Article

Effect of banding and biostimulants in the flowering, production and quality of Persian lime (*Citrus Latifolia* Tan.) in winter

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Abstract

In Mexico, 61 000 hectares of ʽPersian' lime (*Citrus Latifoia* Tan.) Are cultivated, with an average yield of 14 t ha^{-1} (SIAP, 2013), it is produced from May to October and prices are low in the markets. For this reason, the study consisted of evaluating cultural practices and application of biostimulants to induce flowering, production and quality of the fruits in winter. During august 2013 and april 2014 in a ʽPersian' lime orchard in Tlaltizapan, Morelos, Mexico, pruning, banding and the application of urea and Biofol®, carried out in august, September and October, were evaluated in combination. They determined the effects on the trees, the macro and micronutrient content of the leaves and the determination of the physical and biochemical quality of the fruits. With the pruning + urea + ringed in September the highest flowering was obtained and the yield of 20.3 t ha^{-1}, which exceeded between 50 and 400% to the rest of the treatments, showed the highest specific weight, protein content, N, P, Mg and Zn in the leaves; also, the fruits showed greater physical and biochemical quality. Therefore, this treatment favors sprouting, flowering, fruit setting and the yield and quality of the ʽPersian' lime in Winter.

Keywords: *Citrus latifolia* Tan., flowering, production, quality, ringed, urea.

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Introduction

The citriculture represents an activity of great importance within the national fruit industry. The main citrus fruits produced in Mexico are: orange, Mexican lime, Persian lime, grapefruit and tangerine (SIAP, 2013). The Persian Lima contributes with 61 822 ha, with average annual yield of 14 t ha^{-1} and a rural average price of 2 thousand pesos per ton of fruit. It is the main crop that generates currencies, within the citrus species, given that up to 80% of its production is exported, mainly to the United States of America (Contreras *et al*., 2008). Japan is a big importer, in the European Economic Union it is France, England and Holland. Thus, Mexico is the largest producer and exporter of Persian lime in the world (Castellanos, 2009).

In the state of Morelos there is an area of 937 ha, of which 60% are ‛Persian’ lime, 30% orange ‛Valencia’ and 10% Mexican lime, mandarin and grapefruit. In Morelos the plantations are recent, they are in production and expansion, reason why they come to represent an economically viable alternative for the morelenses producers within the scheme of productive reconversion and new windows of opportunities for the export (Lugo *et al*., 2009; Alia *et al*., 2011 a).

The production of ‛Persian’ lime in Mexico occurs in the months of May to October, which coincides with the low prices of the national and international markets (Curtí-Díaz *et al*., 1996; Puente, 2002). Production is scarce during the months of December to April, reaches the highest prices and the crop is profitable (Ariza *et al*., 2004). In this context, the use of cultural practices can control the time of flowering, being a technique to improve the profitability of the crop (Ruiz, 2001), within these are the pruning, ringing and application of chemical substances (Ariza *et al*., 2004).

With the prunings in Persian lime it is tried to regulate the time of flowering and obtain a more uniform production during the year, but the results are incipient and much remains to be investigated (Curti *et al*., 2000). Banding can induce flowering and favor the accumulation of carbohydrates above the ring and growth arrest (Erner, 1986; Ariza *et al*., 2004) indicates that ringing and water stress promotes flowering in Mexican lime for winter production, generates a yield greater than 500% and increased the quality of the fruit between 20 and 40% of weight, green color and improved the ratio total soluble solids/titratable acidity.

The application of some chemical substances, favored the induction of flowering, is one of the most practical agronomic activities Ruiz (2001). Lugo *et al*. (2009), have observed that applications of naphthalenacetic acid favor flowering in Morelos, but have not quantified the effect of the application of these products at different times of production. Ariza *et al*. (2004), mentions that the application of urea at 4% favors the flowering in Mexican lime. Almaguer *et al*. (2011) found no differences in the quality of Persian lime when applying 5% urea, 2% foliar fertilizer, pruning or pruning of productive branches to provoke the production phase-out in Veracruz, Mexico.

For this reason, it was considered important to evaluate the effect and combinations of the times of application of the practices of pruning, ringing and chemical substances in the production and final quality of the fruit in Persian lemon for Winter.

Materials and methods

The study was conducted in Ticumán, Tlaltizapán, Morelos in a 'Persian' lime orchard of 4.5 years of age, with a dry warm Aw0 climate, at 1 000 m above sea level, with a precipitation of 800 mm and average annual temperature of 24 ºC and calcareous Feozem soil.

