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Influence of high density planting and paclobutrazol on quality and bio chemical parameters of mango (*Mangifera indica* L.) cv. Alphonso

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Abstract
The present study was undertaken to know the effects of high density planting and paclobutrazol 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 of 0.57% and the maximum carotenoid content of 2.87 mg/g was found in the treatment of D_4P_2 (7.5x 5.0 m spacing and Paclobutrazol at 2 ml). The treatment of D_3P_2 (5.0 x 5.0 m spacing with 2 ml paclobutrazol) recorded the maximum ascorbic acid content of 39.42 mg/ 100 gm, reducing sugars of 5.29% and total sugars 13.75%. The TSS was found maximum (21.25 ^{0}B) in the treatment of D_4P_2 (7.5 x 5.0 m spacing with Paclobutrazol at 2 ml) and the Non reducing sugar was found maximum (8.37%) in the treatment of D_3P_1. The treatment D_2P_2 (5.0 x 2.5 m spacing with paclobutrazol at 2 ml) recorded the maximum total chlorophyll of 2.09 mg/g and the Proline content was found in the treatment of D_4P_3 (221.54 µg/g).

Keywords: Paclobutrazol, quality, densities and mango

Introduction
Alphonso mango is one of the most expensive varieties of mango and is grown mainly in the western part of India including Sindhudurg, Ratnagiri and Raigad districts of Maharashtra and in the Konkan region of India. Alphonso is generally referred to as 'Hapus' in Maharashtra and Gujarat, also known as Appus, Badami, Gundu and Khader. It is used to make sweets, candies and smoothies and mango drinks. Fruits are orange-yellow in colour, medium-sized and oval/oblique in shape. The high density planting technology is the most viable proposition to increase the productivity by dwarf tree canopy and for efficient and profitable land use. Its basic function is to confine the exploitation zone of the plant with regard to light, water and nutrients, so that highest total yield potential can be realized in the smallest possible area. The main aim of high density planting is to produce more and more from unit area, from one species, in order to make the venture of tropical fruit production more remunerative and sustainable. It is necessary that the impact of system architecture on bio-physical parameters be closely investigated for various agro-ecological situations. With shrinking land-holdings the future lies only in integrated systems that would lead to stable soil and environment health besides getting maximum useful biomass from unit land.
The first report about the use of paclobutrazol (PBZ) on mango (*Mangifera indica* L.) came from India where Kulkarni (1988) [1] tested concentrations of 1.25 to 10 g a.i. per tree on 'Dashehari' and 'Banganepalli'. PBZ is a synthetic plant growth regulator, which has been used in fruit tree crops to control vegetative growth and to induce flowering (Swietlik and Miller, 1985) [2]. PBZ can be applied to mango trees as a foliar spray or as a soil drench (Tongumpai *et al.*, 1991) [3]. Plant growth retardant induced manipulation in physiological activity has been considered important determinant. Among them, paclobutrazol is considered as one of the important plant growth retardants which restricts vegetative growth and induces flowering in many fruit species including mango (Davenport, 2007) [4]. Excessive vegetative growth is a common characteristic of most of the mango cultivars. Efficacy of PBZ (Cultar) was evaluated for use in restricting vegetative growth and yield. Studies have undertaken to know the effects of high density planting and paclobutrazol on growth and yield of mango cv. Alphonso.

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 Center,

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. Paclobutrazol sprayed at different concentrations like P_1 (control), P_2 (2 ml/ l/ m2 of canopy), P_3 (4 ml/ l/ m2 of canopy), paclobutrazol solution contains 23% W/W SC. 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) and expressed as mg g^{-1} fresh weight.

