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Sagar BS
Department of Horticulture, College of Horticulture, Bagalkot, University of Horticultural Sciences, Bagalkot, Karnataka, India

Athani SI
Department of Horticulture, College of Horticulture, Bagalkot, University of Horticultural Sciences, Bagalkot, Karnataka, India

Gopali JB
Department of Horticulture, College of Horticulture, Bagalkot, University of Horticultural Sciences, Bagalkot, Karnataka, India

Allolli TB
Department of Horticulture, College of Horticulture, Bagalkot, University of Horticultural Sciences, Bagalkot, Karnataka, India

Kulapati Hipparagi
Department of Horticulture, College of Horticulture, Bagalkot, University of Horticultural Sciences, Bagalkot, Karnataka, India

Raghavendra S
Department of Horticulture, College of Horticulture, Bagalkot, University of Horticultural Sciences, Bagalkot, Karnataka, India

Mallikarjun Awati
Department of Horticulture, College of Horticulture, Bagalkot, University of Horticultural Sciences, Bagalkot, Karnataka, India

Revanappa
Department of Horticulture, College of Horticulture, Bagalkot, University of Horticultural Sciences, Bagalkot, Karnataka, India

Correspondence
Sagar BS
Department of Horticulture, College of Horticulture, Bagalkot, University of Horticultural Sciences, Bagalkot, Karnataka, India

Influence of different plant densities and pruning seasons on quality and bio chemical parameters of mango (*Mangifera indica* L.) cv. Alphonso

Sagar BS, Athani SI, Gopali JB, Allolli TB, Kulapati Hipparagi, Raghavendra S, Mallikarjun Awati and Revanappa

Abstract
The present study was undertaken to know the effects of high density planting and pruning seasons on quality and bio chemical parameters of mango (*Mangifera indica* L.) cv. Alphonso at Regional Horticulture Research and Extension Centre, Dharwad (University of Horticultural Sciences, Bagalkot) during May - 2016 to June – 2018. The maximum acidity content (0.53%) was observed in D_2T_1 (2.5× 2.5 m spacing with control), the ascorbic acid content was found maximum (39.39 mg/ 100 gm) in the treatment of D_3T_3 (5.0×5.0 m spacing with pruning during current season growth) and the treatment D_4T_3 (7.5×5.0 m spacing with current season growth pruning) recorded maximum TSS of 21.70 ^{0}B. The total sugar content was found maximum (13.34%) in the treatment of D_3T_2 (5.0×5.0 m spacing with previous season growth pruning), highest reducing sugar content (5.19%) was observed in the treatment of D_1T_3 (2.5×2.5 m spacing with pruning during current season growth) and the non reducing sugar content was found highest (8.33%) in the treatment of D_3T_2 (5.0×5.0 m spacing with previous season growth pruning). The treatment of D_4T_2 (7.0×5.0 m spacing with previous season growth pruning) recorded maximum total chlorophyll content (2.15 mg/g) and maximum carotenoid content (2.94 mg/g) and the maximum proline content was found in the treatment D_1T_1 (2.5×2.5 m spacing with no pruning)

Keywords: Pruning, quality, bio chemical and densities

Introduction
Mango (*Mangifera indica* L.) belonging to family Anacardiaceae. It is the most important commercially grown fruit crop of the country. It is called the king of fruits. India has the richest collection of mango cultivars. Cultivation of mango is believed to have originated in South East Asia and it is being cultivated in southern Asia for nearly six thousand years. The word '*Mangifera'* is derived from the Tamil word Mangai and Fero means to bear. The word '*indica*' means Indian and stands for the name of the species. The system of high density planting (HDP) has been successfully implicated in mango, since high density planting results in the better utilization of natural resources. In most of the regions, where mango is grown, solar radiation is abundant and thus productivity largely depends upon its efficient utilization. The system and density of planting need to be designed to intercept the solar radiation effectively. For commercial fruit cultivation, the natural form and shape of fruit trees are to be modified through the practice of pruning to achieve the targeted yield by scientific approach. Proper pruning practices keep the plant in such a shape and condition as to yield fruits of desired quality. Canopy management depends on the nature and growth pattern of plant, number of plants per hectare and pruning techniques.

