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Effect of plant growth regulators and nutrients on seedling growth of kokum (*Garcinia indica* Choisy)

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Abstract
The present investigation on effect of plant growth regulators and nutrients on seedling growth of kokum (*Garcinia indica* Choisy) was carried out at College of Horticulture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli Dist. Ratnagiri during the year 2022-23. The study aims to investigate the effect of different plant growth regulators (PGRs) and nutrients on enhancing kokum seedlings. The strategic use of PGRs and nutrients is anticipated to boost seedling growth and reduce the time required to reach a graftable stage. Growth regulators and nutrient studied are humic acid (0.4% and 0.5%), 19:19:19 (1% and 2%), gibberellic acid (300 and 400 ppm), tricontanol (300 and 400 ppm) and control. The experiment was carried out in randomized block design with three replications. Results revealed that the treatment GA_3 400 ppm recorded the maximum seedling height (29.09 cm), number of leaves (21.22), girth at collar region (3.99 mm), number of node (9.80), internodal length (3.18 cm) and fresh and dry weight of shoot (19.30 g and 5.99 g respectively) and treatment 19:19:19 @ 2% recorded maximum leaf area (39.75 cm^2). Whereas, the minimum values were recorded in control for all the parameters under study.

Keywords: Kokum, gibberellic acid, tricontanol, 19:19:19, humic acid

Introduction
The Kokum tree is also known as the Kokum butter tree, the Goa butter tree, and the mangosteen oil tree. Kokum is the name given to it in Hindi, while other names for it in Marathi include Bheranda, Bhiranda, Kokamba, Kokambi, Ratamba, Ratambi, and Tambada amba. Kokam or Bhirind are the names given to it in Konkani. It is also known as Vrikshamia, Amlabija, Amlapura, and Amlashaka in Sanskrit. Kokum is a prominent fruit of the Guttiferae family. *Garcinia indica*, with 2n = 54 by Krishnaswamy and Raman (1949) [6] and 2n = 48 by Thombre (1964) [14]. Kokum has a long history in Ayurvedic medicine as it was traditionally used to treat sores, tumors, dermatitis, heart complaints, diarrhoea, dysentery, ear infection, and to facilitate digestion. Kokum Juice is also used as a natural remedy for stomach and liver disorders (Bhat *et al.*, 2005; Krishnamurthy, 1984; Krishnamurthy *et al.*, 1982; Mishra *et al.*, 2006) [1, 4, 5, 7]. Kokum is traditionally propagated by sexual means however recently it is also propagated by the vegetative method like softwood grafting. Kokum is a dioecious plant and gender of a plant is only determined after the juvenile stage. The probability of occurring male plants is 50 percent in sexual propagation. Only 10-15 percent male plants in a population are essential. Hermaphrodite plants are also observed but they are mostly poor yielders. The vegetative method of propagation helps to obtain true to type plant. The initial growth of kokum seedlings is very slow, it required 10-12 months to reach the graftable stage under normal management. Kokum seedlings exhibit slow initial growth, taking 10-12 months to reach the graftable stage under normal management. Limited research on kokum seedlings prompts the need for studies to enhance growth and productivity. The extended time required for seedlings to reach a graftable stage is a practical challenge in cultivation. The strategic use of plant growth regulators (PGRs) and nutrients is a well-established approach to enhance seedling growth and accelerate the development of plants to a graftable stage. PGRs such as Gibberellic Acid and Tricontanol are known to stimulate growth, potentially addressing the slow initial growth issue. Nutrient formulations like 19:19:19 and humic acid can enhance nutrient uptake, contributing to overall plant health and vigor. Considering the above facts, the present study has been planned with objective to study the effect of different plant growth regulators and nutrients for enhancing kokum seedlings.

