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Effect of nutrients on growth of yellow type kokum (*Garcinia indica* Choisy) in the initial growth stage

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Abstract
An experiment was carried out at the Horticultural Research and Extension Centre (HREC), Sirsi during 2017-2019 on kokum (*Garcinia indica* Choisy) to study the optimum nutrient dosage for yellow type of kokum in the initial growth stage. One year old grafted yellow kokum plants were planted in the field under uniform replicated trial. The experiment comprised of five treatments with four replications. Among all the treatments T_2 [80% of RDF (1.6 kg FYM, 40:20:20 g NPK per plant))] recorded the maximum plant height (53.43 cm), number of branches (9.81 nos.), N-S plant spread (35.95 cm), E-W plant spread (34.01cm), stem diameter below and above graft union (9.98 mm and 7.15 mm, respectively), number of leaves (74.63 no.), leaf length (7.38 cm), leaf breadth (3.31cm).

Keywords: *Garcinia indica*, yellow type kokum

Introduction
Kokum (*Garcinia indica* Choisy) is known as an underutilized spice tree of culinary, nutraceutical and industrial values in south India, especially in the Konkan region and Western Ghats of Karnataka. Fruit rinds are used in the preparation of juice, as much appreciated health drink. The dried fruit rind is also having many uses including as spice and condiment in the preparation of curries. The seeds are the rich source of fat popularly known as 'kokum butter' and are used in foods, cosmetics and medicines. The kokum butter is the source of stearic acid and oleic acid, while the rind of the fruit contains hydroxy citric acid ((-)-HCA), which is much valued for its anti-obesity activity. Many secondary metabolites recorded from different parts of the species, namely, benzophenones, biflavonoids, xanthones and anthocyanin pigments (Ananthakrishnan and Rameshkumar, 2017) [1]. The commercial cultivation of the crops can be seen in some parts of the Maharashtra where optimum dose of nutrient application for the crop is standardized for the crop (Haldankar *et al.*, 2012) [10]. During the study, it is found that in Karnataka, there are hardly any commercial kokum gardens. The red type of fruits is commonly seen in the wild populations. There are yellow fruiting trees also seen (about 10%) in the population, which is considered as superior for folk medicine preparations. But, there are no reports of studies available on grafted yellow kokum. Hence present study was carried out to standardize the optimum dose of nutrients for the initial stage of grafted yellow kokum plants which influences on the growth of the yielding crop.

Material and Methods
The study was carried out at Horticultural Research and Extension Centre (HREC), Sirsi during 2017-2019. The experimental location receives mean annual rainfall of 2200 mm which is distributed over a period of six months from May to October. The soil of the experimental area is of lateritic in nature. In general, soils are shallow to medium in depth and reddish-brown to dark yellowish-brown in colour. A uniformly grown, one-year-old grafted yellow kokum plants were collected from a local nursery. The field study was laid out in to Randomized Complete Block Design (RCBD) with five treatments and four replications. About 80 nos. of grafted plants were used for the planting by following 2 × 2 m spacing. The pits were dug in the marked area of a dimension of 45 × 45 × 45 cm. The grafted plants were

planted in the middle of the pit so that graft region was just above the ground level. The nutrient doses recommended in the Konkan region was considered as standard for the fixing the treatment combinations (Haldankar *et al*., 2012) [10]. The details of the treatments were as given below.

T_1: (control): 2 kg FYM, 50:25:25 g NPK per plant
T_2: 80% of RDF (1.6 kg FYM, 40:20:20 g NPK per plant)
T_3: 120% RDF (2.4 kg FYM, 60:30:30 g NPK per plant)
T_4: 1 kg commercial compost + Vermicompost (equivalent to RDF)
T_5: 50% basal dose of RDF + 50% RDF as a foliar spray (in 2 splits at Nov. and Jan.)

The fertilizers, FYM, vermi-compost and commercial composts were applied as per treatments during August, around the plant as band application method and mixed in the soil at 15 cm deep in the basin followed by light irrigation to maintain soil moisture. The foliar spray of nutrients was taken in two split doses during November and January for respective plants. Observations on different growth characters were recorded from the day planting till 21st months after planting at every three months interval.

Results and Discussion

Data on growth parameters were recorded from the kokum plants which are presented in the tables (Tables 1 to 4).

