

## Yield of roselle varieties in relation to apical pruning dates

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### Abstract

The state of Michoacán is the second producer of roselle in Mexico. In this species, pruning helps to increase the yield of calyxes per unit area. Therefore, the objective was to evaluate the effect of apical pruning dates on the yield of four roselle varieties sown in the dry tropics of Michoacán. The study was conducted during the spring-summer cycle, 2021, in the locality of Melchor Ocampo, Cunuato, Churumuco, Michoacán. The varieties evaluated were: Reina Roja (control), Patriota, Estrella Costeña and Mulata. The apical pruning was carried out at 70, 90 and 107 days after sowing (das) and a control without pruning. A completely randomized experimental design with 4 x 4 factorial arrangement, with 10 repetitions, was used. The following variables were recorded: plant height, diameter at the base of the stem, number of lateral branches, fresh and dry weight of the calyxes per plant. An analysis of variance ( $\alpha= 0.05$ ) was performed to determine the effect of the factors and their interactions, a mean comparison test (Tukey  $p \leq 0.05$ ) and Pearson correlation between the variables were also performed. Apical pruning influenced the yield of calyxes of the four roselle varieties; the highest production was generated at 90 das; the Mulata and Estrella Costeña varieties produced 1 159.6 and 1 107.3 kg ha<sup>-1</sup>. The yields obtained in the trial exceeded those reported at the state (570 kg ha<sup>-1</sup>) and national (430 kg ha<sup>-1</sup>) levels. In general, roselle varieties responded positively to the apical pruning apical and if it is not carried out, the production decreases.

**Keywords:** *Hibiscus sabdariffa* L., agronomic management, cultural work, yield.

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## Introduction

Roselle (*Hibiscus sabdariffa* L.) is an annual or biannual semi-woody shrubby plant that belongs to the Malvaceae family and reaches between one and three meters in height (Ortiz-Márquez, 2008). It is native to Asia and tropical Africa, but is currently cultivated in tropical and subtropical regions, since it has edible calyxes (Mariod *et al.*, 2017), which according to the color, four types can be distinguished: greens, pinks, reds and dark reds (Babalola *et al.*, 2001).

Among the bioactive compounds that have been extracted from the calyxes are: alkaloids, ascorbic acids,  $\beta$ -carotenes, citric acid, flavonoids, polyphenols and anthocyanins (delphinidin-3-glucoside or hibiscin) (Riaz and Chopra, 2018). In Mexico, there are several types of roselle that have variation in color, size and shape of calyxes, leaves and size of the plant, which are known locally as criolla Tecoanapa, Sudan, Jersey, Rosalíz, China Criolla, Reyna, Alma Blanca and Coneja (Contreras *et al.*, 2009; Serrano, 2008; Caro *et al.*, 2012; Alejo, 2016).

At the national level, in 2019, 18 654 ha were cultivated with roselle, distributed in 11 states, among which Guerrero, Michoacán and Oaxaca stand out. In Michoacán, 1 780 ha were cultivated, with a production of 884.3 t of dried calyxes per cultivation cycle and a gross economic benefit of \$69 510 950 million pesos (SIAP-SADER, 2022). Michoacán ranks second in organic and conventional roselle production; however, the yield per hectare obtained is 570 kg, which is low compared to other states where 1 t ha<sup>-1</sup> has been obtained, which is related to management practices, environmental conditions, phytosanitary problems and seed selection. Poor yield in roselle is attributable; however, it is possible to achieve higher yields with the use of improvements in agronomic management, population density (El-Naim *et al.*, 2012; Bobadilla-Carrillo *et al.*, 2016), irrigation (Babatunde and Mofoke, 2006), outstanding genetic materials (Caro-Velarde *et al.*, 2012), among other aspects.

