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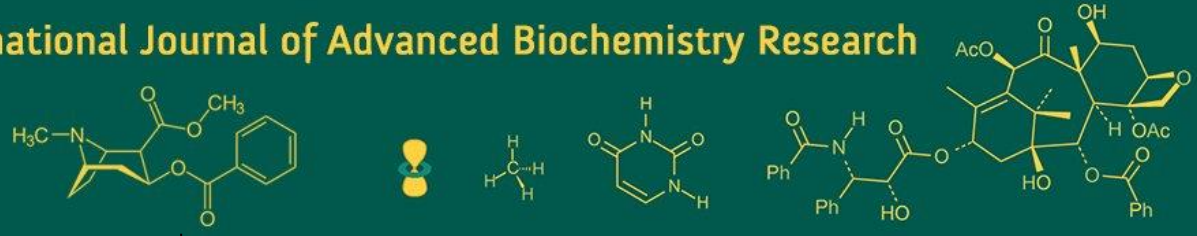

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Effect of micronutrient formulation on growth and flower yield of annual chrysanthemum

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Abstract
An experimental study was conducted to evaluate the foliar application of PDKV grade II micronutrient at different spraying time on flower yield and quality of annual chrysanthemum at Horticulture Section, College of Agriculture, Nagpur in 2023-24. The experiment was laid out in Factorial Randomized Block Design consisting of twelve treatments replicated thrice. The result of experiment was in respect of growth parameters *viz*,. plant height was recorded significantly maximum in treatment of PDKV grade II micronutrient concentration 1.5 percent as well as in spraying at 45 DAT. Number of branches plant^{-1} and plant spread were recorded significantly maximum in treatment of PDKV grade II micronutrient concentration 1.0 percent as well as in spraying at 45 DAT in annual chrysanthemum. For yield parameters i.e. number of flowers plant^{-1}, flower yield plant^{-1}, flower yield plot^{-1} and hectare^{-1} were recorded maximum in PDKV grade II micronutrient concentration 1.0 percent as well as in spraying at 45 DAT. The interaction effect of treatment combination of PDKV grade II micronutrient concentration 1.0 percent as well as in spraying at 45 DAT were recorded significantly maximum in number of branches plant^{-1}, number of flowers plant^{-1}, flower yield plant^{-1}, flower yield plot^{-1} and hectare^{-1} in annual chrysanthemum.

Keywords: Annual chrysanthemum, PDKV Grade II micronutrient, spraying time, flower yield

Introduction
Annual chrysanthemum belongs to one of the largest family of flowering plants 'Asteraceae'. It is considered as one of the most important cultivated commercial loose flower crops grown all over India which includes 160 species of chrysanthemum. It comprises of three species *viz.*, *Chrysanthemum segtum* (Corn marigold), *Chrysanthemum carinatum* (tricoloured chrysanthemum) and *Chrysanthemum coronarium* (Crown daisy or garland chrysanthemum). Among annual chrysanthemum, *Chrysanthemum coronarium* has its own importance and it is also referred as *Leucanthemum coronarium* or *Glebionis coronarum*. It is a winter annual and it is native to Mediterranean region. It is distributed throughout Europe, Northern Africa and Asia (Anon., 2007). It is mainly propagated through seeds, which produces daisy like golden yellow to white flowers. Annual chrysanthemums are relatively short duration crop and they are less photosensitive and thus capable of growing throughout the year under moderate climatic conditions. The plant is considered to be hardier, vigorous and it grows taller. It completes its life cycle within 120- 150 days.
Micronutrients plays an important role in flower production and its deficiency lowers the productivity in chrysanthemum. PDKV grade II micronutrient formulation contains copper, boron, zinc, manganese, molybdenum and iron which are responsible for metabolic activities in flower physiology. They are used in lower amounts as compared to macronutrients such as N, P and K. Zinc has major role in chlorophyll synthesis, involved in biosynthesis of plant growth hormone and plays positive role in photosynthesis and nitrogen metabolism for auxin and protein synthesis, seed production and proper maturity. Boron is a constituent of cell membrane and it is essential for cell division. It acts as a regulator of potassium/calcium ratio in plants and helps in nitrogen absorption and translocation of sugar in plants, with increase in flower size and yield. Iron increases the chlorophyll content of the plant, reflecting on the colour of the leaves. Iron plays a critical role in metabolic process such as DNA synthesis, respiration and photosynthesis.