The results of the experiment clearly indicated that the application of 80% RDF (T_2) registered maximum plant height (53.43 cm). Whereas, T_4 recorded minimum plant height (45.59 cm) at 21 MAP. The plants received RDF dosage, recorded higher values during the initial months, the per cent increase in plant height from the day of planting till 21st month recorded maximum (65.71 %) in T_2. The plants in T_1 recorded the lowest per cent increase (41.90 %) for plant height. The maximum plant height in T_2 might be due to the synergic effect of organic manures (FYM) along with inorganic fertilizers. The number of branches was increased in all the treatments from the initial stage to the 21st MAP (Table 1). Among the nutrient treatments, the significantly highest number of branches were observed in T_2 (80% of RDF) from 6th MAP to 21st MAP (2.81 and 9.81 nos., respectively) which was followed by T_5 (2.13 no. to 5.94 no.). A significantly lowest number of branches were recorded in the treatment T_4 (1.75 to 4.19 nos.). It was also evident from the data that, the per cent increase in the number of branches during the growth period was found to be maximum (532.50%) in T_2, whereas, lowest in the treatment T_4 (234.17%). Similar findings were also reported by Sahu *et al*. (2015) [16] in guava. Maximum plant height may be attributed to the fact that the better nourishment caused beneficial effects such as accelerated rate of photosynthesis, assimilation, cell division. The minimum plant height in T_4 (1 kg commercial compost + Vermicompost (equivalent to RDF)) might be due to no application of inorganic nutrients and ultimately due to the supply of insufficient quantity of nutrients. Garg and Singh (2010) [7] in cape gooseberry, Khattak *et al*. (2005) [13] reported that 4 kg NPK per tree gave the maximum plant height (19.26 cm), plant spread (19.22 cm) in guava.

The plant spread (N-S) was recorded increased trend throughout the growth period from the initial stage to 21st MAP, but the significant difference was observed from 9 MAP (Table 2). Significantly highest N-S plant spread (25.21 cm to 35.95 cm) was recorded in the treatment T_2 during the study period, which was found to be on par with T_5 (24.60 cm to 33.06 cm). Significantly least plant spread was recorded in the treatment T_4 (26.05 cm at 21st MAP). The data on per cent increase in the plant spread was recorded maximum in T_2 (80 % RDF) (93.23 %) and minimum plant spread was observed in the treatment T_4 (52.98 %). A similar trend was observed for plant spread in East-West direction after application of different doses of nutrients. The treatments T_2 recorded significantly highest E-W plant spread at 9th MAP to 21th MAP (27.54 cm to 34.01cm) which was on par with treatment T_3 (25.47 cm to 31.47 cm) and T_4 (25.36 cm to 31.19 cm). Significantly lowest plant spread was recorded in the treatment T_5 (22.66 cm to 27.75 cm) throughout the study period. The maximum per cent increase (104.74 %) in the East-West plant spread was recorded in the treatment T_2 and the minimum plant spread was in the treatment T_4 (73.15%). This increment in vegetative growth might be due to more absorption of nitrogen, phosphorus and potassium by plant, which combined with carbohydrates in the leaves leading to the formation of amino acids, proteins, chlorophyll and other amides. These effects increase the photosynthetic activity of the plants and greater synthesis of carbohydrates which is responsible for building up new tissue and are associated with several metabolic processes, which in turn favour better development of plants, hence enhanced stem growth. Similar growth response due to application of NPK levels were obtained by Bhobia *et al.* (2005) [5] obtained maximum increase in plant spread [East-West (25.00 %) and North-South (24.38 %)] in treatment where 100 per cent N was applied through urea in guava cv. Hisar Surkha. Baksh *et al.* (2008) [2] observed significantly increase in plant spread (0.33 m) with the application of NPK (900:600:900 g tree^{-1}) as compared to control in guava.

