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EFFECT OF FOLIAR APPLICATION OF MICRONUTRIENTS AND POTASSIUM HUMATE ON GROWTH AND FLOWERING OF TABERNAEMONTANA DIVARICATA (L.)

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ABSTRACT
Tabernaemontana divaricata (L.) (Crape jasmine) is a commercial important loose flower suitable for year round production in India. Many studies have revealed the beneficial effect of micronutrients viz., $ZnSO_4$, $FeSO_4$, $MgSO_4$, Borax, and Potassium humate on flower crops. Hence, a field experiment was conducted in a farmer's field at Manarpalyam village of Selam district, Tamilnadu during 2021 to study the effect of foliar application of 7 different combinations of $ZnSO_4$(0.3%), $FeSO_4$(0.5%), $MgSO_4$ (0.3%), Borax(0.3%), and Potassium humate (1%) along with one control treatment. Foliar treatments were applied at 30 days interval. Data pertaining to growth and yield parameters were recorded at periodical intervals. The results revealed that the growth and yield parameters were significantly enhanced in all the treatments when compared to control. The maximum branches, leaves, DMP, number of flowers, flower weight, and flower yield were recorded in treatment with $ZnSO_4$ @ 0.3% + $FeSO_4$ @ 0.5% + $MgSO_4$ @ 0.3 % + Borax 0.3 % + Potassium humate @ 1% on 30 days interval when compared to control. It was followed by the application of $ZnSO_4$ @ 0.3% + $FeSO_4$ @ 0.5% + $MgSO_4$ @ 0.3 % + Potassium humate @ 1% on 30 days interval.
Key Words : Tabernaemontana divaricata, Crape jasmine, $ZnSO_4$, $FeSO_4$, $MgSO_4$, Borax, Potassium humate

INTRODUCTION
The area under commercial flower production is increasing every year as the consumption and demand for loose flowers is constantly increasing during past ten years. During 2019-2020 in India, flower crops are cultivated in an area of 307000ha with a production of 694 million cut flowers and 2300 Mt of loose flowers (Agricultural Statistics at a glance, 2020). Recently, along with major loose flowers viz., jasmines, chrysanthemeum, tuberose, crossandra, coxcomb, and rose, which are traditionally cultivated, Crape jasmine (Tabernaemontana divaricata) is also finding a place in market. Crape jasmine is an evergreen shrub containing large, glossy dark green leaves, white fragrant 5-petaled tubular flowers is being cultivated as loose flower. It is gaining commercial importance in landscape industry also. When compared with jasmine, the crape jasmine is hardy, low input crop with high productivity and self life. Hence, they are used

as alternate loose flowers during off season production.

The growth, yield and quality of flower crops are influenced by the application of micronutrients. Although required in smaller quantities, they are essential for crop growth and development. Presently micronutrient has become the most important nutrient management practice among flower growers. Many studies have revealed the beneficial effect of micronutrients viz., ZnSO4, FeSO4, MgSO4, and Borax on flower crops. These micro nutrients were found increasing the growth, flowering, yield and quality parameters, like plant height, plant spread, number of branches, early flowering, number of flowers per plant, flower weight, flower yield, flower diameter and leaf chlorophyll content (Zende, 1996; Balakrishnan et al.,2007). In addition to micro nutrients, the humic acid has been attributed to the increase in chlorophyl content, respiration process, hormonal responses, plant membrane penetration or a combination of these processes contribute for plant growth (Mallikarjuna et al., 1987). In crape jasmine aslo foliar application of micronutrients and humic acid will have beneficial effects, as in other flower crops. The present study was carried out with the objective of finding the influence of foliar application of micronutrients and Potassium humate on the growth and flowering of crape jasmine.

MATERIALS AND METHODS

A field experiment was carried out in the Manarpalyam village of Selam district, Tamilnadu during 2021 to study the effect of foliar application of micronutrients viz., ZnSO4, FeSO4, MgSO4, Borax, and Potassium humate in different combinations. The experiment was laid in Randomized Block Design with eight treatments and three replications. The rooted cuttings of T.divaricata Cv. Meenampalli local obtained from a farmer's field were planted in plots of 3m x 6m dimension in a spacing of 1.5m X 2m for assessing their growth and yield performance. Standard package of practices were adopted throughout the experiment to grow a healthy crop. As per the following treatment schedule, foliar micronutrients were applied on 30, 60, 90, 120, 150 and 180 days after planting.

