J. Agr. Sci. Tech. (2014) Vol. 16: 385-393

Vegetative and Reproductive Development of 'Ataulfo' Mango under Pruning and Paclobutrazol Management

D. A. García De Niz[1], G. L. Esquivel[2*], R. B. Montoya[2], B. G. Arrieta Ramos[2], G. A. Santiago[2], J. R. Gómez Aguilar[2], and A. R. Sao José[3]

ABSTRACT

Pruning of the plant canopy and paclobutrazol application to the root zone are agronomic practices that improve harvest yield in mango (*Mangifera indica* L.) orchards. To assess the effect of pruning and paclobutrazol treatment on the vegetative and reproductive development of 'Ataulfo' mango, three pruning dates (20 April, 20 May, and 20 June) and three concentrations of paclobutrazol (PBZ) (7.5, 11.25, and 15 mL of active ingredient) were used. While control trees presented only one vegetative growth during the productive cycle, trees that were pruned and treated with PBZ had up to three vegetative growth cycles before flowering, regardless of whether pruning occurred in April, May, or June. The number of vegetative shoots and inflorescences (m^{-2}) were equal when trees were pruned and PBZ was applied. When pruning was performed in April or May, the time of harvest occurred 28 days earlier compared to the control. Pruning in April numerically resulted in the greatest production efficiency (7-11 kg m^{-2}). For all the three pruning dates, fruit production of trees treated with PBZ and pruning was from 38 to 98 kg; these values were always less than those obtained for the control trees. The greatest incidence of seedless fruits (57-80%) occurred when pruning was performed in June.

Keywords*:* Fruit growth flowering, Forced production, Growth inhibitor, Seedless fruit.

INTRODUCTION

The most critical problems affecting 'Ataulfo' mango (*Mangifera indica* L.) cultivation in Mexico are the marked seasonality of the harvest, typically in May and June; the high incidence of parthenocarpy in 'Ataulfo' mango; and the limited technology available for advancing or delaying the time of harvest.

Mango undergoes one to three vegetative growth cycles each year, depending on the cultivar, tree age, nutrition, relative humidity and night-time and daytime temperatures (Davenport, 2007), however, in 'Ataulfo' pruning can improve twice vegetative growth (Vázquez-Valdivia *et al*., 2009). Flowering occurs after the period of vegetative development and shoot maturation (shoot achieved from four to five months) (Davenport, 2003). Each vegetative growth cycle ranges from 3 to 6 weeks. Increases in shoot length and diameter occur during the first 2 weeks, and the completion of shoot maturation 1-2 months thereafter (Ramírez and Davenport, 2010). Reproductive growth occurs on mature shoots once a year, but this type of growth can occur at different times on the same tree (Ramírez, *et al*., 2010a)

The technologies available for advancing or delaying harvest are pruning, growth

[1] Post degree on Agricultural, Biological and Fisheries Sciences, Autonomous University of Nayarit, Km 9, Tepic-Compostela Highway, Xalisco Nayarit. Mexico. P.C. 63780

[2] Agriculture Academic Unit, Autonomous University of Nayarit, Km 9, Tepic-Compostela Highway, Xalisco Nayarit. P. C. 63780, Mexico.

[*] Corresponding author: e-mail: gollole@hotmail.com

[3] State University of Southwest Bahia, Bem Querer Road, Km 4, P.C. 95, CEP 45.100-000, Vitória da Conquista, Bahia Brazil.

[DOR: 20.1001.1.16807073.2014.16.2.6.2]

regulators, trunk ringing, hydric stress, irrigation, nutrition, and age of the last flush (Ramírez *et al.*, 2010b). Pruning is commonly used in fruit trees, with the goal of controlling growth and stimulating the formation of vegetative and reproductive shoots. In mango, pruning is also useful for removing diseased branches, defining tree structure, inducing early flowering, increasing second-cycle yield and improving fruit quality (Davenport, 2006; Yeshitela *et al.*, 2005; Gil *et al.*, 1998).

