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Impact of Micronutrients and Nanoparticles on the Flowering Life of *Anthurium andraeanum* cv. Tropical Red

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ABSTRACT: Anthurium is a slow growing perennial that requires shady, humid conditions as found in tropical forests. The media for growing Anthurium, whether in pot or bed, should be light, well drained and rich in organic matter. The spathe is usually heart-shaped. The flowers are on the spadix above the spathe. The study was plotted according to a Completely Randomized Design (CRD) with Duncan's Multiple Range Test (DMRT). The experiment was conducted during the year 2018-2019 and 2021-2022 throughout the year under agroshadenet structure of RKVY Project on Anthurium, Dept. of Floriculture and Landscaping, (OUAT), Odisha. The flowering attributes in *Anthurium andraeanum* cv. Tropical Red also recorded maximum Stalk length (27.33 cm), Stalk circumference (4.92 cm), spathe length (10.52 cm), spathe width (7.4 cm) with application of Zinc oxide nanoparticles@75ppm i.e. treatment (T_7). The maximum duration of bloom life i.e. discoloration of spathe on plant of flower (32.22 days) and highest number of flower yield per plant (25.37 nos.) was recorded with dose of ZnO NPs@ 75 ppm in T_7 and minimum duration of bloom life of flower (29.43 days) and lowest number of flower yield per plant (19.10 nos.) were recorded under control (T_1) during both the years of investigation. It is again observed in respect to spadix characteristics that the Zinc oxide nanoparticles @ 75 ppm used has shown to have maximum spadix length (5.58 cm), spadix diameter (2.82 cm.), days of opening of true flower on spadix (5.23 days), days taken for maturity of true flower (7.32 days), days taken for wilting of true flower (5.20 days) and minimum were recorded in T_1 (Control) during both the years of investigation.

Keywords: Spadix diameter, Bloom life of spathe, Spathe length and Stalk length.

INTRODUCTION

Anthurium is the latest sensation of Indian floriculture scene and the genus *Anthurium* with 700 species is largest genus of the family *Araceae*. Anthurium is a slow growing perennial that requires shady, humid conditions as found in tropical forests. It is used for fresh and dry flower arrangement, exhibition, decoration, bouquet preparation (Beura and Sashani 2015). The media for growing Anthurium, whether in pot or bed, should be light, well drained and rich in organic matter. The spathe is usually heart-shaped. The flowers are on the spadix above the spathe. The five major spathe colours are red, orange, pink, coral and white. Usually bi-colours like red-green, orange-green, pink-green and white-green are known as obake and they are extremely variable in size and shape. INM reduce fertilizer use and increases productivity and quality of flower (Majumdar *et al*., 2014).

The agroclimatic conditions of Odisha along with abundant water availability offer a natural advantage for the commercialization of several unexploited floras in various parts of the state. The climate of Odisha is represented by tropical monsoon weather. Searing hot summers with considerably high monsoon downpours and cool pleasant winters mark the Odisha climate. Rainfall is the main source of water that varies from 1200 millimeters to 1700 millimeters across the state. The warm humid tropical climate of Odisha can easily be adopted for the wide spread cultivation of Anthurium.

Nowadays, micronutrients are gaining momentum among the flower growers because of their nutritional support and also ensure better harvest and returns. The quality of Anthurium flowers is influenced by application of micronutrients and micronutrient based nano particles although required in smaller quantities, they are essential for crop growth and development.

Simultaneously, Nanotechnology is an emerging field in science, whose potentiality seen in almost every field, starting from drug delivery to waste water clean-up, soil remediation and controlled fertilizer application. These nanotechnology uses various engineered nanoparticles (NPs) & encompasses various field of science under one umbrella; including biology, physics, chemistry & engineering. The use of variety of NPs is increasing day by day in agricultural field, where nano particles have found uses as fertilizer & stress-counteractive agents.

MATERIAL AND METHODS

The present investigation on "The impacts of micronutrients and nanoparticles on the vegetative growth of *Anthurium andraeanum* cv. Tropical Red", was carried out in 2018-19 and 2021-2022 throughout the year. The study was plotted according to a Completely Randomized Design (CRD) with Duncan's Multiple Range Test (DMRT). The experiment was conducted during the year 2018-2019 and 2021-2022 under agroshadenet structure of RKVY Project on Anthurium, Dept. of Floriculture and Landscaping, Biotechnology-cum-Tissue Culture Centre, Orissa University of Agriculture and Technology (OUAT), Odisha. The 7 elements known as micronutrients—chlorine, zinc, copper, molybdenum, iron, manganese, boron—are crucial for crop development in extremely small amounts. The micronutrients that fertilization used in my experiment include manganese, copper, zinc, and molybdenum. Enhancing plants' ability to withstand drought stress (DS) requires the use of nanoparticles (NPs). NPs trigger the production of stress-related proteins, boost photosynthesis, promote water absorption, nutrition, preserve membrane integrity, increase harvest index and grain yield. After 10 days of planting, the plants were sprayed with the required solutions of $MnSO_4$, $CuSO_4$, ZnO NPs, MgO NPs was applied at different concentration as per treatments for 3 times at 4 months interval in a year as foliar application. Spraying was done during early morning and late afternoon hours on non-windy days to ensure maximum absorption by the plants.