Materials and Methods

The present investigation was carried out at College of Horticulture, Dr. Balasaheb Sawant Konkan Krushi Vidyapeeth, Dapoli Dist. Ratnagiri (MS) during the year 2022-23. The fresh seed material was collected during the fruiting season and utilized in the experiment. Seeds were sowing on raised bed having dimensions of 1 meter width and 20 cm height for germination. Cocopeat was spread over the topsoil to improve soil structure and moisture retention. After 30-35 days, the germination of the kokum seeds was noted. Within 10 to 15 days after germination sprouted seeds were removed from bed and transfer to polythene bag with 6"X8" size filled with potting mixture of soil and FYM in a 3:1 ratio. One month after transplanting i.e. at four leaf stage first spray of growth regulators and nutrient was taken and further three more sprays were taken at 30 days interval. Treatments were T_1 Humic acid @ 0.4%, T_2 Humic acid @ 0.5%, T_3 19:19:19 @ 1%, T_4 19:19:19 @ 2%, T_5 GA_3 @ 300 ppm, T_6 GA_3 @ 400 ppm, T_7 Tricontanol @ 300 ppm, T_8 Tricontanol @ 400 ppm, T_9 Control. Each treatment consists of 75 seedlings replicated three times in randomized block design. Growth performance was recorded by measuring seedling height, number of leaves, girth at collar region, number of node, internodal length, leaf area and fresh and dry weight of shoot. The data were subjected to statistical analysis as suggested by Panse and Sukhatme (1995) [9].

Results and Discussion

Seedling height (cm)

The maximum seedling height was recorded (Table 1) in treatment GA_3 400 ppm (29.09 cm) this was significantly superior to all other treatments. The minimum was (18.31cm) recorded in treatment control which was at par with humic acid at 0.4%. By promoting meristematic activity, growth regulators like GA_3 can stimulate rapid cell elongation and division in the growing tips of plants, leading to increased height. The results are in accordance with Surakshita *et al.* (2014) [12] in jamun, Vasantha *et al.* (2014) [15] in tamarind and Chiranjeevi *et al.* (2018) [2] in aonla.

Table 1: Effect of foliar application of plant growth regulators and nutrient on seedling height, number of leaves and girth at collar region of kokum

Treatments	150 DAT (Days after transplanting)		
	Seedling height (cm)	Number of leaves	Girth at collar region (mm)
T_1 – Humic acid @ 0.4%	20.03	13.50	2.64
T_2 – Humic acid@ 0.5%	21.60	13.27	2.58
T_3 – 19:19:19 @ 1%	22.52	14.65	3.48
T_4 - 19:19:19 @ 2%	23.26	19.18	3.27
T_5- GA_3 @ 300 ppm	24.80	14.65	3.10
T_6 – GA_3 @ 400 ppm	29.09	21.22	3.99
T_7 – Tricontanol @ 300 ppm	24.48	15.03	3.10
T_8 - Tricontanol@ 400 ppm	22.43	18.45	2.90
T_9- Control	18.31	13.07	2.16
Mean	22.95	15.89	3.02
F test	SIG	SIG	SIG
S.Em (±)	0.90	0.46	0.16
C.D@5%	2.72	1.39	0.49

Number of leaves

The maximum number of leaves (21.22) was recorded in treatment GA_3 400 ppm and this result was significantly superior to all the other treatments. The minimum number of leaves (13.07) was found in treatment control group. The treatment humic acid 0.4% and humic acid 0.5% were at par with the control. GA_3 may have influenced by acting on the apical meristem and stimulating cell division and elongation, potentially through its influence on nucleoprotein synthesis resulted increased in number of leaves. Similar results were reported by Muralidhara *et al.* (2014) [8] in mango, Vasantha *et al.* (2014) [15] in tamarind and Surve (2022) [13] in kokum.

Girth at collar region (mm)

The maximum girth of the seedlings (3.99 mm) was observed in treatment GA_3 @ 400 ppm and was significantly superior to all other treatments. The minimum girth of the seedlings (2.16 mm) was found in control and which was at par with treatment humic acid @ 0.4% and humic acid @ 0.5%. Gibberllic acid stimulated protein synthesis, cell elongation, size increase, and rapid cell division, which resulted in an increase in the girth of the seedling collar in kokum. These findings are in line with the findings of Muralidhara *et al.* (2014) [8] in mango, Vasantha *et al.* (2014) [15] in tamarind and Surve (2022) in kokum.

Number of node

Data presented in Table 2 revealed that the maximum number of nodes was (9.80) found in treatment GA_3 400 ppm. This treatment was significantly superior to all other treatments. The control had the minimum number of nodes (6.40) and humic acid @ 0.4% which was at par to the control. It suggests that GA_3 when applied foliarly, is an effective treatment for promoting node development in kokum seedlings. The study conducted by Surve (2022) [13] in kokum also supports the present findings.