Materials and Methods
The present investigation of "Studies on high density planting in mango (*Mangifera indica* L.) cv. Alphonso" was carried out in Regional Horticulture Research and Extension Centre, Dharwad (University of Horticultural Sciences, Bagalkot,) during May - 2016 to June - 2018. The material used, techniques adopted and observations recorded during the course of the investigation are presented in this chapter. Five year old mango orchard cv. Alphonso established during 2011 was selected for the experiment. The pruning was done after harvesting of fruits in 2016 and 2017. Three different pruning time were employed *viz* T_1 (no pruning), T_2 (previous season growth) and T_3 (current season pruning). Four different densities like 2.5 × 2.5 m (1600 plants/ ha), 5.0 × 2.5 m (800 plants/ ha), 5.0 × 5.0 m (400 plants/ ha) and 7.5 × 5.0 m (267 plants/ ha). Each treatment was replicated three times and four plants were chosen from each replication. The experiment was laid out in two Factorial Randomized Block Design. Quality and Bio Chemical parameters recorded during this study *viz*, TSS was

determined by Voisny Erma hand refractometer (0° to 32° range) and expressed in °Brix. Reducing sugar as per the Dinitro Salicylic acid (DNSA) method. The per cent of non-reducing sugar was obtained by subtracting the values of total sugar with reducing sugar and multiply the same with 0.95 as correction factor and expressed in per cent. The total sugar in the sample was estimated by same method as that of reducing sugar after inversion of the non-reducing sugar using dilute hydrochloric acid and expressed in per cent. Titrable Acidity was estimated by titration using standard NaOH using phenolphthalein indicator. Ascorbic acid content was estimated in mature fruits by 2, 6-dichlorophenolindophenol visual titration method. Chlorophyll is extracted in Dimethyl sulphoxide and the absorption at 663 nm and 645 nm are read in a spectrophotometer. Carotenoid content was estimated following the method as suggested by Hiscox and Israelstom (1979) and expressed as mg g^{-1}. Proline content of the leaf was estimated by the method of Bates *et al.* (1973) [1] and expressed as mg g^{-1} fresh weight.

Table 1: Effect of different plant density and pruning seasons on quality parameters

Treatments	Quality parameters								
	Acidity (%)			Ascorbic acid (mg per 100 gm)			TSS (^{0}B)		
	Season 1 (2016-17)	Season 2 (2017-18)	Pooled (2016-18)	Season 1 (2016-17)	Season 2 (2017-18)	Pooled (2016-18)	Season 1 (2016-17)	Season 2 (2017-18)	Pooled (2016-18)
Spacing (D)									
D_1	0.47	0.48	0.48	37.75	35.90	36.83	18.41	19.58	19.00
D_2	0.49	0.46	0.47	38.34	37.41	37.88	18.76	20.69	19.73
D_3	0.52	0.54	0.53	39.25	38.89	39.08	19.27	20.87	20.07
D_4	0.55	0.51	0.53	39.20	39.24	39.22	19.35	21.42	20.39
S.Em±	0.02	0.01	0.01	0.19	0.50	0.12	0.07	0.35	0.14
CD @5%	0.05	0.03	0.02	0.55	1.47	0.34	0.21	1.03	0.41
Mulching (M)									
T_1	0.54	0.52	0.53	38.55	37.36	37.96	18.75	18.73	18.75
T_2	0.50	0.49	0.49	38.64	38.00	38.32	19.01	20.47	19.74
T_3	0.49	0.50	0.49	38.71	38.22	38.47	19.08	22.73	20.91
S.Em±	0.02	0.01	0.01	0.16	0.43	0.33	0.06	0.30	0.12
CD @5%	0.05	NS	0.02	NS	NS	NS	0.18	0.89	0.35
Interaction									
D_1T_1	0.53	0.51	0.52	37.68	35.38	36.54	17.88	18.16	18.02
D_1T_2	0.48	0.43	0.46	37.83	35.93	36.88	18.63	20.15	19.39
D_1T_3	0.38	0.50	0.44	37.73	36.38	37.06	18.71	20.42	19.57
D_2T_1	0.54	0.53	0.53	38.12	36.54	37.35	18.64	19.51	18.07
D_2T_2	0.39	0.41	0.39	38.36	37.86	38.11	19.72	20.96	20.85
D_2T_3	0.51	0.42	0.47	38.52	37.82	38.17	18.92	23.60	21.26
D_3T_1	0.54	0.52	0.53	39.26	38.41	38.84	19.25	19.21	19.23
D_3T_2	0.50	0.44	0.47	39.19	38.81	39.00	19.22	20.58	19.90
D_3T_3	0.51	0.52	0.52	39.31	39.45	39.39	20.34	22.83	21.09
D_4T_1	0.55	0.51	0.53	38.25	39.10	38.67	20.24	21.05	20.65
D_4T_2	0.52	0.39	0.45	39.19	39.38	39.29	19.46	20.16	19.82
D_4T_3	0.48	0.50	0.49	39.27	39.23	39.25	19.34	24.06	21.70
S.Em±	0.03	0.02	0.01	0.33	0.54	0.17	0.12	0.61	0.24
CD @5%	0.09	0.05	0.03	0.86	1.66	0.53	0.36	1.78	0.71

