Colegio de Postgraduados

Assessment of Harvest Losses in Mejhoul Date Variety in Northwest Mexico

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ABSTRACT

Objective: To assess date losses during harvest and identify the factors causing them.

Design/methodology/approach: A complete randomized block design with ten repetitions was used; the different farms where data on the evaluated variables were taken were the treatments. In each treatment, 10 plants were selected from which data on average fruit weight, polar and equatorial fruit diameter, fruit weight, number of clusters per plant, and yield in tons per hectare were taken.

Results: For yield in tons per hectare of good fruits during the date harvest in the 2023 cycle, an average of 11 t ha^{-1}, 14 t ha^{-1}, 8 t ha^{-1}, and 15 t ha^{-1} was found for the plantations of El Pólvora, El Pino, Las Palmas and Cucapah respectively. In losses during the harvest, Cucapah Farm presented the highest losses with an average of 1.2 t ha^{-1}, while El Pino was the one that presented the lowest losses with an average of 0.7 t ha^{-1}. Fruits with a percentage greater than 10% of peeled skin are also considered losses during the harvest, because they cannot be marketed for fresh consumption.

Limitations on study/implications: Data were collected only from the harvest; exact dates of irrigation and fertilizer application are not available as the study was conducted with cooperating producers. This factor is crucial for the quality and yield of date palm cultivars.

Findings/conclusions: The age of the plant represents a significant difference in the yield per hectare due to the number of clusters it has; the more clusters it has, the higher the yield. The relative humidity directly affects the quality of the dates, and there are a more significant number of bulging fruits (with peeled skin). In this evaluation, we found that the rains during August and September 2023 significantly affected the losses during the date harvest in that season.

Keywords: Losses, Date Palm, Harvest, Agroclimatic Conditions.

Citation: Mendoza-Gómez, A., Beleño-Cabarcas, M. T., Torres-Ramos, R., Morales-Maza, A., Cázarez-Flores, L. Ll., Bazante-González, I., Zazueta-Torres, N. D., & Escobosa-García, M. I. (2024). Assessment of Harvest Losses in Mejhoul Date Variety in Northwest Mexico. *Agro Productividad*. https://doi.org/10.32854/agrop.v17i11.3121

Academic Editor: Jorge Cadena Iñiguez
Associate Editor: Dra. Lucero del Mar Ruiz Posadas
Guest Editor: Daniel Alejandro Cadena Zamudio

Received: May 15, 2024.
Accepted: September 11, 2024.
Published on-line: December 09, 2024.

Agro Productividad, 17(11) supplement. November. 2024. pp: 93-101.

INTRODUCTION

The date palm (*Phoenix dactylifera* L.) is one of the oldest crops in history, with evidence of its use dating back to 4000 B.C. in southern Iraq and Mesopotamia (Propenoe, 1913

& 1973). Today, the date palm dominates value chains due to modernization, sustainable production systems, and the expansion of exports, thereby contributing to sustainable development goals (FAO, 2022).

In Mexico, date production, especially of the Mejhoul variety, has gained increasing importance, particularly in Baja California, due to its high demand in international markets. This variety of date palm was introduced to Mexico in 1968 through the importation of offshoots from the United States, establishing itself in the San Luis Río Colorado Valleys in Sonora and Mexicali, Baja California (Salomón, 2021). Today, Mejhoul, known as "the jewel of dates," accounts for 94% of the total area dedicated to date cultivation in Mexico. Its popularity is due to its attractive appearance, large size, brown color, juicy flesh, and exceptional flavor (Abdelouahhab & Abdallah, 2023).

According to the Secretariat of Rural Development (SADER), Mexico ranks third in the world in Mejhoul date production, after Israel and the United States. It is estimated that the area planted in Mexico is 3,268 hectares, producing 19,465 tons of dates, providing significant benefits to farmers and their families (SADER, 2022). In recent years, Northwest Mexico has experienced remarkable growth in the development of large commercial areas dedicated to date palm cultivation, especially in the Mexicali Valley, Baja California, and San Luis Río Colorado, Sonora. These regions have stood out for their ability to achieve excellent yields due to their favorable agroclimatic conditions. The increase in date production has significantly boosted the local economy, providing job opportunities and improving the quality of life for many rural families.

However, date production faces significant challenges. Climatic variations, such as abrupt changes in temperature and irregular precipitation, directly affect fruit growth and quality. Agricultural management practices also play a crucial role; inadequate management can lead to decreased yields and date quality, affecting competitiveness in the international market.

