Revista Mexicana de Ciencias Agrícolas

DOI: https://doi.org/10.29312/remexca.v16i3.3605

Article

Yield of six grape varieties in Nuevo León

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Abstract

The vine (*Vitis vinifera* L.) is one of the oldest and most economically important crops in the world. Due to the relevance that this crop has taken on in Mexico and in the state of Nuevo León, in 2023, the proposed objective was to evaluate the yield of six grape varieties in the vineyard of the Center for Research in Agricultural Production of the Autonomous University of Nuevo León; the varieties used were Chardonnay, Chenin Blanc, Merlot, Cabernet Sauvignon, Malbec and Shiraz. For sampling, three plants per variety and 25 grapes per plant were taken and the weight of the production and the yield in kg ha^{-1} were evaluated. The total sugar content was evaluated using the variables of pH and degrees Brix. An analysis of variance (Anova) was performed considering a *p*-value ≤ 0.05. The results indicate significant differences in the variables of degrees Brix, pH and yield per hectare. Regarding degrees Brix, the Shiraz cultivar with an average of 26.5 and Chardonnay with 24.1 were the ones that showed the highest values. In terms of pH, the Shiraz cultivar presented the highest value (4.04) and Cabernet Sauvignon the lowest (3.46). The Malbec cultivar had the highest yield with 8 772.8 kg ha^{-1}, followed by the Cabernet Sauvignon cultivar with 5 765.5 kg ha^{-1}, so the study suggests that these vine varieties can be considered as an alternative crop for the southern region of the state of Nuevo León.

Palablas clave:

Vitis vinifera, degrees Brix, yield.

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Introduction

Worldwide, the vine (*Vitis vinifera* L.) is one of the oldest and most economically important crops. There are around 5 000 varieties, but only 30 are commercially exploited. Twenty-three thousand grape varieties are registered in the Vitis International Variety Catalogue, including improved varieties, hybrid, historical, unrecognized or extinct varieties, and wild species, which are listed several times under synonyms (Maul, 2015).

The Domaine de Vassal Research Center in France grows the largest grape variety in the world. It includes 2 300 grape varieties of the species *Vitis vinifera*, 800 crosses or interspecific hybrids, 230 rootstocks, and 28 species of wildlife. Currently, some 2 500 varieties are authorized for quality winemaking according to the legal regulations of the countries where they are distributed (Togores, 2011).

Depending on the use of grapes, for the production of wine, fresh or table consumption, the varieties must meet certain morphological characteristics that facilitate their recognition and are more or less sensitive to certain climatological conditions (Dominé, 2008); in the European Union (EU), each country defines the varieties for the respective use, particularly for high-quality winemaking and they are divided into white and red, for the production of wines in both categories (Sabogal, 2007).

In 2022, more than 258 million hectoliters (hl) of wine were produced in the world (Cavazos, 2017), placing the vine as the fourth most produced fruit, after bananas, oranges, and apples (Rehm and Espig, 1984). The largest producing countries were Italy with 49.8 hl, France with 45.6 hl, and Spain with 35.7 hl. In Mexico, a production of 452 927 t of grapes is estimated in 2022, with 16% destined for industrial use, which is equivalent to almost 36 million liters of wine.

Approximately 71% of Mexican wine production is concentrated in the states of Aguascalientes, Baja California, and Zacatecas; the rest is mainly distributed among the states of Coahuila, Querétaro, Chihuahua, Guanajuato, San Luis Potosí, Puebla, Sonora, and Nuevo León. Around 80 grape varieties are grown, of which 50% are for industrial use, mainly for wine. Six varieties account for more than 50% of the cultivated area: Chardonnay (17%), Cabernet Sauvignon (13%), Ugni blanc or Trebbiano (8%), Carignan (7%), and Merlot (6%) (Salazar, 2005; Consejo Mexicano Vitivinícola, 2023; SIAP, 2023).

