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Integrated nutrient management affects growth and development of China aster

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Abstract
A field experiment titled "Effects of Integrated Nutrient Management practices on vegetative growth and flowering of China aster (*Callistephus chinensis* (L.) Nees)" was conducted at the demonstration plot of College of Horticulture, Odisha University of Agriculture and Technology, Chiplima, Sambalpur during the year 2021- 2022 to study the effects of Integrated Nutrient Management on china aster (*Callistephus chinensis* (L.) Nees). The said experiment was laid out in a Randomized Block Design with 11 treatments along with 3 replications. The treatments were designed by using different combinations of *Azotobacter*, *Azospirillum*, PSB and FYM with 50% RDF and 100% RDF as control. The result revealed that various treatments produced significant influence on different vegetative and flowering parameters. The application of treatment T_{10} (*Azospirillum* + PSB + FYM + 50% RDF) resulted in significantly highest plant height at 30 DAP (8.83 cm) and the treatment T_3 (PSB + 50% RDF) resulted in the significantly highest number of leaves at 30 DAP (11.08). The treatment T_9 (*Azotobacter* + PSB + FYM + 50% RDF) resulted in significantly highest number of leaves at 60 DAP (121.07) and 90 DAP (127.24), an essential factor in the growth and development of the plants. Apart from this, the treatment T_9 (*Azotobacter* + PSB + FYM + 50% RDF) also facilitated a significantly higher value of plant diameter at 90 DAP (0.96 cm).

Keywords: *Azotobacter*, *Azospirillum*, PSB, China aster

Introduction
China Aster (*Callistephus chinensis* (L.) Nees) is one of the most traditional and popular annual flowering plants grown throughout the world. It belongs to the family Asteraceae and is native to China (Navalinskien *et al*., 2005) [11]. The genus *Callistephus* derives its name from two Greek words '*Kalistos*' meaning 'most beautiful' and '*Stephus*' meaning 'a crown' that refers to the flower head. *Callistephus* has also been known as 'summer aster'. *Callistephus* is a monospecific genus comprising of *C. chinensis* as the only species which is a diploid plant (2n=18). Linnaeus initially named it as *Aster chinensis* which was later changed into *Callistephus chinensis* by Nees (Janakiram, 2006) [5]. In terms of popularity, China aster follows chrysanthemum and marigold respectively. It is a half-hardy in nature. It is usually grown in open field and lath houses for production of cut flowers commercially used for interior decoration, preparation of bouquets and making garlands. China aster is also used for bedding, potting and mixed herbaceous borders. Some dwarf cultivars are used for edging and window boxes. Cut flowers have longer shelf-life and are thus used in floral decoration and vases. The flowers of China aster are also used for flower arrangement, garland making and worshipping. Apart from commercial cultivation, China aster also finds its use in landscape gardening in order to create an aesthetic mass effect. It is thus conclusive that china aster gains its popularity as one of the most preferred flower crops because of its wider spectrum of attractive colours and comparatively longer vase life (Chaitra & Patil, 2007) [2]. China asters are available in blue, lavender, white, magenta and rose (Desai, 1967) [3]. The growing popularity of China aster cultivation in India is due to its diversified colours.

Commercial floriculture is gaining huge importance in Indian agriculture. The National Horticulture Board published the National Horticulture Database (second advance estimates) for the commercial year 2019-2020 according to which the estimated share of China aster cultivation is in an area of 1020 hectares with a production of 800 million tonnes. China aster is cultivated worldwide on a commercial scale with leading countries being France, Germany, India, UK, North America, Japan, Russia, Europe and Switzerland. The leading commercial cultivators of China aster in India are Karnataka, Tamil Nadu, West Bengal and Maharashtra (Singh, 2006) [15]. Karnataka ranks highest in the commercial production of China aster in

India. However, the overall production and productivity of China aster in the country is expected to be enhanced along with maintenance of soil health with the use of integrated nutrient management practices in the crop so as to fetch proper profit and foreign exchange for the farmers.

Materials and Methods

The investigation was carried out at the demonstration plot of College of Horticulture, Odisha University of Agriculture and Technology, Chiplima, Sambalpur during the year 2021-2022. The plot was ploughed, harrowed and clods were crushed until the soil was in well pulverized condition and fairly levelled followed by dividing the field into 33 plots. The experimental field was laid out as per plan of layout. China aster seeds were grown in the nursery of College of Horticulture, Odisha University of Agriculture and Technology, Sambalpur. The seeds were sown on 10/10/2021. The roots of the seedlings were dipped with the bio inoculants according to the treatments used. Transplanting was carried out on 10/11/2021 in the plot already laid out as per plan at a spacing of 30cm ×30 cm. Uniform and healthy seedlings were selected for transplanting. Recommended fertilizers used are 250:250:250 NPK kg/ha. Total 11 treatments with 3 replications were there.