Experimental development

During the months of February to April, the following treatments and application times were evaluated: 1) control (without application of practices and chemical substances); 2) prune in august; 3) pruning and ringing in September; 4) prune, urea at 6% and ringed in September; 5) Biofol® application and ringed in September; 6) pruning in September; 7) pruning and ringing in October; 8) pruning and ringing in august and 9) pruning, urea at 6% and ringed in October.

In the trees that were pruned, this was done by eliminating 30 cm of the crown of the tree, to perform the banding and application of chemical substances. The banding was done with a mini saw for arch of 152 mm and above the graft area, in two or three main branches, later, the cut was sealed with acrylic spray paint. The urea at 6% and the Biofol® at 3 L ha^{-1} were sprinkled on the foliage, in both cases the adherent Inex-A® was used in a dose of 2 ml per liter of water.

Agronomic management

In the 'Persian' lemon orchard, the chemical fertilization of 180-40-75 (N-P-K) and 20 kg of vermicompost per tree was applied to the foliage. Polyiquel multi was applied at a dose of 3 L ha^{-1}. Also, applications were made of Imidacloprid + cyfluthrin (300 ml ha^{-1}), thiamethoxam + citroline (200 ml ha^{-1}) and mineral oil (2 L ha^{-1}) for the control of insect pests as leaf miner (*Phyllosnictis citrella* Stainton), aphids (*Aphys gossypi* and *A. spiraecola*) and diaforin (*Diaphorina citri* Kuwayama). The presence of gomosis (*Phytophthora* sp.) Was controlled with phosetyl aluminum (500 g) in 200 L^{-1} of water. In irrigation, a micro-sprinkler system was used, with an expenditure of 100-120 L d^{-1}.

Variables evaluated

The effect of the treatments on 'Persian' lime trees was determined at tree height at 3 m and 3 m in crown diameter, as well as the number of flowers and fruits set on a selected branch of 75 cm in length and 1.6 m in height from the ground level in each cardinal point of the tree, these evaluations were made every fifteen days, after the application of the treatments, during the period from October to December 2011. The number of outbreaks was determined in four branches per tree, which was obtained during the period from September to November 2011.

The concentration of chlorophyll was determined with a SPAD 502 (Minolta®, Japan), as well as the total sugars in mature leaves were obtained with the colorimetric method (Witham *et al*., 1971). The total protein content was determined in the leaves by the colorimetric method, for which black amido was used as a source of staining (Höfner *et al*., 1989). From each experimental unit, 12 samples of leaves of 3.14 cm^2 were obtained, which were oven-dried for 48 h at 50 ºC and weighed on an analytical balance (Scientech®, USA), with the data generated, the specific gravity was calculated. was obtained by dividing the dry weight (mg) between the foliar area (cm^2) (Reyes *et al*., 1999).

The yield of fruits per tree was determined from the harvests made during January and April. Which was obtained from the total weight of the production of each tree in a mechanical scale with capacity of 10 kg and sensitivity of 0.025 kg. Which were determined in kilograms per hectare (kg ha^{-1}).

The content of N, P, K, Ca, Mg, Cu, Fe, Mn and Zn was determined from the samples of terminal buds with flowers, for this a random outbreak was collected from each cardinal point of a tree by treatment, determined three repetitions. These were transferred to the laboratory, where they were washed with distilled water and the excess water was removed with sanitas® later, they were placed in brown paper bags and dried in a mechanical ventilation stove at 70 °C for three days. For the determination of N, the Semimicro-Kjeldahl method was used, while the concentrations of P, K. Ca, Mg Cu, Fe, Mn and Zn were obtained by wet digestion of the dry material with a mixture of perchloric and nitric acids. The reading of extracts was determined by atomic emission spectroscopy and induction of coupled plasma ICP-AES Varian™ Liberty II model (Gómez *et al*., 2011a and 2011b).

A sample of six fruits harvested from each treatment was determined the mass of the fruit with a digital balance (OHAUS®, USA), the polar and equatorial diameters of the fruit with a digital vernier (Mitutoyo®, Japan). The components of color luminosity (L^*), chromaticity (C^*) and hue (h) were determined with a portable spectrophotometer (X-rite®, Mod. 3290, USA) (McGuire, 1992).