T. No.	Treatment details
T_1	Potassium humate @ 1% on 30 days interval
T_2	$ZnSO_4$ @ 0.3% + $FeSO_4$ @ 0.5% on 30 days interval
T_3	$ZnSO_4$ @ 0.3% + $FeSO_4$ @ 0.5% + $MgSO_4$ @ 0.3 % on 30 days interval
T_4	$ZnSO_4$ @ 0.3% + $FeSO_4$ @ 0.5% + $MgSO_4$ @ 0.3 % + Borax 0.3 % on 30 days interval
T_5	$ZnSO_4$ @ 0.3% + $FeSO_4$ @ 0.5% + Potassium humate @ 1% on 30 days interval
T_6	$ZnSO_4$ @ 0.3% + $FeSO_4$ @ 0.5% + $MgSO_4$ @ 0.3 % + Potassium humate @ 1% on 30 days interval
T_7	$ZnSO_4$ @ 0.3% + $FeSO_4$ @ 0.5% + $MgSO_4$ @ 0.3 % + Borax 0.3 % + Potassium

	humate @ 1% on 30 days interval
T_8	Control

The plant protection measures were adopted to control weeds, pest and diseases. The plant bushes are pruned at 50cm height from the ground level. Harvesting of flower was done during evening hours by plucking the unopened flower buds. Initially harvesting was done once in two days. At peak flowering season harvesting was done every day. Four plants were randomly selected at each plot in all the three replications and were tagged for recording the non-destructive parameters. Data pertaining to growth and yield parameters were recorded at periodical intervals. The data recorded were subjected to statistical analysis by adopting the standard procedure (Panse and Sukhatme, 1967). The critical differences were worked out at 5% probability significance.

RESULTS AND DISCUSSION

Growth parameters

The results showed that foliar application of zinc sulphate, ferrous sulphate, magnesium sulphate, Borax and potassium humate markedly influenced the growth characters of crape jasmine. Among all treatments,T7 (ZnSO4 @ 0.3% + FeSO4 @ 0.5% + MgSO4 @ 0.3 % + Borax 0.3 % + Potassium humate @ 1% on 30 days interval) recorded the highest plant height of 165.33cm which 11% higher when compared to Control (T8) and it was followed by T6 (ZnSO4 @ 0.3% + FeSO4 @ 0.5% + MgSO4 @ 0.3 % + Potassium humate @ 1% on 30 days interval) (Table 1). The least plant height of 147.62 cm was recorded in control T8. There was 7 per cent increment in intermodal length observed between the best treatments T7 (14.08 cm) and control T8 (13.04 cm). A similar trend was observed for internodal length also. The increase in the plant height and intermodal length observed in the treatments which received ZnSO4 @ 0.3% + FeSO4 @ 0.5% + MgSO4 @ 0.3 % + Borax 0.3 % + Potassium humate @ 1% (T7) might be due to the influence of Zinc in the synthesis of Auxin IAA carbohydrate metabolism, and protein synthesis (Shukla et al., 2009). Further, iron as an important catalyst in the enzymatic reactions would have helped in larger biosynthesis of photo-assimilates, thereby enhancing growth of plants. The influence of Mg observed in the present study could be due to its influence on metabolic processes of plants, as explained by Ismail Cakmak and Atilla (2010). Additions of humic acid along with micronutrients have played an additive effect in enhancing plant height in the current study. Present results are in accordance with the earlier report by Tara Chand Saini, et al. (2015) on chrysanthemum.