Results and Discussion

Among all the treatments, the treatment T_{10} (*Azospirillum* + PSB + FYM + 50% RDF) showed the highest plant height (8.83 cm) at 30 days followed by T_6 (*Azotobacter* + *Azospirillum* + FYM + 50% RDF) which recorded the plant height to be 7.43 cm and these were statistically at par. Moreover, the lowest results of plant height at 30 days were obtained from the treatment T_7 (*Azotobacter* + PSB + 50% RDF) i.e. 5.01 cm. The highest value of plant height at 60 days after planting was recorded by the treatment T_2 (*Azospirillum* + 50% RDF) as the plant height recorded was 35.83 cm followed by the treatment T_3 (PSB+ 50% RDF) as the recorded height was 34.83 cm. The lowest value of plant height recorded at 60 days after planting was obtained from the treatment T_{11} (100% RDF) i.e. 24.07 cm. The results for the plant height recorded at 90 days after planting was similar to the recordings at 60 days with respect to the treatments as the highest and lowest values were observed from the treatments T_2 and T_{11} respectively. The highest value of plant height at 90 days was thus recorded as 45.57 cm and the lowest value recorded was 34.42 cm with treatments T_2 and T_{11} respectively.

At 30 days after planting, the treatment T_2 (*Azospirillum* + 50% RDF) has produced the highest plant spread followed by the treatment T_8 (*Azospirillum* + PSB + 50% RDF) with the values as 87.50 cm and 86.4 cm respectively which are statistically at par. The treatment T_4 (FYM + 50% RDF) has however shown the minimum plant spread (56.38 cm). Among all the treatments, at 60 days after planting, the treatment T_3 (PSB + 50% RDF) resulted in the highest plant spread i.e. 34.52 cm followed by T_2 (*Azospirillum* + 50% RDF) with the value as 30.99 cm which are statistically at par. The treatment T_{10} (*Azospirillum* + PSB + FYM + 50% RDF), however, produced the minimum value for the plant spread at 60 days after planting i.e. 18.16 cm. At 90 days after planting, the maximum plant spread value was seen for the treatment T_3 (PSB + 50% RDF) with the value as 40.90 cm and this was followed by the treatment T_2 (*Azospirillum* + 50% RDF) having the value 30.08 cm. Among all the treatments, the treatment T_{10} (*Azospirillum* + PSB + FYM + 50% RDF) resulted in the lowest value of plant spread i.e. 23.07 cm at 90 days after planting.

Among all the treatments, at 30 days after planting, the treatment T_{10} (*Azospirillum* + PSB + FYM + 50% RDF) showed the highest increase in plant spread (N-S) value is 66.41 cm and this was followed by the treatment T_9 (*Azotobacter* + PSB + FYM + 50% RDF) which resulted in the value i.e. 66.33 cm. These values were statistically at par. Besides, the minimum plant spread obtained was from the treatment T_4 (FYM + 50% RDF) having the value 60.92 cm. At 60 days after planting, the maximum value of plant spread was obtained with the treatment T_2 (*Azospirillum* + 50% RDF) followed by the treatment T_3 (PSB + 50% RDF) having the values 30.83 cm and 30.72 cm respectively which were statistically at par.

However, the treatment T_{10} (*Azospirillum* + PSB + FYM + 50% RDF) was responsible for the minimum plant spread with respect to east – west direction as the value stood at 19.27 cm. Among the applied treatments, the treatment T_6 (*Azotobacter* + *Azospirillum* + FYM + 50% RDF), at 90 days after planting showed the highest plant spread with a promising result of 40.61 cm which was followed by the treatment T_2 (*Azospirillum* + 50% RDF) with the result as 36.73 cm. Moreover, these values were found to be statistically at par. Besides, the treatment T_{10} (*Azospirillum* + PSB + FYM + 50% RDF) produced the minimum plant spread at a value of 25.32 cm.

The variation of primary branches as seen with respect to the different treatments. Since the values of primary branches for 30, 60 and 90 DAP were found to be similar, the values are tabulated under a single column.

It is indicative from the table that the treatment T_7 (*Azotobacter* + PSB + 50% RDF) provided the maximum number of primary branches i.e. 9.55. This result was followed by 8.14 which was exhibited by the treatment T_9 (*Azotobacter*+ PSB + FYM + 50% RDF). These results were statistically at par. Among all the treatments, the treatment T_8 (*Azospirillum* + PSB + 50% RDF) proved to provide the lowest number of primary branches i.e. 5.88. The secondary branches at 60 days after planting showed the maximum number with the treatment T_3 (PSB+ 50% RDF) with the value as 16.58 followed by the treatment T_2 (*Azospirillum* + 50% RDF) and treatment T_5 (*Azotobacter* + *Azospirillum* + 50% RDF) resulting in similar values i.e. 13.03.