Each fruit was extracted juice, weighed separately as well as the shell, to determine the percentage of juice. The titratable acidity was determined in aliquots of 5 mL of the juice, by means of the equation proposed by Ladaniya (2008), this is the following:

$$\text{Titratable acidity (\% citric acid)} = \frac{(\text{mL of spent NaOH}) \times (\text{N of NaOH}) \times (\text{final volume}) \times (\text{Meq citric acid 64}) \times 100}{(\text{total titration volume}) \times (\text{volume of juice}) \times 1\,000}$$

The total soluble solids were determined by placing between one and three drops of the juice in a refractometer (PAL-1, Atago®, Japan), expressing the values in °Brix. With the values of total soluble solids and titratable acidity, the relationship of both variables indicating the sweetness or acidity of the fruit was determined (Ladaniya, 2008).

Statistical analysis

The results in each variable were analyzed by analysis of variance and tests of separation of means were applied by means of the DMS test with a probability of 5%, using the SAS V9.2 program (Castillo, 2011).

Results and discussion

Formation of the plants, buds and lime flowers 'Persian'

Pruning in Persian lime trees was very important for production, since they were maintained at 3 m in all the trees, except for the control trees, where the height was maintained at 4.1 m (Table 1). Curti *et al*. (2012) when evaluating the behavior of 'Persian' lime in four rootstocks (Carrizo, Rugoso, Swingle and Volkameriana) quantified an average height between 2.6 and 3.4 m; however, with the Volkameriana rootstock they reached an average height of 2.8 m, which is lower than that obtained in the present work.

The diameter of the crown was between 3 and 4 m, where the witness had the largest diameter (Table 1). Other authors indicate that the diameter of the cup of Persian lime in different rootstocks is between 4 and 4.5 m, in trees of 11 years of age, in particular in the rootstock Volkameriana 4.5 m was reached (Curti *et al*., 2012). Stenzel and Neves (2004), indicate a crown diameter of 6.6 m with the Volkameriana rootstock. The differences evaluated are attributed to the characteristics of the soil where they are developed. In this experiment, the trees with pruning, ringing, application of urea and Biofol® in September and October showed the lowest height and diameter of the crown, compared with trees without pruning or pruning carried out in august (Table 1). It is observed that the development of tree height and crown was superior to that reported by Curti *et al*. (2012).

Table 1. Morphological characteristics of 'Persian' lime trees in winter.

Treatment	Height (m)	Diameter (m)	Buds per branch (num.)	Total flowers (num.)
Witness	4.1 a^{z}	4 a	0 c	13 bc
Pruning in august	3 b	3.3 ab	1.6 b	7 c
P + ringed in September	3 b	3 c	1.4 b	10 c
P + U + A in September	3 b	3 c	3.4 a	38 a
P + B + A in September	3 b	3 c	2.2 b	28 ab
P in September	3 b	3 c	1.9 b	14 bc
P + A in October	3 b	3 c	1.3 b	14 bc
P + A in august	3 b	3 c	2.4 ab	7 c
P + U + A in October	3 b	3 c	2.3 b	9 c
DMS	0.1	0.2	1.1	15.5
CV	2.1	4.5	34.9	17
Significance	***	***	***	*

^{z}Promments with different letters in the direction of the columns indicate significant statistical differences according to the minimum significant difference test (DMS 0.05); CV= coefficient of variation; DMS= significant at <0.05, <0.01, <0.0001 (*, **, ***); P= pruning; U= urea; A= ringed; B= Biofol®.

There are significant differences between treatments for the number of outbreaks. It is seen in the trees of lime 'Persian' with pruning + urea (6%) + ringed in September issued on average more than three shoots per branch, while the control trees (without pruning) the emission of shoots was scarce, the rest of the treatments produced between one and two shoots (Table 1).

Citrus pruning is done to optimize the size of trees, facilitate their management, increase production and extend the productive life of plantations (Amoros, 1989). In pruning the balance of carbohydrates and nitrogen should be considered for its realization, since it stimulates the development of shoots and they occur in greater proportion when having few carbohydrates due to the effect of pruning and at the same time nitrogen applications are made (Medina *et al*., 2004). There was a greater number of outbreaks in treatments with 6% urea application, this may be due to the aforementioned relationships.

