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Studies on the effect of micronutrients on growth and quality in gaillardia (*Gaillardia pulchella* Foug)

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Abstract
The experiment entitled "Studies on the effect of micronutrients on growth and quality in gaillardia (Gaillardia pulchella Foug.)" was conducted during the Rabi season of the year 2021-2022 at Floricultural Research Station, Rajendranagar, Sri Konda Laxman Telangana State Horticultural University. Among the treatments, the treatment T6 (RDF + Zn (10 kg/ha) + Mn (10 kg/ha) + B (4 kg/ha) + Fe (5 kg/ha) soil application + Zn EDTA + Mn EDTA + B + Fe EDTA (@ 0.4% each as foliar application) recorded maximum plant height (61.05 cm), plant spread N-S (48.70 cm), plant spread E-W (49.44 cm) and number of branches per plant (49.41), whereas minimum plant height (30.80 cm), plant spread N-S (25.50 cm), plant spread E-W (25.09 cm) and number of branches per plant (27.18) were recorded by T_1 (RDF @ 150:80:60 Kg/ha NPK (control). It was observed that the maximum quality attributes viz., early flower bud initiation (47.31 days), early flower bud to open (53.41 days), flower diameter (5.83 cm), flower longevity on plant (10.19 days), shelf life (11.16 hours), plant fresh weight (3.16 kg), plant dry weight (1.01 kg) and chlorophyll content (48.30) maximum in the treatment of T_6 (RDF + Zn (10 kg/ha) + Mn (10 kg/ha) + B (4 kg/ha) + Fe (5 kg/ha) soil application + Zn EDTA +Mn EDTA + B +Fe EDTA (@ 0.4% each as foliar application).

Keywords: Gaillardia, micronutrients, local yellow

Introduction
Gaillardia (Gaillardia pulchella Foug.) is one of the important flower crop that belongs to the Asteraceae family. Gaillardia commonly known as "Blanket flower" and "Fire wheel". The origin of Gaillardia is Central and Western United States. However, it is native to America. The genus name Gaillardia was proposed in Honor of Mr. M. Gaillard, a French patron of botany.

Gaillardia is an attractive flower that is available in single, semi double or double forms with brilliant colours like red, orange, yellow, yellow tipped red, red tipped yellow, scarlet etc. with a remarkable long flowering period. It can be used as both loose and cut flowers. It is widely marketed as a loose flower and it is extensively used in preparation of garlands and for decoration purposes.

Balanced plant nutrition is essential for successful production of flower crops. Quality of flower is the foremost priority to fetch market price. Integrated supply of micronutrients with macronutrients in adequate amount and suitable proportions is one of the most important factors that control the quality and yield of flower crops (Ganesh and Kannan, 2013) [2].

Micronutrients are essentially as important as macronutrients to have better growth, yield and quality in plants. In the past, there was no need of micro nutrients because these trace elements were naturally supplied by soil (Ganesh and Kannan, 2013) [2].

Micronutrients are to be necessarily taken up by the plants from soil or supplemented through foliar application for good growth and yield of crops and maximizing the efficient use of applied N, P and K. In the absence of these micronutrients, the plants are known to suffer from physiological disorders which eventually lead to imbalanced growth and low yield (Zende, 1996) [3].

Micronutrients are involved in all metabolic and cellular functions. Plants differ in their need for micronutrients; viz., Boron (B), Iron (Fe), Zinc (Zn), Copper (Cu), Chloride (Cl), Manganese (Mn), Molybdenum (Mo) and Nickel (Ni). Theseelements are active that makes them essential as catalytically active cofactors of enzymes, others have enzyme activating functions, and yet others fullfil a structural role in stabilizing proteins. Improvement in growth characters due to micronutrient application might basically be due to enhanced photosynthetic and other metabolic activities related to cell division and elongation (Hatwar *et al.*, 2003) [4].

Materials and Methods

The present investigation entitled "Studies on the effect of micronutrients on growth and quality in gaillardia (*Gaillardia pulchella* Foug.)" was carried out during the *Rabi* season of the year 2021-2022 at Floricultural Research Station, Rajendranagar, Sri Konda Laxman Telangana State Horticultural University. Healthy seed was sowing on the raised bed and transplanted in main field at a spacing of 30 cm x 30 cm after one month.

