Colegio de Postgraduados

Assessment and selection of flowering inducers to increase productivity of mango cv. Ataulfo (*Mangifera indica* L.)

Ariza-Flores, Rafael[1*]; Cano-García, Miguel Angel[1]; Cadena-Iñiguez, Pedro[2]; Valle-de la Paz, Mariel[3]; Gálvez-Marroquín, Luis Antonio[4]

[1] Instituto Nacional de Investigaciones Forestales Agrícolas y Pecuarias. Unidad Regional del CIRPAS. Melchor Ocampo No. 7, Santo Domingo Barrio Bajo, Villa de Etla, Oaxaca. C. P. 68200.
[2] Instituto Nacional de Investigaciones Forestales Agrícolas y Pecuarias. Campo Experimental Centro de Chiapas. Km 3 Carretera Ocozocoautla-Cintalapa, Ocozocoautla de Espinoza, Chiapas. C.P. 29140.
[3] Universidad Autónoma de Guerrero, Escuela Superior de Ciencias Naturales, C.P. 39105.
[4] Instituto Nacional de Investigaciones Forestales Agrícolas y Pecuarias. Campo Experimental Valles Centrales de Oaxaca. Melchor Ocampo No. 7, Santo Domingo Barrio Bajo, Villa de Etla, Oaxaca. C. P. 68200.
* Correspondence: arizafr77@hotmail.com

ABSTRACT

Objective: To assess new flowering inducers used to increase the fruit yield in mango cv. Ataulfo trees, to substitute paclobutrazol.

Design/methodology/approach: Ten-year-old mango cv. Ataulfo trees were used, homogeneous in terms of health. The treatments evaluated were prohexadione calcium, cytokinins, itaconic acid, phosphonitrate, potassium nitrate and paclobutrazol. The experimental design was completely random blocks with five repetitions; each experimental unit and repetition consisted of one tree. The number of inflorescences, percentage of flowering, number of fruits, fruit yield by hectare, and profitability of treatments were assessed. The data were analyzed through ANOVA and Tukey's means comparison ($p<0.05$).

Results: There were no significant effects of the treatments for number of inflorescences, percentage of flowering, and number of fruits; however, the homogeneous formation of inflorescences was found with itaconic acid. Prohexadione calcium (P-Ca) presented the highest fruit yield (19.32 t ha^{-1}), but it does not differ from paclobutrazol (10.34 t ha^{-1}). The highest profitability of the crop was obtained with prohexadione calcium, in which for each peso invested the amount of $1.51 was recovered.

Findings/conclusions: Prohexadione calcium can be an alternative for the use of paclobutrazol to induce flowering and increase the fruit yield of mango cv. Ataulfo in the Coast of Guerrero.

Keywords: itaconic acid, cytokinins, flowering promoters.

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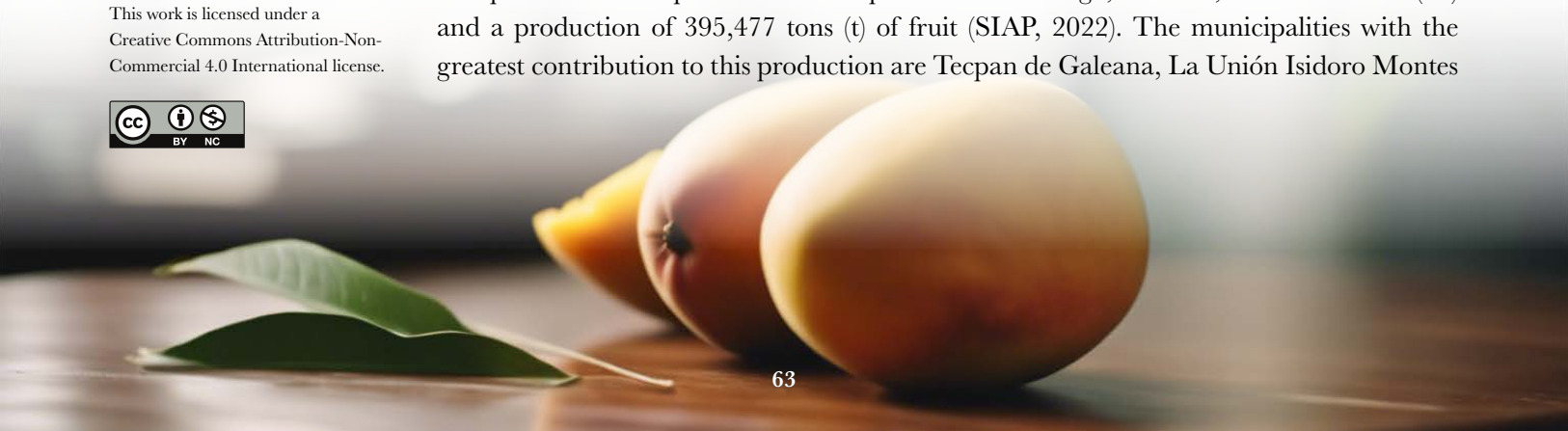
INTRODUCTION