Godínez (1988) mentions that the pruning in roselle consists of removing 10 to 15 cm of the terminal bud in the early stages of growth (1.2 to 1.25 m). With this practice, the plants present an immediate response to the breaking of apical dominance, stimulating lateral growth and an increase in the diameter of foliage, consequently, there is a greater area of bud production and an increase in the production of calyxes (Escobar, 1997). Hidalgo and Cano (2007) point out that, with pruning at 75 days after sowing, a higher yield of roselle calyxes is observed (Babatunde *et al.*, 2002; Terron, 2015). Rojas (2005) indicates that plants sown in June with height >1.5 m should be pruned to prevent greater growth and stimulate branching, which makes the work in the harvest easier for the cutter because the flower is not very tall.

As for yield, Hidalgo and Cano (2007) state that pruning at 75 days after transplantation significantly affects the yield of calyxes; however, it is suggested to carry out more tests to accurately determine the best pruning time for each of the cultivars, since they have different cycles. In the particular case of roselle cultivars in Michoacán, there are no documented works on the application of apical pruning or topping, usually, it is a cultural practice that roselle producers do not perform. Due to the above, the objective of the present study was to evaluate the effect of apical pruning on the yield of four roselle varieties sown in conditions of the dry tropics of the state of Michoacán, in order to increase the production of this crop in the entity.

## Materials and methods

### Location of the study

The evaluation was carried out in the locality of Melchor Ocampo Cunuato, municipality of Churumuco, in the state of Michoacán, located at 17° 45' 54.62" north latitude and 81° 47' 36.02" west longitude, at an average altitude of 600 m. The climate is of the BS1(h<sup>1</sup>) w(w) type, warm semi-dry with rainfall in summer, very warm [(Köppen modified by García (1973)]. According to the data of the 'Pastoria' weather station of the municipality of Churumuco, Michoacán, the total annual rainfall for 2021 was 1 036 mm, the beginning of rains for this region was in May (27.6 mm) and the end in November (12 mm), the largest amount of rainfall was concentrated in July (276.1 mm), temperatures ranged between 27 and 29.9 °C, with an annual average of 28.4 °C.

According to the FAO-ISRIC and SICS (1999) classification, the soil corresponds to an eutric Regosol, with moderate to high susceptibility to erosion, with very little organic carbon; it is too thin and hard, solid at the same time when dried and has no salic properties (INAFED, 2019). The terrain is flat with an average slope of 2% (INEGI, 2009). The vegetation surrounding the study area is mainly made up of tropical deciduous forest (INEGI, 2009).

### Description of varieties

The Mulata, Estrella Costeña and Patriota varieties were characterized in the Iguala Experimental Field of the National Institute of Forestry, Agricultural and Livestock Research (INIFAP, for its acronym in Spanish).

Mulata (JAM-007-231117): 5-6.5 cm calyx length, 4 to 5 cm calyx width, 110 days to flowering (sowing in June), 145 days to harvest, 150-175 cm plant height, 6 branches plant<sup>-1</sup>, 900-1 000 kg ha<sup>-1</sup> in dry calyx yield, with high antioxidant content and sweet taste.

Estrella Costeña (JAM-05-231117): 8-9.5 cm calyx length, 8.5 to 9.5 cm calyx width, 120 days to flowering (sowing in June), 150 days to harvest, 170-190 cm plant height, 5 branches plant<sup>-1</sup>, 1 300 kg ha<sup>-1</sup> in dry calyx yield, high antioxidant content and sweet taste.

Patriota (JAM-008-231117): 6.5 to 8 cm calyx length, 5.5 to 7 cm calyx width, 120 days to flowering (sowing in June), 165 days to harvest, 170-200 cm plant height, 5 branches plant<sup>-1</sup>, 1 000 kg ha<sup>-1</sup> in dry calyx yield, with high antioxidant content and sweet taste.

Reina Roja (control): 5.7 cm of calyx length, 2.9 cm of calyx width, 102 days to flowering, (sowing in July), 120 days to harvest, 192-200 cm plant height, 7 branches plant<sup>-1</sup>, 440 kg ha<sup>-1</sup> in dry calyx yield, with high antioxidant content and sweet taste (own characterization).