Internodal length (cm)

The highest internodal length (3.18 cm) was found in treatment GA_3 400 ppm which was at par with tricontanol at 300 ppm, had an internodal length of 2.98 cm. The lowest internodal length was found in control with a value of 2.03 cm which was at par with humic acid @ 0.4% and humic acid @ 0.5%. GA_3 can be an effective treatment for enhancing internodal length in kokum seedlings. Surve (2022) [13] and Muralidhara *et al*. (2014) [8] support present findings.

Leaf area (cm^2)

The highest leaf area recorded (39.75 cm^2) was found in treatment 19:19:19 @ 2%. The lowest leaf area recorded at this stage was 26.36 cm^2, and it was observed in treatment

control. This treatment was at par with humic acid @ 0.4% and humic acid @ 0.5. Nutrients play a crucial role in plant growth and development, including the growth of healthy foliage. As suggested by Patil *et al*. (2017) [11] in mango, foliar application of nutrients can be an effective way to supply essential elements directly to the leaves, where they can be readily absorbed and utilized by the plant.

Table 2: Effect of foliar application of plant growth regulators and nutrient on number of node, internodal length and leaf area of kokum

Treatments	150 DAT (Days after transplanting)		
	Number of node	Internodal length (cm)	Leaf area (cm^2)
T_1 – Humic acid @ 0.4%	7.48	2.21	27.35
T_2 – Humic acid@ 0.5%	7.79	2.34	26.68
T_3 – 19:19:19 @ 1%	9.10	2.81	34.50
T_4 - 19:19:19 @ 2%	8.64	2.40	39.75
T_5- GA_3 @ 300 ppm	8.20	2.71	32.04
T_6 – GA_3 @ 400 ppm	9.80	3.18	36.18
T_7 – Tricontanol @ 300 ppm	8.15	2.98	29.12
T_8 - Tricontanol@ 400 ppm	8.04	2.52	30.01
T_9- Control	6.40	2.03	26.36
Mean	8.18	2.58	31.33
F test	SIG	SIG	SIG
S.Em (±)	0.35	0.12	0.75
C.D@5%	1.08	0.36	2.28

Fresh and dry weight of shoot

The treatment GA_3 @ 400 ppm resulted in the maximum fresh weight of shoots, measuring 19.30 g which indicates treatment had a significant positive impact on shoot growth. The control had the minimum fresh weight of shoots, measuring 8.85 g. These results demonstrate that the application of GA_3 at 400 ppm was highly effective in promoting shoot growth, resulting in the maximum fresh weight of shoots. The result of study support the findings of various research workers, Jaiswal *et al.* (2018) [3] in kagzi lime, Patel *et al*. (2022) [10] in kagzi lime and Muralidhara *et al*. (2014) [8] in Mango.

The treatment GA_3 at 400 ppm resulted in the maximum dry weight of shoots, measuring 5.99 g. GA_3 at 400 ppm had a significantly positive impact on shoot dry weight. The control had the minimum dry weight of shoots, measuring 2.20 grams.

Table 3: Effect of foliar application of plant growth regulators and nutrient on fresh and dry weight of shoot of kokum

Treatments	Fresh weight of shoot (g)	Dry weight of shoot (g)
T_1 – Humic acid @ 0.4%	14.47	3.87
T_2 – Humic acid@ 0.5%	16.20	4.10
T_3 – 19:19:19 @ 1%	13.80	3.08
T_4 - 19:19:19 @ 2%	10.43	2.82
T_5- GA3 @ 300 ppm	13.98	3.10
T_6 – GA3 @ 400 ppm	19.30	5.99
T_7 – Tricontanol @ 300 ppm	12.17	3.05
T_8 - Tricontanol@ 400 ppm	12.10	3.03
T_9- Control	8.85	2.20
Mean	13.48	3.47
F test	SIG	SIG
S.Em (±)	0.40	0.15
C.D@5%	1.21	0.45

Conclusion

From the present investigation, it was concluded that the maximum seedling height, number of leaves, girth at collar region, number of node, internodal length and fresh and dry weight of shoot was recorded in treatment GA_3 400 ppm. The maximum leaf area was noticed in treatment 19:19:19 @ 2%. Whereas, the minimum value were recorded in control treatment for all parameters under study. These results provide valuable insights into the effectiveness of different plant growth regulators and nutrients in enhancing the seedling growth of kokum. The specific concentrations and formulations used in the study can be considered for optimizing seedling growth of kokum.

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