J. Hortl. Sci.
Vol. 7(2):134-137, 2012

Effect of Paclobutrazol application on nutrient dynamics, vigour and fruit yield in 'Alphonso' mango (*Mangifera indica* L.)

S.C. Kotur
Division of Soil Science and Agricultural Chemistry
Indian Institute of Horticultural Research, Bangalore - 560 089, India
E-mail: sckotur@gmail.com

ABSTRACT

Application of Paclobutrazol to 22 year-old 'Alphonso' mango trees significantly retarded plant height, plant spread and tree volume. Number of flushes and vigour of emerging new flush also decreased significantly besides production of fewer leaves, reduced leaf area, twig length and dry matter content. Fruit yield increased significantly in trees receiving Paclobutrazol treatment, compared to 'control' trees in all four years of study. This increase was distinctly higher during the on-years 2005 and 2007 by 133% and 77%, respectively, over 'control' due to more profuse flowering and fruit-set. Differences in mineral composition of various tree parts were significant except for N and P content. Paclobutrazol application caused significant increase in Ca, Mg and Mn content in the leaf. Substantial reduction observed in dry matter content and reduced leaf area accompanied by greater removal of nutrients by increased fruit production under Paclobutrazol, application may weaken the tree significantly. The trees would then need proper and adequate nutrient management *vis-à-vis* untreated trees, to achieve sustainable productivity.

Key words: 'Alphonso' mango, *Mangifera indica* L., nutrient dynamics, tree vigour, yield, Paclobutrazol

INTRODUCTION

Paclobutrazol application is recommended as a potent measure to induce regular bearing in 'Alphonso' mango where alternate bearing is an observed phenomenon. Substantial physiological changes in the tree, such as, inhibited growth of meristem, thickened roots and decreased root length are known to be induced by Paclobutrazol ([2RS, 3RS]-1-[-chlorophenyl]-4, -4-dmethyl-2-[1, 2, 4-triazol-1-yl] pent-3-ol) application (Blaike *et al*, 2004). Singh (2000) envisaged Paclobutrazol as the best bet to reduce tree vigour, promote flowering, increase fruit-set and yield in 'Dushehri' mango. Earlier studies on 19-year old productive mango trees during the late rainy season (Kotur, 2006) have shown that active roots substantially bunch towards the trunk and soil-surface with Paclobutrazol application, as against untreated 'control' trees. Therefore, effect of this growth retardant was studied on vigour, fruit yield and nutrient dynamics within a tree in 22-year old 'Alphonso' mango trees.

MATERIAL AND METHODS

'Alphonso' mango (*Mangifera indica* L.) trees were raised under rain-fed condition on a red sandy-loam (Typic Haplustalf) soil having a textural B_t horizon at 20cm+ depth (>41% clay) overlying a loamy layer (11-14% clay). The soil had pH 5.7, organic carbon 0.3%, cation exchange capacity 8.7 cmol(p+)/kg and Bray-I P 20µg/g soil. Of the 40 uniform, productive mango trees, 20 were treated twice with Paclobutrazol @3.75 a.i/tree in 10 concentric holes, 30cm deep at 1.5m distance from the trunk. The first application was in September 2004, and the second in September 2007, when the soil was sufficiently moist. The trees received 800g of N, 200g of P and 700g of K, applied in two equal splits each year in June (pre-monsoon) and September (post-monsoon). Fruit yield was recorded in 10 uniform plants each, from the two set of trees spanning the period 2005 to 2008 in both 'control' and paclobutrazol treated plants. The years 2005 and 2007 were on-years, while 2006 and 2008 were off-years under the alternate-bearing cycle of 'Alphonso' mango trees. Twigs of the new flush were collected from the same trees to record number of flushes and their vigour during July 2007. Height and spread of the tree (east-west and north-south) were recorded in December 2008 in the same trees. Tree volume was calculated assuming the crown to be spheroid. Data were analyzed using Completely Randomized Design, with 10 replications. In another study, four trees each (being replications in a factorial experiment) from two sets of

Table 1. Traits for vigour in 'Alphonso' mango trees influenced by paclobutrazol application