## Experiment management

The land was fallowed and furrowed by means of animal traction and a plow. Subsequently, the four roselle varieties were sown, with a spacing of 0.50 m between bushes and 0.8 m between furrows, at a density of 25 000 plants ha<sup>-1</sup>, three seeds per position were sown at a depth of 1 cm, this activity was carried out at the beginning of the rainy period (July 8, 2021). The experiment was conducted under rainfed conditions. Two manual weeding were performed during the crop cycle, 30 and 60 days after sowing (das), in addition, a hilling was carried out with animal traction and a plow. To prevent the attack of the leaf-cutting ant (*Atta mexicana*), monitoring was carried out every third day. The weeding was done manually (August 8, 2021) with a hoe.

## Study variables

Based on what was described by Godínez (1988), in 10 random plants, apical pruning was carried out at 70, 90 and 107 das, 15 cm of the apical meristem of the plants were cut with the use of pruning scissors (Truper<sup>®</sup>). The variables recorded were: plant height (m) recorded with a metal grade rod, diameter of the stem base (cm) measured with a digital vernier (Truper<sup>®</sup>), number of branches through direct counting, fresh weight (g) and dry weight (g) of calyxes per plant in each of the varieties, for this activity a Volke<sup>®</sup> digital portable scale (mod. SF-400), with precision in grams, was used.

The harvest was carried out when the calyxes reached maturity and consisted of cutting the 40 plants per treatment, later the calyxes were separated from the fruit (capsule) and the fresh weight per plant was obtained to extrapolate it to the hectare. The calyxes were dried outdoors for seven days, with a moisture loss coefficient of 2.5-13.7%, depending on the variety, and the dry weight of calyxes in grams per plant was recorded to estimate the yield of dry calyxes per hectare (kg ha<sup>-1</sup>).

## Experiment design

A CRB experimental design was used, with 4 x 4 factorial arrangement, four roselle varieties (factor a) and 4 pruning dates (factor b), with 10 repetitions per treatment, each roselle plant represented an experimental unit. An analysis of variance (Anova) was performed with the Glimix procedure with confidence limits of 95% and a significance level  $\alpha=0.05$ , to determine the effect of the factors and their interactions (a\*b).

The statistical model was  $Y_{ijk}=\mu +A_i+B_j+AB_{ij}+E_{ijk}$ , where:  $Y_{ijk}$ = value of the response variable of repetition 1 of level i of A and level j of B,  $\mu$ = Overall mean,  $A_i$ = effect of level i of factor A (variety),  $B_j$ = effect of level j of factor B (pruning),  $AB_{ij}$ = interaction of level i of A and level j of B,  $E_{ijk}$ = experimental error corresponding to repetition k of level i of A and j of B. When there were significant differences, a Tukey mean comparison test was performed ( $\alpha=0.05$ ); in addition, a Pearson correlation analysis was performed between the variables with the PROC CORR procedure. All statistical analyses were performed with software SAS ver. 9.4 (SAS Institute, 2013).

## Results and discussion

The varieties and pruning factor, the variables were highly significant, except for the basal diameter of the stem, which did not show differences between treatments. Similar in varieties\*pruning, in the basal diameter of the stem no differences were obtained between the treatments (Table 1).

**Table 1. Analysis of variance of the effect of varieties, pruning dates and their interactions on roselle yield components.**

Source of variation	DF	Variables				
		PHE (cm)	DBS (cm)	Num. of branches	Fresh yield (kg ha <sup>-1</sup> )	Dry yield (kg ha <sup>-1</sup> )
Variety (a)	3	119.44 ***	46.02 ***	32.2 ***	311.12 ***	28.69 ***
Pruning (b)	3	19.31 ***	1.04 ns	174.47 ***	320.41 ***	256.4 ***
a*b	7	39.5 ***	8.39 ns	7.39 ***	146.83 ***	15.26 ***

DF= degrees of freedom; PHE= plant height; DBS= diameter of the stem; ns= not significant; \*\*\*= statistically significant  $\leq 0.001$ .