In Mexico, Nuevo León joins the grape-producing states, mainly in the municipalities of García, Santiago, Montemorelos, Iturbide, Linares, Allende, Cadereyta Jiménez, and Higueras, as an alternative crop in the citrus-growing region of the state of Nuevo León. The research aimed to evaluate the yield of six vine varieties in the region of Linares, Nuevo León.

Materials and methods

Study area

This work was conducted in the vineyard of the Center for Research in Agricultural Production (CIPA, for its acronym in Spanish) of the Autonomous University of Nuevo León. The CIPA is located on the Monterrey-Cd. Victoria Highway km 145, Linares, Nuevo León, Mexico (CIPA, 2018) (Figure 1).

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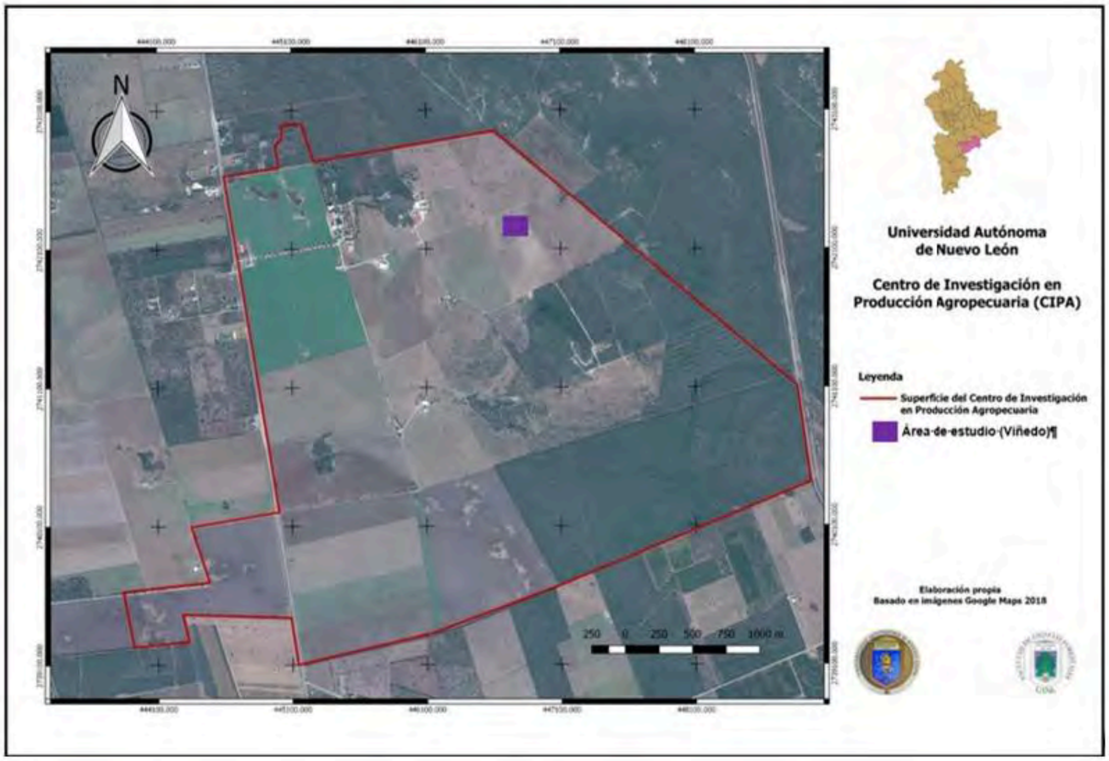
Figure 1. Map of the location of the study area.



Soils

The soils that predominate in the municipality of Linares, Nuevo León, according to INEGI (2009), present the following types and proportions: black or dark gray vertisols (40.9%), Leptosol (28.5%), Regosol (9.9%), Calcisol (6.2%), and Luvisol (0.1%). In the study area where the vineyard is located, the predominant soils are Vertisol, soils of semi-arid to sub-humid and Mediterranean climates, with marked seasonality of drought and rainfall.