Paclobutrazol (PBZ) is a growth regulator that inhibits gibberellin biosynthesis and blocks the oxidation reactions of kaurene to kaurenic acid, a precursor of gibberellin synthesis (do Carmo and Silva, 2005; Mansuroglu *et al.*, 2009; Ruíz *et al.*, 2003; Villa-Ruano *et al.*, 2010). In mango, PBZ reduces vegetative shoot formation, promotes early flowering, increases flowering, increase the number of set fruit, decreases alternate bearing, increases yield, and advances harvest from 45 to 51 days in *cv*s. Tommy Atkins and Manila (Avilán *et al.*, 2005; Avilán *et al.*, 2008; do Carmo and Silva, 2005; Fonseca *et al.*, 2005; Jamalian *et al.*, 2008; Mansuroglu *et al.*, 2009; Nguyen and Nguyen, 2005; Silva *et al.*, 2007; Yeshitela *et al.*, 2004). In 'Ataulfo' mango, an advancement of the harvest of up to 30 days was previously reported (Vázquez-Valdivia *et al.*, 2009). In studies investigating 'Tommy Atkins', 'Manila', 'Haden', 'Springfels', 'Edward' and 'Ataulfo' mango, the PBZ application doses ranged from 1 to 2 g of ai m^{-2} of canopy diameter (Avilán *et al.*, 2008; Cárdenas and Rojas, 2003; do Carmo and Silva, 2005; Fonseca *et al.*, 2005; Nguyen and Nguyen, 2005; Silva *et al.*, 2007; Yeshitela *et al.*, 2004). The objective of this study was to evaluate the effect of PBZ application and the date of pruning on the vegetative and reproductive development of 'Ataulfo' mango.

MATERIALS AND METHODS

The study was conducted using 20-year-old 'Ataulfo' mango trees with native *Mangifera indica* L as rootstock, 10 and 12 m in height and diameter, respectively, planting distance of 10×10 m, located in the Huaristemba municipality of San Blas, Nayarit, Mexico. The altitude of the site is 14 m, and the geographic coordinates are 21° 40' 51.45" N latitude and 105° 11' 25.32" W longitude. The climate at the site is hot and humid (22.61°C and 85.82% annual average) with an annual precipitation of 1,300 mm (National Institute for Federalism and Municipal Development, State Government of Nayarit, 2009). The study was conducted during the 2010-2011 production cycle. Before the experiment was conducted, the soil was sampled and analyzed to determine its characteristics and to devise the appropriate nutrition program. The soil had a clay texture, a pH of 7.4, and an electrical conductivity (EC) of 0.1 dS m^{-1}. Trees were irrigated by flooding system once per month beginning from November until one month before harvest.

The three pruning dates that were investigated were April 20, May 20, and June 20. On each of these dates, three PBZ concentrations were tested: 7.48, 11.2 and 14.96 g ai (PBZ). The control condition was no pruning and no PBZ. There were six replicates for each treatment with one tree per replicate. For pruning, fruits from the cycle and intercrossed branches were removed (April and May pruning fruit was in growing stage, in June pruning fruit was in physiological maturation stage) and the canopy was reduced to a height of 4.5 m. Forty-one days after pruning, 500 mL of PBZ suspension was applied at each cardinal point at a depth of 15 cm and 1.5 m from the tree base. The temperature and relative humidity were recorded with HOBO® Pro v2 equipment at 30-minute intervals. The vegetative stage variables were vegetative shoots m^{-2}, number of vegetative growths per shoot and vegetative growth vigor. For each of these variables, measurements were made at four shoots located at each cardinal point for each tree until the floral shoots developed. The reproductive stage variables were number of inflorescences m^{-2}; flowering-to-harvest period, determined using the scale proposed by Yeshitela *et al.* (2003); and number of set fruit m^{-2}. These variables were quantified at aheight of 2.5 m from the canopy. The following variables were also quantified: productive efficiency in kg m^{-2}, using the method proposed by Medina-Urritia *et al.* (2007); incidence of fruit without seed; incidence of non-commercial mango; and production per tree. A completely randomized statistical design was used. Analysis of variance and a test for comparison of means (Tukey's test, P≤ 0.05) were performed using the SAS® program 9.2.

RESULTS AND DISCUSSION

Number of Vegetative Shoots m^{-2}

For all three pruning dates, a greater number of vegetative shoots m^{-2} was observed on trees treated with PBZ. For the treatment condition and the untreated control, the values were approximately 6.0 and 3.5 vegetative shoots m^{-2}, respectively (Table 1). For the pruning in May, no significant differences were observed among the different PBZ concentrations. Similar results were reported by Pavone *et al.* (2008), who applied pruning and PBZ to 'Tommy Atkins' mango. Although these researchers observed an increase in the number of vegetative shoots that emerged, this difference is attributable to pruning rather than PBZ. Davenport (2003) indicates that vegetative shoot number is related to tree age, high nitrogen level, and water abundance.