### Comparison of means of individual effects

#### Plant Height (PHE)

In varieties, the mean comparison test (Tukey, 0.05) indicated three groups for this variable, where the highest PHE occurred in the Mulata variety (without pruning) with 230.8 cm, followed by the Patriota variety with 213.9 cm and the lowest growths in height were for the Reina Roja variety (control) with 188.8 cm and the Estrella Costeña variety with 192.1 cm and its absolute control with 192.1 cm (Table 2).

Regarding factor b (pruning), the highest PHE was obtained with pruning at 107 das with 203.3 cm, followed by PHE of 192.7 cm with pruning at 70 and 90 das (Table 2). Apical pruning stopped the growth of the main stem of plants and the size of each variety with its intrinsic characteristics, the height of the varieties would be expected to decrease compared to the same unpruned varieties; however, pruning stimulates the formation of lateral branches, which, in several cases, exceed the main stem, hence the plants appear taller when they have been pruned than when they were not. In addition, plants compete for sunlight, which directly affects their production as it is a photoperiod plant (Chavarría, 2012).

#### Diameter at the base of the stem (DBS)

In the factor varieties, Mulata reached the highest DBS with 2.1 cm, followed by Patriota (unpruned) with 1.97 cm, in group three the *var* Patriota (with pruning) had 1.91 cm, followed by the *var* Mulata (without pruning) with 1.9 cm, the lowest DBS corresponded to the varieties Estrella Costeña and its control (unpruned) with 1.6 cm (Table 2). These results are similar to those reported in Cuba, in six sowing densities of roselle flower, where the ranges of the DBS were very similar, since in high densities the DBS was from 1.89 to 2.18 cm and low densities from 1.83 to 2.15 cm (Terán and Soto, 2004).

**Table 2. Comparison of means of the effect of varieties, pruning dates and their interactions on roselle yield components (Tukey,  $p \leq 0.05$ ).**

Source of variation	Variables				
	PHE (cm)	DBS (cm)	Num. of branches	Fresh yield (kg ha <sup>-1</sup> )	Dry yield (kg ha <sup>-1</sup> )
	Variety				
Estrella Costeña (1)	192.1 (0.97) c	1.6 (0.02) e	8.2 (0.17) b	4844.4 (7.2) a	1107.3(2.7) ab
Absolute control 1	191.6 (1.7) c	1.7 (0.02) de	6.9 (0.3) d	3524.4 (7.2) b	979.4 (4.6) bc
Mulata (2)	192.3 (0.97) c	2.1 (0.02) a	11 (0.17) a	5182.5 (9.7) a	1159.6 (2.7) a
Absolute control 2	230.8 (1.7) a	1.9 (0.02) bc	6.7 (0.3) d	3370.6 (9.7) b	901.9 (4.6) cd
Patriota (3)	213.9 (0.97) b	1.91 (0.02) bc	8.5 (0.17) b	4723.3 (7.2) a	775.21 (2.7) d
Absolute control 3	194 (1.7) c	1.97 (0.02) ab	8.1 (0.17) bc	3276.3 (7.2) b	585.6 (4.6) e
Reina Roja (4)	188.8 (0.97) c	1.82 (0.02) c	7.2 (0.17) c	5088.2 (9.7) a	992.3 (2.7) bc
Absolute control 4	192.1 (1.7) c	1.82 (0.02) c	6.9 (0.3) d	5175.6 (7.2) a	885 (4.6) cd
	Pruning				
70 das	192.7 (1.2) b	1.8 (0.02) a	7.9 (0.1) b	4612.5 (6.1) b	706.7 (1.8) d
90 das	194.3 (1.2) b	1.9 (0.02) a	10.6 (0.1) a	6267.2 (6.1) a	1372.5 (1.8) a
107 das	203.3 (1.2) a	1.8 (0.02) a	6.9 (0.1) c	3999.1 (6.1) c	946.6 (1.8) b
No pruning	202.1 (1.2) a	1.8 (0.02) a	7.1 (0.1) c	3861.7 (6.2) c	837.9 (1.8) c

PHE= plant height; DBS= diameter at the base of the stem; different letters in columns indicate significant differences with  $p \leq 0.05$ , the standard error is shown in parentheses.