Treatment	Tree height (m)	Tree spread (m)	Tree volume (m^3)	Number of leaves/twig	Length of twig (cm)	Leaf area/ shoot (cm^2)	Dry weight/ shoot (g)	Number of flushes/tree
Control	4.25	7.67	130.93	16	14.4	847	2.43	310
Paclobutrazol	3.58	6.77	84.48	13	11.1	496	1.40	159
SEm (±)	0.140	0.259	9.738	0.4	0.46	46.6	0.087	9.2
CD (*P*=0.05)	0.415	0.769	28.791	1.2	1.35	138.4	0.258	27.2

Table 2. Fruit yield (kg/tree) during on- and off-years in 'Alphonso' mango

Treatment	2005 (on-year)	2006 (off-year)	2007 (on-year)	2008 (off-year)	Mean of on-years	Mean of off-years
Control	79.4	18.6	59.6	35.2	75.6	26.9
Paclobutrazol	185.1	28.0	105.2	54.7	140.3	41.5
SEm (±)	8.60	1.56	6.10	3.17	6.52	1.82
CD (*P*=0.05)	25.54	4.64	18.13	9.41	19.37	5.40

'control' and paclobutrazol-treated trees (being factor-1) were further sampled to monitor nutrient dynamics within a whole plant, in seven parts (from root to leaf, being factor-2) during July 2007. In these trees, samples from root, trunk and the primary branch were drawn using a screw-hole auger. The samples from secondary branch to leaf were collected from a secondary branch that was selected at random and severed from the tree. The branch was separated into secondary, tertiary and quaternary branches, twig and leaf. Representative samples were collected from each separately, washed, dried in a draft air oven for 72h at 70ºC. These were then powdered and analyzed for mineral nutrient content using standard analytical procedures Chapman and Pratt (1961).

RESULTS AND DISCUSSION

Growth and fruit-yield

Growth and twig properties: Application of Paclobutrazol caused significant retardation in tree growth and vigour (Table 1) in terms of plant height, plant spread and tree volume. It also significantly reduced number of flushes and vigour of the new flush. New twigs showed fewer leaves, reduced leaf area, shorter twigs and reduced dry matter. These results are in agreement with reports of Kulkarni (1988) and Kurien and Iyer (1993). The latter workers also observed that the retardant effect of paclobutrazol was superior to that of Cycocel and Alar. In peach (*Prunus persica* L.), Falcon *et al* (1998) observed 40% reduction in leaf area and 29% lower dry matter content under Paclobutrazol treatment.

Fruit yield: Fruit yield increased significantly in all four years of study in trees receiving Paclobutrazol treatment (Table 2). Similar increase in fruit yield has been reported by Kulkarni (1988), Voon *et al* (1991) and Burondkar and Gunjate (1993). The increase, however, was distinctly higher during the on-years 2005 and 2007 (133% and 77% respectively) over 'control' due to more profuse flowering and fruit-set. Mean increase was 86%. During the off-years 2006 and 2008, the corresponding enhancement in fruit yield owing to paclobutrazol application was 51% and 55% respectively over 'control'. Mean increase was 54%

Nutritional composition of the tree

Effect of Paclobutrazol treatment: Differences in nutrient composition in different parts of the mango tree with application of Paclobutrazol compared to untreated 'control' were not significant in respect of N and P (Table 3). Paclobutrazol treated trees showed significantly higher content of K, Ca, S, Mn and Zn, while, 'control' trees showed higher content of Mg, Fe and Cu.

Nutrient content in different parts of mango tree: Earlier studies have been confined to nutrient composition of the leaf (Reiger, 1990; Werner, 1993). In this study, total nutrient content varied widely in different parts of the mango tree and, significantly, in respect of individual nutrients. Four characteristic regions were apparent within a tree (Table 3). Leaf and quaternary branch, among various parts of the tree, showed distinctly higher contents, of most nutrients. Tertiary, secondary and primary branches showed either low or intermediate nutrient content. Trunk contained significantly higher amount of nutrients compared to the tertiary and primary branches. Root, in contrast, showed nutrient content close to that in trunk. Between 'control' and paclobutrazol treated trees, N, P, Fe, Zn and Cu content did not differ significantly, while, Ca, Mg and S content, the

Table 3. Effect of Paclobutrazol on mineral composition of different plant parts in 'Alphonso' trees