In trees with pruning + urea + ringed and pruning + Biofol® + ringed in september, 38 and 28 flowers were quantified, respectively, which presented between 80 and 50% more flowers with respect to the other treatments (Table 1). It has been reported that the application of urea + light pruning in Mexican lime trees and lime ʽPersian' favors significantly the formation of flowers, while the application of urea and Biofol® favors higher production of flowers during the winter (Ariza *et al*., 2004; Almaguer *et al*., 2011). The increase in flowering is due to the conversion of urea to ammonium, which reduces growth by the synthesis of ethylene and induces flowering (Lovatt *et al*., 1988).

Effects on chlorophyll, total sugars and specific weight of the leaves

No effect of the different treatments on the relative concentration of chlorophylls (SPAD units) and the concentration of total sugars in the leaves was determined (Table 2).

Significant differences were detected in the specific weight of the leaves due to the effect of the treatments. The ʽPersian' lime trees where pruning + urea (6%) + ringed in September and pruning + urea + ringed in October were obtained were the highest values of 7 and 7.5 mg cm^{-2} (Table 2). The specific weight is an indirect way of estimating photosynthesis (Secor *et al*., 1982), indicating a greater accumulation of carbohydrates per leaf area with high values, which may explain some physiological relationships of citrus fruits in the process of photosynthesis and increases the mooring of fruits by blocking flow through the phloem (Reyes *et al*., 1999; Iglesias *et al*., 2006), ringing decreases photosynthesis in vegetative buds in development but stimulates the formation of fruiting buds (Rivas *et al*., 2007).

The obtained results indicate that, the application of urea and the ringing favor to a greater specific weight of the sheets of lime ʽPersian'; with banding, the accumulation of carbohydrates in the canopy is promoted and it provides a rich source of energy for the flowering, fruit setting, development and maturation of the fruit (Goren *et al*., 2004). This is confirmed at a concentration of 54 mg g^{-1} of total sugars in leaves of trees with pruning + urea + ringed in September, with respect to the rest of the treatments (Table 2).

The protein content in leaves of ʽPersian' lime trees, in which pruning + urea + ringed was carried out in September and pruning + urea + ringed in October had concentrations of 3.3 and 2.8 mg g^{-1} of fresh weight, the rest of the treatments showed concentrations between 1.9 and 2.4 mg g^{-1} of fresh weight. It can be seen that, the control trees had the lowest concentration with 1.8 mg g^{-1} of fresh weight (Table 2). The high content of nitrogen in the leaves implies a higher rate of photosynthesis (Calderon *et al*., 1997) and consequently higher concentration of carbohydrates, therefore an adequate concentration of nitrogen and carbohydrates favors moderate growth and high fructification in Mexican lime (Medina *et al*., 2004).

Table 2. Physical, biochemical and performance analysis of ‘Persian’ lime trees.

Treatment	Chlorophylls (SPAD units)	Specific weight (mg cm^{-2})	Total sugars (mg g^{-1} of fresh $weight^{-1}$)	Total protein (mg g^{-1} of fresh $weight^{-1}$)	Yield per tree (kg $tree^{-1}$)	Yield (t ha^{-1})
Witness	56.8	6.3 b-d	44.9	1.8 c	24.6 c	8.8 c
Pruning in august	53.7	5.6 d	33.5	1.9 bc	9.2 d	3.3 d
P + A in September	54.1	6 cd	46.4	2.1 bc	9.5 d	3.4 d
P + U + A in S	59.9	7.5 a	54.4	3.3 a	57.1 a	20.3 a
P + B + A in S	56.5	5.8 cd	45.7	2.3 bc	40.1 b	14.4 b
P in September	55.3	6.7 a-c	34.5	1.9 c	10.1 d	3.6 d
P + A in October	57.9	6 b-d	41.5	2.3 bc	9.7 d	3.5 d
P + A in August	59.3	6.2 b-d	26.5	2.4 bc	14.5 cd	5.1 cd
P + U + A in October	57.2	7 ab	43.5	2.8 ab	9.1 d	3.3 d
DMS	7.1	1	20.2	0.9	10.4	3.7
CV	7.6	9.2	28.6	21.2	29.7	29.7
Significance	ns	*	ns	**	***	***

z= averages with different letters in the direction of the columns indicate significant statistical differences according to the minimum significant difference test (DMS 0.05). CV= coefficient of variation; DMS= significant at <0.05, <0.01, <0.0001 (*, **, ***); ns= not significant; P= pruning; U= urea; A= ringed; S= September.