Table 1: Effect of different plant density and paclobutrazol concentration 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	0.50	0.48	0.49	37.54	37.43	37.49	18.45	18.96	18.71
D_2	0.51	0.45	0.48	38.30	38.66	38.48	18.81	19.05	18.93
D_3	0.51	0.49	0.49	39.29	37.17	38.24	19.26	20.50	19.89
D_4	0.50	0.51	0.51	39.10	36.74	37.92	19.33	21.14	20.23
S.Em±	0.02	0.01	0.02	0.17	0.40	0.21	0.32	0.31	0.22
CD @5%	NS	0.04	NS	0.51	1.17	0.60	NS	0.91	0.66
Mulching (M)									
P_1	0.51	0.44	0.47	38.55	36.33	37.44	18.82	19.52	19.17
P_2	0.56	0.55	0.55	38.94	38.76	38.85	19.61	21.10	20.36
P_3	0.45	0.46	0.45	38.19	37.41	37.80	18.46	19.12	18.79
S.Em±	0.01	0.01	0.02	0.15	0.34	0.18	0.27	0.27	0.19
CD @5%	0.04	0.04	0.07	0.44	1.01	0.52	0.80	0.78	0.57
Interaction									
D_1P_1	0.50	0.43	0.47	37.54	37.32	37.43	18.31	19.32	18.82
D_1P_2	0.54	0.55	0.54	37.95	38.19	38.06	19.20	19.47	19.34
D_1P_3	0.45	0.45	0.46	37.15	36.78	36.97	17.83	18.10	17.99
D_2P_1	0.48	0.34	0.41	38.29	38.29	38.28	18.60	17.32	17.96
D_2P_2	0.56	0.55	0.56	38.61	38.95	38.78	19.57	20.05	19.81
D_2P_3	0.45	0.46	0.46	38.01	38.74	38.38	18.25	19.78	19.01
D_3P_1	0.54	0.49	0.51	39.29	33.54	36.41	19.14	20.17	19.65
D_3P_2	0.54	0.53	0.53	39.70	39.11	39.42	19.88	22.17	21.04
D_3P_3	0.43	0.44	0.44	38.88	38.88	38.88	18.77	19.15	18.96
D_4P_1	0.49	0.48	0.49	39.09	36.18	37.65	19.21	21.28	20.24
D_4P_2	0.56	0.57	0.57	39.49	38.79	39.14	19.80	22.70	21.25
D_4P_3	0.45	0.48	0.46	38.71	35.25	36.99	18.97	19.44	19.21
S.Em±	0.03	0.02	0.04	0.82	0.69	0.36	0.55	0.54	0.39
CD @5%	0.08	0.07	0.11	NS	2.02	1.04	1.24	1.58	1.14

D1- 2.5 × 2.5 m (1600 plants/ ha)
P_1- Control
P_3 – Paclobutrazol at 4 ml D2- 5.0 × 2.5 m (800 plants/ ha)
P_2- paclobutrazol at 2 ml
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 paclobutrazol concentration 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	12.41	12.41	12.41	4.87	4.89	4.89	7.16	7.15	7.15
D_2	12.85	12.86	12.85	5.02	4.93	4.97	7.44	7.53	7.48
D_3	13.43	13.41	13.42	4.98	5.00	4.99	8.02	7.99	8.00
D_4	12.93	13.19	13.06	4.66	4.69	4.68	7.85	8.08	7.96
S.Em±	0.11	0.08	0.08	0.08	0.07	0.04	0.05	0.05	0.06
CD @5%	0.32	0.25	0.25	0.24	0.21	0.13	0.13	0.14	0.17
Mulching (M)									
P_1	12.82	12.79	12.80	4.48	4.40	4.44	7.92	7.97	7.95
P_2	13.19	13.16	13.18	5.08	5.09	5.09	7.70	7.67	7.68
P_3	12.70	12.96	12.83	5.09	5.14	5.12	7.23	7.42	7.32
S.Em±	0.10	0.07	0.07	0.07	0.06	0.04	0.04	0.04	0.05
CD @5%	0.28	0.21	0.22	0.20	0.18	0.11	0.12	0.12	0.15
Interaction									
D_1P_1	12.29	12.31	12.30	4.42	4.31	4.37	7.48	7.60	7.54
D_1P_2	12.50	12.52	12.52	5.04	5.05	5.05	7.10	7.10	7.10
D_1P_3	12.43	12.41	12.42	5.17	5.31	5.25	6.89	6.75	6.82
D_2P_1	12.72	12.75	12.74	4.59	4.34	4.47	7.73	7.99	7.86
D_2P_2	13.28	13.28	13.28	5.17	5.18	5.17	7.70	7.70	7.68
D_2P_3	12.54	12.55	12.55	5.29	5.28	5.28	6.89	6.90	6.90
D_3P_1	13.38	13.33	13.36	4.56	4.55	4.56	8.39	8.34	8.37
D_3P_2	13.75	13.73	13.75	5.30	5.29	5.29	8.02	8.02	8.02
D_3P_3	13.15	13.16	13.16	5.09	5.15	5.11	7.66	7.61	7.63
D_4P_1	12.87	12.77	12.81	4.34	4.39	4.37	8.10	7.97	8.01
D_4P_2	13.23	13.13	13.18	4.82	4.84	4.83	7.99	7.87	7.95
D_4P_3	12.68	13.69	13.19	4.82	4.84	4.83	7.46	8.41	7.93
S.Em±	0.25	0.21	0.15	0.14	0.13	0.12	0.08	0.08	0.10
CD @5%	NS	0.43	0.42	0.41	0.37	0.35	0.24	0.24	0.29