Moreover, the threat of climate change adds a layer of complexity to these challenges. Rising temperatures and prolonged droughts are putting additional pressure on date producers. Therefore, this research focuses on estimating losses during the harvest of the Mejhoul date variety in Northwest Mexico, with the aim of providing producers with a clear overview of the main factors contributing to these losses and how to mitigate them.

MATERIALS AND METHODS

Study Area Location

The research was conducted during the 2023 season in the Mexicali Valley, which covers an area of approximately 3,709 km^2 and is situated in a broad tectonic basin formed by sediments deposited by the Colorado River and the alluvial fans of the Sierra Cucapá (Lira, 2005). It is bounded to the east by the Colorado River, to the west by the mountain ranges (Sierra Cucapá, Sierra El Mayor, and Cerro El Centinela), and to the north by the sandy mesa on which the border with the United States is located. The Valley is part of the Sonoran Desert, specifically the Bajo Delta of the Colorado River subunit (Shreve and Wiggins, 1964), characterized by a nearly flat surface with altitudes slightly exceeding 40 meters above sea level (asl).

Treatments and Variables

Four strategic farms in the Mexicali Valley were selected, with different ages of plantations (El Pólvora at 30 years, El Pino at 11 years, Las Palmas at 9 years, and Cucapah at 12 years). In each farm, the common variety was Mejhoul. Ten plants were selected as replicates, and a randomized complete block design with 10 replicates was used, applying the statistical model for this design according to the methodology of Steel and Torrie (1980). The treatments consisted of the different farms where data on the evaluated variables were collected, maintaining the common Mejhoul date palm variety in each one. The evaluated variables were the number of clusters per plant (NCPP), Total fruit weight per cluster (TFWC) in kg, losses per cluster (LPC) in kg, average fruit weight (AFW) in grams, polar and equatorial diameter of the fruit (PDF, EDF) in centimeters, Weight of Good Fruits per Cluster, Bulging Fruits per Cluster, Crystalline Fruits per Cluster, and Waste Fruits per Cluster and per Plant (WGFC, WBFC, WCFC, and WWFC) in kg, and yield in tons per hectare of good, bulging, crystalline, and waste fruits.

The numerical data obtained in the field were organized and subjected to analysis of variance and multiple comparisons of means using the Tukey test with $\alpha \leq 0.05$ in the R statistical software package.

Field Procedure

At the four selected farms, 10 plants were sampled, and the harvest was carried out manually. Date fruits from each cluster were collected and placed in separate containers; the total weight of each cluster was recorded in kilograms, and the data were noted in the field notebook. Subsequently, the fruits in each cluster were classified, starting by separating those with damage from disease, pests or that were dried; in general, fruits that were unusable and went directly to waste were classified as waste.

Then, fruits that did not lose moisture on the cluster and remained yellowish were identified. These fruits require more sun to lose moisture and were classified as crystalline fruits. Fruits with more than 10% peeled skin are not suitable for fresh commercialization

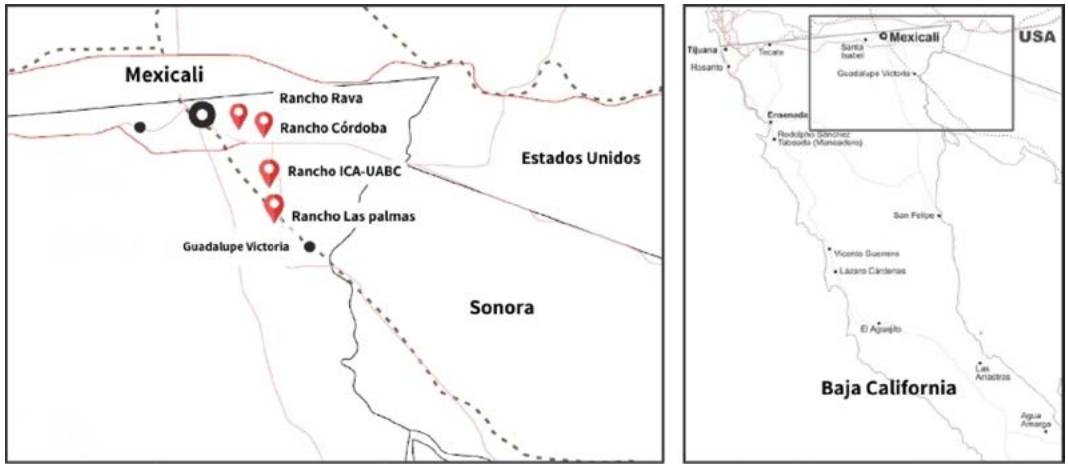

Figure 1. Location map of farms in the Mexicali Valley to assess date losses during harvest.