The design adopted was Randomized Block Design with nine treatments replicated thrice. Treatments included T1-RDF @ 150:80:60 Kg/ha NPK. (control), T2-RDF + Zn (10 kg/ha) + Mn (10 kg/ha) + B (4 kg/ha) + Fe (5 kg/ha) soil application, T3-RDF + Zn (5 kg/ha) + Mn (5 kg/ha) + B (2 kg/ha) + Fe (2.5 kg/ha) soil application, T4-RDF + Zn EDTA + Mn EDTA + B + Fe EDTA (@ 0.4 % each) foliar application (3 sprays at 30 DAT, 45 DAT and 60 DAT), T5-RDF + Zn EDTA + Mn EDTA + B + Fe EDTA (@ 0.2 % each) foliar application (3 sprays at 30 DAT, 45 DAT and 60 DAT), T6-RDF + Zn (10 kg/ha) + Mn (10 kg/ha) + B (4 kg/ha) + Fe (5 kg/ha) soil application + Zn EDTA + Mn EDTA + B + Fe EDTA (@ 0.4 % each as foliar application (3sprays at 30 DAT, 45 DAT and 60 DAT), T7-RDF + Zn (10 kg/ha) + Mn (10 kg/ha) + B (4 kg/ha) + Fe (5 kg/ha) soil application + Zn EDTA + Mn EDTA + B +Fe EDTA (@ 0.2 % each as foliar application (3sprays at 30 DAT, 45 DAT and 60 DAT), T8-RDF + Zn (5 kg/ha) + Mn (5 kg/ha) + B (2 kg/ha) + Fe (2.5 kg/ha) soil application + Zn EDTA + Mn EDTA + B + Fe EDTA (@ 0.4 % each as foliar application (3sprays at 30 DAT, 45 DAT and 60 DAT) and T9-RDF + Zn (5 kg/ha) + Mn (5 kg/ha) + B (2 kg/ha) + Fe (2.5 kg/ha) soil application + Zn EDTA + Mn EDTA + B +Fe EDTA (@ 0.2% each as foliar application (3sprays at 30 DAT, 45 DAT and 60 DAT). Soil application of micronutrients applied 10 days after transplanting and foliar sprays of micronutrients will be applied thrice at 30 DAT, 45 DAT and 60 DAT, the observations recorded were plant height (cm), plant spread (cm2), number of branches per plant, days taken for flower bud to initiation (days), days taken for flower bud to open (days), flower diameter (cm), flower longevity on plant (days), shelf life (days), plant fresh weight (g), plant dry matter (g), chlorophyll content (spad) and the data was statistically analysed.

Results and Discussion

Growth parameters (at the time of flowering)

The data regarding the height of the plant recorded at the time of flowering as influenced by effect of micronutrients presented in Table 1.

Plant height (cm)

Among the treatments, plant height varied significantly, Maximum plant height (61.05 cm) was recorded in T6 (100% RDF + Zn (10 kg/ha) + Mn (10 kg/ha) + B (4 kg/ha) + Fe (5 kg/ha) soil application + Zn EDTA +Mn EDTA + B + Fe EDTA (@ 0.4 % each as foliar application) and was at par with treatment T7 (RDF + Zn (10 kg/ha) + Mn (10 kg/ha) + B (4 kg/ha) + Fe (5 kg/ha) soil application + Zn EDTA + Mn EDTA + B + Fe EDTA (@ 0.2 % each as foliar application) (58.66 cm) and T2 (RDF + Zn (10 kg/ha) + Mn (10 kg/ha) + B (4 kg/ha) + Fe (5 kg/ha) soil application) (55.53 cm). Whereas minimum plant height (30.80 cm) was recorded in the Treatment T1 (RDF @ 150:80:60 Kg/ha NPK. (control) which is on par with T5 (RDF + Zn EDTA + Mn EDTA + B + Fe EDTA (@ 0.2% each) foliar application) (35.62 cm), T4 (RDF + Zn EDTA + Mn EDTA + B + Fe EDTA (@ 0.4% each) foliar application) (36.37 cm), T9 (RDF + Zn (5 kg/ha) + Mn (5 kg/ha) + B (2 kg/ha) + Fe (2.5 kg/ha) soil application + Zn EDTA + Mn EDTA + B + Fe EDTA (@ 0.2% each as foliar application) (42.06 cm) and T3 (RDF + Zn (5 kg/ha) + Mn (5 kg/ha) + B (2 kg/ha) + Fe (2.5 kg/ha) soil application (45.89 cm)). It might be due to the fact that the absorption of nutrient through soil application is maximum which lead to increased plant height. The results are in close conformity with the findings Chopde *et al.* (2016) [1] in gladiolus, Tayade *et al.* (2018) [5] in tuberose, Poornima *et al* (2016) [6] in rose and Pal *et al.* (2016) [8] in gerbera.