Performance

With respect to performance, highly significant differences between treatments were demonstrated. Fruit yields per tree were 57.1 and 40.1 kg in lime trees ‘Persian’ with pruning + urea + ringed in September and with pruning + Biofol® + ringed in September, respectively, in the rest of the treatments were between 9.1 and 24.4 kg $tree^{-1}$ (Table 2). The yield per hectare showed the same behavior, obtaining between 20.3 and 14.4 t ha^{-1}, for the 'Persian' lime trees with pruning + urea + ringed in September and with pruning + Biofol® + ringed in September (Table 2), respectively.

In Mexico, the national average yield is 14 t ha^{-1}, although in some states such as Yucatan and Colima indicate yields above 20 t ha^{-1}, in this study only similar yields were obtained with the harvest from January to April. With the ringing and pruning the production of Mexican lime was increased (Ariza *et al*., 2004) and the application of biostimulants is induced to the flowering and production of Mexican lime (Ariza *et al*., 2015). In general, carrying out these activities in august has no beneficial effect.

Analysis of nutrients in outbreaks

The analysis of nutrients in the reproductive shoots of each evaluated treatments, presented in trees with pruning + urea + ringed a higher content of N and P, these were not significantly different trees with pruning and control (Table 3a); N (ammonium) favors increasing the flowering, in general it alters sprouting and leaves when applied in winter (Lovatt *et al*., 1988;

Menino *et al*., 2003), so their accumulation may be related. Also, no differences were found in the content of K and Ca. For the Mg content, it was high in trees with pruning + urea + ringed in September (Table 3a).

In micronutrients of Cu, Fe and Zn, high values were shown in trees with pruning + urea + ringed, so that only significant differences were found for Zn (Table 3b). The highest content of Mg and Zn in the trees was presented with cultural practices (pruning, banding) and application of urea, which seem to be associated with the metabolism of chlorophylls and carbohydrates in leaves (Lavon *et al*., 1995; Patil, 2013), although the mechanisms are not yet known.

Table 3a. Content of macronutrients in ‘Persian’ lime sprouts.

Treatment	N (%)	P (%)	K (%)	Ca (%)	Mg (%)
Witness	1.7	0.13	0.66	2.6	0.2 b
P + U + A in September	1.78	0.16	0.61	2.35	0.26 a
P in September	1.69	0.13	0.6	2.76	0.18 b
DMS	0.32	0.14	0.39	1.35	0.2
CV	9.53	15.85	31.18	26.3	6.4
Significance	ns	ns	ns	ns	**

z= averages with different letters in the direction of the columns indicate significant statistical differences according to the minimum significant difference test (DMS 0.05); CV= coefficient of variation; DMS= significant at <0.05, <0.01, <0.0001 (*, **, ***); ns= not significant; P= pruning; U= urea; A= ringed.

Table 3b. Micronutrient content in Persian lime sprouts.

Treatment	Cu ($mg\ kg^{-1}$)	Fe ($mg\ kg^{-1}$)	Mn ($mg\ kg^{-1}$)	Zn ($mg\ kg^{-1}$)
Witness	30.4	54.9	3580	22.7 b
P + urea (U) + A in September	93.8	116.2	4218	94.96 a
P in September	73.1	75.35	3512	88.46 a
DMS^z	54.58	67.61	1563	48.8
CV	41.52	41.17	20.7	21.2
Significance	ns	ns	ns	**

z= averages with different letters in the direction of the columns indicate significant statistical differences according to the minimum significant difference test (DMS 0.05); CV= coefficient of variation; DMS= significant at <0.05, <0.01, <0.0001(*, **, ***); ns= not significant; P= pruning; U= urea; A= ringed.

Physical and biochemical quality of the fruits

The ‘Persian’ lime fruits showed a weight of between 77.7 and 125.7 g (Table 4) also, there are highly significant differences between treatments. De Souza *et al*. (2003), report average fruit mass between 64 and 82 g, while Stuchi *et al*. (2009) between 81.3 and 96.7 g. Therefore, the evaluated fruits of the present study showed an average weight higher than 97 g, only the fruits of the trees with pruning + urea + ringed in October showed a weight lower than 80 g (Table 4). The greater mass of the fruits is associated to a greater time adhered in the tree, since a gradient of increase in mass is observed when carrying out the practices of the treatments in august, September and October (Table 4).

