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Sakshi R Solav
Floriculture and Landscaping, College of Agriculture, Nagpur, Maharashtra, India

Dr. Seema A Thakre
Assistant Professor (Hort.), Horticulture Section, College of Agriculture, Nagpur, Maharashtra, India

Pallavi Thakre
Young Professional I, Horticulture, College of Agriculture, Nagpur, Maharashtra, India

Pranjali S Khandre
PG Scholar, Floriculture and Landscaping, College of Agriculture, Nagpur, Maharashtra, India

Rangoli Bidkar
Floriculture and Landscaping, College of Agriculture, Nagpur, Maharashtra, India

Corresponding Author:
Sakshi R Solav
Floriculture and Landscaping, College of Agriculture, Nagpur, Maharashtra, India

Response of tuberose to the formulation of micronutrient

Sakshi R Solav, Seema A Thakre, Pallavi Thakre, Pranjali S Khandre and Rangoli Bidkar

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Abstract
An experimental study was conducted to evaluate the foliar application of micronutrient formulation at different spraying frequency on vegetative growth, flower yield and quality of tuberose at Floriculture Section, College of Agriculture, Nagpur during the year 2024-25. The experiment was laid out in Factorial Randomized Block Design consisting of twelve treatment combinations and replicated thrice. The result revealed that maximum plant height was recorded in treatment of micronutrient formulation 1.5% at 6 spraying frequency. However, leaves plant^{-1} and tillers plant^{-1} were recorded maximum in treatment of micronutrient formulation 1.0% at 4 and 6 spraying frequency respectively. In quality parameter i.e. maximum diameter of floret and length of floret were recorded at micronutrient formulation 1.0% concentration with 4 spraying frequency. As less inter floret length was recorded at micronutrient formulation 1.5% concentration at 4 spraying frequency. In respect of yield parameters maximum florets spike^{-1}, florets plot^{-1} and florets ha^{-1} were recorded in treatment micronutrient formulation 1.0% concentration at 4 spraying frequency. The interaction effect of treatment combination of micronutrient formulation 1.0% concentration with 4 spraying frequency were recorded significantly maximum in florets spike^{-1}, florets plot^{-1} and florets ha^{-1} in tuberose.

Keywords: Tuberose, micronutrient formulation, spraying frequency

Introduction
Tuberose is a native of Mexico and belongs to the family Amaryllidaceae it is a half-hardy bulbous perennial perpetuating through bulbs and bulblets. Stem is a condensed structure that remains concealed within scales. Prajwal is hybrid variety developed from the cross of Shringar x Mexican single released from IIHR Bangalore in 2014. The florets are slightly pinkish white, and at full bloom are white. Tuberose Flowers are of good source of essential oil, which are utilized in preparation of various cosmetic and perfume. A single type flower of tuberose has high essential oil content 0.08 to 0.10% which is obtained by solvent extraction method. The common constituents of tuberose are geraniol, benzyl alcohol, methyl benzoate methyl salicylate eugenol, benzyl benzoate and methyl anthranilate.

Micronutrients play vital role for a range of physiological functions in plants, such as photosynthesis, respiration, and the action of enzymes. Nevertheless, a lack of these micronutrients can hinder plant development, lower yields, and negatively affect flower quality. Tuberose is especially susceptible to micronutrient deficiencies because of its considerable nutrient requirements and sensitivity to soil conditions. Applying micronutrients through foliar methods provides a focused and effective strategy to address deficiencies and encourage plant development. Among the micronutrients Zn, Fe, B, Mn and Mo improved the yield appreciably and foliar spray of micronutrients proved to be economical in flowering crops. To sum up, research on the foliar application of micronutrients in tuberose is essential for maximizing plant quality, growth, and productivity by keeping this as a view present keeping this as a view present research work was planned to find out the suitable dose of micronutrient formulation as the foliar application at different spraying frequency on flower yield and quality of tuberose.