The evaluation was made by counting the days for each treatment between the date of planting and the emergence of the Ist flower bud (spathe initiation). After treatment, within 50 to 70 days; spathe initiation was noted in terms of days and average was calculated. After spathe initiation, little bit of beautiful spathes appears in a variety of colours. That spathe initiation on tagged plants was recorded and expressed in days. After spathe appearance, in different cultivars the spathe unfolds, gradually revealing many, bisexual blooms of various sizes distributed throughout the length of the spadix. Here the calculation was recorded in days. It's the Peduncle length. It was measured as the distance between the base of the flower stalk to the base of the spathe. The average stalk length was worked out and expressed in centimetres. At 1.5 m above ground; flower stalk circumference was measured by thread & then put on a scale which was calculated in centimetres. The spathe length was measured from the base to the tip of the spathe from tagged plants and average was calculated and given in centimeters. The spathe width was measured at its middle of the spathe using a scale, and the average was given in cm. Bloom life indicates the day from marketable appearance of spathe to discoloration of spathe on plant. It was observed on five randomly selected flowers from each treatment were tagged and counted in days. Number of flowers from the tagged plants was counted according to the cultivars every month for two years i.e., 2018-19 & 2021-22. The average number of flowers per plant was then worked out per year. The spadix length was measured from the point of attachment to the peduncle and spathe to the tip of spadix with the help of scale and expressed in centimeters followed by working out the average spadix length. From marketable appearance of flower, the real flower in the spadix was seen to open called true flower. The observation was recorded in terms of days and average was calculated. After opening of genuine flower on spadix, to get matured which was noted in days.

Flower parameters

1. Days to flower / spathe initiation from the day of treatment (days). The evaluation was made by counting the days for each treatment between the date of planting and the emergence of the Ist flower bud (spathe initiation). After treatment, within 50 to 70 days; spathe initiation was noted in terms of days and average was calculated.

2. Days to 1st spathe appearance (days). After spathe initiation, little bit of beautiful spathes appears in a variety of colours. That spathe initiation on tagged plants was recorded and expressed in days.

3. Days to unfurling of spathe from spathe appearance (days). After spathe appearance, in different cultivars the spathe unfolds, gradually revealing many, bisexual blooms of various sizes distributed throughout the length of the spadix. Here the calculation was recorded in days.

4. Days to Formation of marketable spathe from the day of unfurling (days). From the date of unfurling of spathe to the days it took for the 1st bloom completely open in marketable size. Here the calculation was recorded in days.

5. Stalk length (cm). It's the Peduncle length. It was measured as the distance between the base of the flower stalk to the base of the spathe. The average stalk length was worked out and expressed in centimeters.

6. Stalk circumference (cm). At 1.5 m above ground; flower stalk circumference was measured by thread & then put on a scale which was calculated in centimeters.

7. Spathe length (cm). The spathe length was measured from the base to the tip of the spathe from tagged plants and average was calculated and given in centimetres.

8. Spathe width (cm). The spathe width was measured at its middle of the spathe using a scale, and the average was given in cm.

9. Bloom life of spathe (days). Bloom life indicates the day from marketable appearance of spathe to discoloration of spathe on plant. It was observed on five randomly selected flowers from each treatment were tagged and counted in days.

10. Flower yield per plant (Nos.). Number of flowers from the tagged plants was counted according to the

cultivars every month for two years i.e., 2018-19 & 2021-22. The average number of flowers per plant was then worked out per year.

11. Spadix length (cm). The spadix length was measured from the point of attachment to the peduncle and spathe to the tip of spadix with the help of scale and expressed in centimetres followed by working out the average spadix length.

12. Spadix diameter (cm). The greatest spadix diameter was measured by thread & then put on a scale which was calculated in centimetres.

13. Days opening of true flower on spadix (days). From marketable appearance of flower, the real flower in the spadix was seen to open called true flower. The observation was recorded in terms of days and average was calculated.

14. Days taken for the maturity of true flower (days). After opening of genuine flower on spadix, to get matured which was noted in days.

15. Days taken for wilting of true flower (days). By keeping track of the number of days it took for the tagged plants to wilt after being harvested, the field life of flowers was evaluated in their natural environment.