In Mexico, mango (*Mangifera indica* L.) is one of the most important fruit trees as a result of profits generated from the export of fruit to the United States. The state of Guerrero occupies the fourth place in surface planted with mango, with 26,917.50 hectares (ha) and a production of 395,477 tons (t) of fruit (SIAP, 2022). The municipalities with the greatest contribution to this production are Tecpan de Galeana, La Unión Isidoro Montes



de Oca, Cuajinicuilapa, Atoyac de Álvarez, Petatlán, Zihuatanejo de Azueta and Acapulco de Juárez. The Ataulfo cultivar occupies the second place in planted surface, after the Manila cultivar with 8,463 ha, which is preferred by producers due to the attractive color, flavor and aroma of the fruit.

One of the main problems affecting mango producers is the seasonality of the harvest which is between the months of March and July. This results in an excessive offer of the product and price reduction in the market, decreasing the sale prices and lowering the crop's profitability. This situation is given by agroecological limitations (high temperatures, drought, and rainfall outside of season, among others), as well as the inadequate management of the plantation (excessive use of agrochemicals and others), in the various producing regions of the state.

There are studies about flowering inducers in mango with positive results, such as potassium nitrate (Sandoval *et al.*, 2011), ammonium nitrate, paclobutrazol (Pérez *et al.*, 2011), alone or in combination with other inducers (Morales *et al.*, 2020). The use of paclobutrazol increased since it induces flowering even without inductive environmental conditions in the state of Nayarit (Pérez *et al.*, 2011).

Prohexadione calcium has promoted fruit flowering, mooring and production in temperate climate crops such as apple (Ramírez *et al.*, 2006), while in mango cv. Ataulfo, it has reduced the vegetative growth and increased flower budbreak under the edaphoclimatic conditions of Nayarit (Pérez-Barraza *et al.*, 2016). On the other hand, cytokinins have promoted greater flowering in fruit trees such as mango and Persian lime (Moreira *et al.*, 2002, Ambriz *et al.*, 2021). However, the inducers show different effects based on edaphoclimatic conditions, nutritional status of the tree, and others (Singh, 2013).

Because of this, the objective of this study was to assess and select new flowering inducers, which can substitute paclobutrazol to increase the productivity of the mango cv. Ataulfo crop in the coast of Guerrero.

MATERIALS AND METHODS

In 10-year-old mango cv. Ataulfo trees found in the locality of Coyuca de Benítez, Guerrero, the following products were assessed: prohexadione calcium (Apogee®), cytokinins (Citomax®), itaconic acid, phosphonitrate, potassium nitrate and the regional control used, paclobutrazol. The doses and dates of application are presented in Table 1.

Table 1. Products, doses, and dates of application.

Treatment	Dose	Application Method	Number of applications
Prohexadione Calcium	250 g L^{-1}	To the foliage	October 1, 16 and 31, 2019
Cytokinins	300 mL L^{-1}		
Itaconic acid	250 g L^{-1}		
Phosphonitrate	400 g L^{-1}		
Potassium nitrate	8 g L^{-1}		
Paclobutrazol	10 mL L^{-1}	Drained to the base of the stem	October 1 and 16, 2019

Pruning the buds was done in the month of September. The agronomic management consisted in applying fertilization, controlling fruit flies and trips, and managing the anthracnosis disease. The experimental design used was completely random with five repetitions. The experimental unit and repetition was constituted by one tree.

The variables evaluated were the following:

Number of inflorescences. Four branches located on each cardinal point were marked with red tape. A circular ring with one-meter diameter was placed on each of them, with which the number of inflorescences was quantified in six samples, from January to April.

Percentage of flowers. The percentage of flowers on each of the trees was estimated visually, and this was done in three sampling dates from February to the last week of March.

Number of fruits. In four cardinal points, the number of fruits with the size of a marble found within the one-meter diameter ring was quantified. This activity was carried out in four sampling dates, from the third week of February to the second week of April.

Fruit yield. Once the fruits reached physiological maturity, the harvest was carried out and they were weighed on a mechanical scale of 20 kg to obtain the yield per tree. The fruit yield per hectare was estimated with these values.

All the variables were transformed into square root, to fulfill the assumptions of normality. Later, they were analyzed through analysis of variance (ANOVA) and means comparison was done through Tukey's multiple range test ($p<0.05$). Likewise, the profitability for each treatment based on the treatment's total cost (TC), total income (TI), net income (NI) and profit per peso invested (PPI) were determined. To obtain the total income, the price of one kg of mango was multiplied by the production contained based on a hectare. The net income was calculated with the difference of the total income and the total cost. Finally, the profit per peso invested was determined by dividing the net income by the total cost.