Number of branches per plant

The data on number of branches per plant as influenced by effect of micronutrients presented in the table 1.

Number of branches per plant was found to be significantly influenced by all the treatments. Among the treatments, T6 (RDF + Zn (10 kg/ha) + Mn (10 kg/ha) + B (4 kg/ha) + Fe (5 kg/ha) soil application + Zn EDTA + Mn EDTA + B + Fe EDTA (@ 0.4% each as foliar application) recorded maximum number of branches per plant in (49.41) and on par with treatment T7 (44.35). Minimum number of branches per plant was recorded significantly in T1 (RDF @ 150:80:60 Kg/ha NPK. (Control) (27.18) and on par with treatment T5 (31.95).

It might be due to the application of the soil and foliar application of micronutrients influence translocation and transcription mechanism of protein biosynthesis, also stimulation of cell division and cell elongation while increasing plasticity of cell wall and formation of energy rich phosphates resulted in greater number of productive branches. Similar kind of observations were reported by Chopde *et al.* (2016) [1] in gladiolus and Tayade *et al*. (2018) [5] in tuberose.

Table 1: Effect of micronutrients on plant height (cm) and number of branches per plant in gaillardia (*Gaillardia pulchella* Foug.)

Treatments	Plant Height (cm)	Number of branches per plant
T_1: 100% RDF 150:80:60 Kg/ha NPK	30.80c	27.18c
T_2: RDF + Zn (10 kg/ha) +Mn (10 kg/ha) + B (4 kg/ha) + Fe (5 kg/ha) soil application	55.53ab	40.25b
T_3: RDF +Zn (5 kg/ha) + Mn (5 kg/ha) + B (2 kg/ha) +Fe (2.5 kg/ha) soil application	45.89c	34.25bc
T_4: RDF + Zn EDTA + Mn EDTA + B + Fe EDTA (@ 0.4% each) foliar application	C	BC
T_5: RDF + Zn EDTA + Mn EDTA + B + Fe EDTA (@ 0.2% each) foliar application	C	C
T_6: RDF + Zn (10 kg/ha) + Mn (10 kg/ha) + B (4 kg/ha) + Fe (5 kg/ha) soil application + Zn EDTA +Mn EDTA + B +Fe EDTA (@ 0.4% each as foliar application	61.05a	49.41a
T_7: RDF + Zn (10 kg/ha) + Mn (10 kg/ha) + B (4 kg/ha) + Fe (5 kg/ha) soil application + Zn EDTA + Mn EDTA + B +Fe EDTA (@ 0.2% each as foliar application	58.66ab	44.35ab
T_8: RDF + Zn (5 kg/ha) + Mn (5 kg/ha) + B (2 kg/ha) + Fe (2.5 kg/ha) soil application + Zn EDTA +	51.17b	37.42bc

Mn EDTA + B +Fe EDTA (@ 0.4% each as foliar application		
T_9: RDF + Zn (5 kg/ha) + Mn (5 kg/ha) + B (2 kg/ha) + Fe (2.5 kg/ha) soil application + Zn EDTA + Mn EDTA + B +Fe EDTA (@ 0.2% each as foliar application	42.06c	35.63bc
S.E.M±	2.65	2.20
CD @ 5 %	7.96	6.61

Plant spread North-South (cm)

The data enunciated on plant spread in North- South direction at the time of flowering as influenced by micronutrients are presented in the table 2.