Among the treatments, the treatment T_{10} (*Azospirillum* + PSB + FYM + 50% RDF) produced the minimum number of secondary branches (5.09). According to the table, the trends in the secondary branches show a slight variation at 90 days after planting with a minor increase in the number. The treatment T_3 (PSB+ 50% RDF), at 90 days after planting, exhibited the highest value of secondary branches i.e. 18.36 which was followed by treatment T_5 (*Azotobacter* + *Azospirillum* + 50% RDF) with the value as 15.51 which were statistically at par. However, the treatment T_{10} (*Azospirillum* + PSB + FYM + 50% RDF) produced the lowest number of secondary branches i.e. 7.83.

The number of leaves at 30 days after planting have shown significant increase with the treatment T_3 **(**PSB+ 50% RDF**)** whereas the treatment T_9 (*Azotobacter* + PSB + FYM + 50% RDF) resulted in the highest number of leaves at 60 and 90 days after planting. Among all the treatments, the treatment T_3

(PSB+ 50% RDF**)** provided the highest number of leaves (11.08) at 30 days after planting followed by treatment T_{10} (*Azospirillum* + PSB + FYM + 50% RDF), which were statistically at par with the value as 10.83.

However, the treatment T_9 (*Azotobacter* + PSB + FYM + 50% RDF) resulted in the lowest number of leaves (7) in this case. Among the treatments, the treatment T_9 (*Azotobacter* + PSB + FYM + 50% RDF) showed the highest number of leaves at 60 and 90 days after planting i.e. 121.07 and 127.24 respectively. The second highest number of leaves at 60 days after planting was exhibited with the treatment T_7 (*Azotobacter* + PSB + 50% RDF) having the value 115.64. This value was statistically at par with the highest value pertaining to the treatment T_9. Similarly, the second highest number of leaves at 90 days after planting was provided by the treatment T_7 (*Azotobacter* + PSB + 50% RDF) as well with a value of 122.57 which shows that the values were statistically at par. The lowest number of leaves at 60 and 90 days after planting have resulted from the treatment T_{11} (100% RDF) with the values as 52.46 and 61.27 respectively.

At 30 days after planting, the plant diameter or more specifically the stem diameter have shown significant variation. Among the treatments applied, the treatment T_{11} (100% RDF) produced significant increase in the plant diameter with the maximum value of 0.47 cm which was followed by the treatment T_9 (*Azotobacter* + PSB + FYM + 50% RDF) with the value as 0.45 cm and these values are statistically at par. However, the lowest value of plant diameter was shown by the treatment T_1 (*Azotobacter* + 50% RDF) with the value 0.35 cm. Among all the treatments, at 60 days after planting, the treatment T_{10} (*Azospirillum* + PSB + FYM + 50% RDF) produced the maximum plant diameter (0.74 cm) followed by the treatment T_4 (FYM + 50% RDF) with the value as 0.703 cm which are statistically at par. The minimum value of plant diameter was seen with the treatment T_2 (*Azospirillum* + 50% RDF) having the result as 0.64 cm. Moreover, at 90 days after planting, the treatments have shown a significant variation in the plant diameter. The highest results of plant diameter, among all the treatments applied, has been shown by the treatment T_9 (*Azotobacter* + PSB + FYM + 50% RDF) having the value as 0.96 cm and this was followed by the value 0.956 cm produced by the treatment T_{11} (100% RDF) which are statistically at par. The minimum value of plant diameter i.e. 0.86 cm was exhibited by two treatments which are T_1 (*Azotobacter* + 50% RDF) and T_2 (*Azospirillum* + 50% RDF) respectively.