RESULTS AND DISCUSSION

Scrutinization taken on *Anthurium andraeanum* cv. Tropical Red regarding floral characteristics both on Spathe parameters and Spadix parameters. Particularly in case of spathe parameters like days of 1st flower initiation from day of treatment, days to 1st spathe appearance, days of unfurling of spathe and days of marketable appearance of spathe from days of unfurling as influenced by the foliar application of different micronutrients and nanoparticles, either alone or in combinations were recorded and the data was statistically analyzed and presented in Table 1 & Fig. 1 whereas stalk length, stalk circumference, spathe length and spathe width data was statistically analyzed and presented in Table 2 & Fig. 2 and again bloom life of flower and flower yield per plant was mentioned in Table 3 & Fig. 3. In consider to Spadix parameters like Spadix length and Spadix circumferences influenced by the foliar application of different micronutrients and nanoparticles, either alone or in combinations were recorded and the data was statistically analyzed and presented in same Table 3 & Fig. 3. Similarly Days of opening of true flower on spadix, Days taken for maturity of true flower and Days taken for wilting of true flower data was statistically analyzed and presented in Table 4 & Fig. 4 of *Anthurium andraeanum* cv Tropical Red.

The data obtained from Table 1 & Fig. 1 proclaimed that foliar application of Zinc oxide Nanoparticles (ZnONPs) @100 ppm (T_8) exhibited least days taken to first flower initiation from day of treatment (50.87 days and 50.03 days for 1st year and 2nd year, respectively).

The pooled data of both the years also showed minimum days taken to first flower initiation from day of treatment (50.45 days) by the plants applied with ZnONPs @100 ppm (T_8) which was at par with the treatments T_7 (ZnONPs @75 ppm) with the values 50.87 days. However, maximum days taken to first flower initiation from day of treatment (70.03 days, 70.47 days and 70.25 days for 1st year, 2nd year and pooled, respectively) was found to be recorded in the treatment T_1 (control) Ahlawat *et al*. (2003).

Foliar application of ZnONPs @ 100ppm (T_8) exhibited quickest days to 1st spathe appearance from the days of flower initiation in 1st year (5.33 days) and 2nd year (5.20 days). Earliest first spathe appearance from the days of flower initiation (5.27 days) in the pooled data was found also in the treatment T_8 (ZnONPs @ 100ppm). On the other hand, maximum days to first spathe appearance was recorded 6.57 days, 6.80 days and 6.88 days under T_1 (control) for 1st yr., 2nd yr. and pooled yr. respectively.

For the character days of unfurling of spathe, the treatment T_8 (ZnONPs @ 100ppm) exhibited lowest days in 1st year (3.03 days) and 2nd year (2.90 days). The pooled data of two years also exhibited minimum days of unfurling of spathe (2.97 days) with the foliar spray of ZnONPs @ 100ppm (T_8) which was followed by treatments T_7 (ZnONPs @ 75 ppm) with data recorded 3.11 days. Whereas largest days of unfurling of spathe (6.23 days, 7.47 days and 6.85 days) for 1st yr., 2nd yr. and pooled yr. was recorded in the plants of control (T_1).

Foliar application of ZnONPs @ 100 ppm(T_8) recorded minimal days of marketable appearance of spathe from days of unfurling (5.20 days and 5.07 days for 1st year and 2nd year respectively) in the cv. Tropical Red. The pooled data revealed that lowest days of marketable appearance of spathe from days of unfurling (5.13 days) was exhibited by the plants applied with ZnONPs @ 100 ppm(T_8). Maximal days of marketable appearance of spathe from days of unfurling (7.30 days, 7.57 days and 7.43 days) for 1st yr., 2nd yr. and pooled mean was found in the plants of control (T_1).

The results pertaining in Table 2 & Fig. 2 to the stalk length, stalk circumference, spathe length and spathe width conceded that the foliar application of Zinc oxide Nanoparticles (ZnONPs) @75 ppm(T_7) significantly emphasized highest Stalk length (26.93 cm & 27.73 cm), Stalk circumference (4.61 cm & 5.23 cm), Spathe length (10.34 cm & 10.70 cm) and Spathe width (7.53 cm. & 6.23 cm) for 1st year and 2nd year in comparison to all other treatments.

Table 1: Effect of micronutrients and nano particles on Floral parameters of *Anthurium andraeanum* cv. Tropical Red (1).