Copper is one of the micronutrients needed in very minute quantities by the plants. Copper activates some enzymes in plants which are involved in lignin synthesis and it is essential in several enzyme systems. Manganese is used in plants as a major contributor to various biological systems including photosynthesis, respiration and nitrogen assimilation. It is also involved in pollen germination, pollen tube growth, root cell elongation and resistance to root pathogens. Molybdenum is a key element which transforms nitrogen into amino acids. Keeping this view present research work was planned to find out the suitable dose of PDKV grade II micronutrient as the foliar application at different spraying time on flower yield and quality of annual chrysanthemum.

Materials and Methods

A field experiment was conducted during winter of 2023 to access the "Effect of PDKV grade II micronutrient formulation on growth, flower yield and quality of annual chrysanthemum" at farm of Horticulture Section, College of Agriculture, Nagpur. The experiment was laid out in Factorial Randomized Block Design consisting two factors. Factor 'A" consist of four levels of PDKV grade II micronutrient *Viz.*, G_1: Water spray, G_2: PDKV grade II micronutrient conc. 0.5%, G_3: PDKV grade II micronutrient conc. 1% and G_4: PDKV grade II micronutrient conc.1.5% and in factor 'B' consist of spraying time *i.e.* T_1: at 30 DAT, T_2: 45 DAT & T_3: 60 DAT. Overall, twelve treatment combinations which were replicated trice.

Seedling of annual chrysanthemum was prepared on nursery bed and 40 days old seedling was transplanted in main field at the spacing 45 cm x 30 cm. Inorganic fertilizer 100:50:50 kg NPK / ha was applied in the form of Urea, Single Super Phosphate and Muriate of Potash. Half dose of N and full dose of P & K was applied at the time of transplanting and remaining half dose of N was applied 30 DAT.

Foliar spraying of PDKV grade II micronutrient with different concentrations was carried out at different time interval i.e. 30 days after transplanting, 45 days after transplanting and 60 days after transplanting as per the treatment in annual chrysanthemum.

The observations in respect of flower yield and quality parameters were recorded after flowering. Statistical method suggested by Panse and Sukhatme (1967) [11] were utilized for data analysis.

Results and Discussion

1. Effect of PDKV grade II micronutrient

a. Growth parameters

The data in respect of growth parameter as influenced by PDKV grade II micronutrient was presented in Table 1.

Plant height: The Data from table 1 exhibited the significant difference among the different concentrations of PDKV grade II micronutrient on plant height at 75 DAT. The treatment PDKV grade II micronutrient concentration @ 1.5% had recorded significantly maximum plant height (103.45 cm) followed by the treatment PDKV grade II micronutrient concentration @ 1.0% (101.19 cm) and PDKV grade II micronutrient concentration @ 0.5% (97.33 cm). Whereas, minimum plant height (94.87 cm) was recorded under control treatment. It might be due to simulative effects of zinc and iron present in the PDKV grade II micronutrient would be the source for increase in plant vegetative growth. These results are in close conformity with Barman and Pal (1999) [5], Misra (2001) [9] and Annasamy *et al*. (2023) [2] in chrysanthemum and Aruna *et al*. (2007) [4] in crossandra.