Number of primary branches, secondary branches and leaves were significantly enhanced in all the treatments when compared to control. There was more than 13 per cent enhancement observed in number of plant spread (83.42 cm), primary branches (9.28), secondary branches (22.78) and leaves (113.32) at T7 (ZnSO4 @ 0.3% + FeSO4 @ 0.5% + MgSO4 @ 0.3 % + Borax 0.3 % + Potassium humate @ 1% on 30 days interval) when compared to control (T8). It was followed by T6 (ZnSO4 @ 0.3% + FeSO4 @ 0.5% + MgSO4 @ 0.3 % + Potassium humate @ 1% on 30 days interval) with more than 11 per cent enhancement compared to control (Table 1). The least plant spread (72.54 cm), number of primary branches (8.21), secondary branches (20.16) and leaves (98.54) were recorded in Control (T8). Enhancement in plant spread observed in the present study is contributed by an increase in the number of branches and number of leaves due to foliar application of micronutrients and potassium humate. Application of foliar ZnSo4 could have contributed to improvement in the root system that helped water and nutrient absorption and utilization. Ferrous sulphate, being an essential component of several dehydrogenases, proteinase, and peptidase, might have promoted synthesis and functioning of growth hormones. Application of magnesium significantly increases all growth parameter as compared with the control plants. The present results coincide with those obtained by Basole et al., (2003), Gupta et al., (2003).

The chlorophyll content was recorded the highest in T7 ($ZnSO_4$ @ 0.3% + $FeSO_4$ @ 0.5% + $MgSO_4$ @ 0.3 % + Borax 0.3 % + Potassium humate @ 1% on 30 days interval) followed by T6 ($ZnSO_4$ @ 0.3% + $FeSO_4$ @ 0.5% + $MgSO_4$ @ 0.3 % + Potassium humate @ 1% on 30 days interval). All these factors contributed to cell multiplication, cell division and cell differentiation resulting in increased photosynthesis and translocation of food material which enhanced the plant spread. This could be attributed to better flow of various micronutrients, which might have favored production of auxillary buds resulting in formation of more number of branches. These results observed in present study are in line with the reports Kakade et al. (2009) in China aster, and Poornima et al. (2018) in Rose. Enhanced growth observed in treatments with potassium humate in the present study may be due to the role of potassium in plant metabolism and increased mineral uptake by plants as suggested by Bassiouny et al.,(2003) and Hossain et al.,(2009). Humic acid in high concentrations increased the number of leaves, which could be due to a positive mineral effect and also hormone-like activity of humic acid on vegetative growth in plants (Elkhateeb et al., 2011; Abourayya et al 2020).

Dry matter production recorded (115.21 g/plant) in T7 ($ZnSO_4$ @ 0.3% + $FeSO_4$ @ 0.5% + $MgSO_4$ @ 0.3 % + Borax 0.3 % + Potassium humate @ 1% on 30 days interval) was 15 per cent higher when compared to control (T8) which recorded (100.18 g/plant). Enhancement in DMP recorded in the next best treatment T6 ($ZnSO_4$ @ 0.3% + $FeSO_4$ @ 0.5% + $MgSO_4$ @ 0.3 % + Potassium humate @ 1% on 30 days interval) was 113.54 g/plant which is 13 per cent higher when compared to control (Table 1). Enhanced dry matter production observed in the treatments which received potassium humate might be due to the fact that humic acid could sustain photosynthetic tissues and thus total dry weight would increase. In addition to the direct effect on plant metabolic processes, humic acid has beneficial effects on nutrient uptake, transportation, and availability of micronutrients (Bohme and Thilua, 1997). This could be the reason for enhancement in all growth attributes observed in the present study due to addition of potassium humate along with micro nutrients in plant height in the ($ZnSO_4$ @ 0.3% + $FeSO_4$ @ 0.5% + $MgSO_4$ @ 0.3 % + Borax 0.3 % + Potassium humate @ 1% on 30 days interval) and T6 ($ZnSO_4$ @ 0.3% + $FeSO_4$ @ 0.5% + $MgSO_4$ @ 0.3 % + Potassium humate @ 1% on 30 days interval). The present results are in line with the findings of Keerthishankar et al., (2020), Bhoomi et al. (2019), DeoKumar Paswan and Saravanan (2019) and Zala et al. (2021) in jasmine.