### Number of branches

In relation to the varieties, the largest number of branches occurred in the *var* Mulata (with pruning) with 11 branches plant<sup>-1</sup>, followed by the varieties Patriota (with pruning) and Estrella Costeña (with pruning), with 8.5 and 8.2 branches plant<sup>-1</sup>, respectively. The lowest number of branches occurred in the unpruned treatments, which corresponds to the Reina Roja variety (without pruning) and the Estrella Costeña variety (without pruning) with 6.9 branches plant<sup>-1</sup>, respectively (Table 2). This indicates that pruning stimulated the formation of branches.

Regarding the pruning dates, the highest number of branches was obtained when pruning was carried out at 90 das, with 10.6 branches plant<sup>-1</sup> on average, while the lowest data were obtained in the control, which was the treatment without pruning with 7.1 branches plant<sup>-1</sup> and at 107 das with 6.9 branches plant<sup>-1</sup> (Table 2), which reflects that if pruning is done very late, the roselle plant does not develop more branches due to its photoperiod condition, that is, short days occur and the plants begin to form flower buds, without time for more vegetative buds to form.

### Yield of fresh calyxes (kg ha<sup>-1</sup>)

For varieties, Mulata with pruning reached a yield of 5 182.5 kg ha<sup>-1</sup>, followed by the absolute control (unpruned) with 5 175.6 kg ha<sup>-1</sup> and the local variety Reina Roja with pruning, which had 5 088.2 kg ha<sup>-1</sup>. The lowest yields correspond to the Estrella Costeña, Mulata and Patriota varieties,

the three without pruning with 3 524.4, 3 370.6 and 3 276.3 kg ha<sup>-1</sup>, respectively (Table 2). Regarding the factor pruning, the best yield of fresh calyxes occurred when apical pruning was carried out at 90 das with 6 267.2 kg ha<sup>-1</sup>, followed by pruning at 70 das with 4 612.5 kg ha<sup>-1</sup> and the lowest yields occurred in the pruning carried out at 107 das, and in the absolute control of the local variety Reina Roja without pruning with 3 999.1 and 3 861.7 kg ha<sup>-1</sup>, it was confirmed that pruning can contribute to the increase in roselle production, but it must be done in an appropriate time, in this case, 90 das is recommended, since if it is done very late, it will not contribute to the yield (Table 2).

In this regard, Escobar (1997) indicates that, when the topping is carried out in roselle plants, they show an immediate response to the breaking of apical dominance, lateral growth is stimulated and the diameter of the foliage increases, therefore, there is a greater area of production of flower buds and an increase in the production of calyxes. For their part, Hidalgo and Cano (2007) mention that, when apical pruning is carried out at 75 das, there is a significant difference in the increase in the rate of return of the crop, apical growth stops and branching is promoted, which translates into a higher yield of roselle calyxes.

Regarding yield, Cano (2008) states that topping significantly benefits the yield of calyxes, where the highest production was recorded at 75 das. The results obtained in this study with pruning at 90 das showed the highest yield of fresh calyxes in the Mulata, Reina Roja, Estrella Costeña and Patriota varieties. In addition, Terron (2015) indicates that topping benefits and accelerates fruiting and in herbaceous crops, it favors the evolution to flower of certain axillary buds or formation of more abundant and uniform buds, as happened in this case.