Plant spread in North-South direction was found to be significantly different in all the treatments. Among all the treatments, T6 (RDF + Zn (10 kg/ha) + Mn (10 kg/ha) + B (4 kg/ha) + Fe (5 kg/ha) soil application + Zn EDTA + Mn EDTA + B + Fe EDTA (@ 0.4 % each as foliar application) recorded maximum plant spread in North-South direction (48.70 cm) was and was at par with treatment T7 (46.27 cm). Whereas as minimum plant spread in North- South direction (25.50 cm) was recorded in the Treatment in T1 (RDF @ 150:80:60 Kg/ha NPK. (Control). Which is at par with T5 (27.79 cm), T4 (29.08 cm), T3 (30.19 cm), T9 (32.58 cm) and T8 (34.92 cm).

Plant spread East-West (cm)

The data enunciated on plant spread in East-west direction at the time of flowering influenced by the application of micronutrients as presented in the table 2.

Plant spread in East-West direction was found to vary significantly in all treatments. T6 (RDF + Zn (10 kg/ha) + Mn (10 kg/ha) + B (4 kg/ha) + Fe (5 kg/ha) soil application + Zn EDTA + Mn EDTA + B + Fe EDTA (@ 0.4 % each as foliar application) maximum plant spread in East-West direction (49.44 cm) was recorded and was at par with treatment T7 (47.11 cm) and T2 (45.28 cm). Whereas as minimum plant spread in East-West direction (25.09 cm) recorded in the Treatment in T1 (RDF @ 150:80:60 Kg/ha NPK. (Control)). Which is at par with T5 (26.43 cm), T4 (27.16 cm), T3 (31.94 cm), T9 (32.47 cm) and T8 (34.64 cm). Application of micronutrients both as soil and foliar spray might have enhanced the uptake of micronutrients there by resulted in more branches and plant spread. The results are in close affirmative with the findings of Kumar *et al*. (2010) in respect of spread of plant in China aster.

Table 2: Effect of micronutrients on plant spread (cm) in gaillardia (*Gaillardia pulchella* Foug.)

Treatments	Plant Spread N-S (cm)	Plant Spread E-W (cm)
T_1: 100% RDF 150:80:60 Kg/ha NPK	25.50b	25.09b
T_2: RDF + Zn (10 kg/ha) +Mn (10 kg/ha) + B (4 kg/ha) + Fe (5 kg/ha) soil application	41.41ab	45.28a
T_3: RDF +Zn (5 kg/ha) + Mn (5 kg/ha) + B (2 kg/ha) +Fe (2.5 kg/ha) soil application	30.19b	31.94b
T_4: RDF + Zn EDTA + Mn EDTA + B + Fe EDTA (@ 0.4% each) foliar application	B	B
T_5: RDF + Zn EDTA + Mn EDTA + B + Fe EDTA (@ 0.2% each) foliar application	27.79b	26.43b
T_6: RDF + Zn (10 kg/ha) + Mn (10 kg/ha) + B (4 kg/ha) + Fe (5 kg/ha) soil application + Zn EDTA +Mn EDTA + B +Fe EDTA (@ 0.4% each as foliar application	48.70a	49.44a
T_7: RDF + Zn (10 kg/ha) + Mn (10 kg/ha) + B (4 kg/ha) + Fe (5 kg/ha) soil application + Zn EDTA + Mn EDTA + B +Fe EDTA (@ 0.2% each as foliar application	46.27a	47.11a
T_8: RDF + Zn (5 kg/ha) + Mn (5 kg/ha) + B (2 kg/ha) + Fe (2.5 kg/ha) soil application + Zn EDTA + Mn EDTA + B +Fe EDTA (@ 0.4% each as foliar application	34.92b	34.64b
T_9: RDF + Zn (5 kg/ha) + Mn (5 kg/ha) + B (2 kg/ha) + Fe (2.5 kg/ha) soil application + Zn EDTA + Mn EDTA + B +Fe EDTA (@ 0.2% each as foliar application	32.58b	32.47b
SE m±	3.51	2.49
CD @ 5 %	10.54	7.47

Quality Parameters

Days taken for flower bud to initiation (days)

The data on days taken for flower bud to initiation in gaillardia influenced by effect of micronutrients is presented in the table 3.