Materials and Methods
A field experiment was conducted during summer, 2024 on “Response of tuberose to the formulation of micronutrient” at Floriculture Section, College of Agriculture, Nagpur. The research was laid out in Factorial Randomized Block Design with four levels of

micronutrient formulation *viz*., M1: Water spray, M2: micronutrient formulation 0.5% conc., M3: micronutrient formulation 1.0% conc., M4: micronutrient formulation 1.5% conc. and three levels of spraying frequency i.e. S1-2 Spray (30 and 60 DAP), S2-4 Spray (30, 60, 90 and 120 DAP) and S3-6 Spray (30, 60, 90, 120, 150 and 180 DAP) with twelve treatment combinations and replicated thrice.

Tuberose bulbs having uniform weight (30 gm) were selected and treated with 2.5% copper oxychloride fungicide for 15 minutes before planting. Bulbs were planted at 5 cm depth with spacing 30 cm x 30 cm. A recommended dose of 200:300:200 kg NPK ha^{-1} applied. The full dose of P_2O_5 and K_2O and half dose of N was given before planting. While remaining half dose of N was divided into two split up doses, half dose of N was given 45 days after planting and remaining half dose of N was given 45 days after second dose of nitrogen.

Foliar application of micronutrient formulation at different concentrations and at different spraying frequency was started 30 days after planting. The plants were selected randomly from each plot for various observation on growth, yield and quality parameters were recorded time to time up to harvesting of flowers and bulbs. The data was analysed statistically as per the method suggested by Panse and Sukatme (1967) [8].

Results and Discussion

1. Effect of micronutrient formulation

a. Growth parameters

The data regarding the growth parameters plant height, leaves plant^{-1} and tillers plant^{-1} as influenced by different micronutrient formulation presented in table 1.

Plant height: The data from table 1 showed that, an application of micronutrient formulation 1.5% concentration (M4) treatment was recorded significantly maximum plant height (74.69 cm) which was followed by the treatment 1.0% concentration (M3) (70.26 cm). Whereas, minimum plant height (60.83 cm) was recorded in control treatment (M1). It might be due to effect of zinc and iron are involved in chlorophyll synthesis and photosynthetic activity. Similar findings were recorded in Yadav *et al*. (2003) [14] and Devi *et.al* (2017) and Patel *et al*. (2017) [9] in tuberose,

Leaves plant^{-1}: Data in table 1 indicated that, significantly maximum leaves plant^{-1} (60.49) was recorded in the treatment micronutrient formulation 1.0% concentration (M3) which was followed by micronutrient formulation 1.5% concentration (M4) (56.20). Whereas, minimum leaves plant^{-1} (50.09) was recorded in control treatment (M1). These variation in respective of leaves plant^{-1} might be due to synthesis of optimum amount of tryptophane which is accelerated by zinc and helps the plant to maintain vegetative growth of plant. The result are in close agreement with the findings of Kumar *et al*. (2003) [4] in tuberose and Halder *et al*. (2007) [3] In gladiolus and Tejas *et al*. (2024) [12] in Annual chrysanthemum.

Tillers plant^{-1}: Maximum tillers plant^{-1} (5.79) was recorded with the application of micronutrient formulation 1.0% concentration (M3) which was followed by micronutrient formulation 1.5% concentration (M4) (5.41). Whereas, minimum tillers plant^{-1} (4.52) was recorded in control treatment (M1). This might be due to synthesis of optimum amount of tryptophane which is accelerated by zinc. Similar results obtained by Devi *et.al* (2017) in tuberose.

Quality parameters Diameter of floret

The result from table 1 exhibited the significant differences among the different micronutrient formulation on diameter of floret. Maximum diameter of floret (3.78 cm) was recorded in the treatment foliar application of micronutrient formulation 1.0% concentration (M3) which was followed by (3.59 cm) micronutrient formulation 1.5% concentration (M4). While, minimum diameter of floret (2.90 cm) was recorded in treatment control treatment (M1). The above results are in close agreement with Haldar *et al*. (2007) [3] and Tayde *et al*. (2018) [6] in tuberose.