Number of Vegetative Growths per Shoot

The control trees underwent only one vegetative growth cycle (Table 1). When the pruning was conducted in April, the number of vegetative growths per shoot decreased from 2.33 to 1.5 as the PBZ dose increased. This trend was not observed when the pruning was conducted in May or June, and the results for all PBZ concentrations were statistically equal. One explanation for this result is that the shoots had less time to grow when pruning was conducted earlier in the growth season. In a study on 'Zebda' mango, Shaban (2009) concluded that severe pruning treatments significantly increased the number of new growths per shoot and that high PBZ doses decreased shoot length and diameter. According to Vázquez and Pérez (2006) and Yeshitela *et al.* (2004), 'Ataulfo' mango shoot can be considered potentially reproductive when it contains one or more vegetative growths and an apical leaf bud. Davenport (2007) reported that one or more vegetative growths can occur naturally on individual shoots each year, depending on the cultivar, tree age, and climatic conditions.

Vigor of Vegetative Growths

For the April pruning, the vigor of the first growth cycle was statistically equal to that of the control (diameter and length). However, for the May and June pruning, the growth of the control trees was more vigorous than that of PBZ-treated trees with significantly greater values for shoot diameter, and length and number of leaves (Table 1). This result can be attributed to the fact that the treated trees underwent more vegetative growth cycles than the control trees. Yeshitela *et al.* (2004) reported similar results for the number of leaves: as the concentration of PBZ increased, the number of leaves decreased. Shaban (2009) suggested that this behavior was due specifically to the effect of PBZ as a gibberellin synthesis inhibitor rather than the effect of pruning.

Number of Inflorescences m^{-2}

The greatest number of inflorescences was observed when pruning was performed in April (6.31 m^{-2}), although the results indicated no significant difference. Compared to the control, the PBZ treatments

[DOR: 20.1001.1.16807073.2014.16.2.6.2]

Table 1. Number of shoots, number of growths, and vigor of vegetative growths (diameter [mm], length [cm] and number of leaves) of 'Ataulfo' mango trees on the three pruning dates with three doses of PBZ.[a]

Pruning date	PBZ g ai	Shoots m^{-2}	Growths per shoot	First growth			Second growth			Third growth		
				D	L	H	D	L	H	D	L	H
A	0	3.58 b	1.00 c	10.7 a	26.9 a	18.2 a	0.0 b	0.0 b	0.0 b	0.0 b	0.0 b	0.0 b
	7.5	6.53 a	2.33 a	11.7 a	27.8 a	10.9 b	11.4 a	29.7 a	7.2 a	10.6 a	29.0 a	15.7 a
	11.2	6.73a	1.83 ab	10.6 a	24.7 a	10.3 b	7.2 a	15.2 ab	11.8 a	6.1 ab	17.0 ab	10.0 ab
	15.0	6.40 a	1.50 b	10.0 a	24.6 a	10.6 b	8.5 a	22.1 a	13.3 a	1.9 b	3.7 b	2.5 b
	CV	22.69	5.69	10.28	13.45	18.47	59.3	70.53	72.36	118.02	116.36	118.24
	P> F	0.0013	0.0003	0.1086	0.3958	0.0001	0.0001	0.0001	0.0001	0.0009	0.0005	0.0010
M	0	3.58 b	1.0 a	10.7 a	26.9 a	18.2 a	0.0 b	0.00 b	0.0 b	0.0 a	0.0 a	0.0 a
	7.5	4.81 ab	1.66 a	9.6 ab	20.5 abc	11.0 b	8.1 a	19.5 a	13.6 a	1.6 a	3.5 a	2.8 a
	11.2	5.73 ab	1.83 a	8.9 ab	18.0 c	10.1 b	6.0 a	12.5 a	10.1 a	1.7 a	5.0 a	3.5 a
	15.0	6.56 a	1.83 a	8.6 b	20.2 bc	9.5 b	9.8 a	21.8 a	16.2 a	3.7 a	9.0 a	5.7 a
	CV	27.95	24.46	10.87	17.45	21.28	58.34	64.06	65.87	258.76	263.19	272.03
	P> F	0.0122	0.0035	0.0073	0.0028	0.0001	0.0001	0.0001	0.0001	0.3944	0.4223	0.5187
J	0	3.58 b	1.00 b	10.7 a	26.9 a	18.2 a	0.0 b	0.00 b	0.0 b	0.0 a	0.0 a	0.0 a
	7.5	6.88 a	1.66 ab	7.6 b	17.4 b	8.0 b	6.5 a	12.1 ab	11.4 a	1.2 a	2.5 a	1.8 a
	11.2	6.78 a	1.83 a	8.4 b	21.2 ab	8.6 b	5.8 a	8.8 ab	9.6 ab	4.7 a	11.5 a	8.4 a
	15.0	6.36 a	1.83 a	8.2 b	23.6 ab	9.0 b	6.2 a	12.6 a	11.8 a	3.0 a	8.5 a	5.8 a
	CV	24.36	31.57	10.28	19.02	21.42	89.67	107.68	99.56	191.27	203.50	197.58
	P> F	0.0020	0.0269	0.0001	0.0079	0.0001	0.0012	0.0066	0.0036	0.1014	0.1319	0.1112

