Effect of chemicals, PGRs and pruning on morpho-physiological parameters in mango under high density planting

D ABITHA[1], S SRINIVASAN[1], M KAVINO[2] and P MAHESWARI[1]

[1]Department of Crop Physiology, [2]Department of Fruit Crops
Tamil Nadu Agricultural University, Coimbatore 641003 Tamil Nadu, India
Email for correspondence: seenu.sp@gmail.com

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ABSTRACT

Investigations on the effect of canopy management in mango (*Mangifera indica* L) cv Alphonso using chemicals, different growth regulators and pruning methods under high density planting were conducted during 2015-2016. The treatments were evaluated in terms of changes in morpho-physiological attributes. Among eight treatments, soil drenching of paclobutrazol registered the lowest canopy diameter and length and highest girth of shoots. The chlorophyll a, b and total chlorophyll contents and SPAD value of the leaves were significantly improved by the application of growth retardants particularly paclobutrazol and chlormequat chloride. Specific leaf weight was markedly improved by the application of growth retardants. Statistically superior soluble protein content and maximum level of total phenolics were observed in paclobutrazol applied trees followed by triple spray of chlormequat chloride at pre-flowering stage (Dec 2015).

Keywords: Mango; canopy management; parameters; paclobutrazol; chlormequat chloride

INTRODUCTION

Mango (*Mangifera indica* L) belongs to the family Anacardiaceae. It is an excellent source of vitamin A and C. India continues to be the largest mango producing country in the world accounting for more than 50 per cent of the world production. India's share is around 52 per cent of world production ie 12 million tons as against world's production of 23 million tons (http://nhb.gov.in/report_files/mango/MANGO. htm). In Tamil Nadu mango is grown in an area of about 1.48 lakh hectares with the production of 896.78 MT. The national average productivity is 6.6 tons per hectare.

Though India is the largest producer of mango in the world but the productivity is only 6.6 tons per hectare as against 30 tons in Israel. The productivity of Tamil Nadu is still lower (4.8 tons per hectare). Though many reasons are attributed for low productivity, poor canopy management is also considered as one of the major limiting factors in mango production. Being a tropical fruit, in India it is seldom pruned or treated with chemical PGRs to regulate the canopy growth and development to achieve better yield and quality of fruits.

Last week of September or first week of October is the best time for applying paclobutrazol in mango trees to check the vegetative growth. Soil applied paclobutrazol absorption is vital but it is critical while the active ingredient may be leached away from the rhizosphere if it coincides with heavy rain which is highly unreliable. Northeast monsoon commences on 5 Oct and the rain may extend till first week of December in Tamil Nadu. Hence reapplication of paclobutrazol is difficult and the reapplication is a costliest management practice too. Therefore there is need to find out an alternate chemical which is suitable for foliar spray or other canopy management practices such as second and tip pruning to get flowering in mango under high density planting. Alphonso can be grown both under conventional and high density planting. Trees under high density planting are more vigorous. The growth regulating chemicals such as chlormequat chloride, TIBA, ethephon and daminozide have been studied widely under conventional planting. Therefore this study was undertaken to study the influence of different growth regulating chemicals and pruning methods on morpho-physiological attributes under high density planting.

MATERIAL and METHODS

The present investigations were undertaken on canopy management in mango (*Mangifera indica* L) cv Alphonso through different growth regulators and pruning methods under high density planting during the year 2015-2016. The study was carried out in a farmer's field located at Petathapuram, near Karamadai, Coimbatore, Tamil Nadu. Uniform and five-year-old Alphonso mango trees were selected for the study. The experiment was laid out in a randomized block design having eight treatments and five replications. Each replication consisted of five trees. The trial was laid out on trees spaced at 5 x 5 m.

Treatments used were T_1 (Control), T_2 (Soil drenching with paclobutrazol 2.5 ml/m of canopy diameter), T_3 (Foliar spray of chlormequat chloride 6,000 ppm), T_4 (Foliar spray of TIBA 500 ppm), T_5 (Foliar spray of ethephon 2,000 ppm), T_6 (Foliar spray of daminozide 2,500 ppm), T_7 (Second pruning at pre-flowering) and T_8 (T_7 + tip pruning). The soil application of paclobutrazol @ 2.5 ml/m of canopy diameter was given on 29 Sep 2015. The required quantity of paclobutrazol was dissolved in water (1 ml/litre) and poured in small holes (10-15 cm deep) around the collar region as has also been suggested by Burondkar and Gunjate (1993).