Climate

According to the Köppen classification, modified by García (1973), the climate of the area is semi-warm subhumid, with two summer rainy seasons, from March to June and from September to October. Rainfall varies between 400 and 1 850 mm per year, an average of approximately 800 mm (Flores, 2022). It occurs in two rainy periods (March-June and September-October). The average annual temperature is 22.4 °C, with temperatures above 40 °C in summer and below 0 °C in winter (Salazar, 2017).

Vegetation

The vegetation present in the study area consist of scrub, forest, rainforest, and grassland (INEGI, 2009). The use of land in the municipality is mainly for agriculture, with 49%, and the rest is made up of the urban area (1%), scrubland (29.6%), forest (16%), rainforest (4%), and grassland (0.4%).

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Site description

Vineyard established with a population density of 2 400 plants ha^{-1} with an age of 10 years, formed into two arms with agronomic management of training pruning, weed, disease and fungal control work, fertilization, and weekly irrigation.

Variety description

Six varieties were evaluated: two white (Chardonnay and Chenin Blanc) and four red (Merlot, Cabernet Sauvignon, Malbec, and Shiraz). The Chardonnay variety comes from the region of Burgundy, France, where such varied and complex wines are produced; this variety has managed to conquer the world due to its amazing ability to adapt to the climate and soil and also in terms of the winemaking process. It produces prestigious smooth and strong wines in line with its corresponding quality all over the world. In addition, it is the most suitable white grape variety for barrel maturation, with a yield of 8 457 kg ha^{-1} (Ortega, 2002; Dominé, 2008).

The Chenin Blanc variety is widely grown in areas of California and South Africa due to its high acidity, which produces, even in hot climates and with significant yields, weighted but neutral wines, which are used for large-scale production and are mostly blended. With a maximum average yield of 6 000 kg ha^{-1} (Vargas, 1994; Dominé, 2008).

The Merlot variety or cultivar, this grape is appropriate for the production of varietal wines or for blends with other more intense species with greater tannic potential. It is a grape appreciated in northern Italy and southeastern Europe, is fruity and velvety, ripens more quickly than the Cabernet variety and appears as a varietal of international interest. With an average yield of 4 853 kg ha^{-1} of grapes (Tacuba, 2018).

As for the Cabernet Sauvignon variety or cultivar, it has risen internationally and has become the most appreciated red variety. As a late-ripening and resistant variety, it develops very well in hot climate areas: California, Australia, Chile, and even Italy and Spain, with a maximum average yield of 12 403 kg ha^{-1} (Alave, 2011).

The Malbec variety or cultivar first spread through the area of Bordeaux, France, but was replaced by Merlot (Madero, 2008). It is widespread throughout all the wine-growing areas of Argentina, the most internationally recognized. It produces high-intensity musts of color very close to the original, the grapes *in natura*. With an average yield of 6 730 kg ha^{-1} (Apcarian, 2006; Viticultura, 2023).

The Shiraz variety is very successful in the world, it is found in Europe, Australia, Chile, South Africa, and California, and produces bright red and dark musts, soft tannins, and good quality wines, its exquisite and complex aromas of violet, black cherries, wild herbs, and various spices and its exuberance, strength, and exquisite tannins surprise winegrowers and those who like to drink wine more and more every day. With a maximum average yield of 7 112 kg ha^{-1} (Alcalde, 1989; Dominé, 2008; Reyes, 2020).

Sampling

To determine the plants to be sampled, the formula used was: $n= (s^2 * t_{(n-1)})^2 / (X * E)$. Where: n= number of samples needed to perform the statistically valid study; S^2= variance of stem diameters of sampled plants; t= tabular t-value with (n^{-1} degrees of freedom) at 0.05% error; $\bar{x}$= mean value of the data collected on the stem diameter and E= permissible error= 5%= 0.05.