The stem diameter below the graft union in T_2 was increased from 6.49 mm (3rd MAP) to 9.98 mm (21st MAP). The per cent increase in the stem diameter below the grafts union was found to be maximum in the treatment T_2 (77.71 %), which was found to be minimum in the treatment T_4 (43.29 %) during the study period. This is because plant absorb nutrient at certain level beyond that plant remain constant and it won't absorb nutrient. In the present study same result was observed *i.e.* RDF at 80% gave increased growth. This might be due to synergistic effect between nitrogen and phosphorus. Phosphorus play an important role in cell division and root development, application of maximum dose of fertilizer at vegetative growth phase may finally enhance the stem girth. These findings are well supported by the findings of Goenaga and Rivera (2005) [8] reported that stem thickness of nursery plants observed maximum by the application of 9g of NPK (15:4.8:10.8 %) fertilizers per plants. Kaur and Chahil (2006) [12] who recorded the maximum stem girth (1.90 cm) with the application of NPK (400:200:100 g per tree) in guava.

There was no significant difference among the treatments observed for the number of leaves per plant up to three months after planting in white kokum plants (Table 2). However, significantly the highest number of leaves (22.94 no.) at 6 MAP was found in the treatment T_1 but treatment T_2 recorded the maximum number of leaves from 9 MAP to 21 MAP (24.75 no. to 74.63 no., respectively) and lowest number of leaves was observed in the treatment T_4 from 12 MAP to 21 MAP (26.50 nos. to 47.88 nos., respectively). The percentage increase in the number of leaves produced per plant also recorded significant results. The treatment T_2 showed amaximum increase (388.79 %) in the leaves produced, while, the treatment T_4 recorded minimum per cent increase in the number of leaves per plant till 21 months. Plant growth enhanced with the application of organic and inorganic fertilizers might be due to the direct effect of the higher amount of inorganic nitrogen, which is an integral part of protein and chlorophyll molecules which might have increased the foliage of the plant and thereby enhanced the photosynthesis. Boughalleb *et al*. (2011) [6] reported maximum number of leaves in the nursery plants of lemon and orange by the application of NPK fertilizers of 100:25:50 mg per litre, respectively. Baviskar *et al*., 2018 [3] revealed that application of 300 g nitrogen, 150 g phosphorus and 150 g potassium per plant increased number of leaves during both the years of experimentation in guava.

The periodic observation on leaf length recorded a significant difference among the nutrient treatment for leaf length (Table 3) during the study period. In the initial stage, there were no significant results recorded. Among the treatments, T_2 has recorded significantly maximum leaf length from 3 MAP to 21 MAP (6.84 cm to 7.38 cm). The treatment T_4 was recorded significantly lowest leaf length (5.35 cm to 5.85 cm) throughout the study period. The per cent increase in the leaf length did not show significant results. But the treatment T_2 recorded maximum per cent increase (17.23 %) in the leaf length from 3rd month to 21st months after planting. Leaf breadth differed significantly among the treatments. There was no significant result registered during the initial stage. But later on the treatments recorded significant difference from three months after planting. The leaf breadth was increased from 3 MAP to 21 MAP (3.14 to 3.31cm) in T_2 which was statistically on par with T_3 (3.05 cm to 3.14 cm) and T_1 (3.04 cm to 3.16 cm). However, significantly minimum leaf breadth was recorded with the treatment T_4 (2.60 cm to 2.74 cm). The per cent increase in the treatment was found to be maximum (11.39 %) in the treatment T_2 which was low in treatment T_5 (1.08 %). However, the maximum leaf length to breadth ratio was recorded in the treatment T_2 and the lowest was recorded in T_4. This trend was continued till the end of the study. An increase in leaf character by combined application of inorganic fertilizers with FYM might be due to the better availability of the required quantity of nutrients and improved soil conditions which promoted the vegetative growth and also the leaf area (Kaur and Kaur, 2017) [11]. Nitrogen positively influenced the vegetative growth of the plant, phosphorus plays an important role in photosynthesis and accumulation of photosynthates and potassium plays an important role in carbohydrate and protein synthesis and the regulation of water relations. These nutrients also play an important role in metabolic activities of the plant resulting in the synthesis of chlorophyll and cytochromes which are essential for photosynthesis and respiration process in the plants as reported by Gupta *et al*. (2019) [9]. Good leaf characters (leaf length, breadth and leaf area) was observed with the application of N, 9.85; P, 2.86; K, 7.99 g per plant in 'Valencia' sweet orange on Rangpur lime nursery tree (Bernardi *et al*., 2000) [4]. Goenaga and Rivera (2005) [8] reported that maximum leaf area of mangosteen seedlings was observed with the application of NPK fertilizers (15:4.8:10.8%). Application of NPK (459:184:876 mg dm^{-3}) recorded maximum growth of aerial parts in the nursery plants of sweet orange (Prado *et al*., 2009) [15].