Characters		1. Days to flower/spathe initiation from the day of treatment (Days)			2. Days to 1st spathe appearance (Days)			3. Days to unfurling of spathe from spathe appearance (Days)			4. Days to formation of marketable spathe from the day of unfurling (Days)		
Treatments		st 1 yr (2018-19)	nd 2 yr. (2021-22)	Pooled analysis	st 1 yr (2018-19)	nd 2 yr. (2021-22)	Pooled analysis	st 1 yr (2018-19)	nd 2 yr. (2021-22)	Pooled analysis	st 1 yr (2018-19)	nd 2 yr. (2021-22)	Pooled analysis
Control	T_1	70.03	70.47	**70.25** ^{a}	6.57	6.80	**6.68** ^{a}	6.23	7.47	**6.85** ^{a}	7.30	7.57	**7.43** ^{a}
$MnSO_4$@0.2%	T_2	69.30	69.13	**69.2** ^{a}	6.23	6.63	**6.43** ^{ab}	5.83	6.27	**6.05** ^{b}	7.07	7.30	**7.18** ^{ab}
$MnSO_4$ @ 0.4%	T_3	64.50	63.90	**64.20** ^{b}	6.30	6.40	**6.35** ^{ab}	6.23	6.23	**6.23** ^{b}	6.97	7.07	**7.02** ^{bc}
$CuSO_4$ @ 0.5%	T_4	59.53	58.03	**58.78** ^{c}	6.10	6.20	**6.15** ^{bc}	5.23	5.43	**5.33** ^{c}	6.60	6.93	**6.77** ^{c}
$CuSO_4$ @ 0.75%	T_5	56.43	55.50	**55.97** ^{cd}	5.80	5.80	**5.8** ^{cd}	4.63	4.53	**4.58** ^{d}	6.10	6.30	**6.2** ^{d}
ZnONPs@50 ppm	T_6	51.87	51.13	**51.50** ^{de}	5.67	5.47	**5.57** ^{de}	3.47	3.60	**3.53** ^{f}	5.87	5.80	**5.83** ^{ef}
ZnONPs@75 ppm	T_7	51.10	50.63	**50.87** ^{e}	5.47	5.00	**5.23** ^{e}	3.17	3.07	**3.11** ^{fg}	5.57	5.37	**5.47** ^{g}
ZnONPs@100ppm	T_8	50.87	50.03	**50.45** ^{e}	5.33	5.20	**5.27** ^{e}	3.03	2.90	**2.97** ^{g}	5.20	5.07	**5.13** ^{h}
MgONPs@50 ppm	T_9	53.33	53.40	**53.37** ^{cde}	5.77	5.47	**5.62** ^{de}	3.53	3.53	**3.53** ^{f}	5.70	5.53	**5.62** ^{fg}
MgONPs@75 ppm	T_{10}	54.27	54.40	**54.33** ^{cde}	5.67	5.67	**5.67** ^{de}	3.73	3.80	**3.77** ^{e}	5.90	5.87	**5.88** ^{ef}
MgONPs@100ppm	T_{11}	55.17	55.57	**55.37** ^{cd}	5.57	5.77	**6.00** ^{cd}	4.33	4.40	**4.37** ^{de}	6.07	5.93	**6.00** ^{de}

Table 2: Effect of micronutrients and nano particles on Floral parameters of *Anthurium andraeanum* cv. Tropical Red (2).

Characters		5. Stalk length (cm.)			6. Stalk circumference (cm.)			7. Spathe length (cm.)			8. Spathe width (cm.)		
Treatments		st 1 yr (2018-19)		nd 2 yr. (2021-22) Pooled analysis	st 1 yr (2018-19)	nd 2 yr. (2021-22)	Pooled analysis	st 1 yr (2018-19)	nd 2 yr. (2021-22)	Pooled analysis	st 1 yr (2018-19)	nd 2 yr. (2021-22)	Pooled analysis
Control	T_1	14.87	16.13	**15.5** ^{f}	2.73	2.93	**2.83** ^{e}	7.38	7.07	**7.23** ^{e}	4.13	4.35	**4.24** ^{f}
$MnSO_4$@0.2%	T_2	16.43	17.10	**16.77** ^{f}	3.77	3.73	**3.75** ^{d}	7.47	7.17	**7.32** ^{e}	4.50	4.70	**4.6** ^{f}
$MnSO_4$ @ 0.4%	T_3	16.70	17.73	**17.22** ^{ef}	4.07	4.03	**4.05** ^{cd}	7.97	7.90	**7.93** ^{d}	4.87	5.03	**4.95** ^{ef}
$CuSO_4$ @ 0.5%	T_4	17.70	18.27	**17.98** ^{ef}	4.30	4.13	**4.22** ^{bcd}	8.30	8.23	**8.27** ^{d}	4.93	5.23	**5.08** ^{e}
$CuSO_4$ @ 0.75%	T_5	18.23	20.07	**19.15** ^{e}	4.63	4.20	**4.42** ^{abc}	8.77	9.03	**8.9** ^{c}	5.07	5.33	**5.2** ^{de}
ZnONPs@50 ppm	T_6	19.20	23.43	**21.32** ^{d}	4.57	5.07	**4.81** ^{ab}	9.23	9.50	**9.37** ^{b}	7.33	5.43	**6.38** ^{bc}
ZnONPs@75 ppm	T_7	26.93	27.73	**27.33** ^{a}	4.61	5.23	**4.92** ^{a}	10.34	10.70	**10.52** ^{a}	7.53	6.23	**7.40** ^{a}
ZnONPs@100ppm	T_8	25.10	27.30	**26.20** ^{b}	4.43	5.20	**4.82** ^{ab}	10.60	10.47	**10.51** ^{a}	7.47	5.93	**7.03** ^{ab}
MgONPs@50 ppm	T_9	24.20	25.57	**24.88** ^{c}	4.27	4.47	**4.37** ^{abc}	10.07	10.33	**10.20** ^{a}	6.93	5.80	**6.48** ^{b}
MgONPs@75 ppm	T_{10}	23.63	24.27	**23.95** ^{cd}	4.43	4.60	**4.52** ^{abc}	9.93	10.20	**10.07** ^{a}	6.73	5.77	**6.25** ^{c}
MgONPs@100ppm	T_{11}	22.63	23.83	**23.23** ^{cd}	3.87	4.30	**4.08** ^{cd}	9.33	9.87	**9.6** ^{b}	6.23	5.53	**5.88** ^{d}

