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Effect of nutrients and shoot retention on quality of fruits and soil nutrient status in rejuvenated guava (*Psidium guajava* L.) CV Sardar

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Abstract
A present study was conducted with the objective to study the physico-chemical characters of fruit and soil nutrient status under different treatments of shoot retention and nutrition in the rejuvenated guava which was conducted during 2018-2019 at orchard of Fruit Science Department, Kittur Rani Channamma College of Horticulture, Arabhavi (UHS, Bagalkot), Karnataka. Among shoot thinning 3 shoots per branch (S_1) had highest fruit quality parameters *viz*., TSS (11.50 º B), Ascorbic acid (170.86 mg/100g), reducing (4.24%), non-reducing (3.48%), total sugars (7.72%), soil characters like pH (8.02), EC (0.28 dSm^{-1}) and organic carbon (0.67%). Plants supplemented with 100% RDF (200: 80: 150 NPK g/plant) + (Zn+B+Mg) 0.3% each (F_6) has recorded maximum TSS (11.42 º B), Ascorbic acid (189.92 mg/100g), reducing (4.40%), non-reducing (3.46%), total sugars (7.86%) and soil characters like pH (8.01), EC (0.26 dSm^{-1}) and organic carbon (0.66%). Interaction effect has got non-significant results for all the parameters. +However, the treatment S_1F_6 consisting of 3 shoots per branch and 100 per cent RDF (200:80:150 NPK g/plant) + (Zn+B+Mg) 0.3 per cent each has recorded moderate fruit physico-chemical parameters and soil nutrient status.

Keywords: Guava, rejuvenation, shoot retention, nutrients, soil, sardar

Introduction
Guava (*Psidium guajava* L.) is an important fruit crop in many tropical and subtropical regions and is native to Tropical America stretching from Mexico to Peru. It has adapted in India so well that it appears to be an Indian fourth largest fruit crop grown in India. Guava is an evergreen fruit species well adapted to a wide range of soil and agro climates and is acclaimed as 'Super fruit' owing to its high nutritional and nutraceutical profile (Singh *et al.*, 2015) [17]. Guava is considered to be poor man's fruit and richest natural sources of vitamin C. It also contains a fair source of vitamin A, riboflavin, thiamine and minerals like calcium, phosphorus and iron. Guava fruit is a favourite dessert, very delicious and is consumed in different ways (Suresh and Shakila, 2017) [18]. Rejuvenation technology involves the heading back of exhausted trees (showing marked decline in annual production and quality of produce) to 1.0 to 1.5-meter height above the ground level during May-June or December-February to facilitate the production of new shoots from below the cut point and allow the development of fresh canopy of healthy shoots (Jahangeer *et al.*, 2011) [7]. Guava is a pruning responsive crop, pruning of guava is highly desirable to maintain their vigour and productivity as well as to improve fruit size. Studies have reported that the time and level of pruning influence growth, flowering and yield of guava. With this background the present study was carried out to find out the effect of pruning intensities on yield of guava cv. Lucknow 49. Manipulation of tree growth using canopy management practices to control tree growth patterns, tree shape for high fruit production of desired size and quality (Singh, 2001) [16]. The thinning of shoots per branch is also one of the canopy management practices in the rejuvenation of old orchards (Bhagawati *et al.*, 2015) [2]. Nutrients can be made available to the plants by the basal as well as foliar application. Nitrogen, phosphorus and potassium are the major and essential nutrients required by the plants in larger quantities. These are responsible for maximizing physiological activities of the plant which ultimately affect the growth, development, fruiting and quality until the fruits attain physiological maturity (Nijjar, 1996) [13]. In rejuvenated orchards nutrient and water management is much more important, soil application of FYM, inorganic and organic fertilizers were applied for proper growth and development of the plants. Hence, the present investigation was undertaken to study the influence of nutrients and shoot retention on quality of fruits and soil chemical properties in rejuvenated guava cv. Sardar.