The foliar sprays were given once in thirty days from the last week of Sep 2015. Totally three sprays were given in the morning hours using hand sprayer. The trees were well irrigated before the application of growth regulators and were given complete wetting. First pruning that is total removal of past season's growth was done after the harvest (Jul 2015). Second pruning was done in the middle of Dec 2015. Crowded and inward growing branches were removed to open up the canopy to facilitate the penetration of sunlight as well as aeration. This was done to remove the vegetative flush just prior to flowering. Trees under this treatment received two extra irrigations just before flowering in order to induce vegetative flush and later the young flushes were cut back.

The results of the present investigations are presented in different sectors viz morpho-physiological attributes and biochemical constituents. The study comprised laboratory experimentation as well as field studies on the existing trees. The data related to field and laboratory investigations were subjected to statistical scrutiny.

RESULTS and DISCUSSION

Tree height: Commercial orchards must maintain control of both tree size and orchard productivity in order to remain productive (Davenport 2006). The maintenance of optimum tree height in any crop is highly essential to make harvest and other cultural operations easier. In the present study the tree height after the imposition of treatments was recorded and highest tree height was registered in untreated trees followed by T_7 (Second pruning at pre-flowering) and T_8 (T_7 + tip pruning).

The lowest tree height was observed in trees treated with paclobutrazol (181.4 cm) followed by the treatment T_3 (Foliar spray of chlormequat chloride 6,000 ppm) (197.5 cm) as shown in Table 1. The application of growth regulators (inhibitors) has a suppressive effect on plant height in mango. Soil drenching of paclobutrazol displayed a quicker and stronger inhibition effect compared with other growth regulators or pruning methods. Foliar application of growth regulators also significantly reduced the tree height.

Canopy diameter: In the present investigations the tree spread at the time of flowering (Jan 2015) was found to be the highest in control (242.4 cm) closely followed by the treatments T_7 (240.2 cm) and T_8 and the lowest in paclobutrazol applied trees (T_2: Soil drenching with paclobutrazol 2.5 ml/m of canopy diameter) (188.8 cm) followed by chlormequat chloride applied trees (Table 1). It might be due to the fact that growth inhibitors markedly inhibited the length of new shoot thereby decreased the canopy diameter. Application of growth retardants ensures the bud dormancy to certain extent. This is in accordance with the work of Lal and Mishra (2008) in mango, Kumar and Rattanpal (2010) and Pilania et al (2010) in guava. Maintenance of optimum canopy size and shape is very essential for better productivity. Canopy diameter which decides the fruiting area of trees is an important trait for fruit trees like mango.

Specific leaf weight (SLW): SLW is highly correlated with development of reproductive organ namely flower and ultimately yield (Arnon 1975). Saxena et al (1978) viewed that the higher SLW might be related to higher cell surface to volume ratio.

In the present study all the growth regulators improved the SLW. Soil application of paclobutrazol (T_2) was able to enhance the SLW positively as

Table 1. Effect of different growth regulators and pruning methods on tree height and canopy diameter

Treatment	Tree height (cm)	Canopy diameter (cm)
T_1: Control	242.0	242.4
T_2: Paclobutrazol 2.5 ml/m	181.4	188.8
T_3: Chlormequat chloride 6,000 ppm	197.5	200.4
T_4: TIBA 500 ppm	198.9	207.2
T_5: Ethephon 2,000 ppm	199.6	210.1
T_6: Daminozide 2,500 ppm	201.7	212.3
T_7: Pre-flowering pruning	227.1	240.2
T_8: T_7 + tip pruning	218.8	230.2
Mean	212.3	193.1
SEd	0.33	0.028
	4.78	0.058

T_1: Control, T_2: Soil drenching with paclobutrazol 2.5 ml/m of canopy diameter, T_3: Foliar spray of chlormequat chloride 6,000 ppm, T_4: Foliar spray of TIBA 500 ppm, T_5: Foliar spray of ethephon 2,000 ppm, T_6: Foliar spray of daminozide 2,500 ppm, T_7: Second pruning at pre-flowering, T_8: T_7 + tip pruning

recorded in December 2015. Same results were reported by Sankhla et al (1985) on soybean and sugarbeet. In Dec 2015 the highest or statistically superior SLW of 3.36 mg/cm was observed in paclobutrazol applied trees (T_1) while the lowest value was recorded in T_8 (1.75 mg/cm) followed by T_1 (1.80 mg/cm). Significant difference was found among treatments.