RESULTS AND DISCUSSION

No significant differences were observed in the number of inflorescences of mango cv. Ataulfo in five sampling dates ($p>0.05$); however, itaconic acid promoted the highest number of inflorescences for the third sampling, compared to the absolute control (Table 2). In general terms, the highest numbers of inflorescences were present in trees treated with cytokinins and itaconic acid.

Regarding the percentage of flowering in mango cv. Ataulfo trees, there were no significant differences ($p>0.05$). In general, the trees treated with cytokinins and itaconic acid promoted more than 85% flowering, while with paclobutrazol it reached 60% (Table 3). In previous studies, cytokinins have promoted higher percentage of flowering in mango cv. Tommy Atkins trees and higher yield and fruit quality (Moreira *et al.*, 2002). Meanwhile, there are no reports about itaconic acid and its effects to induce flowering in the scientific literature, and therefore studies are required to determine the mechanism that takes place in order to promote flowering.

The treatments presented similar effects in the number of fruits per tree, except in the third sampling. However, the trees treated with cytokinins and itaconic acid presented the highest number of fruits (Table 4).

Table 2. Number of inflorescences of mango cv. Ataulfo in function of seven inducers.

Treatment	Sampling dates						Total
	January 24, 2020	February 8, 2020	February 22, 2020	March 7, 2020	March 25, 2020	April 14, 2020	
Prohexadione Calcium	2.20 a[x]	01.60 a	01.40 ab	11.00 a	16.00 a	1.60 a	33.8
Cytokinins	0.60 a	03.80 a	12.20 ab	59.80 a	11.20 a	0.00 a	87.6
Itaconic acid	0.80 a	03.60 a	19.20 a	50.20 a	0.00 a	0.00 a	73.6
Phosphonitrate	0.00 a	00.20 a	04.00 ab	20.20 a	0.00 a	0.00 a	24.4
Potassium nitrate	4.60 a	01.00 a	01.40 ab	12.80 a	7.00 a	0.00 a	26.8
Paclobutrazol	0.00 a	01.60 a	14.40 ab	36.60 a	1.40 a	0.00 a	54.0
Control	0.00 a	00.00 a	00.00 b	10.40 a	0.20 a	0.00 a	10.6

[x]. Means with the same letter are statistically equal.

Table 3. Percentage of flowering in mango cv. Atulfo trees with inducers.

Treatment	Sampling dates			Total
	February 22, 2020	March 7, 2020	March 25, 2020	
Prohexadione Calcium	12.00 a[x]	19.40 a	17.200 a	48.6
Cytokinins	27.00 a	59.20 a	8.000 a	94.2
Itaconic acid	17.60 a	67.40 a	0.600 a	85.6
Phosphonitrate	9.00 a	41.00 a	0.600 a	50.6
Potassium nitrate	9.20 a	13.00 a	13.800 a	36.0
Paclobutrazol	19.40 a	39.00 a	1.600 a	60.0
Control	2.00 a	21.00 a	1.000 a	24.0

[x]. Means with the same letter are statistically equal.

Table 4. Number of fruits on trees treated with flowering promoters.

Treatment	Sampling dates				Total
	February 22, 2020	March 7, 2020	March 25, 2020	April 14, 2020	
Prohexadione Calcium	4.80 a[x]	6.80 a	22.80 b	3.00 a	37.4
Cytokinins	0.00 a	25.60 a	78.20 ab	11.20 a	115.0
Itaconic acid	0.00 a	7.80 a	138.60 a	4.40 a	150.8
Phosphonitrate	0.00 a	4.40 a	47.60 ab	5.40 a	57.4
Potassium nitrate	7.60 a	0.00 a	43.20 ab	9.20 a	60.0
Paclobutrazol	0.00 a	2.00 a	85.00 ab	10.20 a	97.2
Control	0.00 a	0.00 a	32.80 ab	3.40 a	36.2

[x]. Means with the same letter are statistically equal.

A significant difference was found in the fruit yield of mango cv. Ataulfo trees treated with flowering inducers ($p<0.05$). The highest fruit yield was obtained with P-Ca, which was greater only than the absolute control (Table 5). In this regard, Pérez-Barraza *et al.* (2016) conclude that Prohexadione calcium reduces vegetative growth, increases and

Table 5. Fruit yield from mango trees treated with seven flowering promoters.