Number of branches plant^{-1}: The result exhibited the significant differences among the different concentrations of PDKV grade II micronutrient on number of branches plant^{-1} at 60 DAT. The treatment PDKV grade II micronutrient concentration @ 1.0% had recorded maximum number of branches per plant (32.50) followed by PDKV grade II micronutrient concentration @ 1.5% (31.48) and PDKV grade II micronutrient concentration @ 0.5% (28.46). Whereas, minimum number of branches plant^{-1} (24.35) was recorded under control treatment. This might be due to the fact that, iron and zinc present in PDKV grade II micronutrient is known to 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 resulting in an increased plant height with a greater number of productive branches. These results are closely related with Chopde *et al*. (2016) [6] in gladiolus, Verma *et al.* (2017) [5] in China aster and Tayade *et al*. (2018) [13] in tuberose.

Plant spread (cm): The result exhibited the significant differences among the different concentrations of PDKV grade II micronutrient regarding plant spread at 50 percent flowering stage. The treatment PDKV grade II micronutrient concentration @ 1.0% recorded significantly maximum plant spread (71.49 cm) which was found at par with treatment PDKV grade II micronutrient concentration @ 1.5% with plant spread (71.29 cm). Whereas, control treatment recorded minimum (46.92 cm) plant spread. This increase in plant spread might be due to the application of micronutrients that have caused the utilization of food material for increasing the horizontal branches and thus increased the plant spread. Kakade *et al*. (2009) [8] reported the similar results in respect of plant spread in China aster.

b. Yield parameter

The data in respect of yield parameter as influenced by PDKV grade II micronutrient was presented in Table 1.

Number of flowers plant^{-1}

The result exhibited from Table 1 showed the significant differences among different concentrations of PDKV grade II micronutrient regarding number of flowers plant^{-1}. The treatment PDKV grade micronutrient concentration @ 1.0% recorded significantly maximum number of flowers plant^{-1} in annual chrysanthemum (50.65) which was found at par with the treatment PDKV grade micronutrient concentration @ 1.5% (50.42). Whereas, control treatment recorded minimum number of flowers plant^{-1} (40.73) in annual chrysanthemum. The micronutrients help in increasing the foliage coverage at initial growth stages and in the later stages, which helps in translocation of assimilates is also responsible for obtaining higher number of flowers per plant (Amarananjundeswara *et al*., 2020) [1].

Flower yield plant^{-1}, plot^{-1} and ha^{-1}

Data from table 1 exhibited the significant differences among different concentrations of PDKV grade II

micronutrient regarding flower yield plant^{-1}. The treatment PDKV grade micronutrient concentration @ 1.0% recorded significantly maximum flower yield plant^{-1} (193.50 g), flower yield plot^{-1} (4.84 kg) and ha^{-1} (179.14 q) which was found at par with the treatment PDKV grade II micronutrient concentration @ 1.5% (190.89 g plant^{-1}, 4.77 kg plot^{-1} & 176.73 q ha^{-1} respectively). Whereas control treatment recorded minimum flower yield plant^{-1} (121.89 g), plot^{-1} (3.05 kg) & ha^{-1} (112.84 q). This might be due to the response of micronutrients which assist in movement of fundamental sugars in plant membranes and encourage appropriate cell division, cell wall growth, development and micronutrient application is key factor which play a dominant role in successful production and thereby helped in obtaining flower yield plant^{-1}. Similar results were also reported by Halder *et al*. (2007) [7] in Gladiolus, Satpute *et al*. (2013) [12] in okra and Vala *et al*. (2014) [14] in Bitter gourd.

2. Effect of spraying time

a. Growth parameters

The data in respect of plant height as influenced by spraying time micronutrient was presented in Table 1

Plant height (cm): Data from table 1 showed non-significant differences at 75 days after transplanting, in respect of plant height. This might be due to less effect of treatment combinations on plant height at 75 days after transplanting.

Number of branches plant^{-1}: The result exhibited the significant differences among the different spraying time regarding the number of branches plant^{-1} at 60 days after transplanting. The treatment foliar spray of 45 DAT recorded significantly maximum branches plant^{-1} (30.43) which was found at par with spraying time 30 DAT (29.53). Whereas, minimum branches plant^{-1} (28.40) was recorded under spraying of 60 DAT. This might be due to spray of micronutrients precisely given during these specific phenology stages ensures optimal growth of plants and also helped to increase number of branches plant^{-1}.