[a] Means with the same letter within a column are not significantly different (Tukey's test, P≤ 0.05). CV= Coefficient of Variation; D= Diameter; L= Length; H= number of leaves; A= 20 April; M= 20 May, and J= 20 June.

resulted in at least two additional inflorescences m^{-2} (Table 2), and the highest PBZ dose produced the greatest number of inflorescences. The results are consistent with those obtained by Yeshitela *et al.* (2004), when tested 0.5 and 2.0 g L^{-1} of paclobutrazol in 'Tommy Atkins' and 'Keitt' mango, wherein the greatest PBZ dose yielded a greater number of inflorescences than the control. Similarly, Cárdenas and Rojas (2003), do Carmo and Silva (2005), and Pavone *et al*. (2008) found that pruning and PBZ treatment had similar effects in 'Tommy Atkins', 'Sprinfels', 'Edward' and 'Haden' mango.

Flowering-to-harvest Period

In the treatments that combined pruning in April or May with PBZ treatment, anthesis occurred on 15 December 2010, and the time that elapsed between flowering and harvest was 140 days. This results differed with those obtained in 'Haden' and 'Tommy Atkins' where blooming to harvest period was 120 days using pruning, Paclobutrazol or Uniconazol and NO_3^- (Davenport, 2003). When pruning in June and PBZ application were combined, anthesis occurred on 28 December 2010, with a flower-to-harvest period of 143 days. The time of harvest occurred 28 days earlier, consistent with the results obtained by Vázquez *et al.* (2009) for 'Ataulfo' mango. Using an integrated management program of pruning, fertilization, nitrates and PBZ, Vázquez *et al.* (2009) observed an advancement of harvest of approximately 30 days. Quijada *et al.* (2009) similarly advanced flowering by

Table 2. Number of inflorescences m^{-2}, number of set fruits m^{-2}, incidence of seedless fruit (%), incidence of non-commercial fruits (%) and production per tree (kg) for 'Ataulfo' mango trees on three pruning dates and with three PBZ doses.[a]

Pruning date	PBZ g ai	Inflorescences	Set fruit	Productive efficiency	fruit without seed	Non-commercial fruits	Production
	0.0	4.06 a	2.16 a	8.9 ab	64.2 ab	12.9 a	95.0 a
	7.5	6.45 a	2.33 a	7.6 b	66.4 a	4.6 b	62.0 a
	11.2	6.21 a	2.00 a	9.3 ab	50.8 ab	4.7 b	77.3 a
	15.0	6.28 a	3.33 a	11.6 a	47.4 b	8.1 ab	98.4 a
	CV	27.70	83.11	23.37	20.51	61.32	29.21
A	P> F	0.0543	0.6762	0.0331	0.0235	0.0177	0.0601
	0.0	4.06 a	2.16 a	8.9 a	64.2 a	12.9 a	95.0 a
	7.5	4.45 a	0.66 a	6.6 a	71.0 a	4.4 b	53.2 b
	11.2	5.40 a	2.50 a	7.7 a	65.3 a	8.4 ab	64.0 ab
	15.0	5.65 a	2.00 a	9.3 a	58.6 a	4.6 b	69.4 ab
	CV	34.74	90.99	28.48	16.05	55.42	34.58
M	P> F	0.3412	0.2728	0.2193	0.2662	0.0068	0.0463
	0.0	4.06 b	2.16 a	8.9 a	64.2 a	12.9 a	95.0 a
	7.5	5.41 ab	2.00 a	5.1 b	73.8 a	7.1 a	43.4 b
	11.2	5.76 ab	3.33 a	5.1 b	71.9 a	4.1 a	43.3 b
	15.0	5.93 a	1.00 a	4.6b	80.3 a	11.5 a	38.7 b
J	CV	21.69	120.97	34.86	14.20	72.38	42.39
	P> F	0.0429	0.4929	0.0064	0.0886	0.1022	0.0012
A		5.75 a	2.45 a	9.30 a	57.20 c	7.57 a	83.17 a
M		4.89 a	1.83 a	8.33 a	64.76 b	7.58 a	70.38 ab
J		5.29 a	2.12 a	6.55 a	72.53 a	8.92 a	55.08 b
CV		28.22	99.42	28.10	16.70	64.71	35.51

[a] Means with the same letter within a column are not significantly different (Tukey's test, P≤ 0.05). CV= Coefficient of Variation; A= 20 April; M = 20 May, and J= 20 June.