D1- 2.5 × 2.5 m (1600 plants/ ha)
T_1- Control (un-pruned)
T_3 – current season
D2- 5.0 × 2.5 m (800 plants/ ha)
T_2- previous season growth
D3- 5.0 × 5.0 m (400 plants/ ha)
D4- 7.5 × 5.0 m (267 plants/ ha)

Table 2: Effect of different plant density and pruning seasons on quality parameters

Treatments	Quality parameters								
	Total sugar (%)			Reducing sugars (%)			Non reducing sugars (%)		
	Season 1 (2016-17)	Season 2 (2017-18)	Pooled (2016-18)	Season 1 (2016-17)	Season 2 (2017-18)	Pooled (2016-18)	Season 1 (2016-17)	Season 2 (2017-18)	Pooled (2016-18)
Spacing (D)									
D_1	12.46	12.30	12.38	4.92	4.71	4.82	7.17	7.22	7.19
D_2	12.83	12.75	12.79	4.48	4.42	4.46	7.91	7.92	7.91
D_3	13.29	13.31	13.30	4.83	4.81	4.82	8.00	8.05	8.03
D_4	12.93	12.97	12.96	4.55	4.74	4.64	7.90	7.60	7.75
S.Em±	0.09	0.12	0.11	0.07	0.07	0.05	0.05	0.04	0.04
CD @5%	0.35	0.35	0.32	0.20	0.20	0.13	0.17	0.12	0.12
Mulching (M)									
T_1	12.78	12.79	12.79	4.59	4.68	4.65	7.78	7.69	7.74
T_2	12.90	12.90	12.90	4.74	4.46	4.60	7.71	7.85	7.78
T_3	12.95	12.81	12.89	4.76	4.87	4.81	7.74	7.55	7.65

S.Em±	0.07	0.10	0.09	0.06	0.06	0.07	0.05	0.04	0.04
CD @5%	NS	NS	NS	NS	0.17	NS	NS	0.10	NS
Interaction									
D_1T_1	12.33	12.35	12.34	4.72	4.31	4.53	7.24	7.64	7.43
D_1T_2	12.54	12.56	12.55	4.90	4.60	4.75	7.27	7.56	7.41
D_1T_3	12.51	12.00	12.25	5.15	5.21	5.19	6.99	6.45	6.73
D_2T_1	12.65	12.65	12.65	4.51	4.41	4.47	7.74	7.83	7.79
D_2T_2	12.88	12.83	12.86	4.52	4.53	4.52	7.96	7.90	7.93
D_2T_3	12.95	12.77	12.86	4.42	4.35	4.39	8.04	7.99	8.02
D_3T_1	13.25	13.25	13.25	4.74	5.03	4.88	8.08	7.80	7.95
D_3T_2	13.33	13.36	13.34	4.57	4.58	4.57	8.32	8.35	8.33
D_3T_3	13.29	13.31	13.30	5.18	4.89	5.02	7.60	8.01	7.80
D_4T_1	12.90	12.90	12.90	4.41	5.01	4.72	8.07	7.48	7.77
D_4T_2	12.84	12.84	12.85	5.16	4.86	5.01	7.29	7.58	7.44
D_4T_3	13.05	13.18	13.12	4.28	5.03	4.66	8.33	7.74	8.03
S.Em±	0.15	0.21	0.19	0.12	0.12	0.10	0.11	0.08	0.07
CD @5%	0.43	0.57	0.32	0.34	0.34	0.28	0.33	0.25	0.21

D1- 2.5 × 2.5 m (1600 plants/ ha)
T_1- Control (un-pruned)
T_3 – current season
D2- 5.0 × 2.5 m (800 plants/ ha)
T_2- previous season growth
D3- 5.0 × 5.0 m (400 plants/ ha)
D4- 7.5 × 5.0 m (267 plants/ ha)

Table 3: Effect of different plant density and pruning seasons on bio-chemical parameters