Treatment/ Plant part	N(%)	P(%)	K(%)	Ca(%)	Mg(%)	S(%)	Fe (µg/g)	Mn(µg/g)	Zn(µg/g)	Cu(µg/g)
Effect of application of Paclobutrazol										
Control	0.39	0.084	1.03	3.82	1.38	0.04	129	38	11.0	43.0
Paclobutrazol	0.39	0.085	1.02	5.57	0.93	0.06	113	54	13.7	39.1
SEm (±)	0.006	0.0019	0.024	0.121	0.033	0.001	3.6	1.1	0.26	1.35
CD (*P*=0.05)	NS	NS	0.069	0.346	0.094	0.002	10.3	3.2	0.76	3.85
Mineral composition of different parts of the tree										
Leaf	0.49	0.09	0.06	7.00	2.21	0.13	100	135	22.0	5.6
Quaternary branch	0.48	0.18	1.92	5.84	1.02	0.06	53	50	24.8	9.5
Tertiary branch	0.35	0.10	0.86	4.25	0.94	0.03	74	25	8.3	2.6
Secondary branch	0.40	0.05	0.84	3.68	0.77	0.03	63	20	5.9	11.7
Primary branch	0.38	0.05	0.90	3.74	0.87	0.03	99	22	7.3	53.3
Trunk	0.35	0.07	1.04	4.89	1.26	0.03	158	37	10.7	129.6
Root	0.31	0.05	0.90	3.46	0.99	0.03	302	33	7.4	75.1
SEm (±)	0.001	0.004	0.045	0.226	0.061	0.002	6.7	2.1	0.50	2.52
CD (*P*=0.05)	0.031	0.010	0.128	0.648	0.176	0.005	19.3	6.0	1.42	7.20

Table 4. Interaction effect of Paclobutrazol application on mineral composition in different parts of 'Alphonso' mango tree

Plant part	N(%)		P(%)		K(%)		Ca(%)		Mg(%)		S(%)		Fe (µg/g)		Mn(µg/g)		Zn(µg/g)		Cu(µg/g)	
	C	P	C	P	C	P	C	P	C	P	C	P	C	P	C	P	C	P	C	P
Leaf	0.50	0.48	0.10	0.09	1.05	1.07	5.29	8.72	1.64	2.79	0.10	0.16	103	98	113	156	22.2	21.7	6.4	4.8
Quaternary branch	0.43	0.52	0.15	0.21	1.36	2.48	4.52	7.16	1.33	0.71	0.05	0.08	51	54	37	63	20.5	29.1	8.0	11.0
Tertiary branch	0.34	0.35	0.09	0.10	0.70	1.01	3.73	4.77	1.30	0.59	0.03	0.03	80	68	21	30	7.8	8.9	3.0	2.2
Secondary branch	0.39	0.40	0.05	0.06	0.83	0.86	2.80	4.56	1.13	0.43	0.02	0.03	59	67	18	22	5.4	6.5	19.4	4.0
Primary branch	0.36	.41	0.05	0.04	0.98	0.81	2.46	5.03	1.18	0.57	0.02	0.03	130	68	18	27	6.9	7.8	40.7	65.8
Trunk	0.35	0.34	0.09	0.06	1.17	1.51	5.90	3.89	1.65	0.87	0.02	0.04	174	141	29	46	8.2	13.2	92.1	93.1
Root	0.37	0.24	0.07	0.03	1.12	0.68	2.43	4.88	1.43	0.54	0.04	0.01	306	298	33	33	6.4	8.5	131.6	92.5
SEm (±)	0.015		0.005		0.06		0.320		0.087		0.003		9.5		2.9		0.70		3.65	
CD (*P*=0.05)	0.044		0.014		0.181		0.916		0.249		0.007		27.3		8.4		2.01		10.18	

C = Control; P = Paclobutazol application

latter trees showed distinctly higher amount of nutrients in different tree parts. Application of Paclobutrazol caused significantly higher content of Ca, Mg, S, Mn and Zn in our study. Werner (1993) reported increased N, Ca, Mn, Zn and B, and reduced P, K and Cu content, in 'Blanco' mango leaves. In peach, Reiger (1990) noted significant increases in Ca, Mg, B and Mn content with concomitant reduction of N, P, K, Fe and Mo in the leaf. Further, these workers observed that magnitude of these changes was proportional to the degree of growth-suppression.