D1- 2.5 × 2.5 m (1600 plants/ ha)
P_1- Control
P_3 – Paclobutrazol at 4 ml
D2- 5.0 × 2.5 m (800 plants/ ha)
P_2- paclobutrazol at 2 ml
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 paclobutrazol concentration on Bio Chemical parameters

Treatments	Bio Chemical 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	1.06	1.09	1.07	1.55	1.56	1.55	153.03	153.22	153.12
D_2	1.54	1.71	1.62	1.95	1.97	1.96	144.41	145.59	144.34
D_3	1.81	1.77	1.79	2.70	2.73	2.72	142.03	142.83	142.44
D_4	1.61	1.64	1.63	2.43	2.41	2.42	159.72	160.45	160.09
S.Em±	0.03	0.05	0.05	0.04	0.06	0.07	1.56	1.30	1.42
CD @5%	0.10	0.15	0.18	0.14	0.19	0.21	4.75	3.83	4.25
Mulching (M)									
P_1	1.52	1.52	1.53	2.23	2.24	2.23	108.30	109.67	108.99
P_2	1.68	1.69	1.68	2.51	2.50	2.51	133.09	134.96	134.02
P_3	1.43	1.46	1.43	1.74	1.75	1.75	208.01	206.94	206.98
S.Em±	0.02	0.03	0.04	0.03	0.05	0.05	1.51	1.13	1.14
CD @5%	0.07	0.11	0.12	0.10	0.15	0.16	4.57	3.31	3.57
Interaction									
D_1P_1	1.07	1.16	1.11	1.71	1.72	1.71	111.39	113.53	112.45
D_1P_2	1.12	1.10	1.11	1.79	1.82	1.81	138.44	140.35	139.39
D_1P_3	0.98	1.00	0.98	1.15	1.13	1.14	209.26	205.78	207.52
D_2P_1	1.59	1.56	1.57	2.06	2.12	2.08	103.33	106.67	105.00
D_2P_2	2.07	2.11	2.09	2.21	2.19	2.20	129.32	133.14	131.23
D_2P_3	1.38	1.46	1.41	1.59	1.61	1.59	200.57	196.97	196.78
D_3P_1	1.85	1.70	1.78	2.58	2.62	2.61	101.70	103.40	102.57
D_3P_2	1.76	1.77	1.77	3.14	3.15	3.15	121.89	123.46	122.68