Treatments	Quality parameters								
	Total Chlorophyll (mg g^{-1})			Carotenoid content (mg g^{-1})			Proline content (µg g-1)		
	Season 1 (2016-17)	Season 2 (2017-18)	Pooled (2016-18)	Season 1 (2016-17)	Season 2 (2017-18)	Pooled (2016-18)	Season 1 (2016-17)	Season 2 (2017-18)	Pooled (2016-18)
Spacing (D)									
D_1	1.16	1.17	1.16	1.56	1.59	1.57	119.64	120.66	120.15
D_2	1.76	1.73	1.74	2.19	2.28	2.24	103.89	103.38	103.62
D_3	1.93	1.94	1.94	2.35	2.44	2.39	107.36	108.53	107.95
D_4	1.91	1.95	1.93	2.60	2.73	2.67	112.76	114.72	113.74
S.Em±	0.04	0.06	0.08	0.09	0.06	0.08	1.12	1.14	0.95
CD @5%	0.13	0.16	0.23	0.26	0.18	0.25	3.36	3.44	2.88
Mulching (M)									
T_1	1.50	1.49	1.50	1.88	2.00	1.94	109.80	110.30	110.04
T_2	1.89	1.90	1.89	2.30	2.38	2.34	110.57	111.18	110.86
T_3	1.68	1.71	1.78	2.35	2.39	2.37	112.37	114.00	113.19
S.Em±	0.03	0.04	0.07	0.07	0.04	0.07	0.85	0.97	0.73
CD @5%	0.10	0.13	0.20	0.21	0.11	0.19	2.55	2.83	2.11
Interaction									
D_1T_1	0.96	0.98	0.97	1.15	1.20	1.17	116.37	118.01	117.16
D_1T_2	1.27	1.26	1.26	1.76	1.77	1.76	121.55	120.73	121.14
D_1T_3	1.25	1.28	1.27	1.77	1.78	1.78	121.83	123.24	122.54
D_2T_1	1.54	1.43	1.48	2.05	2.05	2.05	106.33	104.83	105.58
D_2T_2	2.11	2.08	2.09	2.20	2.28	2.25	101.18	101.33	101.24
D_2T_3	1.62	1.67	1.65	2.33	2.51	2.42	104.17	105.21	104.69
D_3T_1	1.87	1.91	1.90	2.11	2.15	2.13	102.60	101.85	102.22
D_3T_2	2.05	2.04	2.04	2.30	2.53	2.42	108.63	112.17	110.40
D_3T_3	1.88	1.87	1.88	2.63	2.63	2.64	111.79	110.83	111.31
D_4T_1	1.63	1.66	1.65	2.20	2.61	2.41	113.90	115.73	114.82
D_4T_2	2.11	2.19	2.15	2.93	2.95	2.94	111.73	110.67	111.20
D_4T_3	1.98	2.00	1.99	2.66	2.65	2.65	112.63	117.77	115.20
S.Em±	0.06	0.08	0.14	0.16	0.12	0.16	1.68	1.93	1.54
CD @5%	0.17	0.24	0.40	0.48	0.34	0.45	5.11	5.66	4.61

D1- 2.5 × 2.5 m (1600 plants/ ha)
T_1- Control (un-pruned)
T_3 – current season
D2- 5.0 × 2.5 m (800 plants/ ha)
T_2- previous season growth
D3- 5.0 × 5.0 m (400 plants/ ha)
D4- 7.5 × 5.0 m (267 plants/ ha)

Result

Acidity (%)

The pooled data of both the seasons is presented in the Table 1. The highest acidity was recorded in the plants spaced at 7.5 x 5.0 m (0.53%) which was on par with the treatment 5.0 x5.0 m (0.53%), and the lowest acidity was recorded in the plants spaced at 5.0 x 2.5 m (0.47%). Among the different pruning seasons, it showed significant difference with highest acidity in control (0.53%) and the lowest acidity was recorded in the treatment current season growth (0.49%). In interaction, the treatment D_2T_1, D_3T_1, D_4T_1 (0.53%) recorded the highest acidity which was on par with D_3T_1 (0.53%), D_4T_1 (0.53%), D_1T_1 (0.52%), D_3T_3 (0.52%) whereas, the lowest acidity was recorded in the treatment D_2T_2 (0.39%).