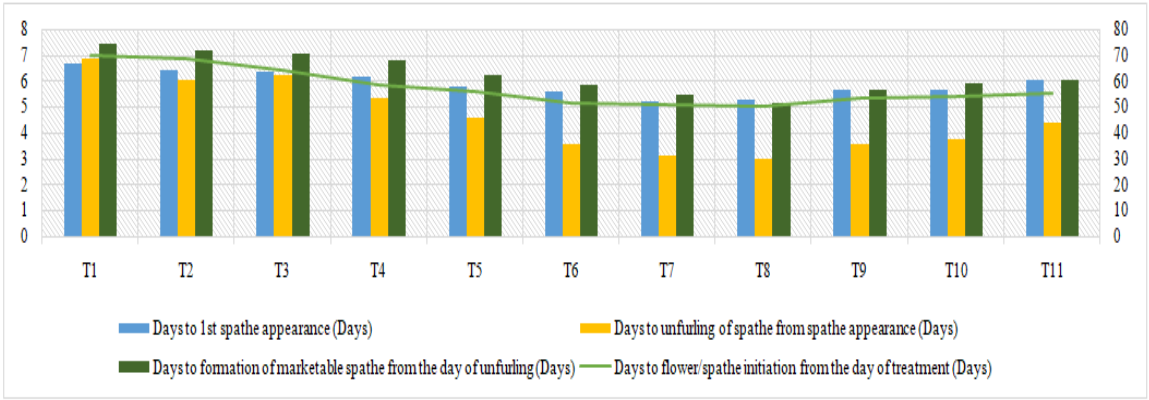

Fig. 1. Effect of micronutrients and nanoparticles on floral characteristics like days to spathe initiation from day of treatment, days to 1st spathe appearance, days to unfurling of spathe appearance, days to formation of marketable spathe from the day of unfurling of Anthurium cultivar Tropical Red.

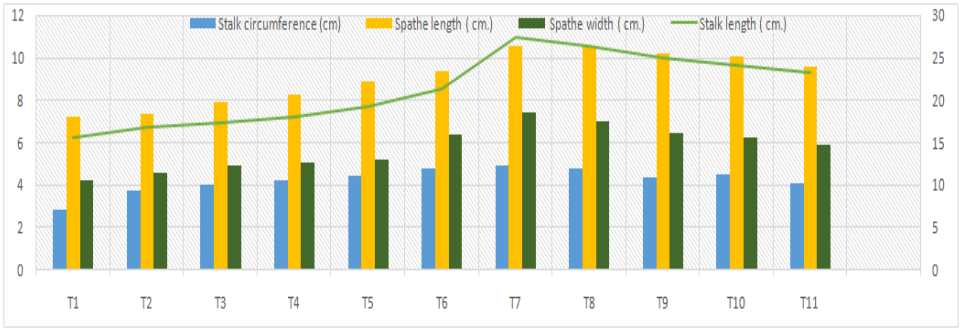

Fig. 2. Effect of micronutrients and nanoparticles on floral characteristics like Stalk length, Stalk circumference, Spathe length and Spathe width of Anthurium cultivar Tropical Red.

The pooled data for two years with respect to stalk length (27.33 cm) was found to be expeditious in the treatment T_7 (ZnONPs @75ppm). Similarly, the pooled data of two years also exhibited maximum stalk circumference (4.92 cm) with the foliar spray of ZnONPs @75ppm (T_7). Minimum Stalk length (14.87 cm, 16.13 cm and 15.5 cm) and stalk circumference (2.73 cm, 2.93 cm and 2.83 cm) for 1st yr., 2nd yr. and pooled mean was found in the plants of control (T_1) respectively. One more time the pooled data revealed that largest spathe length (10.52 cm) and spathe width (7.40 cm) was exhibited by the plants applied with ZnONPs @ 75 ppm(T_7); whereas lowest spathe length (7.38 cm,7.07 cm & 7.23 cm) & spathe width (4.13 cm, 4.35 cm & 4.24 cm) for 1st year, 2nd year and pooled year was recorded in the plants of treatment T_1 (control).

The perusal of data mentioned on Table 3 & Fig. 3 on bloom life (appearance of marketable spathe to discoloration of spathe on plant) in 1st year revealed that the plants sprayed with ZnONPs @75ppm (T_7) unveiled longest bloom life (31.60 days). In the 2nd year also, lengthiest bloom life (32.83 days) was recorded in the treatment T_7 (ZnONPs @75ppm). The pooled data of two years revealed that the prolong bloom life (32.22 days) was recorded in the treatment T_7 (ZnONPs @75ppm) which was followed by the treatments T_8 (ZnONPs @100ppm) and T_6 (ZnONPs @50ppm) with the values 31.22 days and 31.00 days respectively. However, shorten bloom life of 28.83 days (1st year), 30.03 days (2nd year) and 29.43 days (pooled) was observed in the treatment T_1 (control).