### **Yield of dry calyxes (kg ha<sup>-1</sup>)**

The best yield occurred in the Mulata variety with 1 159.6 kg ha<sup>-1</sup>, followed by Estrella Costeña with 1 1107.3 kg ha<sup>-1</sup>, Reina Roja and Estrella Costeña (without pruning) with 992.3 and 979.4 kg ha<sup>-1</sup>, respectively. The lowest yields occurred in the Patriota variety with pruning and without pruning with 775.2 and 585.6 kg ha<sup>-1</sup>, respectively, with an increase in yield of 41% compared to the highest yield shown by the Mulata variety (Table 2).

In the factor pruning, the best yield was obtained when the apical pruning was performed at 90 das with 1 372.5 kg ha<sup>-1</sup>, followed by pruning at 107 das with a yield of 946.6 kg ha<sup>-1</sup>, the lowest yields occurred in the absolute control (unpruned) and at 70 days with 837.9 and 706.7 kg ha<sup>-1</sup>, respectively, which represents a higher yield of 44%, when pruning at 90 das (Table 2). According to the reports of SIAP-SADER (2022), in 2019 in Michoacán, the yield ranged between 290 and 870 kg ha<sup>-1</sup>, with an average of 580 kg ha<sup>-1</sup> of dehydrated roselle and the one reported at the national level which is 430 kg ha<sup>-1</sup>. Undoubtedly, agronomic practices contribute to improving the production of any crop, in this case the use of improved varieties (Mulata) and the control Reina Roja, as well as topping at 90 das showed the best results. For their part, Slamet *et al.* (2013) indicated that apical pruning influenced the increase in diameter, as well as the fresh and dry weight of the calyx, in addition, an increase in the content of anthocyanins was obtained.

### Effect varieties\*pruning

Table 3 shows the interactions between factors a\*b in plant height, stem diameter, number of branches, and fresh and dry calyx yield per hectare. The Mulata variety and pruning at 90 das showed the best combination between factors a\*b, in the variables number of branches (12.9), weight of fresh calyces (6 763.2 kg ha<sup>-1</sup>) and weight of dry calyces (1 623.1 kg ha<sup>-1</sup>) (Table 3).

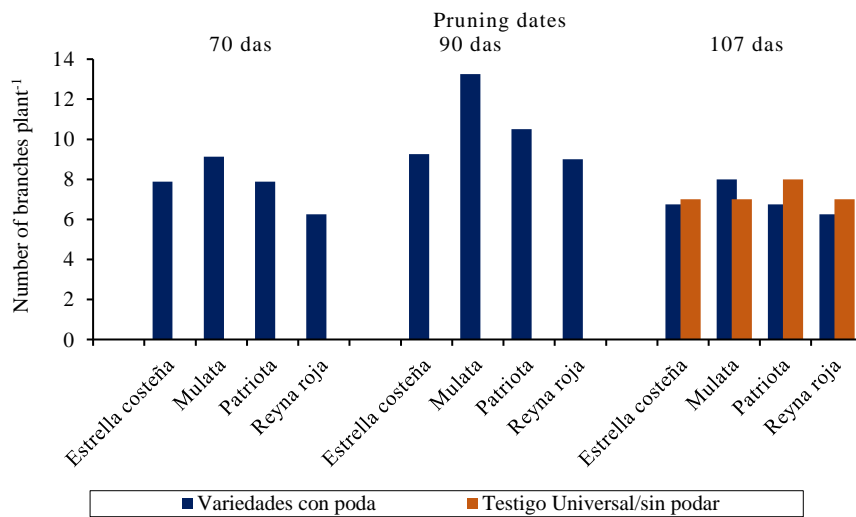
**Table 3. Tukey's comparison of means ( $p \leq 0.05$ ) of the effect of interaction varieties\*pruning in roselle plants.**

