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Effect of foliar spray of bio-stimulants and micronutrients on growth and flowering of coorg mandarin (*Citrus reticulata* Blanco.) under hill zone of Karnataka

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Abstract
A field experiment was conducted at College of Horticulture, Mudigere during 2019-20. The experiment was laid out in Randomized complete block design (RCBD) with eleven treatments replicated thrice. Treatments comprised of different levels of bio-stimulants and micronutrients, sprayed at three different stages such as vegetative, flowering and fruit set. Results of the experiment revealed that, Sea Weed Extract - Biovita at 0.5 % exhibited superior performance than the other treatments with respect to morphological parameters *viz.*, plant height (1.97 m), stem girth (6.30 cm), plant spread (1.59 m in N-S and 1.51 m in E-W), canopy volume (6.23 m3), number of new shoots per plant (44.26), length of newly emerged shoots (20.50 cm) and leaf area (11.33 cm2), followed by Citrus special at 0.5 % and the lowest was recorded with control. Flowering parameters like days taken for first flower emergence (28.67 days), days taken for 50 per cent flowering (34.00 days), number of flowers per cluster (6.03), number of flower clusters per plant (56.33), flowering intensity (33.69) were maximum with biovita at 0.5 per cent and minimum was recorded with control.

Keywords: sea weed extract, auxins and cytokinins

Introduction

Citrus is one of the most important fruit crops of the globe, extensively cultivated in tropical and sub-tropical climate. Citrus is primarily valued for the fruit, which is either used alone as fresh fruit, processed into juice or added to dishes and beverages. The fruits are well known for their dietary, nutritional, medicinal and cosmetic properties and are also good source of citric acid, flavonoids, phenolics, pectin, limonoids, ascorbic acid *etc*. In India, citrus ranks 3rd in area and production, area of citrus fruit was about 10.034 million hectares with a production of 13.20 million tons and average productivity of 10.30 tons per hectare. Total mandarin production in India is 5.30 million tons with 0.43 million hectares area and 10.40 tons per hectare as productivity (Anon., 2018) [4].

In India, a wide number of species of citrus are cultivated of which mandarin covers the largest area. Mandarin orange, botanically called as *Citrus reticulata Blanco* and is also treat as a "fancy fruit" commercially used for dessert purpose. There are three distinct ecotypes of mandarin (*Citrus reticulata* Blanco) in India, the Nagpur mandarins, the Coorg mandarins and the Khasi mandarins. Coorg mandarin is a famous ecotype of mandarin grown in the agro- ecology of the region over a century in South India. Coorg mandarin trees are large, spreading in habit with compact dense foliage, sparingly spinous and prolific in fruit bearing. The fruits have a relatively tight skin compared to that of Nagpur mandarin. Fruits have 9 to11 segments with orange-golden yellow pulp vesicles. The pulp texture is fine and tender with pleasant distinct flavour with sugar and acid blend. The Coorg mandarin was conferred with the status of geographical indicator in the year of 2005-06, because of the unique characteristics. In Karnataka, the area under citrus fruits is estimated to be 18.40 thousand hectares with a production of 4.08 lakh tons. The mandarin area is about 3.93 thousand hectares and production 46.25 thousand tons (Tripathi, 2020) [13].

Materials and Methods

The experiment was carried out at research block of department of Fruit Science, College of Horticulture, Mudigere. It is situated in the Western Ghats and represents the typical hill zone (Zone-9 and Region- VI) of Karnataka and lies at 13° 25' North latitude and 75° 25' East longitude with an altitude of 982 m above MSL. For conducting this study six year old uniform trees of mandarin orange were selected. The average maximum and minimum temperature of the experimental site was 28.45 ℃ and 19.0.3 ℃, respectively. with mean relative humidity of 78.93 %.

There were 11 treatment replicated thrice tested in randomized complete block design. The effects of Biovita (0.25 and 0.5 %), Humic acid (0.25 and 0.5 %), ZnSO4 (0.25 and 0.5 %), Boron (0.1 and 0.2 %), Citrus special (0.25 and 0.5 %) and Control (water spray) was studied. The micronutrient were applied as a foliar sprays thrice at monthly interval from December 2019 to February 2020, sprays were given in evening hours between 4pm to 5pm. Observation on morphological and flowering parameters

were recorded and data were subjected to statistical analysis, respectively.