Moreover, the number of flowers yield per plant in the 1st year was significantly elevated (24.17 nos.) with the foliar application of ZnONPs @75ppm (T_7). In the 2nd year too, the excessive number of flowers yield per plant (26.57 nos.) was revealed by the plants of treatment T_7 (ZnONPs @75ppm). The pooled data of both the years for number of flowers recorded highest results (25.37 nos.) with the application of ZnONPs @75ppm (T_7) followed by ZnONPs @100ppm (T_8) with the value 23.65 nos. Least number of flowers per plant for 1st year (18.5 nos), 2nd year (19.7 nos) and pooled (19.10 nos.) was recorded in the plants of treatment T_1 (control).

Table 3: Effect of micronutrients and nano particles on Floral parameters of *Anthurium andraeanum* cv. Tropical Red (3).

Characters		9.Bloom life (Days)			10. Flower yield per plant (Nos.)			11.Spadix length (cm.)			12. Spadix circumference (cm.)		
Treatments		1st yr (2018-19)	2nd yr. (2021-22)	Pooled analysis	1st yr (2018-19)	2nd yr. (2021-22)	Pooled analysis	1st yr 2018-19	2nd yr. (2021-22)	Pooled analysis	1st yr (2018-19)	2nd yr. (2021-22)	Pooled analysis
Control	T_1	28.83	30.03	**29.43** ^{e}	18.50	19.70	**19.10** ^{e}	3.33	3.80	**3.5** ^{f}	1.23	1.37	**1.30** ^{e}
$MnSO_4$@0.2%	T_2	29.03	30.13	**29.58** ^{de}	20.30	20.40	**20.35** ^{de}	3.73	4.10	**3.92**^{ef}	1.30	1.47	**1.38** ^{e}
$MnSO_4$ @ 0.4%	T_3	29.23	30.37	**29.80** ^{de}	20.37	20.73	**20.55** ^{de}	3.80	4.20	**4.00** ^{def}	1.40	1.57	**1.48** ^{e}
$CuSO_4$ @ 0.5%	T_4	29.97	30.50	**30.23** ^{d}	20.67	21.07	**20.87** ^{cd}	4.10	4.33	**4.22** ^{de}	1.43	1.60	**1.52** ^{e}
$CuSO_4$ @ 0.75%	T_5	30.43	31.03	**30.73** ^{b}	21.23	21.23	**21.23** ^{d}	4.43	4.37	**4.40** ^{d}	1.90	2.03	**1.97** ^{d}
ZnONPs@50 ppm	T_6	30.63	31.37	**31.00** ^{b}	21.40	21.40	**21.40** ^{c}	5.17	4.83	**5.00** ^{bc}	2.20	2.63	**2.42** ^{bc}
ZnONPs@75 ppm	T_7	31.60	32.83	**32.22** ^{a}	24.17	26.57	**25.37** ^{a}	5.50	5.67	**5.58** ^{a}	2.60	3.03	**2.82** ^{a}
ZnONPs@100ppm	T_8	30.70	31.73	**31.22** ^{b}	23.00	24.30	**23.65** ^{b}	5.30	5.43	**5.37** ^{ab}	2.43	2.87	**2.65** ^{ab}
MgONPs@50 ppm	T_9	30.10	30.70	**30.40** ^{cd}	20.53	23.23	**21.88** ^{c}	4.77	5.37	**5.06** ^{bc}	2.37	2.47	**2.42**^{bc}
MgONPs@75 ppm	T_{10}	30.40	30.77	**30.58** ^{c}	20.43	22.87	**21.65** ^{c}	5.07	5.33	**5.20** ^{abc}	2.30	2.40	**2.35** ^{c}
MgONPs@100ppm	T_{11}	29.83	30.97	**30.40** ^{cd}	19.93	21.80	**20.87** ^{d}	4.67	5.13	**4.9** ^{c}	2.10	2.10	**2.10** ^{d}

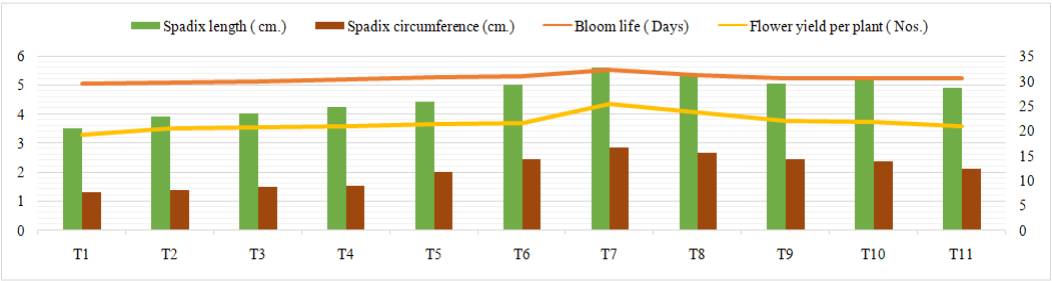

Fig. 3. Effect of micronutrients and nanoparticles on floral characteristics like Bloom life, Flower yield per plant, Spadix length and Spadix circumference of Anthurium cultivar Tropical Red.