Flowering parameters

The number of days taken for first flowering was significantly varied due to the foliar application of micronutrients and Potassium humate. The flowering was 2 days early in treatments T7, T6, T5, and T4 (Table 2). Early flowering observed due to these treatments is positive results that explain the influence of micro nutrients and potassium humate on flowering stimuli. Among the quality parameters, the length of flower bud was significantly influenced by foliar application of zinc sulphate, ferrous sulphate, magnesium sulphate, Borax and potassium humate. However, the corolla tube length and flower diameter have not enhanced significantly due to the treatments. Among all treatments in T7 (ZnSO4 @ 0.3% + FeSO4 @ 0.5% + MgSO4 @ 0.3 % + Borax 0.3 % + Potassium humate @ 1% on 30 days interval) recorded the highest flower bud length of 2.86 cm which 6% higher when compared to Control (T8) and it was followed by T6 (ZnSO4 @ 0.3% + FeSO4 @ 0.5% + MgSO4 @ 0.3 % + Potassium humate @ 1% on 30 days interval). There was around 13 per cent enhancement in flower weight (Hundred flower weight of 25.48g and single flower weight of 0.265g) observed in T7 (ZnSO4 @ 0.3% + FeSO4 @ 0.5% + MgSO4 @ 0.3 % + Borax 0.3 % + Potassium humate @ 1% on 30 days interval). The increase in weight of flowers might be attributed to increased dry biomass production due to enhanced growth of plants. These findings are in accordance with the results of Singh and Bhattacharjee (1997), who observed an increase in the fresh weight of rose flowers as a result of foliar application of micronutrients. Khalifa et al. (2011) also noted that the fresh weight increase in Iris flowers was due to ZnSO4. Enhancement in flower weight might also be due to the complementary effect of the combination of four micronutrients with potassium humate.

Among all the treatments, the highest number of 61.48 flowers per plant produced in T7 (ZnSO4 @ 0.3% + FeSO4 @ 0.5% + MgSO4 @ 0.3 % + Borax 0.3 % + Potassium humate @ 1% on 30 days interval) was 20 per cent higher when compared to control (51.23 flowers/plant). The next best treatment, T6 (ZnSO4 @ 0.3% + FeSO4 @ 0.5% + MgSO4 @ 0.3 % + Potassium humate @ 1% on 30 days interval) has produced 60.34 flowers/plant, which is 17 per cent higher when compared to control (Table 2). The maximum flower yield (16.26 g/plant/day and 97.56g/ plot/day) recorded in T7 (ZnSO4 @ 0.3% + FeSO4 @ 0.5% + MgSO4 @ 0.3 % + Borax 0.3 % + Potassium humate @ 1% on 30 days interval) was 38 per cent higher when compared to the yield recorded in control (11.78g/plant/day and 70.7g/ plot/day). The next best treatment, T6 (ZnSO4 @ 0.3% + FeSO4 @ 0.5% + MgSO4 @ 0.3 % + Potassium humate @ 1% on 30 days interval) has which recorded 16.26g/plant/day and 97.56 g/plot/day of flower yield. Yield enhancement might be due to improved yield parameters like number of flowers per plant and the single flower weight recorded in this treatment. The increase in flowering attributes might be due to the beneficial role of zinc, boron and iron in enhancing the translocation of carbohydrates, minerals, water and amino acids from the site of synthesis to the storage tissue, especially on flowers, which in turn increases the number, size and weight of flowers.