and are designated for processing; these were classified as bulging fruits. Finally, fruits that are ready for fresh commercialization and can be sent to a controlled atmosphere are those with less than 10% peeled skin, no damage from diseases or pests, and acceptable moisture for storage in the post-harvest area. These fruits have an average weight of 23 to 27 grams and were classified as good fruits.

RESULTS AND DISCUSSION

Hamadttu *et al.* (2022) mention that cultural practices in date palms, such as irrigation, fertilization, and fruit thinning, improve fruit quality. However, this factor can be influenced by environmental conditions prior to harvest and mechanical damage during harvest. They conducted a study using four irrigation levels: 80%, 100%, 120%, and 140% of the palm's evapotranspiration. The study demonstrated that the lowest and highest irrigation water levels significantly affect fruit quality, particularly regarding skin detachment.

Glenn (2016) mentions that date harvest begins in late August in the Mexico and United States regions, and that spontaneous rains during these months can cause losses of up to 20% during harvest, a natural factor that cannot be controlled. He also notes that each mature palm can produce between 100 to 125 kilograms per plant. Similar results were obtained in this study, where the average was 90 kg per plant, and in the 30-year-old plantation, 118 kilograms of dates per plant were achieved.

Table 1 presents the results for the number of clusters per plant. El Pólvora farm has the highest number of clusters per plant, with an average of 20 clusters, while the Cucapah plantation had the lowest number of clusters per plant, with an average of 10 clusters.

Good fruits **Domed fruits** **Crystalline fruits** **Waste fruits**

Figure 2. Classification of date fruits during harvest to assess losses.

Table 1. Date yield per cluster and plant age. Mexicali Valley, Baja California, Mexico. October 2023.

Treatment	Plant age (years)	Number of clusters per plant	Fruit weight per bunch (kg)	Clusters losses (kg)
El Pólvora	30	20.1 [a]	6.02 [b]	0.31 [b]
El Pino	11	14.8 [b]	6.25 [b]	0.32 [ab]
Las Palmas	9	11.1 [bc]	4.87 [b]	0.52 [ab]
Cucapah	12	10.2 [c]	9.57 [a]	0.64 [a]

* Means with the same letter within each column are statistically similar (Tukey, $p \leq 0.05$).

However, Cucapah achieved the highest weight of fruits per cluster, with an average of 9.5 kg. These results align with Glenn (2016), who mentions that a mature date palm can produce an average of 90 to 120 kilograms per year. For the variable of date losses per cluster, Cucapah experienced higher losses with an average of 640 grams per cluster.

The plant age is directly related to the number of clusters each plant produces. It was found that Cucapah Farm has the highest total fruit weight per cluster; however, it also registers the highest date losses during the harvest. This is because, in this plot, the thinning practice was not performed after pollination. Thinning involves removing some fruits per cluster after fruit set to leave an average of 10 to 12 fruits per strand and 45 to 50 strands per cluster, to provide more space for the fruits to develop and reach acceptable quality. According to Morales *et al.*, 2023, this activity ensures fruit quality.

These results are consistent with the information from Glenn (2016), who recommends leaving 10 to 12 fruits per strand and an average of 50 strands per cluster to ensure good quality and quantity of fruit per cluster. Morales *et al.* (2023) mention that for achieving the greatest success in establishing date palm plantations, climate is the most important factor, determining the areas where optimal growth and development of the palms can be achieved. According to various studies, areas within a geographic belt between coordinates 24° N and 34° N are considered the most suitable, as this is where the largest commercial area is established worldwide. In the United States and Mexico, date palms are between 32° and 33°N. Due to climatic factors, the date palm will grow, but the fruit will not develop properly outside the suggested geographic limits.