Length of floret

The result from table 1 exhibited the significant differences among the different micronutrient formulation on length of floret. Maximum length of floret (5.05 cm) was recorded in the treatment foliar application of micronutrient formulation 1.0% concentration (M3) which was at par with (4.88 cm) micronutrient formulation 1.5% concentration (M4). While, minimum length of floret (4.13 cm) was recorded in control treatment (M1). Increased in length of floret may be due to association of zinc in resulting increasing permeability of cell walls, thus mobilizing more water in flowers and also increase the synthesis of micronutrient promotes cell size in turn increased in flower size. Similar findings were given by Vanlalruati *et.al*. (2019) [13] in chrysanthemum.

Inter floret length

The result from table 1 exhibited that the significant differences among the different micronutrient formulation on inter floret length. Less inter floret length (3.73 cm) was recorded in micronutrient formulation 1.5% concentration (M4) which was at par with (3.79 cm) micronutrient formulation 1.0% concentration (M3). While, more inter floret length (3.97 cm) was recorded in control treatment (M1). An optimum supply zinc and boron helps in controlled growth of the length of rachis, resulting in a more compact arrangement of florets. Similar results were shown by Sahana and Sureshkumar (2020) in tuberose.

Yield parameters

The results exhibited from table 1 showed significant differences among different concentration of micronutrient formulation.

Florets spike^{-1}, plot^{-1}, ha^{-1}

Data from table 1 recorded significant differences in term of floret yield. The treatment micronutrient formulation 1.0% concentration (M3) recorded significantly maximum florets spike^{-1} (44.03), florets plot^{-1} (1.75 kg) and florets ha^{-1} (65.13 q). Whereas, control treatment (M1) recorded minimum florets spike^{-1} (35.76), florets plot^{-1} (1.00 kg) and florets ha^{-1} (37.29 q). This might be due to the application of micronutrient, especially Zinc as an essential catalyst in the synthesis of auxin from tryptophan would have encouraged the auxin biosynthesis in the active source which would have led to higher transport and accumulation of photosynthates towards florets and hence, improving yield. Similar findings were recorded by Ganesh and Soorianathasundaram (2015) [2] in tuberose and Pal *et al*. (2016) [7] in gerbera.

Spraying frequency

Growth parameters

The data in respect of growth parameter as influence by spraying frequency was presented in table 1.

Plant height: Data in respect of plant height, maximum plant height (69.14 cm) was recorded in 6 spraying frequency (S3) which was at par with 4 spraying frequency (S2) (68.58 cm). Whereas, minimum plant height (66.53 cm) was recorded in 2 spraying frequency (S1). These results might be due to the different frequency of micronutrients applied was timely available during the active growth period and efficiently adsorbed by the crops. These findings are in closely conformity with the findings of Fahad *et al*. (2014) [1] in gladiolus.

Leaves plant^{-1}: At 4 spraying frequency (S2) recorded significantly maximum leaves plant^{-1} (56.16) which was at par with 6 spraying frequency (55.96). Whereas, minimum leaves plant^{-1} (54.13) was recorded in 2 spraying frequency (S1). This might be due to spray of micronutrients precisely given during these specific phenological stages ensures optimal growth of plants and also helped to increase number of leaves plant^{-1}.

Tillers plant^{-1}: The result shown in table 1 with respect of tillers plant^{-1}, the maximum tillers plant^{-1} (5.22) was recorded with application of 6 spraying frequency (S3) which was at par with 4 spraying frequency (S2) (5.18). Whereas, minimum tillers plant^{-1} (4.96) was recorded in 2 spraying frequency (S1). Longer spraying frequency boosts metabolic processes such as cell division and elongation, especially at the basal nodes, which is responsible form emergence of new tillers.