The number of plants for sampling per cultivar was 3 and the value of ‘n’ (number of sampling plots statistically needed) for sampling of the entire set of plants of all varieties was equal to 14 plots, so it was recommended to mark three plants at random for each of the six varieties, with a total of 18 sampling plots, they were marked with colored ribbons and their coordinates were recorded (Garmin Gpsmap 65 s), which shows uniformity in the morphological characteristics of the plants that make up each cultivar.

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Yield

The plant grapes were harvested in July. Three plants were selected per variety and 25 grapes were randomly taken to estimate the production in kg ha^{-1}.

Chemical analysis

The total sugar content was evaluated using two variables, pH and total soluble solids content or degrees Brix, which allow determining the percentage of sugar or sucrose dissolved in liquids, the most commonly used measure to determine the degree of ripeness. After harvesting, the weight of the grapes was obtained, 25 grapes were randomly taken from the three plants and were individually pressed in a mortar by cultivar, the juice was extracted, and its pH was determined through a refractometer.

Using a digital refractometer (Model HI96813®, United States of America), the degrees Brix (°Bx) of the extracted juice were determined following Benelli *et al*. (2020) methodology, which has a measurement range of 0 to 33 °Brix, the grape juice is extracted and placed on the glass plate of the refractometer, it is closed with the daylight plate, and the total soluble solids are read after the light.

Statistical analysis

An analysis of variance (Anova) was performed considering a *p*-value ≤ 0.05 and comparison of means using the statistical program of IBM SPSS Statistics v. 25.0 (SPSS Inc.)

Results and discussion

Variables under study

The analysis of variance indicates that there are significant differences in terms of the variables of degrees Brix, pH, and yield per hectare between the varieties tested (Table 1); the values presented by variety show that the Shiraz and Chardonnay varieties have the highest values in pH, Malbec and Cabernet Sauvignon have the best yields in production, whereas Shiraz and Chardonnay have the highest degree Brix content (Table 2).

Table 1. Results of the analysis of variance of the variables considered in the study.

Variable	F cal	*p*
Degree Brix (°Bx)	11 829.6	0
pH	7.69	0
Yield (kg $ha^{-1)}$	10.03	0

Variables that obtained a *p*-value ≤ 0.05 are considered to have a statistically significant difference.

Table 2. Results of pH, °Bx and yield of the six vine varieties under study.

Variety	pH	°Bx	Yield (kg ha^{-1})
Cabernet Sauvignon	3.46	21.6	5 756.5
Merlot	3.5	21.3	4 171.6
Malbec	3.64	19.9	8 772.8
Shiraz	4.04	26.5	2 299.8
Chenin blanc	3.49	20.1	3 776.9
Chardonnay	3.74	24.1	2 248.8

Revista Mexicana de Ciencias Agrícolas
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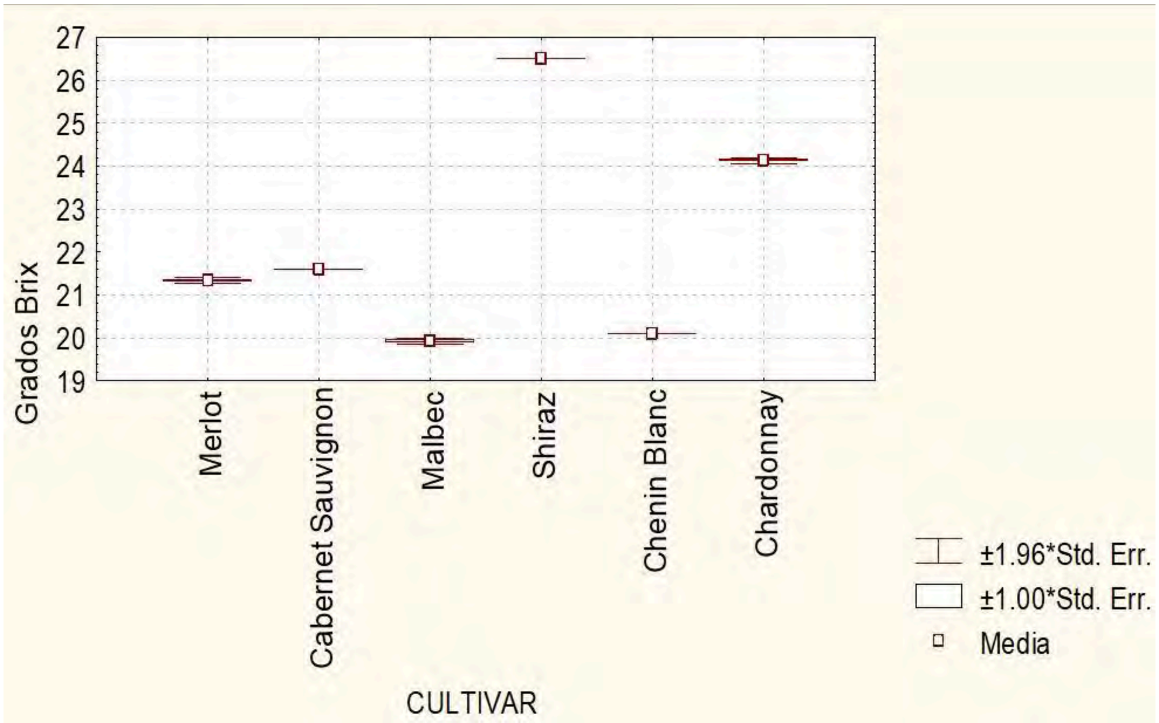
DOI: https://doi.org/10.29312/remexca.v16i3.3605