Table 1: Treatment details

Treatment	Bio-stimulants and Micronutrients
T1	Biovita @ 0.25%
T2	Biovita @ 0.50%
T3	Humic acid @ 0.25%
T4	Humic acid @ 0.50%
T5	ZnSO4 @ 0.25%
T6	ZnSO4 @ 0.50%
T7	Boron @ 0.10%
T8	Boron @ 0.20%
T9	Citrus special @ 0.25%
T10	Citrus special @ 0.50%
T11	Control (water spray)

Results and Discussion

The influence of bio-stimulants and micronutrients in the plant height clearly showed that during the initial vegetative stage there was no significant difference. However, in later stage of plant growth *ie.,* flowering and fruit set stage the plant height was significantly increased in the treatment T2- Biovita at 0.5 per cent (1.79 and 1.97 m), respectively. It was recorded the lowest value of plant height in T11- Control (1.22 and 1.30 m) depicted in the Table 1. This is might be due to biovita have helped in increasing the plant height which was to presence of cytokinin and auxin precursors, which increase the cell division, cell enlargement with better utilization of chemical fertilizers resulting in to rapid vegetative growth. These findings corroborated with (El-Miniawy *et al.,* 2014) [7] in strawberry, Pappachan *et al.* (2017) [10] in mulberry and (Ali and AL-Araji, 2020) [2] in lemon.

The result obtained in the experiment with foliar spray of bio-stimulants and micronutrients on stem girth clearly indicated that during the initial vegetative stage there was no significant difference. However, in later stage of plant growth *ie.,* flowering stage and fruit set stage, the maximum stem girth was recorded in biovita at 0.5 per cent (5.70 and 6.30 cm), respectively whereas minimum stem girth was recorded from control, respectively (4.1 and 4.2 cm) (Table 1). The significant increase in stem girth due to the effect of seaweed extracts may be attributed to the fact that it contains plant hormone-like substances such as auxins, cytokinins and gibberellins and macro and microelements beside growth-promoting substances such as organic amino acids and vitamins, which play major role in promoting cell division and elongation. These contents, thus, stimulated and increased the efficiency, plant carbonation processes and improved plant stem girth in general. The findings are in accordance with the results obtained by De-carvalho *et al*. (2019) [5] in grape, Al-Abedy and Al-Abbasi (2020) [1] in citrus, Pappachan *et al.* (2017) [10] in mulberry and Ali and AL-Araji (2020) [2] in lemon.

The results of the present finding revealed that plant spread was influenced by the foliar application of bio-stimulants and micronutrients. During initial vegetative stage spraying bio- stimulants and micronutrients sprays had no significant influence but at later stages (flowering and fruit set), the plant spread (N-S and E-W) was influenced significantly. The plant spread recorded the highest value in T2 of biovita at 0.5 per cent (1.48 and 1.59 m in N-S) (1.41 and 1.51 m in E-W) respectively, whereas minimum plant spread (N-S and E-W) was recorded from control (Table 2). Possible reason for the increment of plant spread at later stage may be due to composition of the seaweed extract such as natural growth hormones (auxins and cytokinins) that promote plant growth via increasing the number of metabolic events such as cell division and enlargement which in turn leading to increase the number of leaves. Also, the extract contains a considerable amount of macro and micro elements which play an important role in the activation of many enzymes and coenzymes which are involved in several biological processes leading to cell division and enlargement. These results are supported by the findings of El-Miniawy *et al*. (2014) [7] in Strawberry, Sabir *et al.* (2014) [12] in grape, and Ali and AL-Araji (2020) [2] in lemon.

The influence of bio-stimulants and micronutrients on the canopy volume clearly showed that during the initial vegetative stage there was no significant difference. However, at later stages of the plant growth *ie.,* flowering and fruit set stage, the canopy volume significantly increased in the treatment T2 of biovita at 0.5 per cent (4.90 and 6.23 m3), respectively (Table 3). The lowest value of canopy volume was recorded in T11 (control) (1.84 and 2.28 m3). It might be attributed to the presence of macro and micronutrients and some growth promoting substances in the seaweed extracts which in turn increased photosynthates and growth that could be responsible for the increased canopy volume. These findings are in accordance with the results obtained by Pappachan *et al.* (2017) [10] in mulberry and Al-Abedy and Al-Abbasi (2020) [1] in citrus rootstock C-35.

During present investigation the maximum number of new shoots per plant were recorded in the treatment T2- Biovita at 0.5 per cent (44.26) (Table 3), whereas minimum was recorded from the control (31.01). It might be due to the increased nutrient uptake by the sea weed extract sprayed plants and as it contains plant hormone-like substances such as auxins, cytokinins and gibberellins and macro and microelements beside growth-promoting substances such as organic amino acids and vitamins, which play major role in promoting cell division and elongation. These contents, thus, stimulated and increased number of new shoots per plant. This is in conformity with the report that plant containing of plant hormones, especially of cytokines, which have a large and effective role in increasing lateral branching (Al-Naqeeb and Merza, 2020) [3] in volkamer lemon rootstock.

The significant differences were observed among the different treatments with respect to length of newly emerged shoots. In the present study, the maximum length of newly emerged shoots was recorded in biovita at 0.5 per cent (20.50 cm) (Table 3), while the minimum length of newly emerged shoots (11.58 cm) was recorded in the control. It might be attributed to the presence of plant hormones, especially auxins, gibberellins and cytokines, which increase shoot length by stimulating cellular division and elongation, these findings were supported by Ali and AL-Araji, 2020 [2] in lemon.