Plant spread (cm): The result exhibited the significant differences among the different spraying time regarding the plant spread at 50 percent flowering stage. The treatment spraying at 45 DAT recorded significantly maximum plant spread (67.09 cm) which was followed by the treatment spraying at 60 DAT with plant spread (65.12 cm) whereas spraying at 30 DAT recorded minimum (60.54 cm) plant spread. This might be due to direct and rapid absorption of micronutrients applied at these specific spraying time which results in the lateral growth of plants by increasing the number of branches leads to more plant spread.

b. Yield Parameters

The data regarding the yield parameters as influenced due to time of spraying of micronutrient during year 2023 are presented in Table.1

Number of flowers plant^{-1}

The result exhibited the from table 1 showed the significant differences among different spraying time regarding number of flowers plant^{-1}. The treatment micronutrient spraying at 45 DAT recorded significantly maximum number of flowers plant^{-1} (49.54) which was followed by the treatment micronutrient spraying 60 DAT (47.29). Whereas micronutrient spraying 30 DAT treatment recorded minimum (45.11) number of flowers plant^{-1} in annual chrysanthemum. This might be due to the overlapping of spraying time with the phase of flowering, which results in the availability of micronutrients to initiate a greater number of flowering buds thereby helped in increasing the number of flowers plant^{-1}.

Flower yield plant^{-1}, plot^{-1} and ha^{-1}

The result exhibited from table 1 showed the significant differences among different spraying time regarding flower yield plant^{-1}. The treatment micronutrient spraying 45 DAT recorded significantly maximum flower yield plant^{-1} (181.80 g), plot^{-1} (4.54 kg) and hectare^{-1} (168.31 q) which was followed by the treatment micronutrient spraying 60 DAT (167.14 g plant^{-1}, 4.18 kg plot^{-1} & 154.74 q ha^{-1} respectively), whereas micronutrient spraying 30 DAT treatment recorded minimum flower yield plant^{-1} (155.34), plot^{-1} (3.88 kg) and ha^{-1}(143.82 q). This might be due to the availability of all the micronutrients at actual flowering phase and metabolic activities which results in more flower production in turn leads to the increase in flower yield plant^{-1}.

3. Interaction effect

Data in table 2 of interaction effect of different concentrations of PDKV grade II micronutrient and spraying time on number of number of flowers plant^{-1}, flower yield plant^{-1} plot^{-1} and hectare^{-1} showed significant differences.

The result exhibited from table 2 the significant differences on interaction effect of different concentrations of PDKV grade II micronutrient and spraying time on number of flowers plant^{-1} flower yield plant^{-1}, plot^{-1} and hectare^{-1}. Data presented in table 2, it indicates that, number of flowers plant^{-1} (54.84), flower yield plant^{-1} (219.03 g), flower yield plot^{-1} (5.48 kg) and flower yield ha^{-1} (202.78) was recorded maximum in PDKV grade II micronutrient concentration @ 1.0% with micronutrient spraying at 45 DAT which was found at par with the treatment PDKV grade II micronutrient concentration @ 1.5% with micronutrient spraying 45 DAT. Minimum number of flowers plant^{-1} (40.22), flower yield plant^{-1} (120.70 g), plot^{-1} (3.02 kg) and hectare^{-1} (111.74 q). in G_1S_3 i.e. Control. Interaction effect of PDKV grade II micronutrient and spraying time was due to application of micronutrient relieved the plants from chlorosis and produced healthy green leaves which resulted in higher assimilate synthesis and partitioning of the flower growth which may in turn increase the number of flower production and ultimately flower yield. Similar results were also obtained by Pal *et al*. (2016) [10] in Gerbera.