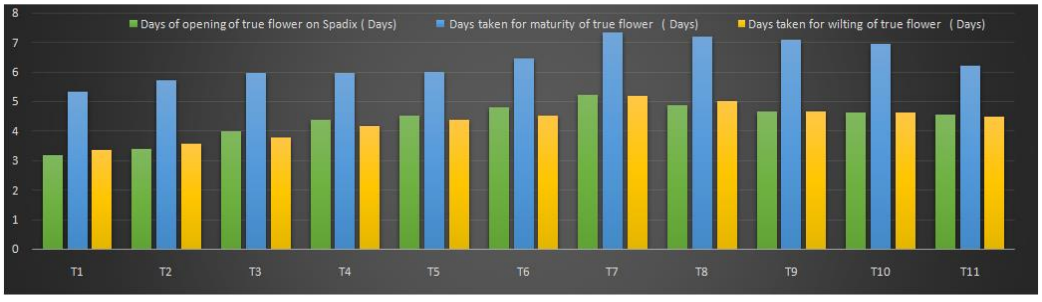

Fig. 4. Effect of micronutrients and nanoparticles on floral characteristics Days of opening of true flower on spadix, Days taken for maturity of true flower, Days taken for wilting of true flower of Anthurium cultivar Tropical Red.

Spadix length and Spadix circumference were also markedly influenced by both micronutrient and Nanoparticles noted in Table 3 & Fig. 3. Foliar spray of optimal concentration assisted the anthurium plants to produce extensive spadix measurements. The treatment effect was more pronounced when the plants were sprayed with ZnONPs @75ppm (T_7). The stalk length and Stalk circumference were measured in this treatment was more extended with the value of 5.5 cm and 2.6 cm (1st year), 5.67 cm and 3.03 cm (2nd year) and 5.58 cm and 2.82 cm (pooled year) respectively. Whereas shortest Spadix length and Spadix circumference were noticed with value of 3.33 cm and 1.23 cm (1st year), 3.80 cm and 1.37 cm (2nd year) & 3.5 cm and 1.30 cm (Pooled year) in the plants of treatment T_1 (control).

Now taking into consideration the Spadix characters; the experiment divulged in Table 4 & Fig. 4 like days of opening of true flower on spadix, days taken for maturity of true flower and days taken for wilting of true flower in the 1st year, furthermost days taken (5.07 days), (7.20 days) and (4.83 days) subsequently was exhibited by the plants of treatment T_7 (ZnONPs @75ppm). In the 2nd year, the perusal of data revealed that foliar application of ZnONPs @75ppm (T_7) produced prolonged days (5.40 days), (7.43 days) and (5.57 days) for days of opening of true flower on spadix, days taken for maturity of true flower and days taken for wilting of true flower respectively. The pooled data of both the years also indicated significant maximum days (5.23 days), (7.32 days) and (5.20 days) which was achieved by the application of ZnONPs @75ppm (T_7) for days of opening of true flower on spadix, days taken for maturity of true flower and days taken for wilting of true flower correspondingly. However, the lowest days of opening of true flower on spadix, days taken for maturity of true flower and days taken for wilting of true flower was found with the value of 3.07 days, 5.20 days and 3.17 days (1st year), 3.30 days, 5.43 days and 3.57 days (2nd year), and 3.18 days, 5.32 days and 3.37 days (pooled) consequently in the treatment T_1 (control).

Considering the above mentioned flowering characters of *Anthurium andraeanum* cv. Tropical Red, it has been concluded that foliar application of ZnONPs @ 100ppm (T_8) significantly expedited the days of 1st flower initiation from day of treatment (50.45 days), days to 1st spathe appearance (5.27 days), days of unfurling of spathe (2.97 days) and Days of marketable appearance of spathe from days of unfurling (5.13 days) whereas the plants sprayed with ZnONPs @75ppm (T_7) exhibited best results w.r.t. stalk length (27.33 cm), stalk circumference (4.92 cm), spathe length (10.52 cm) and spathe width (7.4 cm), (Kaushal and Beura 2019) bloom life of flower (32.22 days) and flower yield per plant (25.37 nos.), spadix length (5.58 cm) and spadix circumference (2.82cm), days of opening of true flower on spadix (5.23 days), days taken for maturity of true flower (7.32 days) and days taken for wilting of true flower (5.20 days) (Saheen *et al*., 2015).

Table 4: Effect of micronutrients and nano particles on Floral parameters of *Anthurium andraeanum* cv. Tropical Red (4).