Bio-stimulants showed significant differences with respect to leaf area. The maximum leaf area (11.33 cm2) was observed in treatment biovita at 0.5 per cent, whereas minimum leaf area (9.74 cm2) was recorded from control (Table 3). The increase in leaf area could be due to the

effective components of seaweed extract such as major and minor elements, growth regulator and vitamins which enhanced cell division metabolism and other biological reactions. This idea goes in parallel with those of El-Miniawy *et al*. (2014) [7] in strawberry, Al-Abedy and Al-Abbasi (2020) [1] in citrus rootstock C-35, Ali and AL-Araji (2020) [2] in lemon and Al-Naqeeb and Merza, (2020) [3] in volkamer lemon rootstock.

First flower initiation in the plant from the date of imposition of treatments was significantly enhanced by bio-stimulant treatments depicted in the Table 4. The enhancement was more pronounced in the treatment biovita at 0.5 per cent (28.67 days) which enhanced the flowering process by 11.00 days than control. The same treatment took minimum number of days required for 50 per cent flowering (34.00 days), while control took maximum number of days required for 50 per cent flowering (47.33 days). It might be due to the early production of florigen and other flower inducing substances in biovita treated plants contributing to early flowering while control recorded the maximum number of days to first flowering and 50 per cent flowering. These results are in corroboration with the findings of Reddy *et al.* (2011) [11] in mango.

The significant differences were observed among the different treatments with respect to number of flowers per cluster and number of flower clusters per plant (Table 4). In the present study, the maximum number of flowers per cluster (6.03) and number of flower clusters per plant (56.33) was recorded in biovita at 0.5 per cent. While the minimum number of flowers per cluster (4.57) and number of flower clusters per plant (35.33) was recorded in the control. The increase in flower number might be due to seaweed extract that produced significant increase in vegetative growth which in turn produced more photosynthates which were probably diverted towards the more flower production. The findings are in accordance with the results obtained by Mohamed and El- Sehraw*y* (2013) [9] in mango and El-Miniawy *et al*. (2014) [7] in strawberry.

In the present investigation, foliar application of biovita at 0.5 per cent recorded maximum flowering intensity (33.69), whereas the minimum was recorded in control (24.92) (Table 4). The increase in flowering intensity might be due to seaweed extract that produced significant increase in vegetative growth which in turn produced more photosynthates which were probably diverted towards the more flower production. The similar results were reported by Mohamed and El- Sehraw*y* (2013) [9] in mango and Lall *et al.,* (2016) [8] in guava.

Table 2: Influence of bio-stimulants and micronutrients at different stages on plant height and stem girth of Coorg mandarin

Treatments	Plant height (m)			Stem girth (cm)		
	Vegetative stage	Flowering stage	Fruit set stage	Vegetative stage	Flowering stage	Fruit set stage
T1 - Biovita @ 0.25%	1.33	1.52	1.62	4.30	4.57	5.07
T2 - Biovita @ 0.50%	1.40	1.79	1.97	4.73	5.70	6.30
T3 - Humic acid @ 0.25%	1.32	1.48	1.54	4.23	4.50	5.00
T4 - Humic acid @ 0.50%	1.33	1.53	1.62	4.33	4.53	5.03
T5 - ZnSO4 @ 0.25%	1.32	1.49	1.58	4.20	4.55	5.05
T6 - ZnSO4 @ 0.50%	1.34	1.53	1.62	4.40	4.58	5.08
T7 - Boron @ 0.10%	1.36	1.48	1.57	4.50	4.57	5.07
T8 - Boron @ 0.20%	1.36	1.53	1.62	4.47	4.57	5.07
T9 - Citrus special @ 0.25%	1.35	1.51	1.60	4.47	4.55	5.05
T10 - Citrus special @ 0.50%	1.37	1.54	1.70	4.67	5.00	5.47
T11 -Control (water spray)	1.13	1.22	1.30	4.00	4.10	4.20
S.Em ±	0.06	0.07	0.09	0.16	0.21	0.25
CD @ 5%	NS	0.22	0.26	NS	0.63	0.74

Table 3: Influence of bio-stimulants and micronutrients at different stages on plant spread N-S of Coorg mandarin