Source of variation	Variables				
	PHE (cm)	DBS (cm)	Num. of branches	Fresh yield (kg ha <sup>-1</sup> )	Dry yield (kg ha <sup>-1</sup> )
1*1	195.1 (1.3) ab	1.7 (0.03) c	8.1 (0.02) c	4842.5 (7.2) c	786.3 (4.6) f
1*2	188.4 (1.3) c	1.7 (0.03) d	9.9 (0.02) b	6093.8 (7.2) ab	1546.9 (4.6) ab
1*3	192.8 (1.3) b	1.7 (0.03) c	6.8 (0.02) d	3596.9 (7.2) d	988.8 (4.6) d
1*4	191.6 (1.7) c	1.7 (0.02) c	6.9 (0.3) d	3524.4 (7.2) d	979.4 (4.6) d
2*1	186.5 (1.3) c	2.1(0.03) a	9.3 (0.02) b	5196.9 (7.2) b	818.1 (4.6) e
2*2	193.7 (1.3) b	2 (0.03) ab	12.9 (0.02) a	6763.2 (7.2) a	1623.1 (4.6) a
2*3	196.8 (1.3) b	1.9 (0.03) b	8.1 (0.02) c	3587.5 (7.2) d	1037.5 (4.6) c
2*4	191.6 (1.7) c	1.7 (0.02) c	6.9 (0.3) d	3524.4 (7.2) d	979.4 (4.6) d
3*1	199.2 (1.3) ab	1.8 (0.03) bc	8.1 (0.02) c	4662.5 (7.2) c	455 (4.6) g
3*2	209.8 (1.3) ab	2 (0.03) ab	10.7 (0.02) ab	6175.0 (7.2) ab	1111.9 (4.6) bc
3*3	232.7 (1.3) a	1.9 (0.03) b	6.8 (0.02) d	3332.5 (7.2) e	758.8 (4.6) f
3*4	191.6 (1.7) c	1.7 (0.02) c	6.9 (0.3) d	3524.4 (7.2) d	979.4 (4.6) d
4*1	190.2 (1.3) b	1.8 (0.03) bc	6.4 (0.02) e	3748.2 (7.2) d	786.3 (4.6) f
4*2	185.2 (1.3) c	1.9 (0.03) b	8.9 (0.02) bc	6036.9 (7.2) ab	1208.1 (4.6) b
4*3	191.1 (1.3) b	1.8 (0.03) bc	6.3 (0.02) 3	5479.4 (7.2) b	1001.2 (4.6) c
4*4	191.6 (1.7) b	1.7 (0.02) c	6.9 (0.3) d	3524.4 (7.2) d	979.4 (4.6) d

The first number of the interaction corresponds to the variety: (1) Estrella Costeña; (2) Mulata; (3) Patriota; and (4) Reina Roja and the second to the days after sowing (das) in which the pruning was performed= 70 (1), 90 (2) and 107 (3) das and without pruning/control (4). PHE= plant height; DBS= diameter at the base of the stem; different letters in columns indicate significant differences with  $p \leq 0.05$ , the standard error is shown in parentheses.

The application of topping influenced the yield of the calyces in fresh and dry weight, which is directly related to the other variables recorded, such as plant height and number of branches; of these variables, the number of branches per plant was the one that was most related to yield, according to the data obtained. The four roselle varieties evaluated responded positively to pruning at 70, 90 and 107 das, and if it is not carried out it, calyx production is low (Figure 1).