Table 1: Growth and yield parameters as influenced by different concentration of PDKV grade II micronutrient and spraying time in annual chrysanthemum

Factors	Growth parameters			Yield parameters			
	Plant height	Number of branches plant^{-1}	Plant spread (cm)	Number of flowers plant^{-1}	Flower yield plant^{-1} (g)	Flower yield plot^{-1} (kg)	Flower yield ha^{-1} (q)
Factor A: PDKV Grade II Micronutrient Concentrations (G)							
G_1 -(Control)	94.87	24.35	46.92	40.73	121.89	3.05	112.84
G_2 - 0.5%	97.33	28.46	67.30	47.45	166.10	4.15	153.77
G_3 - 1.0%	101.19	32.50	71.49	50.65	193.50	4.84	179.14
G_4 - 1.5%	103.45	31.48	71.29	50.42	190.89	4.77	176.73
'F' test	Sig.	Sig.	Sig	Sig	Sig	Sig	Sig
SE (m) ±	0.75	0.27	1.07	0.65	4.08	0.10	3.78
CD at 5%	2.21	0.80	3.13	1.92	11.97	0.30	11.08
Factor B: Spraying time (S)							
S_1 – 30 DAT	97.83	29.09	60.54	45.11	155.34	3.88	143.82
S_2 - 45 DAT	99.78	30.43	67.09	49.54	181.80	4.54	168.31
S_3 - 60 DAT	99.84	28.40	65.12	47.29	167.14	4.18	154.74
'F' test	N.S.	Sig.	Sig	Sig	Sig	Sig	Sig
SE (m) ±	0.65	0.23	0.92	0.57	3.53	0.09	3.27
CD at 5%	-	0.69	2.71	1.66	10.37	0.26	9.60
(C) Interaction effect (G×S)							
'F' test	NS	Sig	Sig	Sig	Sig	Sig	Sig
SE (m) ±	1.31	0.47	1.85	1.13	7.07	0.18	6.54
CD at 5%	-	1.38	5.42	3.32	20.73	0.52	19.19

Table 2: Interaction effect of foliar application of PDKV grade II micronutrient and spraying time on yield parameters of annual chrysanthemum.

Treatments	Number of flowers plant^{-1}	Flower yield plant^{-1} (g)	Flower yield plot^{-1} (kg)	Flower yield hectare^{-1} (q)
G_1S_1	40.61	123.59	3.09	114.42
G_1S_2	41.36	121.38	3.03	112.37
G_1S_3	40.22	120.70	3.02	111.74
G_2S_1	45.91	158.31	3.96	146.57
G_2S_2	48.46	173.55	4.34	160.67
G_2S_3	47.99	166.43	4.16	154.08
G_3S_1	47.66	173.12	4.33	160.27
G_3S_2	54.84	219.03	5.48	202.78
G_3S_3	49.46	188.34	4.71	174.37
G_4S_1	46.27	166.35	4.16	154.01
G_4S_2	53.49	213.24	5.33	197.42
G_4S_3	51.51	193.08	4.83	178.75
F test	Sig	Sig	Sig	Sig
S.E(m) ±	1.13	7.07	0.18	6.54
CD at 5%	3.32	20.73	0.52	19.19

Conclusion

From the above investigation it is concluded that, maximum number of branches plant^{-1}, plant spread, number of flowers plant^{-1}, flower yield plant^{-1}, flower yield plot^{-1}, flower yield hectare^{-1} in annual chrysanthemum were recorded maximum with the treatment of PDKV grade II micronutrient concentration of 1.0 percent and micronutrient spraying at 45 DAT. Whereas, plant height was recorded maximum with the treatment of PDKV grade II micronutrient concentration of 1.5 percent and micronutrient spraying at 45 DAT. In case of yield parameters maximum yield recorded in the treatment combination G_3S_2 i.e. PDKV grade II micronutrient concentration 1.0% + micronutrient spraying at 45 DAT. Hence, interaction of PDKV grade II micronutrient concentration of 1.0% and spraying time at 45 DAT can be used to obtain maximum growth and flower yield in annual chrysanthemum.

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