Characters		13.Days of opening of true flower on Spadix (Days)			14. Days taken for maturity of true flower (Days)			15.Days taken for wilting of true flower (Days)		
Treatments		1st yr (2018-19)	2nd yr. (2021-22)	Pooled analysis	1st yr (2018-19)	2nd yr. (2021-22)	Pooled analysis	1st yr (2018-19)	2nd yr. (2021-22)	Pooled analysis
Control	T_1	3.07	3.30	**3.18** ^{i}	5.20	5.43	**5.32** ^{h}	3.17	3.57	**3.37** ^{e}
$MnSO_4$@0.2%	T_2	3.27	3.50	**3.38** ^{h}	5.60	5.83	**5.72** ^{g}	3.33	3.80	**3.57** ^{de}
$MnSO_4$ @ 0.4%	T_3	3.87	4.10	**3.98** ^{g}	5.83	6.07	**5.95** ^{f}	3.50	4.07	**3.78** ^{cde}
$CuSO_4$ @ 0.5%	T_4	4.27	4.50	**4.38** ^{f}	5.97	5.97	**5.97** ^{f}	3.63	4.67	**4.15** ^{bcde}
$CuSO_4$ @ 0.75%	T_5	4.40	4.63	**4.52** ^{e}	5.77	6.23	**6.00** ^{f}	3.83	4.90	**4.37** ^{abcd}
ZnONPs@50 ppm	T_6	4.67	4.90	**4.78** ^{c}	6.33	6.57	**6.45** ^{d}	3.97	5.10	**4.53** ^{abc}
ZnONPs@75 ppm	T_7	5.07	5.40	**5.23** ^{a}	7.20	7.43	**7.32** ^{a}	4.83	5.57	**5.20** ^{a}
ZnONPs@100ppm	T_8	4.73	4.97	**4.85** ^{b}	7.10	7.33	**7.21** ^{ab}	4.63	5.40	**5.02** ^{a}
MgONPs@50 ppm	T_9	4.53	4.77	**4.65** ^{d}	6.97	7.20	**7.08**^{bc}	4.03	5.30	**4.67** ^{ab}
MgONPs@75 ppm	T_{10}	4.50	4.73	**4.62** ^{d}	6.83	7.07	**6.95** ^{c}	3.77	5.47	**4.62** ^{ab}
MgONPs@100ppm	T_{11}	4.43	4.67	**4.55** ^{e}	6.10	6.33	**6.21** +	3.53	5.40	**4.47** ^{abc}

CONCLUSIONS

The flowering attributes in *Anthurium andraeanum* cv. Tropical Red also recorded maximum Stalk length (27.33 cm), Stalk circumference (4.92 cm), spathe length (10.52 cm), spathe width (7.4 cm) with application of Zinc oxide nanoparticles@75ppm i.e. treatment (T_7) whereas earliness in days to flower opening from day of treatment (35.36 days), days to 1st spathe opening (5.27 days), days to unfurling of spathe from spathe appearance (2.97 days) and days to formation of marketable spathe from the day of unfurling (5.13 days) was found to be in the treatment T_8 (Zinc oxide nanoparticle @ 100ppm). The maximum duration of bloom life i.e. discoloration of spathe on plant of flower (32.22 days) and highest number of flower yield per plant (25.37 nos.) was recorded with dose of ZnO NPs@ 75 ppm in T_7 and minimum duration of bloom life of flower (29.43 days) and lowest number of flower yield per plant (19.10 nos) were recorded under control (T_1) during both the years of investigation.

It is again observed in respect to spadix characteristics that the Zinc oxide nanoparticles @ 75 ppm used has shown to have maximum spadix length (5.58 cm), spadix diameter (2.82 cm), days of opening of true flower on spadix (5.23 days), days taken for maturity of true flower (7.32 days), days taken for wilting of true flower (5.20 days) and minimum were recorded in T_1 (Control) during both the years of investigation.

FUTURE SCOPE

The result of this piece of compendium is unique and will work as knowledge center in future for the students, researchers, professors, entrepreneurs and anthurium growers. Application of Zinc oxide nanoparticle @ 75 ppm enhancing the yield and quality of flowers in Anthurium flower which has been recommended in this investigation. However, in future further more nanoparticles can be used for high yield and quality flower production in different new varieties of Anthurium.

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Conflict of Interest. None.

REFERENCES

Ahlawat, H. K. S. S., Yadav, V. P. and Singh, B. S. (2003). Influence of nitrogen and zinc application on growth, flowering and chlorophyll content of tuberose (*Polianthes tuberosa* L.) cv. Double. *Haryana Journal of Horticultural Sciences*, *32*(3/4), 212-215.

Beura, S. and Sashani, T. (2015). Efficacy of GA3 on growth and flowering regulation of in vitro raised hybrid gerbera under shadenet. *Agri. Sci. Digest*., *35*(3), 173-177

Kaushal, D. and Beura, S. (2019). Influence of combined application of micro and macronutrients on vegetative growth of Anthurium (*Anthurium andraeanum*) cv. Tropical Red. *Journal of Pharmacognosy and Phytochemistry*, *8*(6), 1072-1074.

Majumdar, J., Perinban, S., Tiwari, A. K., Saha, T. N. and Kumar, R. (2014). Integrated nutrient management in commercial flower crops. *Progressive Research*, *9*(1), 28-32.

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