Interaction effects: Nitrogen and P content was *at par* in 'control' and paclobutrazol treated trees, except in the quaternary branch that showed significantly higher values when Paclobutrazol was applied (Table 4). In the case of K, Ca, Mg and S, Paclobutrazol treated trees showed significantly higher values than 'control' trees in all plant parts.

Paclobutrazol, as a growth retardant, affected the extent of flushing and vigour of trees which, over a period of three years, substantially reduced tree volume and tree biomass. In perennial trees, framework of a tree (consisting of the trunk and branches of different order) serve as a reservoir of energy and nutrients. The current status of foliar, floral and fruit growth is largely dependent on nutrients remobilized from this important reserve of the tree. Significant reduction in the biomass of a permanent part of the tree, therefore, results in a definite reduction of tree vigour, particularly, when the active roots become shrunk and withdrawn towards the trunk and soil surface (Kotur, 2006). In other words, reduced root volume and root activity, in conjunction with reduced leaf area, may limit the quantum of nutrients absorbed by a tree, and also adversely affect photosynthetic activity in a tree. Notwithstanding this, persistent, enhanced fruit yield was observed throughout the four years of this study (2005-2008) due to paclobutrazol treatment, especially, during the on-years (2005 and 2007). This places considerable demand on nutrients removed by the fruits, that add to the overall stress placed on trees. Significant changes in composition of different parts of the tree, due to Paclobutrazol treatment, reflect this condition. Under the circumstances, to maintain high yields in Placlobutrazol-treated mango trees, adequate input of nutrient, irrigation and generally good tree-maintenance is warranted (Voon *et al*, 1991). Since the permanent framework of the tree including trunk and branches of different order play an important role in supplying seasonal growth of leaves, flowers and fruits it is necessary to keep the associated nutrient reserves of the tree well-supplied (Kotur and Keshava Murthy, 2010). To ensure usefulness of application Paclobutrazol (to overcome alternate bearing and sustain fruit yield of mango), there is an imminent need to standardize nutrient management by application of fertilizers close to the trunk (in the zone of high root activity) and, perhaps to apply a higher dose of manures and fertilizers to compensate for nutrients removed by high fruit-yield.

ACKNOWLEDGEMENT

The author is grateful to Director, Indian Institute of Horticultural Research, Bangalore, for providing facilities and to Shri N.K. Kacker, Technical Officer, for technical assistance.

REFERENCES

Burondkar, M.M. and Gunjate, R.T. 1993. Control of vegetative growth and induction of early and regular cropping in 'Alphonso' with paclobutrazol. *Acta Hort.*, **341**:206-215

Chapman, H.D. and Pratt, P.F. 1961. Methods of Analysis for Soils, Plants and Waters. Division of Agricultural Sciences, University of California, The United States of America.

Kotur, S.C. 2006. Effect of paclobutrazol on root activity of mango (*Mangifera indica*). *Ind. J. Agril. Sci.*, **76**:143-144

Kotur, S.C. and Keshavamurthy, S.V. 2010. Nutrient dynamics of annual growth flush in mango (*Mangifera indica*). *J. Hortl. Sci.*, **5**:75-80

Kulkarni, V.J. 1988. Chemical control of tree vigour and promotion of flowering and fruiting in mango (*Mangifera indica* L.) using paclobutrazol. *J. Hortl. Sci.*, **63**:557-566

Kurien, R.M. and Iyer, C.P.A. 1993. Chemical regulation of tree size in mango (*Mangifera indica* L.) cv. Alphonso. I. Effects of growth retardant on vegetative growth and tree vigour. *J. Hortl. Sci.*, **68**:349-354

Singh, S. 2000. Effect of (2RS-3RS) paclobutrazol on tree vigour, flowering, fruit set and yield in mango. *Acta Hort.*, **525**:459-462

Voon, C.H., Pitakpaivan, C. and Tan, S.J. 1991. Mango cropping manipulation with Cultar. *Acta Hort.*, **291**:219-228

Werner, H. 1993. Influence of Paclobutrazol on growth and leaf nutrient content of mango (cv. Blanco). *Acta Hort.*, **341**:225-261

(MS received 13 February 2012, Revised 14 November, 2012)