Quality parameters

The data in respect of quality parameter as influenced by spraying frequency was presented in table 1.

Diameter of floret

The result from table 1 exhibited the significant differences of spraying frequency on diameter of floret. Maximum diameter of floret (3.52 cm) was recorded at 4 spraying frequency (S2) which was followed by (3.36 cm) 6 spraying frequency (S3). Whereas, minimum diameter of floret (3.35 cm) was recorded at 2 spraying frequency (S1). Micronutrients applied at particular spraying frequency might help in synchronizing with the plant's requirement. Plants are sprayed with tryptophan as precursor of auxin is synthesize with the help of zinc and causes stem elongation result in better growth and floret diameter.

Length of floret

The result from table 1 exhibited the significant differences of spraying frequency on length of floret. Maximum length of floret (4.74 cm) was recorded at 4 spraying frequency (S2) which was at par with (4.68 cm) 6 spraying frequency (S3). Whereas, minimum length of floret (4.46 cm) was recorded at 2 spraying frequency (S1). Spraying at specific frequency helped to acquire more nutrients which facilitated the plant to obtain maximum length of floret.

Inter floret length

The result from table 1 exhibited that the significant differences of spraying frequency on inter floret length. Less inter floret length (3.81 cm) was recorded at 4 spraying frequency (S2) which was at par with (3.83 cm) 6 spraying frequency (S3). While, more inter floret length (3.91 cm) at 2 spraying frequency (S1).

Yield parameters

The results exhibited from table 1 showed significant differences among different spraying frequency.

Florets spike^{-1}, plot^{-1}, ha^{-1}

The maximum florets spike^{-1} (40.74), florets plot^{-1} (1.40 kg) and florets ha^{-1} (51.81 q) were recorded at application of 4 spraying frequency (S2). Whereas, minimum maximum florets spike^{-1} (38.94), florets plot^{-1} (1.24 kg) and florets ha^{-1} (46.17 q) was recorded at 2 spraying frequency (S1). Spraying at specific time and proper plant growth helped in converting the photosynthates to stored food and results in more production.

Interaction effect

The result shown from table 2 exhibited the significant interaction effect of different micronutrient formulation and spraying frequency. Maximum florets spike^{-1} (45.26), florets plot^{-1} (1.93kg) and florets ha^{-1} (71.95 q) were recorded in treatment combination micron utri ent formulation 1.0% concentration with 4 spraying frequency (M3S2). Whereas, minimum florets spike^{-1} (34.60), florets plot^{-1} (0.96 kg) and florets ha^{-1} (36.84 q) were recorded in treatment combination water spray with 2 spraying frequency (M1S1). Increased number of florets might be due to the application of Boron which helps in regulating semi permeability of cell walls, thus mobilizing more water into flowers and also increase the synthesis of iron which promotes flowering in tuberose. Similar results were also reported by Kumar *et al.* (2012) [5] in tuberose.

Table 1: Growth, quality and yield parameters as influenced by formulation of micronutrient and spraying frequency in tuberose