D_3P_3	1.81	1.86	1.83	2.38	2.42	2.41	202.50	201.63	202.07
D_4P_1	1.60	1.68	1.64	2.55	2.51	2.53	116.78	115.07	115.92
D_4P_2	1.75	1.72	1.74	2.89	2.86	2.87	142.70	142.90	142.79
D_4P_3	1.47	1.52	1.50	1.84	1.86	1.85	219.70	223.37	221.54
S.Em±	0.04	0.04	0.06	0.08	0.07	0.08	2.43	2.31	2.82
CD @5%	0.13	0.15	0.19	0.24	0.22	0.25	7.25	7.11	8.46

D1- 2.5 × 2.5 m (1600 plants/ ha)
P_1- Control
P_3 – Paclobutrazol at 4 ml
D2- 5.0 × 2.5 m (800 plants/ ha)
P_2- paclobutrazol at 2 ml
D3- 5.0 × 5.0 m (400 plants/ ha)
D4- 7.5 × 5.0 m (267 plants/ ha)

Results

Acidity

Pooled data of both the seasons in different plant densities recorded non significant differences. Among the different concentrations of paclobutrazol, the maximum acidity was recorded in the concentration of paclobutrazol at 2 ml (0.55%) and the minimum lowest acidity was recorded in the treatment control (0.44%). Interaction effect between plant densities and paclobutrazol concentrations showed significant effect under these studies, the treatment D_4P_2 (0.57%) recorded maximum acidity which was on par with D_2P_2 (0.56%), D_1P_2 (0.54%), D_3P_2 (0.53%) whereas, the minimum acidity was recorded in the treatment D_2P_1 (0.41%).

Ascorbic acid (mg per 100 gm)

Pooled data of both the seasons recorded in table, the highest ascorbic acid was recorded in spacing 5.0 x 2.5 m (38.48 mg per 100 gm) which was on par with the treatment 5.0 x 5.0 m (38.24 mg per 100 gm) and the lowest ascorbic acid was recorded in 2.5 x 2.5 m (37.49 mg per 100 gm). Among the different concentrations of paclobutrazol, the highest ascorbic acid in paclobutrazol at 2 ml (38.85 mg per 100 gm) and the lowest ascorbic acid was recorded in the treatment control (37.44 mg per 100 gm). In interaction studies, the treatment D_3P_2 (39.42 mg per 100 gm) recorded the highest ascorbic acid which was on par with D_4P_2 (39.14 mg per 100 gm), D_3P_3 (38.88 mg per 100 gm), D_2P_2 (38.78 mg per 100 gm) whereas, the lowest ascorbic acid was recorded in the treatment D_3P_1 (36.41 mg per 100 gm).

Total soluble solids (^{0}B)

The highest total soluble solids in pooled data at different spacing was found highest in 7.5 x 5.0 m (20.23 ^{0}B) and the lowest total soluble solids was recorded in the treatment 2.5 x 2.5 m (18.71 ^{0}B). Different concentrations of paclobutrazol showed significant difference with the highest total soluble solids in the concentration of paclobutrazol at 2 ml (20.36 ^{0}B) and the lowest total soluble solids was recorded in the treatment paclobutrazol at 4 ml (18.79 ^{0}B). In interaction, the treatment D_4P_2 (21.25 ^{0}B) recorded the highest total soluble solids which was on par with D_3P_2 (21.04 ^{0}B), D_4P_1 (20.24 ^{0}B) whereas, the lowest total soluble solids was recorded in the treatment D_2P_1 (17.96 ^{0}B).

Total sugar (%)

Pooled data (2016-18) results of total sugar was found maximum in the spacing 5.0 x 5.0 m (13.42%) which was followed by the spacing 7.5 x 5.0 m (13.06%) and the minimum total sugar was recorded in the treatment 2.5 x 2.5 m (12.41%). Among the different concentrations of paclobutrazol, the maximum total sugar was recorded in the concentration of paclobutrazol at 2 ml (13.18%) and the minimum total sugar was recorded in the treatment control (12.80%). In interaction, the treatment D_3P_2 (13.75%) recorded the maximum total sugar which was on par with D_3P_1 (13.36%), D_3P_1 (13.33%) whereas, the minimum total sugar was recorded in the treatment D_2P_1 (12.30%).