Ascorbic acid (mg per 100 gm)

Pooled data of both the seasons is presented in Table 2. The maximum ascorbic acid was recorded in the plants spaced at 7.5 x 5.0 m (39.22 mg per 100 gm) which was on par with the treatment 5.0 x 5.0 m (39.08 mg per 100 gm) and the minimum ascorbic acid was recorded in 2.5 x 2.5 m (36.83 mg per 100 gm). Among the different pruning seasons, the maximum ascorbic acid content was found in plants pruned at season growth (38.47 mg per 100 gm) but it showed non significant effects. In interaction studies, the treatment D_3T_3 (39.39 mg per 100 gm) recorded the maximum ascorbic acid which was on par with D_4T_2 (39.29 mg per 100 gm), D_4T_3 (39.25 mg per 100 gm), D_3T_2 (39.10 mg per 100 gm) whereas, the minimum ascorbic acid was recorded in the treatment D_1T_1 (36.54 mg per 100 gm).

Total soluble solids (^{0}B)

The highest total soluble solids in pooled data at different densities was found highest in 7.5 x 5.0 m (20.39 ^{0}B) which was on par with 5.0 x 5.0 m (20.07 ^{0}B) and the lowest total soluble solids was recorded in the treatment 2.5 x 2.5 m (19.00 ^{0}B). Among the different pruning seasons it showed significant difference with the highest total soluble solids in plants pruned with current season growth (20.91 ^{0}B) and the lowest total soluble solids was recorded in the treatment control (18.75 ^{0}B). In interaction, the treatment D_4T_3 (21.70 ^{0}B) recorded the highest total soluble solids which was on par with D_2T_3 (21.26 ^{0}B), D_3T_3 (21.09 ^{0}B) whereas, the lowest total soluble solids was recorded in the treatment D_1T_1 (18.02 ^{0}B).

Total sugar (%)

Pooled data (2016-18), results of total sugar was found maximum in the spacing 5.0 x 5.0 m (13.30%) which was followed by the spacing 7.5 x 5.0 m (12.96%) and the minimum total sugar was recorded in the treatment 2.5 x 2.5 m (12.38%). In pruning seasons, the maximum total sugar was recorded in the plants pruned with previous season growth (12.90%) but pruning seasons effects were found non significant. Interaction effect between plant densities and pruning showed significant effect under these studies, the treatment D_3T_2 (13.34%) recorded the maximum total sugar which was on par with D_3T_3 (13.30%), D_3T_1 (13.25%), D_4T_3 (13.12%) whereas, the minimum total sugar was recorded in the treatment D_1T_3 (12.25%).

Reducing sugars (%)

Table presented pooled data, the maximum reducing sugars was recorded in the spacing 5.0 x 5.0 m (4.82%) which was on par with the spacing 2.5 x 2.5 m (4.82%) and the minimum reducing sugars was recorded in the treatment 5.0 x 2.5 m (4.46%). Pruning seasons showed non significant effects. The interactive effect of planting densities and pruning seasons had a positive influence, the treatment D_1T_3 (5.19%) recorded the maximum reducing sugars which was on par with D_3T_3 (5.02%), D_4T_2 (5.01%) whereas, the minimum reducing sugars was recorded in the treatment D_2T_3 (4.39%).

Non reducing sugars (%)

Pooled data of both the seasons was recorded in the Table 3. The maximum non reducing sugars (%) was recorded in the spacing 5.0 x 5.0 m (8.03%) which was on par with the spacing 5.0 x 2.5 m (7.91%) and the minimum non reducing sugars was recorded in the treatment 2.5 x 2.5 m (7.19%). Pruning seasons showed non significant effects. In interaction, the treatment D_3T_2 (8.33%) recorded the maximum non reducing sugars which was followed by the treatment D_4T_3 (8.03%) whereas, the minimum non reducing sugars was recorded in the treatment D_1T_3 (6.73%).

Total Chlorophyll (mg g^{-1})

Pooled data (2016-18) of both the seasons showed maximum total chlorophyll in the plants spaced at 5.0 x 5.0 m (1.94 mg g^{-1}) which was on par with the spacing 7.5 x 5.0 m (1.93 mg g^{-1}) and the minimum total Chlorophyll was recorded in 2.5 x 2.5 m (1.16 mg g^{-1}). Among the different pruning seasons, the maximum total chlorophyll was recorded in the plants pruned with previous season growth (1.89 mg g^{-1}) and the minimum total chlorophyll was recorded in control (1.50 mg g^{-1}). The interactive effect of planting densities and pruning seasons had a positive influence the maximum total chlorophyll was recorded in D_4T_2 (2.15 mg g^{-1}) which was on par with the treatment D_2T_2 (2.09 mg g^{-1}), D_3T_2 (2.04 mg g^{-1}) and the minimum total Chlorophyll was recorded in D_1T_1 (0.97 mg g^{-1}).