Table 2 shows the average yield in tons per hectare for each treatment. Pólvora Farm presents the highest number of clusters per plant, which increases the yield in tons per hectare (Figure A and B). However, the fruit size decreases in this case. On the other hand, the results indicate that the Las Palmas plantation presents larger fruits, which is reflected in higher quality and acceptance for the export market (Figure C). The quality of the date is classified according to its size and weight as follows: premium super jumbo dates of more than 27 g, premium jumbo 23-27 g, premium large 18-23 g, premium medium 15-18 g, if the peeled skin ranges from 0 to 10% (Abdelouahhab & Abdallah, 2023). In Table 2, it is shown that the weights of the dates in the evaluated treatments range from 17 to 24 grams. Regarding the variables of polar and equatorial fruit diameter, no significant differences were found, showing a single homogeneous group in the mean comparison, which indicates that this variable does not significantly influence the average date fruit yield. In Las Palmas Farm, corresponding to Treatment 3, the plantation is nine years old, which is reflected

Table 2. Average Fruit Weight per Cluster and Total Fruit Weight per Plant in Valle de Mexicali, Baja California, Mexico. October 2023.

Treatment	AFW (g)	PFD (cm)	EFD (cm)	WGFC (kg)	WBFC (kg)	WCFC (kg)	TFWP (kg)	Yield (t ha^{-1})
El Pólvora	17.54 ^{b}	4.43 ^{a}	2.43 ^{a}	3.82 ^{a}	1.27 ^{b}	0.61 ^{a}	118 ^{a}	18.43 ^{a}
El Pino	21.04 ^{ab}	4.88 ^{a}	2.61 ^{a}	3.46 ^{a}	1.28 ^{b}	1.18 ^{a}	93 ^{ab}	14.57 ^{ab}
Las Palmas	24.92 ^{a}	5.11 ^{a}	2.71 ^{a}	1.99 ^{b}	1.97 ^{b}	1.18 ^{a}	58 ^{b}	9.14 ^{b}
Cucapah	22.91 ^{a}	4.82 ^{a}	2.69 ^{a}	3.92 ^{a}	3.64 ^{a}	1.05 ^{a}	91 ^{ab}	14.29 ^{ab}

*Means with the same letter within each column are statistically equivalent (Tukey, $p \leq 0.05$).

in a lower number of clusters and, therefore, a lower yield in tons per hectare. Statistically, this treatment shows significant differences and heterogeneity, attributable solely to the age of the plantation.

In Table 2, it is observed that, for the variable of average fruit weight, there are highly significant differences. This indicates that plantations older than 30 years produce fruits of lower quality, primarily due to the number of clusters per plant and the competition among them for nutrients. On the other hand, nine-year-old palms produce fruits of greater weight and quality. As the number of clusters decreases, competition for nutrients is reduced. Additionally, environmental factors also influence fruit formation and filling. According to Zaid and de Wet (2002a), temperature has direct effects on fruit set and growth, with the average temperature needing to be around 25 °C to achieve greater success in fruit set. The ripening process of the date is another critical stage, as temperature directly affects the quality and timing of ripening. Therefore, temperatures during this stage should be above 18 °C from early April, after pollination, and continue until October, when the harvest season is ending. For the variable of weight of good fruits per cluster, two heterogeneous groups in the means are observed, with Cucapah Farm showing the highest fruit weight and Rancho Las Palmas showing the lowest fruit weight per cluster. For the variable of weight of bulging fruits per cluster, regardless of the age of the plantations, all were affected with considerable amounts in this variable, with around 4 kg of bulging fruits per cluster, which is directly related to the climatic conditions prior to the harvest. The recommended average annual relative humidity ranges from 27% to 41%, preferably during the flowering,