Material and Methods

Research was carried out in the fruit science departmental orchard, The experiment was laid out in factorial randomized completely block design (FRCBD) and replicated thrice as follows, the factor 1 consists of 3 levels of thinning, *i.e.*, retaining three shoots per branch (S_1), four shoots per branch (S_2) and Five shoots per branch (S_3). Shoot thinning was done in the 1st week of June. Factor 2 consists of 6 different nutrient levels *viz.*, 50% RDF (100: 40: 75 NPK g/plant) + (Zn+B+Mg) 0.2% each(F_1), 50% RDF (100: 40: 75 NPK g/plant) + (Zn+B+Mg) 0.3% each (F_2), 75% RDF (150: 60: 110 NPK g/plant) + (Zn+B+Mg) 0.2% each (F_3), 75% RDF (150: 60: 110 NPK g/plant) + (Zn+B+Mg) 0.3% each (F_4), 100% RDF (200: 80: 150 NPK g/plant) + (Zn+B+Mg) 0.2% each (F_5), 100% RDF (200: 80: 150 NPK g/plant) + (Zn+B+Mg) 0.3% each (F_6). Recommended doses of fertilizers were applied on per plant basis according to the treatment details in two split doses. 50 per cent of urea was applied in the month of July as basal dose and the remaining 50 per cent urea and full dose of single super phosphate and muriate of potash as top dress applied during October. Micronutrients like zinc in the form of $ZnSO_4$, boron in the form of borax and magnesium in the form of $MgSO_4$ sprayed before and after flowering as per the treatments.

Soil condition

The soil of the experimental field is well drained medium deep black soil having a depth of 90-100 cm with sandy loam texture.

Observations recorded

Fruit quality parameters

Total soluble solids (°Brix)

The total soluble solids (TSS) of the guava pulp was measured using the hand refractometer after calibration by using distilled water.

Ascorbic acid content (mg/100g)

Ascorbic acid content of guava was estimated by using the method given by AOAC (1990), which was based on the reduction of 2, 6-dichlorophenol indophenols (2, 6-DCPIP) by ascorbate.

Titratable acidity (%)

Acidity was estimated as citric acid by taking (ten grams of sample grounded and volume was made up to 100 ml) 10 ml aliquot titrated against 0.1N NaOH using phenolphthalein as indicator. Appearance of light pink colour denoted the end point. It was calculated using the following formula and expressed in percentage. (Eq. wt. of citric acid = 0.064)

$$\text{Acidity (\%)} = \frac{\text{Titter value x N. of NaOH x Eq. wt. of citric acid x Vol. made up x 100}}{\text{Wt. of sample x Aliquot taken x 1000}}$$

Reducing sugars

The reducing and non-reducing sugars present in guava was estimated using 3, 5-Dinitro Salicylic Acid (DNSA) method (Miller, 1972).

Non-reducing sugars (%)

The per cent of non-reducing sugars was obtained by subtracting the values of reducing sugars from that of total sugar and multiplying the same with 0.95 as correction factor and expressed in percentage.

Non-reducing sugar (%) = [Total sugar (%) – Reducing sugar (%)] x 0.95

Total sugars (%)

The total sugars of the product were estimated as same as in case of reducing sugar after inversion of the non-reducing sugar using dilute hydrochloric acid. One ml of evaporated extract was taken and kept in water bath till alcohol completely evaporates and allowed it to cool. Then phenolphthalein indicator was added followed by 1N hydrochloric acid to discolour the solution. Then Dinitro-salicylic acid (DNSA) method for reducing sugars was followed. The result obtained was expressed in percentage.

Soil analysis

Soil analysis of the experimental plot was done by taking soil sample from depth of 30 cm at each sampling spot as per the procedure before and after imposition of treatments.

Soil pH

Soil pH was determined by potentiometric method in 1: 2.5 soil water suspension using pH meter having a glass-calomel combined electrode (Jackson, 1967) [5].