Treatment	kg/tree	t ha^{-1}
Prohexadione Calcium	193.24 a[x]	19.32 a
Cytokinins	123.60 ab	12.36 ab
Itaconic acid	106.24 ab	10.62 ab
Phosphonitrate	106.62 ab	10.66 ab
Potassium nitrate	93.34 ab	9.33 ab
Paclobutrazol	103.44 ab	10.34 ab
Control	47.16 b	4.16 b

[x]. Means with the same letter are statistically equal.

advances flowering and fruit production of mango cv. Ataulfo under the edaphoclimatic conditions in Nayarit. Therefore, P-Ca can be an alternative to paclobutrazol to induce flowering in the mango cv. Ataulfo crop under the edaphoclimatic conditions of the coast of Guerrero.

Regarding the profitability of treatments, it was observed that Prohexadione Ca (P-Ca) presents better results, since it has a production cost of $12,314.00 and a total income of $30,918.00 with a profit per peso invested of $1.51. Meanwhile, the other inducers have a similar profitability range, since their profit per peso invested ranges from $0.21 to $0.47 (Table 6).

Table 6. Profitability of the use of flowering inducers in the cultivation of mango cv. Ataulfo.

Treatment	CT	IT	IN	GPI
Prohexadione Calcium	12,314	30,918	18,604	1.51
Cytokinins	15,266	19,776	4,510	0.29
Itaconic acid	11,501	16,998	5497	0.47
Phosphonitrate	12,005	17,059	5,054	0.42
Potassium nitrate	12,270	14,950	2,680	0.21
Paclobutrazol	13,570	16,550	2,980	0.21
Control	8,575	7,532	−1042	−121.5

TC=Total cost, TI=Total income, NI=Net income, and PPI=Profit per peso invested.

CONCLUSIONS

Itaconic acid and cytokinins promote more than 85% of flowering in mango cv. Ataulfo trees in the edaphoclimatic conditions of the coast of Guerrero. However, new studies are required that allow a greater fruit mooring, yield, and crop profitability. Prohehadione calcium presented the highest fruit yield (19.32 t ha^{-1}) and crop profitability. Therefore, this product can be an alternative to the use of paclobutrazol in order to induce flowering and increase the mango cv. Ataulfo fruit yield in the coast of Guerrero. The suggestion is to conduct more assays with itaconic acid and cytokinins to define times of application and specific doses to induce flowering in all the mango varieties.

REFERENCES

Ambriz-Cervantes, R., Ariza-Flores, R., Alia-Tejacal, I., Gálvez-Marroquín, L.A., Avendaño-Arrazate, C. H. (2021). Agronomic practices and bio-stimulants for persian lime (*Citrus latifolia* Tan.) production in Mexico. *Agroproductividad, 14*(12):145-151.

Morales-Martinez, M., Moscoso-Ramirez, P. A., Castelan-Estrada, Mepivoseth, Contreras-Oliva, A. (2020). Efecto de nitratos solos o con paclobutrazol en la inducción floral y producción en mango cv. Tommy Atkins. *Biotecnia, 22*(2):20-27.

Pérez-Barraza, M. H., Osuna-Enciso, T., Avitia-García, E., Gutiérrez-Espinosa, M. A., Santiago-Cruz, M. J., Ramírez, H., Cano-Medrano, R. (2016). Prohexadiona de calcio reduce crecimiento vegetativo e incrementa brotación floral en mango 'Ataulfo'. *Revista Mexicana de Ciencias Agrícolas, 7*(2): 263-276.

Pérez–Barraza, M.H., Osuna–García, J. A., Sánchez–Lucio, R., Vázquez–Valdivia, V. (2011). El paclobutrazol como promotor de la floración en mango 'Manila', aún sin condiciones ambientales inductivas. *Revista Chapingo Serie Horticultura. 17*(Especial 1): 47-52.

Ramírez, H., Alonso, S., Benavides, A. (2006). Prohexadione-Ca modifies growth and endogenous hormones in the shoot apex in apple trees. *Acta Hortic.*, 727:117-123.

Ricardo-Moreira, M., Becerril-Román, A., Tijerina-Chávez, L. Cajuste, B. J. (2018). Efecto de promotores de floración sobre el estatus nutrimental del mango cv. Tommy Atkins. In: VIII Congreso Ecuatoriano de la Ciencia del Suelo. Guayaquil, Ecuador. p. 1-8.

Sandoval, E.A., Hernández, G.E., López, G.G., Lopez, N.M.C., Alonso, B.M., Palacio, M.V. (2011). Manual para Producción de Mango Ataulfo en el Soconusco Chiapas. Instituto Nacional de Investigaciones Forestales Agrícolas y Pecuarias, ISBN 978-607-425-577-5. Coyoacán, Ciudad de México. 86 p.

SIAP. (2022). Cierre de producción agrícola 1980-2022. Disponible en: https://nube.siap.gob.mx/cierreagricola/. (Fecha de consulta: diciembre de 2022)