Treatments	Plant spread N-S (m)					
	Vegetative stage		Flowering stage		Fruit set stage	
	N-S	E-W	N-S	E-W	N-S	E-W
T1 - Biovita @ 0.25%	0.93	0.82	1.26	1.13	1.37	1.23
T2 - Biovita @ 0.50%	1.15	1.04	1.48	1.41	1.59	1.51
T3 - Humic acid @ 0.25%	0.92	0.81	1.17	1.07	1.28	1.17
T4 - Humic acid @ 0.50%	0.93	0.82	1.22	1.12	1.33	1.22
T5 - ZnSO4 @ 0.25%	0.92	0.81	1.16	1.06	1.27	1.16
T6 - ZnSO4 @ 0.50%	0.94	0.83	1.25	1.15	1.36	1.25
T7 - Boron @ 0.10%	0.96	0.85	1.16	1.06	1.27	1.16
T8 - Boron @ 0.20%	0.96	0.85	1.23	1.13	1.34	1.23
T9 - Citrus special @ 0.25%	0.95	0.84	1.17	1.07	1.28	1.17
T10 - Citrus special @ 0.50%	0.97	0.86	1.27	1.18	1.38	1.30
T11 -Control (water spray)	0.91	0.80	1.07	0.97	1.14	1.07
S.Em ±	0.06	0.06	0.07	0.08	0.07	0.07
CD @ 5%	NS	NS	0.20	0.23	0.21	0.21

Table 4: Influence of bio-stimulants and micronutrients on canopy volume, number of new shoots per plant, length of newly emerged shoots and leaf area of Coorg mandarin

Treatments	Canopy volume (m3)			Number of new shoots per plant	Length of newly emerged shoots (cm)	Leaf area (cm2)
	Vegetative stage	Flowering stage	Fruit set stage			
T1 - Biovita @ 0.25%	2.47	2.89	3.57	36.61	15.67	10.35
T2 - Biovita @ 0.50%	3.45	4.90	6.23	44.26	20.50	11.33
T3 - Humic acid @ 0.25%	2.44	2.57	3.06	33.27	14.30	10.30
T4 - Humic acid @ 0.50%	2.49	2.83	3.46	34.26	14.35	10.33
T5 - ZnSO4 @ 0.25%	2.41	2.58	3.18	33.86	14.30	10.35
T6 - ZnSO4 @ 0.50%	2.54	2.95	3.60	35.84	15.35	10.37
T7 - Boron @ 0.10%	2.70	2.57	3.16	33.28	14.10	10.33
T8 - Boron @ 0.20%	2.67	2.86	3.50	34.48	14.33	10.35
T9 - Citrus special @ 0.25%	2.59	2.66	3.26	33.25	14.10	10.33
T10 - Citrus special @ 0.50%	2.76	3.07	4.06	38.33	19.25	10.57
T11 -Control (water spray)	1.82	1.84	2.28	31.01	11.58	9.74
S.Em ±	0.28	0.34	0.35	2.00	1.03	0.23
CD @ 5%	NS	1.02	1.04	5.89	3.04	0.69

Table 5: Effect of foliar spray of bio-stimulants and micronutrients on days to 1st flower emergence, 50 per cent flower emergence, number of flower clusters per plant and number of flowers per cluster, flowering intensity of Coorg mandarin

Treatments	Days to 1st flower emergence	Days to 50% flowering	Number of flowers per cluster	Number of flower clusters per plant	Flowering intensity
T1 - Biovita @ 0.25%	30.67	36.67	4.82	48.17	27.44
T2 - Biovita @ 0.50%	28.67	34.00	6.03	56.33	33.69
T3 - Humic acid @ 0.25%	31.00	37.00	4.80	45.24	27.44
T4 - Humic acid @ 0.50%	29.67	35.67	4.87	45.48	27.69
T5 - ZnSO4 @ 0.25%	31.67	37.67	4.83	45.33	27.56
T6 - ZnSO4 @ 0.50%	29.33	35.33	4.89	45.85	28.33
T7 - Boron @ 0.10%	30.00	36.00	4.78	41.53	27.38
T8 - Boron @ 0.20%	29.00	35.00	4.87	43.67	28.46
T9 - Citrus special @ 0.25%	29.33	35.33	4.80	47.61	27.69
T10 - Citrus special @ 0.50%	30.00	34.67	6.00	56.27	29.21
T11 -Control (water spray)	39.67	47.33	4.57	35.33	24.92
S.Em ±	1.91	1.48	0.29	2.72	1.31
CD @ 5%	5.63	4.36	0.84	8.02	3.87

Conclusion

On the basis of the results obtained in the present investigation it is concluded that biovita at 0.5 per cent proved significant for improving the growth and flowering of Coorg mandarin with respect to plant height, stem girth and plant spread, plant canopy number of new shoots per plant, length of newly emerged shoots, leaf area, days taken for first flower emergence, days taken for 50 per cent flowering, number of flowers per cluster, number of flower clusters per plant and flowering intensity. The present study also confirmed that the use of bio-stimulant is an eco-friendly technique to enhance crop growth. Thus, it may be recommended that the Coorg mandarin plants can be sprayed with biovita at 0.5 per cent to get maximum growth and flowering.

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