Electrical conductivity (dS/m)

Electrical conductivity of soil samples was measured in soil-water extract of 1:2.5 ratio using conductivity bridge (Jackson, 1973) [6] and expressed in dS/m.

Organic carbon (%)

The soil organic carbon was determined by Walkey and Black's wet oxidation method by using potassium dichromate (Piper, 1957). The organic carbon was calculated by using the formula and expressed in percentage.

$$\text{Organic carbon (\%)} = \frac{\text{(Blank titre value – Sample titre value) x N of FAS x 0.003}}{\text{Weight of soil (g)}} \times 100$$

FAS = Ferrous ammonium sulphate
N = Normality

Available nitrogen (kg/ha)

Available nitrogen in the soil was determined by alkaline potassium permanganate method as suggested by Jackson (1967) [5]. Available nitrogen was calculated by using formula and expressed in kilogram per hectare.

$$\text{Available N (Kg/ha)} = \frac{\text{TV x N of } H_2SO_4 \text{ x 0.014}}{\text{Weight of sample (g)}} \times 2.24 \times 10^6$$

TV- Titre value
N- Normality

Available phosphorous (kg/ha)

The method suggested by Jackson (1967) [5] was employed for determination of available phosphorous. The available phosphorous (P) in the soil was extracted by using Olsen's extractant. The ammonium molybdate solution, stannous chloride solution was added to the filtrate solution. The aliquot was taken and estimated by using spectrophotometer. Standard solution of P with concentration of 0, 0.1, 0.2, 0.4, 0.6, 0.8 and 1.0 ppm were prepared by following same procedure but without using soil sample.

$$\text{Available P (Kg/ha)} = \frac{\text{Graph ppm}}{10^6} \times \frac{\text{Volume of extractant}}{\text{Aliquot}} \times \frac{\text{Volume made}}{\text{Wt. of sample (g)}} \times 2.24 \times 10^6$$

Available potassium (kg/ha)

The available potassium (K) was extracted from soil by using neutral normal ammonium acetate solution. The aliquot was fed to the calibrated flame photometer for K estimation. The instrument was calibrated by 0, 10, 20, 30 and 40 ppm of K standard solution pipetting out of volumetric flask (50 ml) with 100 ppm potassium standard solution. These samples were fed to the flame photometer to obtain flame photometer reading as graph ppm (Jackson, 1973) [6].

$$\text{Available K (Kg/ha)} = \frac{\text{Graph ppm}}{10^6} \times \text{dilution} \times \frac{\text{Vol. of extractant}}{\text{Weight of sample (g)}} \times 2.24 \times 10^6$$