[DOR: 20.1001.1.16807073.2014.16.2.6.2]

more than 30 days for 'Irwin' and 20 days for 'Tommy Atkins' mango using KNO_3 combined with pruning. For the control trees in this study, anthesis occurred on 10 January 2011, and the flowering-to-harvest period was 129 days. The control harvest occurred on the same date as the harvest for trees that were pruned on 20 June.

Number of Set Fruits m^{-2}

No statistic difference was found as the treatments effect, however, the greatest number of set fruit was observed for the treatment that combined pruning in April with the greatest dose of PBZ (3.33 m^{-2}). The numbers of set fruits decreased progressively for the pruning in May (2.0 m^{-2}) and June (1.0 m^{-2}), without significant differences among the three pruning dates (Table 2). These findings are similar to those reported for 'Tommy Atkins' mango by Quijada *et al.* (2009), who reported 4.4 set fruits m^{-2}.

Productive Efficiency

The greatest production efficiency (11.63 kg m^{-2}) was observed for the April pruning date combined with a dose of 14.96 g ai (PBZ). Although this value is not different than the control (8.90 kg m^{-2}), this management allows to increase yield through raising the number of trees per ha and, thus, production efficiency; this value was significantly different than those for all other treatments. Efficiency was reduced for the May pruning and was reduced even further for the June pruning (Table 2). The production efficiency was similar among the other PBZ doses. These findings indicated that PBZ combined with pruning compared with un-pruned trees can be equally productive and raise the possibility that planting density may thus be increased from 100 to at least 277 trees ha^{-1}. Although the production was the same, this technology would reduce the production cost due to harvest practice, which can represent up to 60% of this value. Furthermore, it has been demonstrated that 'Ataulfo' mango without PBZ application can remain without flowering because of weather. These results exceeded those obtained in Araque, Rangel y Rosita, native mangos from Venezuela, by Avilán *et al.* (2003), who reported production efficiencies of 5 and 6 mangos m^{-2}.

Incidence of Seedless Fruits (%)

The percentage of seedless fruits increased with later pruning dates for all treatments. The greatest incidence (80.34) was obtained at a dose of 14.96 g ai PBZ for the June pruning, which was significantly different only from the incidence observed for the April pruning (Table 2). These incidence values exceeded by 50% those reported for 'Nam Dok Mai' mango by Shaban and Ibrahim (2009). In Huaristemba, the temperature and relative humidity during the months in which pollination, fertilization, and fruit set occur for 'Ataulfo' mango are 19.72°C and 99.66%, respectively, at night and 29.93°C and 67.96%, respectively, during the day. These conditions are very different than the night-time and daytime conditions of 20-25 and 10-15°C, respectively, reported by Sukhvibul *et al.* (2005), who observed the greatest incidences of seedless fruit in 'Irwin', 'Kensington' and 'Nam Dok Mai mangos. From these results, we infer that one option for avoiding the heavy impact of climate during the anthesis and fruit set of 'Ataulfo' mango is the combination of pruning and PBZ application during the months of April and May. These combined treatments may help ensure fructification during the following cycle and may help diminish the incidence of parthenocarpy. Furthermore, it is necessary to study the effect of pollinator insects in cross-pollination. Singh (1997) considered that mango pollination was basically entomophily and that common housefly was

[DOR: 20.1001.1.16807073.2014.16.2.6.2]

an important pollinator. Dag *et al.* (1997) found that crossed pollination from Tommy to Lily significantly improved fructification.

Incidence of Non-commercial Mangos

Treatments combining pruning and PBZ exhibited the greatest percentages of commercial fruit for all three pruning dates, and statistically significant differences were observed for the April and May pruning (Table 2). These results are similar to those reported for 'Tommy Atkins' mango by Vega and Molina (1999).