The mean number of days taken for flower bud initiation was found to be significant in all the treatments. T6 treatment (RDF + Zn (10 kg/ha) + Mn (10 kg/ha) + B (4 kg/ha) + Fe (5 kg/ha) soil application + Zn EDTA + Mn EDTA + B + Fe EDTA (@ 0.4 % each as foliar application) recorded minimum days taken for flower bud initiation in gaillardia (47.31 days) on par with T7 (48.89 days) and T2 (48.99 days). While the maximum days taken for flower bud to initiation in gaillardia (54.91 days) was recorded in T1 (RDF @ 150:80:60 Kg/ha NPK. (Control)). Increased growth parameters in T6 might have resulted in accumulation of more photosynthesis there by initiating earlier bud formation. Similar findings were reported by Lahijie (2012) [7] in gladiolus.

Days taken for flower bud to open (days)

Days taken for flower bud to open in gaillardia as influenced by the effect of micronutrients is presented in the table 3.

Among the treatments, T6 treatment (RDF + Zn (10 kg/ha) + Mn (10 kg/ha) + B (4 kg/ha) + Fe (5 kg/ha) soil application + Zn EDTA + Mn EDTA + B + Fe EDTA (@ 0.4 % each as foliar application) recorded minimum days taken for flower bud to open in gaillardia (53.41 days) on par with T7 (55.19 days) and T2 (55.49 days). While the maximum days taken for flower bud to open in gaillardia was recorded in T1 (RDF @ 150:80:60 Kg/ha NPK. (Control), (63.91 days) on par with T3 (62.52 days) and T5 (61.72 days). The optimum dosage of Fe applied both as soil and foliar spray might have triggered the flowers earlier as iron is a structural component of Florien. The present findings of days taken for flower bud to open are in conformity with Pal *et al.* (2016) [8] in gerbera and Chopde *et al.* (2016) [1] in gladiolus.

Table 3: Effect of micronutrients on days taken for flower bud initiation (days) and days taken for flower bud to open (days) in gaillardia (*Gaillardia pulchella* Foug.)

Treatments	Days taken for flower bud initiation (days)	Days taken for flower bud opening (days)
T_1: 100% RDF 150:80:60 Kg/ha NPK	54.91c	63.91c
T_2: RDF + Zn (10 kg/ha) +Mn (10 kg/ha) + B (4 kg/ha) + Fe (5 kg/ha) soil Application	48.99a	55.49a
T_3: RDF + Zn (5 kg/ha) + Mn (5 kg/ha) + B (2 kg/ha) + Fe (2.5 kg/ha) soilapplication	54.32^{bc}	62.52c
T_4: RDF + Zn EDTA + Mn EDTA + B + Fe EDTA (@ 0.4% each) foliarapplication	53.19^{bc}	60.39^{bc}
T_5: RDF + Zn EDTA + Mn EDTA + B + Fe EDTA (@ 0.2% each) foliar application	BC	61.72
T_6: RDF + Zn (10 kg/ha) + Mn (10 kg/ha) + B (4 kg/ha) + Fe (5 kg/ha) soil application + Zn EDTA + Mn EDTA + B + Fe EDTA (@ 0.4% each as foliar application	47.31^{a}	53.41^{a}
T_7: RDF + Zn (10 kg/ha) + Mn (10 kg/ha) + B (4 kg/ha) + Fe (5 kg/ha) soil application + Zn EDTA + Mn EDTA + B + Fe EDTA (@ 0.2% each as foliar application	48.89^{a}	55.19^{a}
T_8: RDF + Zn (5 kg/ha) + Mn (5 kg/ha) + B (2 kg/ha) + Fe (2.5 kg/ha) soil application + Zn EDTA + Mn EDTA + B + Fe EDTA (@ 0.4% each as foliar application	52.70^{bc}	59.50^{b}
T_9: RDF + Zn (5 kg/ha) + Mn (5 kg/ha) + B (2 kg/ha) + Fe (2.5 kg/ha) soil application + Zn EDTA + Mn EDTA + B + Fe EDTA (@ 0.2% each as foliar application	52.26^{b}	59.26^{b}
S.E.M ±	0.81	0.72
CD @ 5 %	2.43	2.17

Flower diameter (cm)

Plant dry matter (kg) as influenced by effect of micronutrients is presented in the table 6.