Increased SLW by the application of paclobutrazol and chlormequat chloride was also reported by Kulkarni (1993). That the application of ethylene increases the SLW was confirmed by Shinde and Jadhav (1995). In control, T_7 and T_8 the SLW was lowered whenever there was rain at the experimental site (Nov 2015, Fig 1a).

Effect of different growth regulators and pruning methods on biochemical constituents

Chlorophyll pigment content of crop can be quantified either calorimetrically or photometrically and the photometric estimation of chlorophyll is expressed in terms of SPAD value. Higher value directly related to the higher chlorophyll content and SPAD value is a direct estimation of chlorophyll content which is considered as one of the important pigments in deciding the fixation of atmospheric carbon dioxide as it is considered as one of the important metabolic events which in turn regulates other metabolic processes in crop plants. The flowering process in mango is largely dependent on availability of metabolites which are mainly used by developing flowers/buds and availability of metabolite is a function of photosynthetic product. The chlorophyll content plays a major role in stimulating flowering process in crops like mango.

Chlorophyll a: There were significant differences among treatments in all months except in Sep 2015 related to chlorophyll a content. There was increasing trend in chlorophyll a content from Sep 2015 to Jan 2016 in the treatments T_2, T_3, T_4, T_5 and T_6. In T_1, T_7, and T_8 the chlorophyll a content increased till Oct 2015 and in Nov 2015 it got declined. Again it increased in Dec 2015 and Jan 2016. The least content was recorded in T_1 (0.942 mg/g) followed by T_8 (1.028 mg/g). The treatment T_2 was found to be significantly superior to other treatments in chlorophyll a content registering a value of 1.657 mg/g in Dec 2016 followed by chlormequat chloride (T_3), T_5 and T_6. The least content was recorded in T_1 (0.942 mg/g) followed by T_8 (1.028 mg/g).

Chlorophyll b: The same trend was followed in chlorophyll b also. Significant differences were observed among treatments in all the months. The treatment T_2 (paculobutrazol) was found to be significantly superior to other treatments in chlorophyll b content registering a value of 0.659 mg/g in Dec 2015 followed by T_3, T_4, T_5 and T_6. The least content was recorded in T_1 (0.376 mg/g) followed by T_8 (0.381 mg/g) in Dec 2015.

Total chlorophyll: The total chlorophyll content represents the assimilating power of the leaves. In Dec 2015 the highest or statistically superior total chlorophyll content of 2.46 mg/g was observed in paclobutrazol applied trees (T_2) followed by chlormequat chloride (T_3, 1.95 mg/g) while the lowest value was registered in the treatment T_8 (1.42 mg/g) followed by T_1 (1.41 mg/g). Significant differences were found among

Table 2. Effect of different growth regulators and pruning methods on SPAD value

Treatment	September 2015	October 2015	November 2015	December 2015	January 2016
T_1: Control	34.2	36.3	32.3	33.1	33.2
T_2: Paclobutrazol 2.5 ml/m	34.1	47.2	56.2	58.2	52.4
T_3: Chlormequat chloride 6,000 ppm	33.4	40.2	44.1	46.4	46.8
T_4: TIBA 500 ppm	35.2	39.1	41.4	42.3	42.9
T_5: Ethephon 2,000 ppm	33.2	37.4	39.1	41.2	42.1
T_6: Daminozide 2,500 ppm	33.3	39.2	40.2	40.2	42.2
T_7: Pre-flowering pruning	34.1	36.3	34.4	35.3	41.4
T_8: T_7 + tip pruning	34.8	36.2	33.2	36.4	34.3
Mean	33.7	38.7	39.87	41.75	41.51
SEd	0.42	0.45	0.48	0.40	0.46
$CD_{0.05}$	0.87	0.92	0.98	0.83	0.94

T_1: Control, T_2: Soil drenching with paclobutrazol 2.5 ml/m of canopy diameter, T_3: Foliar spray of chlormequat chloride 6,000 ppm, T_4: Foliar spray of TIBA 500 ppm, T_5: Foliar spray of ethephon 2,000 ppm, T_6: Foliar spray of daminozide 2,500 ppm, T_7: Second pruning at pre-flowering, T_8: T_7 + tip pruning

Table 3. Effect of different growth regulators and pruning methods on total phenolics (mg/g)