These results are in conformity to the reports by Balakrishnan et al. (2007) on African marigold and Naveenkumar et al. (2009) in chrysanthemum, who observed yield enhancement due to combination of different micronutrients. In the present study, the estimated flower yield was recorded the highest of 54.20kg per day per plant and 12.19 t/ha per annum in T7 (Table 2). The annual per hectare yield estimated in T7 (ZnSO4 @ 0.3% + FeSO4 @ 0.5% + MgSO4 @ 0.3 % + Borax 0.3 % + Potassium humate @ 1% on 30 days interval) was 38 per cent higher when compared to 8.84t/ ha of flower yield estimated in control(T8). Results suggest that application of potassium humate has greater in the foliar nutrient composition along with micronutrients. Application of zinc and iron relieved the chlorosis and increased the synthesis of chlorophyll required for photo assimilation. Moreover, mobility of minerals, photosynthates and aminoacids from the source to sink might have been augmented due to foliar micronutrient in combination with potassium humate, which intern increased the flower bud initiation and flower yield. Similar results were also obtained by Nag and Biswas (2002) in tuberose, Balakrishnan et al. (2007) in African marigold and Naveenkumar et al. (2009) in chrysanthemum due to the addition of humic acid with micro nutrients. Balakrishnan et al., (2007) observed enhancement in all the growth and yield paramaters of marigold with the foliar application of ZnSO4 @ 0.5% + FeSO4 @ 0.5%.

Conclusion:

From the results it could be concluded that the foliar application of ZnSO4 @ 0.3% + FeSO4 @ 0.5% + MgSO4 @ 0.3 % + Borax 0.3 % + Potassium humate @ 1% on monthly intervals form 30 days after planting could be adopted to enhance the flower yield and profit in commercial cultivation of Tabernaemontana divaricata (L.) for loose flower production.

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Table 1. Effect of foliar application of micronutrients and Potassium humate on growth parameters of Tabernaemontana divaricata (L.)

Treatment No.	Plant height	Internodal length cm	Primarybranches/ plant	Secondary branches/ plant	Leaves/ plant[1]	Plant spread	Leaf area cm^2	Chlorophyll content ($mg\ g^{-1}$)	DMP (g /plant)
T1	153.11	13.36	8.54	20.97	103.12	75.91	29.95	1.71	104.84
T2	155.24	13.49	8.67	21.29	104.90	77.22	30.09	1.74	106.64
T3	157.17	13.60	8.79	21.57	106.51	78.40	30.22	1.76	108.28
T4	159.19	13.72	8.91	21.87	108.20	79.65	30.35	1.79	110.00
T5	161.30	13.85	9.03	22.18	109.95	80.94	30.49	1.82	111.78
T6	163.37	13.97	9.16	22.49	111.68	82.21	30.63	1.84	113.54
T7	165.33	14.08	9.28	22.78	113.32	83.42	30.76	1.87	115.21
T8	147.62	13.04	8.21	20.16	98.54	72.54	29.58	1.64	100.18
CD (p=0.05)	**0.93**	**0.05**	**0.06**	**0.14**	**0.77**	**0.57**	**0.06**	**0.01**	**0.79**
S. ED.	**1.87**	**0.11**	**0.11**	**0.28**	**1.56**	**1.15**	**0.12**	**0.02**	**1.59**

Table 2. Effect of foliar application of micronutrients and Potassium humate on flowering and yield parameters of Tabernaemontana divaricata (L.)

Treatment No.	Days taken for first flowering	Weight of 100 flowers (g)	Single flower weight (g)	No. of flowers/ Plant/ day	Flower yield per plant (g/day)	Flower yield per plot (g/day)	Estimated Flower yield (kg/ha/day)	Estimated Flower yield (t/ha/year)
T1	41.55	23.19	0.241	54.41	13.17	79.03	43.90	9.88

T2	41.30	23.59	0.245	55.64	13.71	82.25	45.69	10.28
T3	41.07	23.95	0.249	56.75	14.20	85.17	47.31	10.65
T4	40.83	24.33	0.253	57.92	14.71	88.25	49.02	11.03
T5	40.58	24.73	0.257	59.14	15.24	91.44	50.80	11.43
T6	40.33	25.11	0.261	60.34	15.76	94.58	52.54	11.82
T7	40.10	25.48	0.265	61.48	16.26	97.56	54.20	12.19
T8	42.20	22.16	0.230	51.23	11.78	70.70	39.27	8.84
CD (p=0.05)	**0.11**	**0.17**	**0.002**	**0.54**	**0.23**	**1.40**	**0.78**	**0.21**
S. ED.	**0.22**	**0.35**	**0.004**	**1.08**	**0.47**	**2.84**	**1.58**	**0.43**