Among the treatments, T6 treatment (RDF + Zn (10 kg/ha) + Mn (10 kg/ha) + B (4 kg/ha) + Fe (5 kg/ha) soil application + Zn EDTA + Mn EDTA + B + Fe EDTA (@ 0.4 % each as foliar application) recorded maximum plant dry matter (1.01 kg) and it was at par with T7 (0.96 kg). While the minimum plant dry matter (0.61kg) was recorded in T1 (RDF @ 150:80:60 Kg/ha NPK. (Control). Micronutrients plays a vital role in production of vegetative growth and ultimately encourage the biomass of plant which results in increased fresh and dry weight of plant. The present findings are accordance with the finding of Saini *et al.* (2015) [14] in chrysanthemum.

Table 4: Effect of micronutrients on plant fresh weight (kg) and plant dry weight (kg) in gaillardia (Gaillardia pulchella Foug.)

Treatments	Plant fresh weight (kg)	Plant dry weight (kg)
T_1: 100% RDF 150:80:60 Kg/ha NPK	2.18d	0.61d
T_2: RDF + Zn (10 kg/ha) +Mn (10 kg/ha) + B (4 kg/ha) + Fe (5 kg/ha) soil application	AB	B
T_3: RDF +Zn (5 kg/ha) + Mn (5 kg/ha) + B (2 kg/ha) +Fe (2.5 kg/ha) soil application	C	C
T_4: RDF + Zn EDTA + Mn EDTA + B + Fe EDTA (@ 0.4% each) foliar application	C	CD
T_5: RDF + Zn EDTA + Mn EDTA + B + Fe EDTA (@ 0.2% each) foliar application	D	CD
T_6: RDF + Zn (10 kg/ha) + Mn (10 kg/ha) + B (4 kg/ha) + Fe (5 kg/ha) soil application + Zn EDTA +Mn EDTA + B +Fe EDTA (@ 0.4% each as foliar application	3.16a	1.01a
T_7: RDF + Zn (10 kg/ha) + Mn (10 kg/ha) + B (4 kg/ha) + Fe (5 kg/ha) soil application + Zn EDTA + Mn EDTA + B +Fe EDTA (@ 0.2% each as foliar application	3.04ab	0.96ab
T_8: RDF + Zn (5 kg/ha) + Mn (5 kg/ha) + B (2 kg/ha) + Fe (2.5 kg/ha) soil application + Zn EDTA + Mn EDTA + B +Fe EDTA (@ 0.4% each as foliar application	2.95b	0.87b
T_9: RDF + Zn (5 kg/ha) + Mn (5 kg/ha) + B (2 kg/ha) + Fe (2.5 kg/ha) soil application + Zn EDTA + Mn EDTA + B +Fe EDTA (@ 0.2% each as foliar application	2.75c	0.82bc
S.E.M±	0.05	0.03
CD @ 5 %	0.16	0.10

Conclusion

The application of micronutrients along with 100 % RDF as soil application as well as foliar spray resulted in maximum growth parameters like plant height, plant spread and number of branches per plant in gaillardia. Which was at par with a slight reduction in foliar dosage of micronutrients in T7 treatment.

Similarly, all the flowering and quality parameters like days taken for flower bud to initiation, days taken for flower bud to open, flower diameter, flower longevity on plant, shelf life, plant fresh weight, plant dry matter and chlorophyll content (SPAD) showed the same level.

Future scope

- Effect of micronutrients along with organic fertilizer and their interactions may be studied further.
- The influence of micronutrients on carotenoid content and other bio chemical parameters may be studied further.

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Conflict of interest: None

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