**Figure 1. Number of branches plant<sup>-1</sup> in four roselle varieties, with pruning and without pruning.**

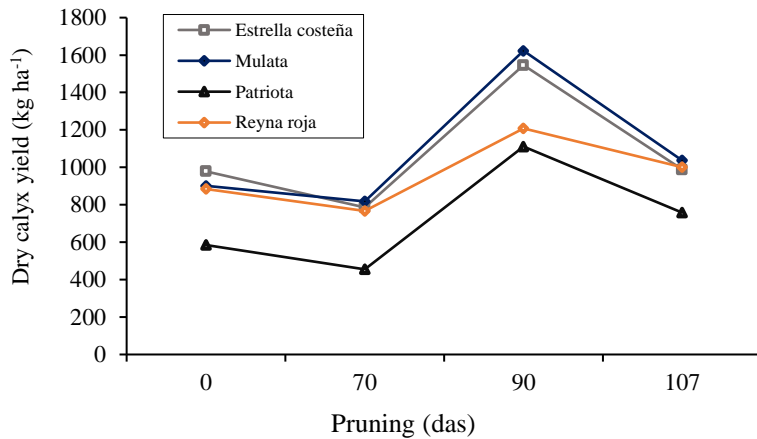
In this study, pruning at 90 das was the best time to increase yield in the production of roselle calyxes (Figure 1). This practice is important, and its use is recommended in the production of roselle from Bajo Balsas in Michoacán because it favors the formation of branches and flower buds. Escobar (1997); Farizatul *et al.* (2016) mention that this practice generates a response of greater area of production of flower buds, therefore, increases the production of calyxes. In addition, Rojas (2005) points out that, when the plant reaches 1.5 m in height, pruning is done to make the harvest easier for the cutter, because the roselle flowers are available at a better height.

In the interaction of pruning dates with dry calyx yield, it was observed that, at 70 das, there is a reduction in yield in all varieties, suggesting that early prunings are favorable to increase yield, on the contrary, at 90 and 107 das, an increase in yield was observed, with better results at 90 das with the Mulata and Estrella Costeña varieties, where yields of 1 623.1 and 1 546.9 kg ha<sup>-1</sup>, respectively, were obtained (Figure 2). Pal (2018) observed 25 branches plant<sup>-1</sup> and basal diameter of 4.6 cm with genotypes from India, where there is likely to be greater diversity than that detected in Mexico (Rubio, 2016). Therefore, and according to the findings, of the agronomic practices that must be carried out in the cultivation of roselle, topping is fundamental to stimulate the development of vigorous lateral branches (MINEP, 2005). However, most roselle producers in the dry tropics region of the state of Michoacán do not do it, basically due to ignorance. This means that the yields obtained are low and the productive potential of roselle cultivars is not optimized.

### Correlations between variables

A positive correlation was detected between the wet and dry weight of the calyxes per plant and the yield of both weights per ha ( $r = 0.62^{***}$ ); that is, the greater the wet weight obtained from the calyxes, the greater the yield of the calyxes in both fresh and dry weight, with a moisture loss between 6 and 10%, which means that, for every 6 to 10 kg of wet calyxes, 1 kg of dry calyxes is obtained. It is opportune to generate information and that it be used to increase the yields of roselle

that producers currently obtain, therefore, a greater profit margin would be obtained for families. Given the climatic conditions of the dry tropics region of the state, the crop is a good alternative for producing in marginalized areas, where other crops do not thrive.



**Figure 2. Interaction of the yield of dry calyxes of four roselle varieties and three pruning dates.**

Likewise, it is important to specify other management practices to improve the productivity and profitability of the crop and that together contribute to obtaining better yields than those currently obtained in the study area and in other roselle-producing areas. These improvement practices can be determining the best sowing density, sowing dates, optimal fertilization, among others.

## Conclusions

The Mulata variety had the largest diameter at the base of the stem, at 70 days; however, the largest number of branches and yield in fresh and dry weight of calyxes correspond to the pruning carried out 90 days after sowing. The pruning at 90 das generated the best yields of the dry calyxes in the four varieties evaluated, with the highest yield in the Mulata and Estrella Costeña varieties, with an increase of 44% with respect to the treatments without pruning.

The effect of the factors varieties\*pruning confirmed that the Mulata variety at 90 das generated better results in number of branches (12.9 branches/plant), yield of calyxes in fresh and dry (6 763.2 and 1 623.1 kg ha<sup>-1</sup>). The yields obtained exceeded by 82.8% those reported by SIAP-SADER (2022) in 2019 for Michoacán, as well as the average production obtained in previous years for this region of the dry tropics of the state and with what was reported at the national level.

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