Result and Discussion

The fruit physiochemical parameters were significantly influenced by different treatments. Among shoot retention highest TSS was recorded in S_1 (11.50 ^{0}B) whereas, lowest in S_3 (10.43 ^{0}B) among nutrition highest TSS was noticed in F_6 (11.42 ^{0}B) which is on par with F_5 (11.26 ^{0}B) and F_4 (11.05 ^{0}B), which is lowest in F_1 (10.43 ^{0}B). Among the treatments, highest ascorbic acid was recorded in S_1 (170.86 mg/100g), F_6 (189.92 mg/100g). The minimum acidity of 0.32 per cent in S_1 and 0.29 per cent in F_6, whereas, maximum in S_3 (0.39%) and in F_1 (0.41%). The highest reducing sugar of 4.24 per cent recorded in S_1 which is at par with S_2 (4.16%) whereas, lowest of 3.95 per cent was recorded in S_3. The highest of 4.40 per cent was observed in F_6 which is at par with F_5 (4.31%) whereas, lowest in F_1 (3.83%). The highest non- reducing sugars was recorded in S_1 (3.48%) and the lowest was recorded in S_3 (3.06%). The results obtained by the influence of nutrients on non-reducing sugars was found significant. The highest was noticed in F_6 (3.46%) which is at par with F_5 (3.37%) whereas, lowest was recorded in F_1 (3.10%). the highest total sugars was recorded in S_1 (7.72%), 7.86 per cent in F_6 whereas, lowest in S_3 (7.01%) and in F_1 (6.92%). TSS was highest with severe pruning followed by moderate and light due to the increased rate of photosynthesis due to more penetration of sun light into the interior tree canopy that increased the TSS content in the fruit harvested from pruned trees by Bhagawati *et al.* (2015) [2]. This might be due to leaves/fruit ratio being relatively high in pruned trees causing increased TSS concentration on account of greater metabolites synthesis reported by Camus *et al.* (2018) [4] in guava so pruning intensity increase the TSS will maximum, it could be obviously due to the better availability of carbohydrates reserved stored in pruned shoots. The increase in ascorbic acid content of fruit juice was due to increase synthesis of catalytic enzymes and co-enzyme which are represented ascorbic acid and synthesized by spray of micronutrients which was reported by Anees *et al.* (2011) [1]. Bhagawati *et al.* (2015) [2] in guava reported lowest acidity in sever pruned guava plants as compare to moderate and light pruning. It could be attributed to the TSS increase at the expense values were lower acidity in the fruits on severely pruned trees. Higher acidity in light pruning is attributed to deposition of higher quantum of acid that is synthesized in leaves in fruits during the development. Increasing the level of pruning increased the sugar acid ratio (SAR) in fruits by Camus *et al.* (2018) [4] in guava. This might be due to increase nutrient uptake by the trees and consequently more synthesis of carbohydrates and other metabolites and their translocation to the fruits. The increased rate of photosynthesis due to more light penetration into interior tree canopy in light pruning increased the soluble solids in fruits of pruned trees which increases sugars reported by Jayswal *et al.* (2017) [8] in guava. The results of influence of nutrients on total, reducing and non-reducing sugars were significant. The combined application of N and K at optimum level resulted in significantly more chemical parameters (TSS, total sugars, reducing sugars, non-reducing sugars, acidity and vitamin-C) which was reported by Boora and Singh 2000 [3] and Kashyap *et al.* 2012 [9]. This is also may be due to the enhancing effect of nitrogen on growth and sufficient availability of phosphorus and potassium already present in the soil which was reported by Kumar *et al.* (2008) [11] in guava. Increase in sugar by zinc might be due to the active enzymatic reaction like transformation of carbohydrates, activity of hexokinase and formation of cellulose which was reported by Anees *et al.* (2011) [1]. The analysis of data pertaining to nutrient status in soil as influenced by shoot thinning and nutrition and their interaction are presented in the Table 1 and 2. The data pertaining to soil pH showed non-significant difference among different shoot thinning. However, the minimum pH was noticed in S_3 (7.44) and maximum was in S_1 (8.02). The results by the influence of nutrients on soil pH was significant. The highest pH value was noticed in F_6 (8.01) whereas lowest was recorded in F_1 (7.56). Electrical conductivity showed non significant variation for shoot thinning. Maximum electrical conductivity was recorded in S_1 (0.28 dS/m) whereas, minimum in S_3 (0.22 dS/m). The interpreted data regarding electrical conductivity revealed significant difference for nutrition. The maximum value of 0.26 dS/m was observed in F_6 and minimum in F_1 (0.22 dS/m). The interpretation of data showed non significant results for shoot thinning. The maximum organic carbon was obtained in S_1 (0.67%) whereas, minimum in S_3 (0.51%). The analysed results dissipated significant differences for nutrition. The highest was obtained in F_6 (0.66%) and lowest in F_1 (0.53%). The results of shoot thinning level depicted non significant differences for nitrogen among the treatments. The highest available nitrogen was recorded in S_1 (221.78 kg/ha) whereas, lowest in S_3 (195.49 kg/ha). The analysis of data of available nitrogen high lightened significant results for nutrition. The results ranging from 201.25 to 220.68 kg/ha for F_1 and in F_6 respectively. Phosphorous was non significantly affected by shoot thinning. The highest phosphorous was recorded in S_1 (17.68 kg/ha) whereas, lowest in S_3 (16.15 kg/ha). The average phosphorous showed significant results as influenced by nutrients. Among the treatments, the maximum was noticed in F_6 (17.81 kg/ha) and minimum in F_1 (16.52 kg/ha). Data recorded on potassium as influenced by shoot thinning was found to be significant. The highest potassium was noticed in S_1 (186.11 kg/ha) and the lowest in S_3 (159.30 kg/ha). The data pertaining to potassium as influenced by nutrition was significant. The maximum 185.05 kg/ha was recorded in F_6 whereas minimum 159.30 kg/ha was in F_1. Non significant variation was found with respect interaction for all the parameters. There were non-significant differences observed for shoot thinning with respect to soil nutrient status. Significant results were observed for soil nutrient status by application of nutrients. The highest level of soil pH, electrical conductivity**,** organic carbon, nitrogen, phosphorus and potassium level was found highest in F_6. The increased organic carbon was due to enhanced root growth, which leads to accumulation of organic residues and direct incorporation of organic matter in soil. Nitrogen, phosphorus and potassium contents have shown increasing trend with increasing levels of the respective nutrients. A buildup of nitrogen and organic carbon in soil with different nitrogen sources and levels combined with bio-fertilizers. It is evident that application of higher dose of fertilizers resulted in more uptake of nitrogen, phosphorus and potassium from the soil which ultimately led to better fruit growth and development. Similar findings were reported by Kotur *et al.* (1997) [10] and Rajput and Shinde (2004) [15].

