.00	13.65	13.83	16.00	16.40	16.20
T_{13}	14.75	14.32	14.54	16.45	16.75	16.60	18.77	20.73	19.75
S.Em±	0.79	0.86	0.82	0.93	0.97	0.95	1.05	1.15	1.10
CD (P =0.050)	2.32	2.50	2.41	2.70	2.83	2.77	3.08	3.35	3.21

Stem Girth

The experimental Data influenced by different levels of integrated nutrient management on stem girth of China aster are presented in Table 4.

Stem girth was significantly altered by combined application of inorganic fertilizer, organic fertilizer and biofertilizer. From the data depicted in Table.4 it can be concluded that significantly higher stem girth respectively was recorded in treatment T_4 (75% RDF + VC + *Azotobacter* + PSB) in first year, second year and also with pooled mean basis respectively. It was found to be *on par* with treatment T_2 (75% RDF + VC + PSB), T_3 (75% RDF + VC+ *Azotobacter*), T_8 (75% RDF + VC + liquid PSB), T_9 (75% RDF + VC + liquid *Azotobacter*) and T_{10} (75% RDF + VC + Liquid *Azotobacter* + liquid PSB) during both the year and mean basis as well. It was showed significant difference with rest of the other treatments. Whereas, the treatment T_{11} (50% RDF + VC + liquid PSB) recorded minimum stem girth during both the year and on pooled mean basis.

The reason for the increased stem girth could be due to micro flora and enzymatic activity accelerated by the application of vermicompost. Biofertilizers promote the growth by several mechanisms such as increasing the supply of nutrients, increasing root biomass or root area and increasing nutrient uptake capacity of the plant. Availability of nitrogen accelerates synthesis of chlorophyll and amino acid which is responsible for vegetative growth and ultimately might be increases the plant stem girth. These findings are in conformity with the findings of Chaitra *et al*. (2007) [3] and Singh *et al*. (2017) [4] in China aster, Krushnaiah *et al*. (2018) [7] in Italian aster and Marak *et al.* (2020) [9] in China aster.

Table 4: Response of integrated nutrient management on stem girth (mm) of China aster

Notation	Treatment	Stem girth (mm)		
		2019-20	2020-21	Mean
T_1	(100% RDF (NPK) Control	7.71	9.05	8.38
T_2	(75% RDF + VC + PSB)	9.15	9.81	9.48
T_3	(75% RDF + VC + *Azotobacter*)	9.38	10.17	9.78
T_4	(75% RDF + VC+ *Azotobacter* + PSB)	9.62	10.43	10.03
T_5	(50% RDF + VC+ PSB)	6.78	7.78	7.28
T_6	(50% RDF + VC+ *Azotobacter*)	7.43	8.38	7.91
T_7	(50% RDF + VC+ *Azotobacter* + PSB)	7.32	8.65	7.99
T_8	(75% RDF + VC + Liquid PSB)	8.90	9.65	9.28
T_9	(75% RDF + VC + Liquid *Azotobacter*)	9.30	10.05	9.68
T_{10}	(75% RDF + VC+ Liquid *Azotobacter* + Liquid PSB)	9.61	10.32	9.97
T_{11}	(50% RDF + VC+ Liquid PSB)	6.43	7.54	6.99
T_{12}	(50% RDF + VC+ Liquid *Azotobacter*)	6.93	8.15	7.54
T_{13}	(50% RDF + VC+ Liquid *Azotobacter* + Liquid PSB)	7.45	8.43	7.94
	S.Em±	0.39	0.44	0.41
	CD (P =0.050)	1.15	1.28	1.21

Conclusion

The increased plant height was recorded by the application of 75% of recommended dose of fertilizer with vermicompost, PSB and *Azotobacter*. Maximum plant spread number of primary branches and stem girth was also documented with the treatment applied as 75% RDF + VC+ PSB + *Azotobacter*. From the analyzed data and on the basis of results obtained it can be concluded that the application of 75% of RDF with 25% of VC including PSB and *Azotobacter* is helpful for increasing vegetative growth of China aster cv. Arka Archana under open field condition of Chhattisgarh state.

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