Treatments	Plant height (cm) (210 DAP)	Leaves plant^{-1} (210 DAP)	Tillers plant^{-1} (150 DAP)	Diameter of floret (cm)	Length of floret (cm)	Inter floret Length (cm)	Floret spike^{-1}	Florets plot^{-1} (kg)	Florets ha^{-1} (q)
Factor (A) Micronutrient formulation									
M1-(Water spray)	60.83	50.09	4.52	2.90	4.13	3.97	35.76	1.00	37.29
M2-0.5%	66.56	54.88	4.76	3.37	4.45	3.91	38.65	1.28	47.22
M3-1.0%	70.26	60.49	5.79	3.78	5.05	3.79	44.03	1.75	65.13
M4-1.5%	74.69	56.20	5.41	3.59	4.88	3.73	41.29	1.34	49.74
'F' test	Sig.	Sig.	Sig	Sig.	Sig.	Sig	Sig	Sig	Sig
SE (m)±	0.82	0.61	0.08	0.04	0.08	0.03	0.48	0.04	0.11
CD at 5%	2.41	1.81	0.25	0.14	0.28	0.08	1.41	0.14	0.32
Factor (B) Spraying frequency									
S1-2 Spray	66.53	54.13	4.96	3.35	4.46	3.91	38.94	1.24	46.17
S2-4 Spray	68.58	56.16	5.18	3.52	4.74	3.81	40.74	1.40	51.81
S3-6 Spray	69.14	55.96	5.22	3.36	4.68	3.83	40.12	1.39	51.56
'F' test	Sig.	Sig.	Sig	Sig.	Sig.	Sig	Sig	Sig	Sig
SE (m)±	0.71	0.53	0.07	0.04	0.07	0.02	0.41	0.04	0.09
CD at 5%	2.41	1.57	0.21	0.12	0.22	0.07	1.22	0.12	0.28
Interaction effect (MXS)									
'F' test	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	Sig	Sig	Sig
SE (m)±	1.74	1.31	0.18	0.10	0.18	0.06	1.02	0.10	0.23
CD at 5%	_	_	_	_	_	_	2.99	0.31	0.69

Table 2: Interaction effect as influenced by formulation of micronutrient and spraying frequency in tuberose

Treatments	Florets spike^{-1}				Florets plot^{-1} (kg)				Florets ha^{-1} (q)			
Spraying frequency (S)												
Micronutrient formulation (M)	S1-2 Spray	S2-4 Spray	S3-6 Spray	Mean	S1-2 Spray	S2-4 Spray	S3-6 Spray	Mean	S1-2 Spray	S2-4 Spray	S3-6 Spray	Mean
M1-Water spray	34.60	36.53	36.17	35.76	0.96	1.04	1.02	1.00	36.84	38.01	37.04	37.29
M2-0.5%	37.19	39.10	39.66	38.65	1.08	1.27	1.52	1.28	39.94	45.91	54.81	47.22
M3-1.0%	41.76	45.26	45.08	44.03	1.54	1.93	1.80	1.75	56.35	71.95	67.10	65.13
M4-1.5%	42.23	42.09	39.56	41.29	1.39	1.37	1.27	1.34	51.56	50.38	47.29	49.74
Mean	38.94	40.74	40.12		1.24	1.40	1.39		46.17	51.81	51.56	
	Factor A (M)		Factor B (S)	Interaction (M X S)	Factor A (M)		Factor B (S)	Interaction (M X S)	Factor A (M)		Factor B (S)	Interaction (M X S)
'F' test	Sig.		Sig.	Sig.	Sig.		Sig.	Sig.		Sig.	Sig.	Sig.
SE (m)±	0.48		0.41	1.02	0.04		0.04	0.10	0.11		0.09	0.23
CD at 5%	1.41		1.22	2.99	0.14		0.12	0.31	0.32		0.28	0.69

Conclusion

From the above experimental trial, it is concluded that, maximum plant height was recorded in the treatment micronutrient formulation 1.5% concentration and 6 spraying frequency. Whereas, maximum leaves plant^{-1} and tillers plant^{-1} were recorded in the treatment 1.0% micronutrient formulation at 4 and 6 spraying frequency respectively. In respect of quality parameters, maximum diameter of floret and length of floret were recorded in treatment micronutrient formulation1.0% concentration and 4 spraying frequency. However, less inter floret length of tuberose was recorded in treatment micronutrient formulation 1.5% concentration and 4 spraying frequency. In yield parameters maximum florets spike^{-1}, florets plot^{-1} and florets ha^{-1} were recorded in 1.0% micronutrient formulation concentration with 4 spraying frequency treatment combination. Hence, interaction effect in respect of florets spike^{-1}, florets plot^{-1} and florets ha^{-1} were significant.

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