The application of various integrated sources of nutrients have significantly influenced different plant growth parameters of China aster such as plant height at 30 DAP, number of leaves at 30, 60 and 90 DAP, plant diameter at 30 and 90 DAP respectively. It was discovered that plant height at 30 DAP had a positive and significant correlation with plant spread at 30 DAP (E-W) and a positive and highly significant correlation with the number of leaves at 30 DAP. This may have been due to the increase in number of axillary buds resulted from adequate nutrient availability. Thus, a proper early growth up to 30 DAP might have facilitated the positive influence on these various parameters. Treatment T_{10} (*Azospirillum* + PSB + FYM + 50% RDF) produced the highest plant height at 30 DAP (8.83 cm). The increase in plant height must have been influenced by adequate supply of nitrogen due to the combined action of *Azospirillum*, FYM and 50% RDF in the soil. *Azospirillum* must have fixed the atmospheric nitrogen along with PSB which is responsible for dissolution of unavailable phosphorus in the soil. These nutrients flow into the plant and facilitate the formation of stimulation of axillary buds so as to influence the increase in plant height. These findings corroborate with the results of the experiment by Abrol *et al*., 2019 [1] in China aster, Palagani *et al*., 2015 [14], in Chrysanthemum and Ichancha *et al*., 2019 [6] in African marigold. The number of leaves at 30 DAP was seen to have positive correlation with secondary branches at 60 DAP, plant spread at 30 DAP (N-S and E-W), plant spread at 60 DAP (N-S and E-W), plant spread at 90 DAP (N-S and E-W), plant diameter at 30 DAP, number of flowers and flower weight with stem. This can be attributed to the fact that an increase in the number of leaves at an early stage of growth might have resulted in a proper amount of photosynthesis so as to provide better nutrition for the growth of various vegetative structures. The number of leaves at 60 DAP was found to have a positive and highly significant correlation with the number of leaves at 90 DAP. Apart from this, with primary branches, there was a positive and significant correlation with number of leaves at 60 DAP. The reason for this result might have been due better nutrition resulting from higher rate of photosynthesis. This may have led to subsequent enhancement of vegetative growth. The number of leaves at 90 DAP and primary branches exhibited a positive and significant correlation, whereas secondary branches at 60 and 90 DAP, plant spread at 30 DAP (N-S), plant spread at 60 DAP (N-S and E-W), plant spread at 90 DAP (N-S and E-W), plant diameter at 30 DAP, and flower diameter exhibited a positive correlation with number of leaves at 90 DAP. This may be attributed to the fact that an increased number of leaves might have resulted in enhanced metabolism due to better photosynthesis ultimately leading to enhanced vegetative growth The treatment T_3 (PSB+ 50% RDF) was observed to have produced the maximum number of leaves at 30 DAP (11.08) whereas the treatment T_9 (*Azotobacter* + PSB + FYM + 50% RDF) resulted in the highest number of leaves at 60 DAP (121.07) and 90 DAP (127.24). The increase in the number of leaves could be attributed to the fact that PSB might have enhanced the root growth leading to the adequate supply of nutrients from the soil. The increase of number of leaves at 60 and 90 DAP might have been due to the nitrogen fixation property of *Azotobacter* in the soil. Thus, the collective action of *Azotobacter* and PSB might have resulted in a better flow of nitrogen and phosphorus nutrients which are responsible for the growth of the plant ultimately resulting in the increase in the number of leaves. These findings are parallel to the findings by Kumar *et al*., 2009 [7] in African marigold and Ravindra, 1998 [14] in China aster. Plant diameter at 30 DAP showed positive correlation with plant diameter at 60 and 90 DAP and flower weight with stem. This may have occurred due to the enhanced nutrient uptake due to better plant/stem diameter in the initial stages of growth. Plant diameter at 90 DAP showed positive correlation with number of flowers, flower diameter and flower weight with stem. This may have been due to better nutrient uptake which might have resulted from enhanced conducting tissue growth so as to mobilize the nutrients applied. The results clearly indicates that the plant diameter at 30 and 90 DAP have been significantly influenced by the treatments T_{11} (100% RDF) and T_9 (*Azotobacter* + PSB + FYM + 50% RDF) respectively. The plant diameter at 30 DAP might have been influenced by the complete application of inorganic fertilizers i.e. 100%

RDF as this might have provided ample nitrogen which is a constituent of nucleic acids ultimately playing a pivotal role in the early stage of plant growth. However, in the case of plant diameter at 90 days, the treatment T_9 must have enriched the nitrogen as well as phosphorus status in the nutrient uptake system. Nitrogen (inorganic and *Azotobacter*) being directly related to plant growth and phosphorus (from PSB and inorganic fertilizers) being a facilitator of cell division and formation of meristematic tissue might have resulted in adequate assimilation of the same fertilizers resulting in a significant growth in the plant diameter. These results are in confirmation with the experiments conducted by Gotmare *et al*., 2007 [4] and Monbir *et al*., 2017 [10] in marigold & Pandey *et al*., 2010 [13], Verma *et al*., 2012 [16], Palagani *et al*., 2015 [12], Laishram *et al*., 2013 [8], Mahadik *et al*., 2017 [9] in different varieties of *Chrysanthemum morifolium.*

Conclusion

Amalgamation of different inorganic fertilizers and biofertilizers affect the growth and development of China aster positively than the recommended dose of fertilizer without hampering soil health. Among the applied treatments, the ninth treatment i.e. T_9 (*Azotobacter* + PSB + FYM + 50% RDF) was observed to have positively influenced the number leaves which is an essential part for the growth and development of the plants ultimately increasing vase life and shelf life of the flowers.

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