Carotenoid content (mg g^{-1})

The pooled data of both the seasons (2016-18) revealed the highest carotenoid content in the plant spacing 7.5 x5.0 m (2.67 mg g^{-1}) which was followed by the treatment 5.0 x5.0 m (2.39mg g^{-1}) and the lowest carotenoid content was recorded in 2.5 x 2.5 m (1.57 mg g^{-1}). With respect to different pruning seasons it showed significant difference with the highest carotenoid content in current season growth (2.37 mg g^{-1}) and the lowest carotenoid content was recorded in the treatment control (1.94 mg g^{-1}). In interaction, the treatment D_4T_2 (2.94 mg g^{-1}) recorded the highest carotenoid content which was on par with D_4T_3 (2.65 mg g^{-1}), D_3T_3 (2.64 mg g^{-1}) whereas, the lowest carotenoid content was recorded in the treatment D_1T_1 (1.17 mg g^{-1}).

Proline content (µg g^{-1})

In present investigation the pooled data revealed, the maximum proline content was recorded in the plants spaced at 2.5 x 2.5 m (120.15 µg g^{-1}) which was followed by the spacing 7.5 x 5.0 m (113.74 µg g^{-1}) and the minimum proline content was recorded in the plants spaced at 5.0 x 2.5 m (103.62µg g^{-1}). Among the different pruning seasons, the maximum proline content was recorded in current season growth (113.19 µg g^{-1}) and the minimum proline content was recorded in control (110.04 µg g^{-1}). Whereas in interaction the maximum proline content was recorded in D_1T_3 (122.54 µg g^{-1}) which was on par with the treatment D_1T_2 (121.14 µg g^{-1}) and the minimum proline content was recorded in D_2T_2 (101.24 µg g^{-1}).

Discussion

The interactive effect of spacing and pruning seasons had a positive influence and showed significant effects. In present investigation the highest titratable acidity was found in the spacing 5.0 x 2.5 m, 5.0 x 5.0 m and 7.5 x 5.0 m from un-pruned plants. Plants spaced at 5.0 x 5.0 m with current season growth showed the maximum ascorbic acid content whereas, previous season growth showed the maximum total sugar and non reducing sugars in the same spacing. Plants spaced at 7.5 x 5.0 m with current season growth showed the maximum total soluble solids and 2.5 x 2.5 m with current season growth showed the maximum reducing sugars. In interaction effects pruning in different densities was found to superior than un-pruned plants. This might be due to pruning helped in opening of canopy for better transmission of light and photosynthates accumulation whereas, poor performance of the un-pruned trees may be due to limitations in photosynthesis as reported by Singh *et al.* (2010) [2]. Pruning treatments slightly improved the fruit quality of mango cv. Amrapali (Pratap *et al.,* 2009) [3].

Pruning influenced the bio-chemical parameters in present investigation like, total chlorophyll were found maximum in previous season growth. Current season growth showed maximum carotenoid and proline content. Better performance of fruits from pruned trees in respect of total carotenoid content may be due to the congenial microclimate created through pruning. Vegetative growth also seems to play a similar dual role in contributing to bio-chemical parameters *i.e.* on one hand, by being a source for the energy and on the other, by being a sink for nutrients and other metabolites during the course of fruit development, possibly through the hormonal pathway. Geranylgeranyl diphosphate (GGDP) is the precursor for carotenoids, and the proximity of potassium (K) as a GGDP stimulant has already been established. As stated earlier, quality is a multifactorially-influenced phenomenon and the carotenoid level in fruits might have influenced other factors besides potassium-mediated translocation of photosynthates which was reported by Tachibana *et al.* (1993) [4].

Severe pruning led to the highest leaf chlorophyll *a* content, while moderate pruning enhanced chlorophyll *b* and TC levels in the 'on'-year. This may be due to the fact that pruning resulted in a higher number of young leaves which contained higher levels of chlorophyll *a* and TC (Majumder and Chatterjee, 1972) [5]. Leaf chlorophyll contents increased during the phase of active growth and declined thereafter, with increasing leaf maturity (Singh *et al.,* 2010) [6]. The chlorophyll 'a', 'b' and total chlorophyll contents were more in heavy pruning treatments at vegetative stage in mango cv. Alphonso as reported by Gopu *et al.* (2014) [7].

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