No significant differences were detected in the polar diameter, but they do express highly significant differences between treatments for the equatorial diameter (Table 4), which showed values between 50.5 and 59.8 mm, which are classified as 230 gauge (Curti e*t al*., 2012). No differences were detected due to the effect of the treatments evaluated on the juice content, which were between 50.5 and 59.8% (Table 4); therefore, the 'Persian' lime harvest is recommended to be made with 45% or more juice (Alia *et al*., 2011 b; Ladaniya, 2008).

In titratable acidity of the juice of the fruits significant differences were detected, reason why they presented lower acidity of the control trees with 5.9%; meanwhile, the fruits of trees with pruning + urea + ringed in October had the highest titratable acidity of 6.9% (Table 4a). Several studies report values between 5.7 and 6.4% (Stuchi *et al*., 2003) and 5.25 and 6.98% (Lye *et al*., 2003) of titratable acidity. The results suggest that although some treatment affected the titratable acidity, the values are similar to those reported in lima 'Persa' by other authors.

The total soluble solids, the SST/AT ratio and the color components were not affected by the treatments evaluated (Table 4). However, the soluble solids were in concentrations between 7.6 and 8.7 °Brix, which are within values reported by other researchers between 7.3 and 8.9 °Brix (Stuchi *et al*., 2003; Lye *et al*., 2003; Stuchi *et al*., 2009). The SST/AT ratio presented values between 1.1 and 1.3, which are similar to those reported by Stuchi *et al*. (2003).

Table 4. 'Persian' lime fruit quality with cultural practices and biostimulants.

Treatment	Fruit mass (g)^z	Polar diameter (mm)	Equatorial diameter (mm)	Juice (%)	Titratable acidity (%)
Witness	109.4 ab	68.2	55.9 b	50.9	5.9 c
P in august	111.8 ab	68.3	56.6 ab	50.1	6.3 bc
P + A in September	110.8 ab	68.5	56 b	46.9	6.3 bc
P + U + A in September	107.7 ab	74	56 b	50.5	6 bc
P + B + A in September	110.5 ab	67.7	56.3 b	51.3	6 c
P in September	97.8 b	65.5	53.9 b	53.3	6.1 bc
P + A in October	99.5 b	64.9	54.6 b	48.7	6.5 b
P + A in august	125.7 a	74.9	59.8 a	50.1	6 bc
P + U + A in October	77.7 c	59.2	50.5 c	46.8	6.9 a
DMS^z	105.6	7.9	3.2	6.1	0.4
CV	19.5	6.9	3.4	7.1	4
Significance	**	ns	**	ns	**

^{z}= averages with different letters in the direction of the columns indicate significant statistical differences according to the minimum significant difference test (DMS 0.05); CV= coefficient of variation; DMS= significant at <0.05, <0.01, <0.0001 (*, **, ***); ns= not significant.

Table 4. Quality of ‛Persian’ lime fruit with cultural practices and biostimulants (continuation).

Treatment	Total soluble solids (°Bx)	Relationship SST/AT	L^*	C^*	h
Witness	7.6	1.2	52.9	42	106.7
Pruning (P) in august	7.6	1.2	53.1	42.7	106.6
P + Ringed (A) in September	7.6	1.2	54.5	41.2	104.2
P + urea (U) + A in September	8.1	1.3	54	41.6	106
P + Biofol® + A in September	7.8	1.3	52	39.5	106.6
P in September	7.7	1.2	55.8	41.7	103.2
P + A in October	7.6	1.1	51.5	40.2	107.8
P + A in August	6.7	1.1	54.5	44.7	106.2
P + U + A in October	8.7	1.2	51.6	40.8	106.2
DMS	1	0.16	5.5	5.5	2.4
CV	8.1	7.5	7.7	7.7	1.3
Significance	ns	ns	ns	ns	ns

ns= were not statistically significant, for the results with the values obtained.

The components of color (Table 4) indicated that the ‛Persian’ lime fruits had a green color (h= between 103.2 and 106.7), pure (C^*= between 39.5 and 44.7) and medium glossy (L^*= between 51.5 and 55.8); these values are lower than those reported by Lye *et al*. (2003) in ‛Persian’ lime fruits in Brazil, since the green color indicates that it was more opaque (h= 120 and C^*= 31.5).

Conclusions

The realization of the pruning, application of urea and ringed in September promotes the budding of flowers and fruits set in ‛Persian’ lime, which favors the production in winter under the environmental and soil conditions of Morelos state; as well as, in the accumulation of N, P, Mg and Zn. The pruning, application of urea and ringed favors the quality of the lime fruit ‛Persian’ produced in winter.

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