Table 1: Effect of nutrient doses on plant height (cm) and number of branches in yellow kokum (*G. indica* Choisy)

Treatment	Plant height (cm)								% increase over initial stage	Number of branches								% increase over initial stage
	Initial	3 MAP	6 MAP	9 MAP	12 MAP	15 MAP	18 MAP	21 MAP		Initial	3 MAP	6 MAP	9 MAP	12 MAP	15 MAP	18 MAP	21 MAP	
T_1	35.49	37.99	39.37	41.01	43.29	45.74	48.11	50.18	41.90	1.44	1.63	2.19	2.56	3.38	4.25	5.31	5.50	295.83
T_2	32.24	34.83	37.38	40.14	43.89	47.84	51.32	53.43	65.71	1.56	1.81	2.81	3.56	4.75	6.19	9.25	9.81	532.50
T_3	31.79	35.23	38.12	40.71	43.21	45.69	48.20	49.29	55.44	1.38	1.50	1.94	2.13	2.81	3.75	5.50	5.81	346.61
T_4	31.05	33.14	35.47	37.39	39.51	41.58	43.58	45.59	46.79	1.25	1.38	1.75	1.94	2.38	2.88	4.00	4.19	234.17
T_5	32.27	35.38	37.83	40.29	42.96	45.58	48.29	49.76	55.01	1.31	1.50	2.13	2.69	3.50	4.06	5.56	5.94	370.54
S.Em.±	1.13	1.09	0.78	0.80	0.82	1.14	0.99	1.34	5.39	0.14	0.12	0.19	0.20	0.25	0.35	0.53	0.46	33.15
CD (5%)	NS	NS	2.42	2.47	2.54	3.52	3.06	4.13	NS	NS	NS	0.59	0.61	0.76	1.07	1.63	1.43	102.15
C.V.(%)	6.94	6.19	4.17	4.01	3.87	5.05	4.14	5.39	20.36	19.67	14.75	17.63	15.40	14.65	16.45	17.89	14.83	18.63

Table 2: Effect of nutrient doses on N-S spread (cm) and E-W spread (cm) in yellow kokum (*G. indica* Choisy)

Treatment	N-S spread (cm)								% increase over initial stage	E-W spread (cm)								% increase over initial stage
	Initial	3 MAP	6 MAP	9 MAP	12 MAP	15 MAP	18 MAP	21 MAP		Initial	3 MAP	6 MAP	9 MAP	12 MAP	15 MAP	18 MAP	21 MAP	
T_1	16.82	17.11	20.64	22.16	23.78	25.04	26.44	27.64	68.47	16.85	18.17	23.50	24.98	26.65	28.10	29.78	30.71	82.14
T_2	18.66	19.01	21.76	25.21	25.76	27.92	32.23	35.95	93.23	17.02	18.93	25.09	27.54	29.39	30.56	33.52	34.01	104.74
T_3	15.14	18.31	20.88	21.10	22.71	25.15	26.31	28.06	85.48	16.00	18.48	23.42	25.47	27.79	29.25	30.46	31.47	98.99
T_4	17.11	18.68	21.51	22.98	24.83	20.87	25.11	26.05	52.98	18.36	18.87	23.31	25.36	27.70	29.19	30.82	31.19	73.15
T_5	17.25	19.43	21.64	24.60	22.77	25.12	32.16	33.06	91.81	15.95	19.12	21.34	22.66	24.75	25.56	28.44	27.75	74.56
S.Em.±	1.10	1.01	0.84	0.72	0.68	1.12	1.52	1.15	7.47	1.33	0.51	0.85	0.91	0.91	1.01	0.77	0.98	12.39
CD (5%)	NS	NS	NS	2.23	2.10	3.46	4.68	3.55	23.01	NS	NS	NS	2.81	2.81	3.10	2.37	3.01	38.18
C.V.(%)	12.93	11.05	7.88	6.24	5.69	9.05	10.68	7.64	19.05	15.79	5.44	7.26	7.24	6.69	7.05	5.04	6.30	28.58

Table 3: Effect of nutrient doses on stem diameter below graft union (mm) and number of leaves in yellow kokum (*G. indica* Choisy)