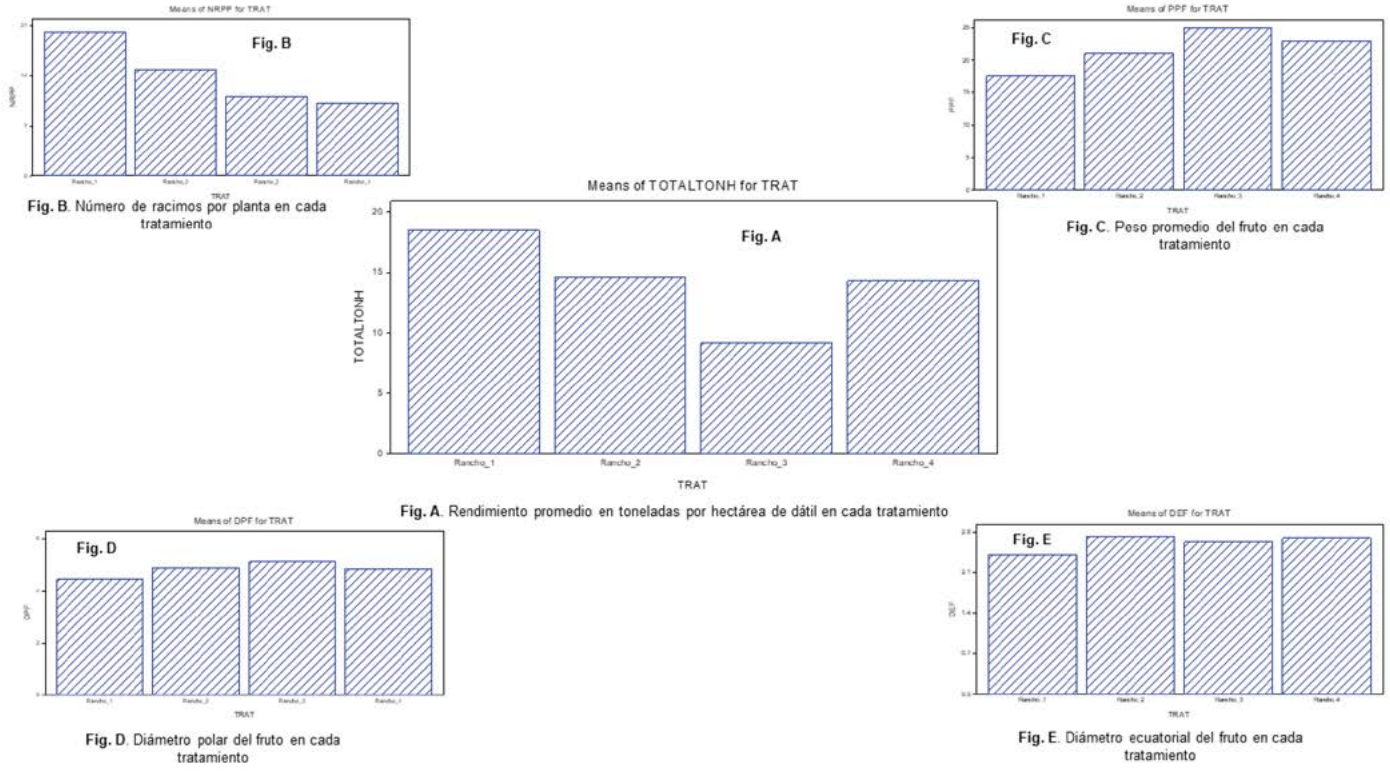

Figure 3. Comparison of date fruit yield in tons per hectare and its relationship with fruit quality and number of clusters per plant.

growth, and fruit maturation (dehydration) periods, which span from March to October (El-Sharabasy *et al.*, 2022).

In Figure 2, the average date fruit weight per cluster in the different ranches is shown. It is observed that Cucapah Farm exhibits the highest quantity of all four variables: good fruits, bulging fruits, crystalline fruits, and waste fruits.

In Table 3, the results for yield in tons per hectare of date fruits harvested from different plantations during the 2023 cycle are presented. The yield per hectare is directly related to the weight per plant, the number of clusters per plant, and the age of the plantation. The Cucapah ranch shows the highest yield in tons per hectare of waste and bulging fruits, while the El Pino and Las Palmas ranches present lower losses during harvest.

According to Morales *et al.*, 2023, air humidity affects the quality of dates, making them highly susceptible to diseases during the maturation and dehydration process. Higher humidity promotes the growth of saprophytic fungi, which appear as black mycelium with small dark hairs that, when touched, release spores that affect nearby fruits. Additionally, high humidity causes dates to become soft and sticky, while low humidity makes them very