Sugar content

Regarding the behavior of the degrees Brix obtained from the varieties tested, as can be seen in Figure 2, the Shiraz cultivar with an average of 26.5 °Bx and the Chardonnay cultivar with an average of 24.1 °Bx were the ones that showed the highest values. They were followed by a group of two varieties (Cabernet Sauvignon and Merlot) with values of 21.6 and 21.3 °Bx; finally, in another group were Chennin Blanc and Malbec, with average values of 20.1 and 19.9 °Bx.

Figure 2. Behavior of degrees Brix by cultivar.



Studies conducted with other grape varieties report similar values; Laura (2017), through the ripening process of the grape, finds values between 22 and 29 °Bx in the Italia, Moscatel, and Negra Criolla varieties, whereas Robles *et al*. (2016) found values of 21 °Bx when carrying out fermentation tests at different temperatures using the Italia cultivar.

With regard to the varieties under study, Matocq (2004) reported similar values of 25 to 26 °Bx for the Shiraz variety; Ortega (2002) obtains lower values (22 °Bx) for the Chardonnay variety and slightly higher values for Cabernet Sauvignon (22.4 °Bx); Pugliese (2023) reports slightly higher values, from 20.2 to 21.1 °Bx, for the Malbec variety; in contrast, Flores (2022) reported the following: Cabernet Sauvignon 19.7 °Bx, Merlot 18.3 °Bx, Malbec 21.7 °Bx, Shiraz 18.1 °Bx, Chenin Blanc 21.1 °Bx.