Table 1: Influence of number of shoots and nutrients on fruit quality parameters in rejuvenated guava

Treatments	TSS (°B)	Ascorbic acid (mg/100 g)	Titratable acidity (%)	Sugars (%)		
				Reducing	Non-reducing	Total
Shoots retention (S)						
S_1	11.50	170.86	0.32	4.24	3.48	7.72
S_2	10.92	163.20	0.34	4.16	3.25	7.41
S_3	10.43	159.82	0.39	3.95	3.06	7.01
S.Em ±	0.08	1.21	0.003	0.03	0.04	0.04
CD at 5%	0.23	3.47	0.009	0.09	0.12	0.12
Nutrition (F)						
F_1	10.43	142.55	0.41	3.83	3.10	6.92
F_2	10.63	150.47	0.38	3.94	3.15	7.08
F_3	10.90	159.68	0.36	4.07	3.21	7.28
F_4	11.05	167.37	0.34	4.15	3.28	7.44
F_5	11.26	177.77	0.31	4.31	3.37	7.67
F_6	11.42	189.92	0.29	4.40	3.46	7.86
S.Em ±	0.11	1.71	0.004	0.04	0.06	0.06
CD at 5%	0.32	4.91	0.012	0.12	0.17	0.17
Interactions (S x F)						
$S_1 F_1$	11.13	149.73	0.38	3.97	3.33	7.30
$S_1 F_2$	11.10	158.70	0.36	4.13	3.38	7.51
$S_1 F_3$	11.54	163.13	0.32	4.18	3.45	7.63
$S_1 F_4$	11.62	172.41	0.30	4.25	3.47	7.72
$S_1 F_5$	11.73	185.07	0.29	4.43	3.53	7.97
S_1F_6	11.90	196.10	0.26	4.45	3.71	8.16
$S_2 F_1$	10.23	140.13	0.40	3.88	3.05	6.93
$S_2 F_2$	10.57	148.17	0.37	4.02	3.08	7.10
$S_2 F_3$	10.78	156.10	0.36	4.17	3.15	7.32
$S_2 F_4$	10.98	167.69	0.33	4.20	3.30	7.50
$S_2 F_5$	11.43	177.11	0.30	4.28	3.41	7.69
$S_2 F_6$	11.50	190.00	0.29	4.42	3.48	7.90
$S_3 F_1$	9.93	137.78	0.44	3.63	2.90	6.53
$S_3 F_2$	10.22	144.53	0.42	3.65	2.98	6.63
$S_3 F_3$	10.38	159.80	0.40	3.88	3.03	6.90
$S_3 F_4$	10.53	162.00	0.38	4.00	3.08	7.09
$S_3 F_5$	10.62	171.13	0.34	4.20	3.16	7.36
$S_3 F_6$	10.87	183.67	0.33	4.34	3.19	7.53
S.Em ±	0.19	2.96	0.007	0.07	0.10	0.10
CD at 5%	NS	NS	NS	NS	NS	NS