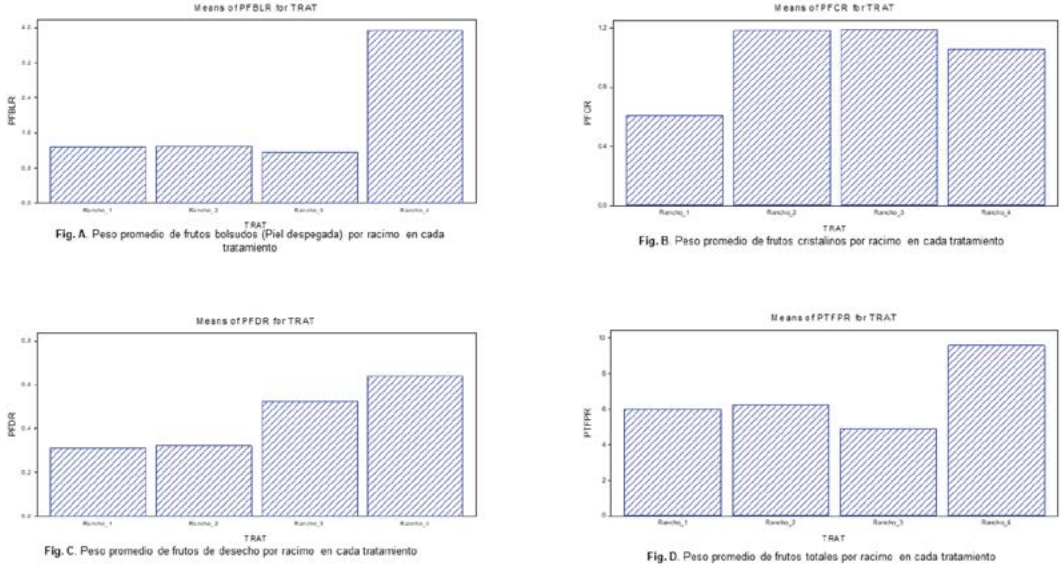

Fig. A. Peso promedio de frutos bolsudos (Piel despegada) por racimo en cada tratamiento

Fig. B. Peso promedio de frutos cristalinos por racimo en cada tratamiento

Fig. C. Peso promedio de frutos de desecho por racimo en cada tratamiento

Fig. D. Peso promedio de frutos totales por racimo en cada tratamiento

Figure 4. Average Date Fruit Yield per Cluster and Its Relationship with Different Ages of Date Palm Plantations in the Mexicali Valley, Baja California. October 2023.

Table 3. Yield in tons per hectare of date fruit (good fruits, crystalline fruits, bulging fruits, and waste fruits) in different plantations in the Mexicali Valley, Baja California, Mexico. October 2023.

Treatment	WGFC (kg)	WCFC (kg)	WBFC (kg)	WWFC (kg)	THAGF (t ha^{-1})	THACF (t ha^{-1})	THABF (t ha^{-1})	THAWF (t ha^{-1})
El Pólvora	75.2 ^{ab}	12.16 ^{a}	24.5 ^{ab}	6.28 ^{a}	11.74 ^{ab}	1.89 ^{a}	3.82 ^{ab}	0.98 ^{a}
El Pino	92.61 ^{a}	17.47 ^{a}	19.1 ^{b}	4.91 ^{a}	14.45 ^{a}	2.73 ^{a}	2.99 ^{b}	0.76 ^{a}
Palmas	55.29 ^{b}	13.86 ^{a}	13.7 ^{b}	5.72 ^{a}	8.63 ^{b}	2.16 ^{a}	2.13 ^{b}	0.89 ^{a}
Cucapah	100.4 ^{a}	10.91 ^{a}	43.1 ^{a}	6.51 ^{a}	15.67 ^{a}	1.71 ^{a}	6.73 ^{a}	1.02 ^{a}

*Means with the same letter within each column are statistically equivalent (Tukey, $p \leq 0.05$).

dry and hard. On the other hand, dry and hot winds cause rapid maturation, leading to the drying of dates and the appearance of a yellow or white ring at the base of the fruit, rendering them unsuitable for export and resulting in significant losses during harvest.

The Cucapah farm, with 12 years of plantation age, showed higher losses during the harvest, with more than one ton of waste fruit per hectare and an average of 6.7 t ha^{-1} of fruit with more than 50% skin detached.

CONCLUSIONS

The age of the plant represents a significant difference in yield per hectare, influenced by the number of clusters present. While an increased number of clusters leads to higher yield, it also results in a decrease in fruit quality. Relative humidity in the environment and pre-harvest rainfall directly affects the quality of dates, leading to a higher number of bulging fruits (with skin separation). This evaluation found that the rainfall during August and September 2023 significantly impacted losses during the date harvest.

ACKNOWLEDGMENTS

To the Baja California Date Product System (SIPRODA) for all the facilities provided for the development of this research.

To the cooperating producers from the Cucapah, Las Palmas, and El Pino farms for allowing us to access their plantations and collect data for the research. To the Institute of Agricultural Sciences at the Autonomous University of Baja California for all the support provided for the development of the evaluation. To the National Institute of Forestry, Agricultural and Livestock Research (INIFAP) for all the technical and scientific support in carrying out this work.

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