Reducing sugars (%)

In the pooled data, the maximum reducing sugars was recorded in the spacing 5.0 x 5.0 m (4.99%) which was on par with the spacing 5.0 x 2.5 m (4.97%) and the minimum reducing sugars was recorded in the treatment 7.5 x 5 m (4.68%). Among the different concentrations of paclobutrazol, the maximum reducing sugars in the concentration of paclobutrazol at 4 ml (5.12%) which was on par with paclobutrazol at 2 ml (5.09%) and the lowest reducing sugars was recorded in the treatment control (4.44%). In interaction, the treatment D_3P_2 (5.29%) recorded the maximum reducing sugars on par with D_2P_3 (5.28%), D_1P_3 (5.25%) whereas, the minimum reducing sugars was recorded in the treatment D_4P_1 (4.37%).

Non reducing sugars (%)

Pooled data of both the seasons is presented in the Table 1. The maximum non reducing sugars was recorded in the spacing 5.0 x 5.0 m (8.00%) which was on par with the spacing 7.5 x 5.0 m (7.96%) and the minimum non reducing sugars was recorded in the treatment 2.5 x 2.5 m (7.15%). Among the different concentrations of paclobutrazol, the maximum non reducing sugars in control (7.95%) and the minimum non reducing sugars was recorded in the concentration of paclobutrazol at 4 ml (7.32%). In interaction, the treatment D_3P_1 (8.37%) recorded maximum non reducing sugars which was followed by the treatment D_4P_3 (8.03%) whereas, the minimum non reducing sugars was recorded in the treatment D_1P_3 (6.82%).

Total Chlorophyll (mg g^{-1})

In the pooled data of both seasons (2016-18) and it depicted the maximum in the plants spaced at 5.0 x 5.0 m (1.79 mg g^{-1}) which was on par with the spacing 5.0 x 2.5 m (1.70 mg g^{-1}) and the minimum total chlorophyll was recorded in the plants spaced at 2.5 x 2.5 m (1.07 mg g^{-1}). With respect to different concentrations of paclobutrazol, the maximum total chlorophyll was recorded in the concentration paclobutrazol at 2 ml (1.68 mg g^{-1}) and the minimum total chlorophyll was recorded in paclobutrazol at 4 ml (1.43 mg g^{-1}). The interactive effect of spacing and paclobutrazol showed positive effects. The maximum total chlorophyll was recorded in D_2P_2 (2.09 mg g^{-1}) which was followed by the treatment D_3P_3 (1.83 mg g^{-1}) and the minimum total chlorophyll was recorded in D_1P_3 (0.98 mg g^{-1}).

Carotenoid content (mg g^{-1})

Pooled data (2016-18) of both the seasons showed the highest carotenoid content in the plant spacing 5.0 x 5.0 m (2.72 mg g^{-1}) which was followed by the treatment 7.5 x 5.0 m (2.42 mg g^{-1}) and the lowest carotenoid content ratio was recorded in the plants spaced at 2.5 x 2.5 m (1.55 mg g^{-1}). Among the different concentrations of paclobutrazol, the highest carotenoid content in paclobutrazol at 2 ml (2.51 mg g^{-1}) and the lowest carotenoid content was recorded in the treatment paclobutrazol at 4 ml (1.75 mg g^{-1}). In interaction, the treatment D_3P_2 (3.15 mg g^{-1}) recorded the highest carotenoid content which was followed by D_4P_2 (2.87 mg g^{-1}) whereas, the lowest carotenoid content was recorded in the treatment D_1P_3 (1.14 mg g^{-1}).