Table 2: Influence of number of shoots and nutrients on soil nutrient status in rejuvenated guava

Treatments	pH	EC (dS/m)	Organic carbon (%)	Nitrogen (Kg/ha)	Phosphorous (Kg/ha)	Potassium (Kg/ha)
Shoots retention (S)						
S_1	8.02	0.28	0.67	221.78	17.68	186.11
S_2	7.84	0.23	0.58	211.40	17.53	170.07
S_3	7.44	0.22	0.51	195.49	16.15	155.86
S.Em ±	0.12	0.010	0.029	4.63	0.30	6.04
CD at 5%	NS	NS	NS	NS	NS	NS
Nutrition (F)						
F_1	7.56	0.22	0.53	201.25	16.52	159.30
F_2	7.63	0.23	0.55	202.91	16.79	162.44
F_3	7.70	0.24	0.56	207.79	17.00	168.25
F_4	7.81	0.24	0.59	209.55	17.11	171.86
F_5	7.88	0.25	0.62	215.14	17.51	177.16

F_6	8.01	0.26	0.66	220.68	17.81	185.05
S.Em ±	0.17	0.014	0.041	6.55	0.43	8.54
CD at 5%	0.48	0.040	0.12	18.83	1.23	24.55
Interactions (S x F)						
$S_1 F_1$	7.73	0.25	0.60	211.75	16.94	171.67
$S_1 F_2$	7.80	0.27	0.64	214.12	17.48	175.08
$S_1 F_3$	7.87	0.27	0.65	221.05	17.52	179.85
$S_1 F_4$	8.04	0.28	0.68	223.08	17.66	183.41
$S_1 F_5$	8.18	0.28	0.69	228.67	18.17	196.67
S_1F_6	8.49	0.30	0.73	232.00	18.31	210.00
$S_2 F_1$	7.63	0.21	0.53	202.00	16.89	160.24
$S_2 F_2$	7.73	0.22	0.54	203.62	17.04	164.00
$S_2 F_3$	7.80	0.23	0.55	210.67	17.53	171.40
$S_2 F_4$	7.93	0.24	0.58	212.15	17.52	172.08
$S_2 F_5$	7.95	0.24	0.62	219.92	18.11	172.67
$S_2 F_6$	7.97	0.25	0.68	220.04	18.10	180.00
$S_3 F_1$	7.30	0.19	0.47	190.00	15.73	145.99
$S_3 F_2$	7.37	0.20	0.48	191.00	15.83	148.25
$S_3 F_3$	7.43	0.21	0.49	191.67	15.94	153.50
$S_3 F_4$	7.47	0.22	0.51	193.42	16.14	160.08
$S_3 F_5$	7.50	0.23	0.55	196.83	16.24	162.16
$S_3 F_6$	7.57	0.24	0.57	210.00	17.00	165.16
S.Em ±	0.29	0.024	0.071	11.35	0.74	14.80
CD at 5%	NS	NS	NS	NS	NS	NS

Conclusion

From the results of the present study, it is clear that the plants with 3 shoots per branch and with 100 per cent RDF (200:80:150 NPK g/plant) + (Zn+B+Mg) 0.3 per cent has highest fruit physiochemical parameters and has good soil nutrient status. Fruit yield of guava for commercial production can be manipulated easily by horticultural practices like pruning under location specific environmental conditions.

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