Treatment	September 2015	October 2015	November 2015	December 2015	January 2016
T_1: Control	6.81	7.21	6.41	6.61	6.73
T_2: Paclobutrazol 2.5 ml/m	6.82	9.42	11.21	11.6	10.42
T_3: Chlormequat chloride 6,000 ppm	6.64	8.13	8.84	9.24	9.21
T_4: TIBA 500 ppm	7.17	7.81	8.22	8.41	8.53
T_5: Ethephon 2,000 ppm	6.63	7.42	7.81	8.21	8.42
T_6: Daminozide 2,500 ppm	6.62	7.84	8.12	8.21	8.41
T_7: Pre-flowering pruning	6.81	7.21	6.81	7.11	8.21
T_8: T_7 + tip pruning	6.82	7.22	6.62	7.22	6.84
Mean	6.75	7.75	7.97	8.27	8.32
SEd	0.08	0.07	0.08	0.71	0.10
$CD_{0.05}$	0.18	0.15	0.18	1.47	0.21

T_1: Control, T_2: Soil drenching with paclobutrazol 2.5 ml/m of canopy diameter, T_3: Foliar spray of chlormequat chloride 6,000 ppm, T_4: Foliar spray of TIBA 500 ppm, T_5: Foliar spray of ethephon 2,000 ppm, T_6: Foliar spray of daminozide 2,500 ppm, T_7: Second pruning at pre-flowering, T_8: T_7 + tip pruning

treatments (Fig 1b). Chlorophyll a, b and total chlorophyll contents were found to be higher in the trees treated with paclobutrazol followed by chlormequat chloride. Wang and Steffens (1985) and Elfving and Proctor (1986) also reported that increase in the chlorophyll content might be the result of accelerated or prolonged synthesis or a delay in breakdown of the pigment.

SPAD value: The SPAD value represents the assimilating power of the leaves (Table 2). Highest SPAD values were recorded in different months in trees treated with paclobutrazol (T_2, 58.2 mg/g) followed by chlormequat chloride (T_3, 46.4 mg/g) which indicates that paclobutrazol and other growth suppressors not only reduce the excess vegetative growth but also increase the chlorophyll content thereby SPAD value which might have increased photosynthetic efficacy of crop resulting in more flowering and fruiting. Naidu and Swamy (1995) also recorded similar results.

Soluble protein: The estimation of soluble protein content is considered as an indirect measure of RuBP carboxylase enzyme activity, a prime enzyme of carbon fixation in photosynthesis. The RuBP carboxylase enzyme is found relatively at higher concentration in soluble protein fraction of leaves. The role of soluble protein in mango cannot be under-estimated. The photosynthetic efficiency of the crop is a combined efficiency of both chlorophyll content and enzyme activity.

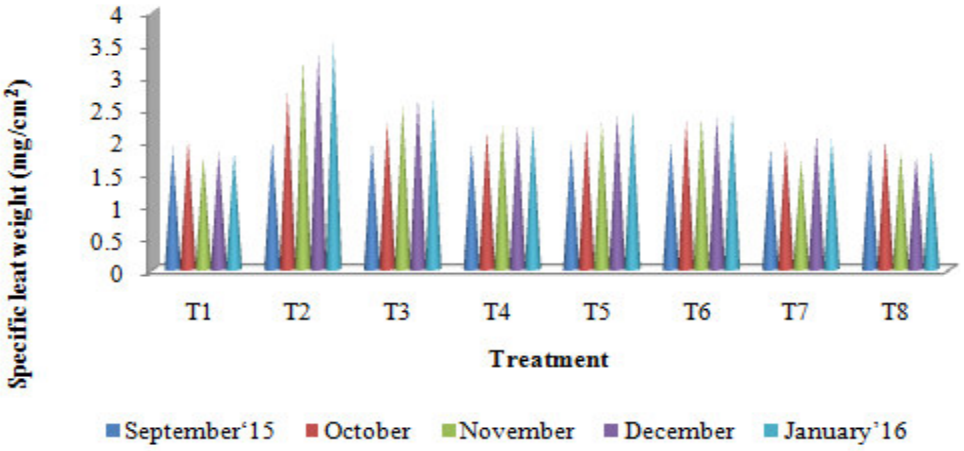

Fig 1a. Effect of different growth regulators and pruning methods on specific leaf weight (mg/cm)