Treatment	Stem diameter below graft union (mm)								% increase over initial stage	Number of leaves								% increase over initial stage
	Initial	3 MAP	6 MAP	9 MAP	12 MAP	15 MAP	18 MAP	21 MAP		Initial	3 MAP	6 MAP	9 MAP	12 MAP	15 MAP	18 MAP	21 MAP	
T_1	5.51	6.18	6.80	7.29	7.78	8.50	9.28	9.42	71.19	15.63	17.38	22.94	23.75	29.94	43.88	57.25	60.31	289.57
T_2	5.63	6.49	7.36	7.93	8.45	9.15	9.91	9.98	77.71	15.38	20.19	21.88	24.75	34.88	48.25	71.31	74.63	388.79
T_3	5.38	6.15	6.86	7.31	7.89	8.16	8.99	9.09	69.85	15.63	19.81	21.75	23.63	28.50	37.19	51.69	54.81	254.91
T_4	5.02	5.23	5.56	5.92	6.29	6.66	7.11	7.19	43.29	15.00	19.00	21.56	23.19	26.50	36.69	45.19	47.88	219.76
T_5	5.29	5.60	6.10	6.47	6.92	7.53	8.06	8.15	54.53	14.06	14.38	17.94	19.50	29.94	41.75	54.31	57.00	305.54
S.Em.±	0.17	0.24	0.24	0.25	0.26	0.19	0.20	0.20	5.55	0.87	1.32	1.03	1.04	1.55	1.80	4.38	4.09	27.19

CD (5%)	NS	0.74	0.75	0.76	0.81	0.57	0.61	0.61	17.09	NS	NS	3.16	3.19	4.78	5.55	13.51	12.61	83.79
C.V.(%)	6.45	8.07	7.50	7.05	7.08	4.64	4.58	4.48	17.52	11.49	14.59	9.68	9.02	10.35	8.68	15.67	13.89	18.64

Table 4: Effect of nutrient doses on leaf length (cm) and leaf breadth (cm) in yellow kokum (*G. indica* Choisy)

Treatment	Leaf length (cm)								% increase over initial stage	Leaf breadth (cm)								% increase over initial stage
	Initial	3 MAP	6 MAP	9 MAP	12 MAP	15 MAP	18 MAP	21 MAP		Initial	3 MAP	6 MAP	9 MAP	12 MAP	15 MAP	18 MAP	21 MAP	
T_1	6.35	6.56	6.60	6.72	6.79	6.93	6.94	6.97	9.68	3.03	3.04	3.05	3.07	3.08	3.11	3.15	3.16	4.46
T_2	6.29	6.84	6.87	7.02	7.12	7.22	7.25	7.38	17.23	2.97	3.14	3.16	3.17	3.19	3.23	3.29	3.31	11.39
T_3	6.08	6.15	6.20	6.24	6.32	6.42	6.47	6.71	10.45	3.01	3.05	3.07	3.07	3.08	3.09	3.12	3.14	4.62
T_4	5.35	5.35	5.42	5.50	5.51	5.72	5.77	5.85	10.06	2.55	2.60	2.63	2.65	2.68	2.71	2.73	2.74	7.86
T_5	5.88	5.93	5.95	6.14	6.26	6.41	6.46	6.47	10.09	2.82	2.87	2.88	2.93	2.94	2.91	2.97	2.98	1.08
S.Em.±	0.24	0.32	0.27	0.32	0.29	0.29	0.28	0.25	1.92	0.10	0.06	0.08	0.07	0.06	0.11	0.07	0.09	1.05
CD (5%)	NS	0.98	0.84	0.99	0.89	0.88	0.88	0.77	NS	NS	0.18	0.24	0.22	0.17	0.33	0.21	0.29	NS
C.V.(%)	8.05	10.37	8.76	10.18	9.03	8.78	8.64	7.44	-	6.72	3.88	5.34	4.74	3.73	7.09	4.56	6.19	-

Conclusion

The findings of the study indicated that grafted yellow kokum plants responded well to added nutrients and showed maximum growth for the application of 80% RDF (1.6 kg FYM, 40:20:20 g NPK per plant). The treatment recorded maximum plant height, number of branches, N-S and E-W plant spread, stem diameter below graft union, number of leaves, leaf length and leaf breadth compared to other treatments.

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