Production per Tree (kg)

For all three pruning dates, trees treated with PBZ and pruning produced 38 to 98 kg; these values were always less than those obtained for the control trees. This result is attributable to the intensity and date of pruning, which reduced the canopy volume by up to 50%. Pruning later in the season resulted in an increase in the incidence of mango parthenocarpy and a negative effect on harvest volume relative to the control (Table 2). Vázquez *et al.* (2009) reported that trees treated with pruning, PBZ, fertilization and KNO_3 produced 77 to 96 kg per tree. The results observed for 'Ataulfo' mango are consistent with those previously reported for 'Haden' (87 kg), 'Tommy Atkins' (56 kg), 'Springfels' (36 kg) and 'Edward' (27 kg) mangos treated with PBZ, pruning and KNO_3 at 6% (Avilán *et al.*, 2001).

CONCLUSIONS

The combination of pruning and PBZ treatment for 'Ataulfo' mango advanced harvest by 40 days when pruning was performed on 20 April or 20 May. Additionally, the flowering-to-harvest period was 140 days compared to 128 days for the control. Trees subjected to pruning and PBZ treatment underwent up to three vegetative growth cycles, regardless of the pruning date, while un-pruned control trees only underwent one cycle. Pruning and PBZ treatment did not increase the production efficiency m^{-2} and did not affect the number of inflorescences. Treatments combining pruning dates and paclobutrazol did not have effect on non-commercial fruits production. However, June pruning resulted in a greater incidence of seedless mango (72.53%).

REFERENCES

1. Avilán, L., Soto, E., Marín, R. C., Pérez, M., Rodríguez, M. and Ruíz, J. 2008. Productividad del Mango en una Población de Alta Densidad Durante el Período de Plena Producción. *Agronomía Trop.,* **58(2):** 181-191.
2. Avilán, L., Marín, R. C., Rodríguez, M. and Ruíz, J. 2005. Producción Forzada de Mango (*Mangifera indica* L.) en Alta Densidad (278 pl ha^{-1}) Durante el Periodo de Crecimiento. *Rev. Fac. Agron.,* **22:** 99-111.
3. Avilán, L., Emaldi, U., Soto, E., Rodríguez, M. and Ruiz, J. 2003. Evaluación de Cultivares "Criollos" de Mango. *Agronomía Trop.,* **53(2):** 119-131.
4. Avilán, L., Marín, R. C. and Rodríguez, M. 2001. Crecimiento, Floración y Producción del Mango Sometido a Diferentes Tratamientos en Plantaciones de Alta Densidad. *Agronomía Trop.,* **51(1):** 29-47.
5. Cárdenas, K. and Rojas, E. 2003. Efecto del Paclobutrazol y los Nitratos de Potasio y Calcio Sobre el Desarrollo del Mango 'Tommy Atkins". *Rev. Bioagro.,* **15(3):** 83-90.
6. Dag, A., Ersenstein, D., Degani, C., El-Batsri, R., Zelig, M., Ziv, G. and Gazit, S. 1997. 'Tommy Atkins' Mango as Pollinizer for 'Lyli'. *Acta Horticulturae*, **455:** 209-216.
7. Davenport, T. L. 2006. Pruning Strategies to Maximize Tropical Mango Production from the Time of Planting to Restoration of Old Orchards. *Hort. Sci.,* **4(3):** 131-135.
8. Davenport, T. L. 2007. Reproductive Physiology of Mango. *Braz. J. Plant Physiol.,* **19(4):** 363-376.
9. Davenport, T. L. 2003. Management of Flowering in Three Tropical and Subtropical

[DOR: 20.1001.1.16807073.2014.16.2.6.2]