Proline content (µg g^{-1})

Pooled data revealed the maximum proline content was recorded in the plants spaced at 7.5 x 5.0 m (160.09 µg g^{-1}) which was followed by the spacing the plants spaced at 2.5 x 2.5 m (153.12 µg g^{-1}) and the minimum proline content was recorded in 5.0 x 5.0 m (142.44 µg g^{-1}). With respect to different concentrations of paclobutrazol, the maximum proline content was recorded in the concentration paclobutrazol at 4 ml (206.98 µg g^{-1}) and the minimum proline content was recorded in control (108.99 µg g^{-1}). Whereas in interaction the maximum proline content was recorded in D_4P_3 (221.54 µg g^{-1}) which was followed by the treatment D_1P_3 (207.52 µg g^{-1}) and the minimum proline content was recorded in D_3P_1 (102.57 µg g^{-1}).

Discussion

In the present investigation, different concentrations of paclobutrazol exhibited significant results with respect to quality parameters. Paclobutrazol at 2 ml recorded the maximum titratable acidity, ascorbic acid, total soluble solids and total sugar whereas, paclobutrazol at 4 ml recorded the maximum reducing sugars. The maximum non reducing sugars was recorded in control plants. Among the different concentrations, paclobutrazol 2 ml influenced the quality of fruits. This may be due to the fact that paclobutrazol application might have diverted the mobilization of photo-assimilates to the developing sink created by maturing fruits. Increase in the content of reducing sugars and sucrose by paclobutrazol treatment in mango has been reported by Rahim *et al.* (2011) [5]. Hasan *et al.* (2013) [6] reported that application of paclobutrazol at 6 ml/m of canopy spread in the month of September increased total soluble solids, reducing sugar and vitamin C. This is in confirmity with Sarker and Rahim (2012) [7] and Vijayalakshmi and Srinivasan (2002) [8] in mango cv. Alphonso. The interactive effect of spacing and paclobutrazol had a positive and significant influence on quality of fruits. Plants spaced at 7.5 x 5.0 m with use of paclobutrazol at 2 ml spray recorded the highest titratable acidity and total soluble solids. Plants spaced at 5.0 x 5.0 m with paclobutrazol at 2 ml recorded the highest ascorbic acid, total sugar and reducing sugars whereas, control showed the highest non reducing sugars in same spacing. Paclobutrazol at 2 ml was found effective in all densities this is because paclobutrazol alters the source-sink relationship in plant and it allows proper light distribution in the plants which is a key factor in increasing the quality of fruits and paclobutrazol improved the nutrient uptake and nutrient mobilization towards growing fruits as reported by Burondkar *et al.* (2013) [9]. Higher fruit quality under paclobutrazol treated trees may be attributed to the earliness in flowering which provided higher number of growing days and favoured biomass accumulation in the fruits which finally improved the fruit quality (Reddy *et al.*, 2013) [10]. This is in conformity with Jayavalli *et al.* (2009) [11] in mango cv. Neelum.

Bio-chemical parameters results differed significantly among the treatments. In present investigation bio-chemical parameters like total chlorophyll and carotenoid were found maximum in paclobutrazol at 2 ml spray. The treatment paclobutrazol at 4 ml recorded the maximum proline content whereas, control plants recorded the maximum chlorophyll stability index. This might be due to carotenoids and lycopene are well documented as potent antioxidants thus, their content in the fruit serves as an important phytonutrient descriptor for fruit quality. There are two possible explanations for chlorophyll response, one is that the cells in the leaves of treated trees might be smaller, as paclobutrazol and uniconazole are growth retardant, mainly interfering with the biosynthesis of gibberellin causing inhibition of cell elongation thereby chlorophyll got more concentrated in reduced cell volume. There was an evidence for the other reason that the amount of chlorophyll actually increased because of phytyl, an essential component of chlorophyll molecule which produced via the same terpenoid pathway in mango by Burondkar (2005) [12].

Application of Paclobutrazol significantly increased the total chlorophyll content whereas, the leaves of the treated plants generally have a rich green color (dark), suggesting high chlorophyll content. Paclobutrazol increased the ascorbic acid and total carotenoids have been reported in fruit crops like papaya by Auxcilia *et al.* (2010) [13]

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