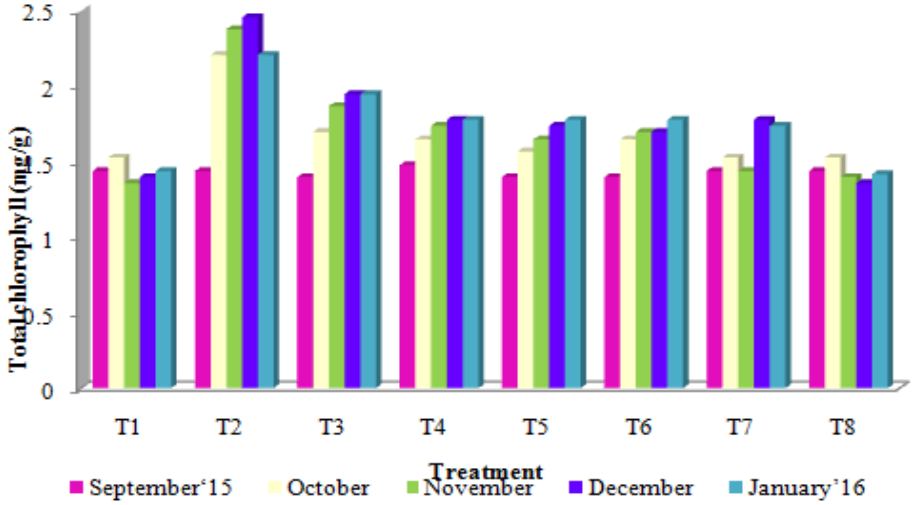

Fig 1b. Effect of different growth regulators and pruning methods on total chlorophyll (mg/g)

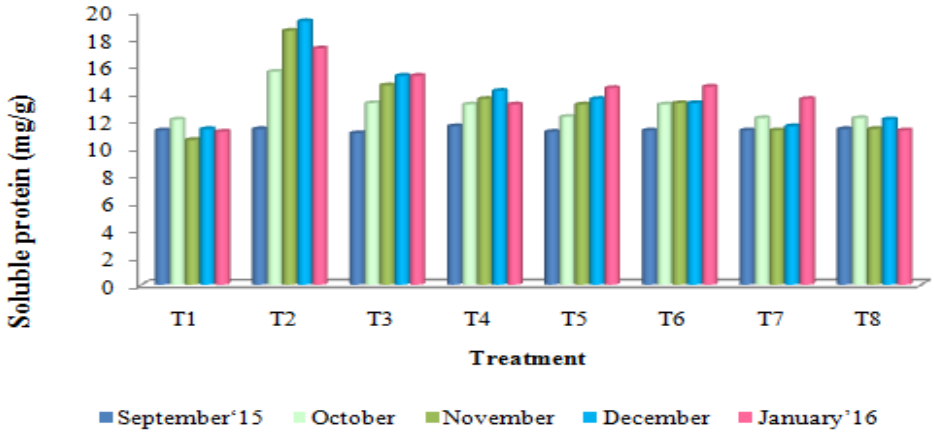

Fig 1c. Effect of different growth regulators and pruning methods on soluble protein (mg/g)

T_1: Control, T_2: Soil drenching with paclobutrazol 2.5 ml/m of canopy diameter, T_3: Foliar spray of chlormequat chloride 6,000 ppm, T_4: Foliar spray of TIBA 500 ppm, T_5: Foliar spray of ethephon 2,000 ppm, T_6: Foliar spray of daminozide 2,500 ppm, T_7: Second pruning at pre-flowering, T_8: T_7 + tip pruning

The soluble protein was noticed increasing till Dec 2015 and in Jan 2016 it decreased irrespective of treatments except in the treatment T_7. In this treatment the soluble protein content increased to 13.6 mg/g in Jan 2016 from 11.6 mg/g in Dec 2015 (Fig 1c). The treatment registered higher soluble protein in the month of Dec (19.3 mg/g) in T_2 followed by T_3 and lowest value was registered in the treatment T_7 (11.6 mg/g) followed by T_8 (12.8 mg/g). Thus the foliar spray of different growth regulators significantly increased the soluble protein content.

Total phenolics: The total phenol content of plant parts as a product of secondary metabolites plays a constructive role in protecting the crop from pests and diseases mainly besides augmenting in some of the internal metabolic processes and thereby regulates the growth process.

The higher phenol content of the leaves in paclobutrazol applied trees and the suppressed vegetative growth could be possible due to reduction in internodal elongation by indirectly preventing the biosynthesis of gibberellins and also due to more accumulation of phenol.

The phenolic content of mango leaf showed an increasing trend from vegetative (Sep 2015) stage to pre-flowering (Dec 2015) stage. Among the treatments paclobutrazol received trees reached a maximum level of total phenolics (11.60 mg/g) in Dec 2015 followed by chlormequat chloride (T_3, 9.24 mg/g) and T_4 (8.41 mg/g). Minimum level of total phenolics was noticed in control (6.61 mg/g) followed by T_8 (Table 3). A similar trend of results was reported by Singh and Sharma (2008).

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