Fruit Tree Species. *HortSci.*, **38(7):** 1331–1335.
10. Do Carmo, M. M. A. and Silva, J. A. 2005. Efeito do Paclobutrazol em Duas Epocas de Produçao da Mangueira. *Bragantia*, **64(2):** 219-225.
11. Fonseca, N., de Castro, M. T. N. and da Silva C. A. L. 2005. Paclobutrazol e Estresse Hídrico no Florescimento e Produçao da Mangueira (*Mangifera indica*) "Tommy Atkins". *Rev. Bras. Frutic.,* **27(1):** 21-24.
12. Gil, P. M., Sergent, E. and Leal, F. 1998. Efectos de la Poda Sobre Variables Reproductivas y de Calidad del Mango (*Mangifera indica* L.) *cv.* Haden. *Bioagro,* **10(1):** 18-23.
13. Instituto Nacional para el Federalismo y el Desarrollo Municipal, Gobierno del Estado de Nayarit [National Institute for Federalism and Municipal Development, State Government of Nayarit]. 2009. *Gobierno del Estado de Nayarit*. Tepic. 15 February 2012. <http://www.elocal.gob.mx/work/templates/enciclo/nayarit/mpios/18012a.htm>.
14. Jamalian, S., Tafazoli, E., Tehranifar, A., Eshghi, S. and Davarynejad, G. H. 2008. The Effect of Paclobutrazol on Fruit Yield, Leaf Mineral Elements and Proline Content of Strawberry *cv.* Selva under Saline Condition. *Amer. Eurasian J. Agr. Environ. Sci.,* **3(1):** 118-122.
15. Mansuroglu, S., Karaguzel, O., Ortacesme, V. and Sayan, M. S. 2009. Effect of Paclobutrazol on Flowering, Leaf and Flower Color of *Consolida orientalis*. *Pak. J. Bot.,* **41(5):** 2323-2332.
16. Medina-Urrutia, V. M., Zapiaín, G. E., Robles, M. M. G., Pérez, O. Z. Williams, T. and Becerra, S. R. 2007. Fenología, Eficiencia Productiva y Calidad de Fruta de Cultivares de Naranjo en el Trópico seco de México. *Rev. Fitotec. Mex.,* **30(2):** 133-143.
17. Nguyen, V. K. and Nguyen, M. D. 2005. Effects of Paclobutrazol Doses on the Floral Induction of Khiew Sawoei Mango at Dong Tien Farm, Ho Chi Minh City. *J. Agr. Sci. Technol.*, **4:** 1-5.
18. Pavone, R. A., Avilán, L. and Herrera. L. 2008. Efecto del Despuntado, Poda y Paclobutrazol, Sobre la Brotación Vegetativa y Reproductiva de Cuatro Cultivares de Mango. *Agronomía Trop.,* **58(4):** 351-356.
19. Quijada, O., Herrera, B., González, R., Casanova, A. and Camacho, R. 2009. Influencia la Poda y de la Aplicación de Nitrato Potásico y Tiosulfato Potásico Sobre el Mango en Maracaibo, Venezuela, II. Producción e Indices de Eficiencia Productiva. *Agronomía Trop.,* **59(3):** 289-296.
20. Ramírez, F. and Davenport, T.L. 2010. Mango (*Mangifera indica* L.) Flowering Physiology. *Scientia Hortic.,* **126(2):** 65-72.
21. Ramírez, F., Davenport T. L. and Fischer, G. 2010a. The Number of Leaves Required for Floral Induction and Translocation of the Florigenic Promoter in Mango (*Mangifera indica* L.) in a Tropical Climate. *Scientia Hortic.,* **123(4):** 443–453.
22. Ramírez, F., Davenport T. L., Fischer, G. and Pinzón, J. C. A. 2010b. The Stem Age Required for Floral Induction of Synchronized Mango Trees in the Tropics. *HortSci.*, **45(10):** 1453–1458.
23. Ruíz. P. F. D., Villegas, M. Á., Hernández, L. A. and Colinas, L. M. T. 2003. Cambios Morfológicos en Plantas de dalia (*Dahlia pinnata* Cav.) Tratadas con Paclobutrazol. *Rev. Chapingo Ser. Hortic.,* **9(1):** 151-161.
24. Shaban, A. E. A. 2009. Effect of Summer Pruning and GA_3 Spraying on Inducing Flowering and Fruiting of 'Zebda' Mango Trees. *World J. Agr. Sci.,* **5(3):** 337-344.
25. Shaban, A. E. A. and Ibrahim, A. S. A. 2009. Comparative Study on Normal and Nubbin Fruits of Some Mango Cultivars. *Austral. J. Basic Appl. Sci.,* **3(3):** 2166-2175.
26. Silva, C. M. G., Rebouças, S. J. A., Silveira, V. A. E., Matsumoto, S. N. and Hojo, R. N. T. 2007. Florescimento e Fructificaçao de Mangueira (*Mangifera indica* L.) *cv.* Rosa Promovidos por Diferentes Doses de Paclobutrazol. *Rev. Bras. Frutic.*, **29(2):** 209-212.
27. Singh, G. 1997. Pollination, Pollinators and Fruit Setting in Mango. *Acta Horticulturae,* **455:** 116-123.
28. Sukhvibul, N., Whiley, A. W. and Smith, M. K. 2005. Effect of Temperature on Seed and Fruit Development in Three Mango (*Mangifera indica L.)* Cultivars. *Sci. Horticulturae*, **105:** 467-474.
29. Vázquez, V. V., Pérez, B. M. H., Osuna, G. J. A. and Urías, L. M. A. 2009. Manejo Integral de Huertos de Mango 'Ataulfo' con Altas Densidades de Plantación. *Rev. Chapingo Ser. Hortic.,* **15(2):** 155-160.

[DOR: 20.1001.1.16807073.2014.16.2.6.2]

30. Vázquez, V. V. and Pérez, B. M. H. 2006. Dosis y Épocas de Aplicación de Ácido Giberélico en la Floración y Cosecha del Mango 'Ataulfo'. *Rev. Fitotec. Mex.,* **29(3):** 197-202.
31. Vega, V. E. and Molina, E. 1999. Fertilización Nitrogenada en el Cultivo de Mango *cv.* Tommy Atkins, en Guanacaste, Costa Rica. *Agron. Costarricense,* **23(1):** 37-44.
32. Villa-Ruano, N., Betancourt-Jimenez, M. G. and Lozoya-Gloria, E. 2010. cDNA Isolation and Gene Expression of Kaurene Oxidase from Montanoa Tormentosa (*Zoapalte*). *Rev. Latinoam. Quím.*, **38(2):** 81-88.
33. Yeshitela, T., Robbertse, P. J. and Stassen, P. J. C. 2003. The Impact of Panicle and Shoot Pruning on Inflorescence and Yield Related Developments in Some Mango Cultivars. *J. Appl. Hort.,* **5(2):** 69-75.
34. Yeshitela, T., Robbertse, P. J. and Stassen, P. J. C. 2004. Effects of Various Inductive Periods and Chemicals on Flowering and Vegetative Growth of 'Tommy Atkins' and 'Keitt' Mango (*Mangifera indica L.*) Cultivars. *New Zealand J. Crop Hort. Sci.,* **32:** 209-215.
35. Yeshitela, T., Robbertse, P. J. and Stassen, P. J. C. 2005. Effects of Pruning on Flowering, Yield and Fruit Quality in Mango (*Mangifera indica* L.) *Aust. J. Exp. Agr.* 45:1325-1330

نمو رویشی و زایشی درخت انبه رقم آتولفو دراثر مدیریت هرس و کاربرد پکلوبوترازول

د. ا. گارسیا دنیز، گ. ل. اسکوبول، ر. ب. مونتویا، ب. گ. آریتا راموس، گ. ا. سانتیاگو، ج. ر. گومس آگویلار، و ا. ر. سائو جوزه

چکیده

هرس کردن شاخسار وکاربرد ماده پکلوبوترازول در ریشه گاه درختان انبه (*Mangifera indica L.*) از شمار کارهای زراعی برای بهبود عملکرد در باغ های انبه هستند. در پژوهش حاضر، برای ارزیابی اثر هرس کردن و تیمار با ماده پکلوبوترازول روی رشد رویشی و زایشی انبه Ataulfo، سه تاریخ هرس(۲۰ آوریل، ۲۰ مه، و ۲۰ ژوئن) و سه غلظت PBZ (۷/۵، ۱۱/۲۵ ، و۱۵ میلی لیتر ماده فعال) به کار رفتند. مشاهده شد که در حالیکه درختان تیمار شاهد در دوره باردهی فقط یک دوره رشد رویشی داشتند، درختان هرس شده و تیمار شده باPBZ ، در هر سه تاریخ هرس، قبل از گلدهی تا سه چرخه رشد رویشی نشان دادند. شمار شاخه ها وگل آذین ها در هر متر مربع در تیمارهایی که هرس شده و PBZ دریافت کرده بودند باهم برابر بود. در تیمار هرس درماه آوریل یا ماه مه، تاریخ برداشت ۲۸ روز زودتر از تیمار شاهد بود. هرس کردن در ماه آوریل از نظر کمیّ بیشترین کارآیی تولید (۱۱-۷ کیلوگرم در متر مربع) را داشت. برای هر سه تاریخ هرس، تولید میوه درختان تیمار شده با PBZ و هرس شده بین ۳۸ تا ۹۸ کیلو گرم بود که همواره کمتر از درختان شاهد بود.همچنین، بیشترین تعداد میوه های بی هسته (۸۰-۵۷٪) در تیمار هرس در ماه ژوئن مشاهده شد.

[DOR: 20.1001.1.16807073.2014.16.2.6.2]