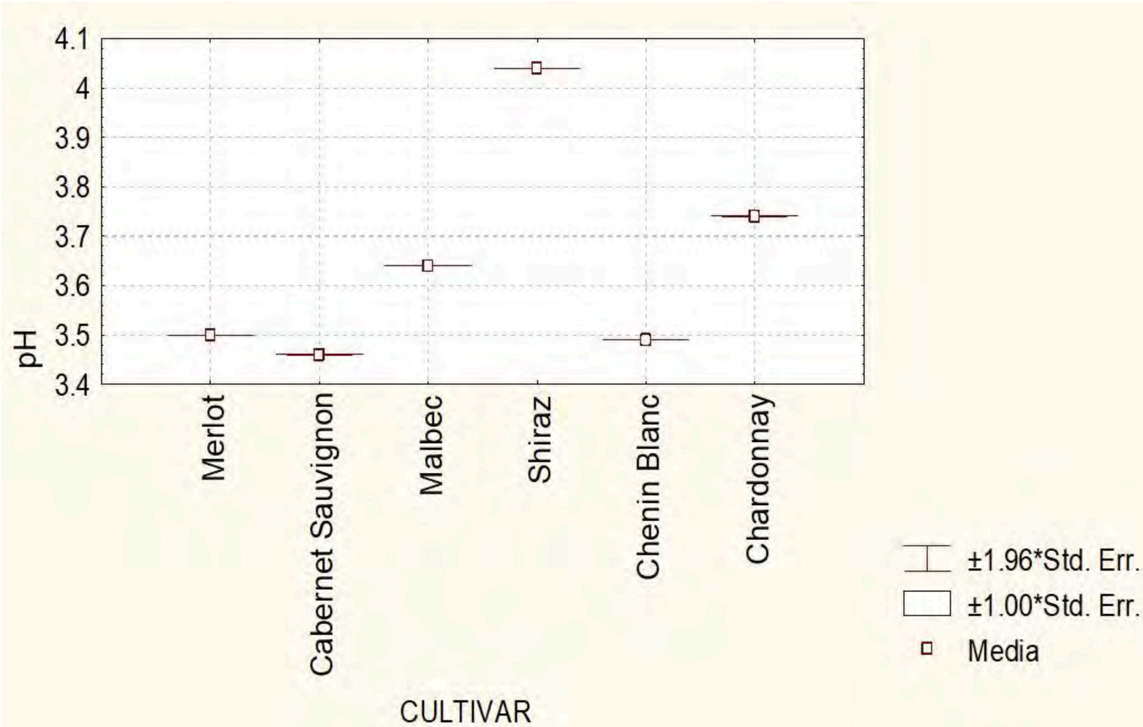
The homogeneity presented and minimal variation in the Brix content of each of the varieties compared to other studies indicates the good management of the crop and the ability of the varieties to adapt to the ecological characteristics of the study area.

pH analysis

As can be seen in Table 2 and Figure 3, the pH found in the six varieties tested was different (p= 0). White wines usually have a pH between 3 and 3.3 while most reds are usually between 3.3 and 3.6. The Shiraz cultivar resulted with the highest pH, with a value of 4.04, followed by the Chardonnay cultivar with a pH of 3.74; due to their values close to a pH of 4, the risk of oxidation increases.

DOI: https://doi.org/10.29312/remexca.v16i3.3605

Figure 3. Behavior of the pH values presented by the vine varieties tested.



With descending pH values, Malbec (3.64), Merlot (3.5), Chenin Blanc (3.49) and Cabernet Sauvignon (3.46) with the lowest value. Regarding the varieties under study, Ojeda (1996) reports values from 3.13 to 3.4 for Chenin Blanc; Matocq (2004) reports similar values, from 3.7 to 3.8, for the Shiraz variety; Ortega (2002) obtains lower values for the Chardonnay variety (3.31) and the Cabernet Sauvignon variety (3.28); Keller (2012) reported the highest pH for the Merlot and Chardonnay varieties and attributed it to a higher canopy density (Smart *et al*., 1985; Morrison and Noble, 1990) as a result of the high number of shoots of these vines.

Other results mentioned by Méndez (2005) are that the pH value gives an idea of the state of ripeness of the grape and the time of harvest, and it should not be allowed to descend and must remain in a range from 3 to 4, which coincides with the values presented for the six vine varieties.

Yield of varieties

The statistical analyses of the behavior of the yields per hectare of the varieties tested found differences between them (p= 0). The cultivar with the highest yield, away from the others, was Malbec with an average production per hectare of 8 772.8 kg ha^{-1a}, followed in descending order by the Cabernet Sauvignon cultivar with 5 765.5 kg ha^{-1b}, at a lower level were Merlot 4 176.1 kg ha^{-1c} and Chenin Blanc 3 776.9 kg ha^{-1c}; finally, with lower yields were Shiraz 2 299.8 kg ha^{-1d} and Chardonnay 2 248.8 kg ha^{-1d} (Table 2 and Figure 4).

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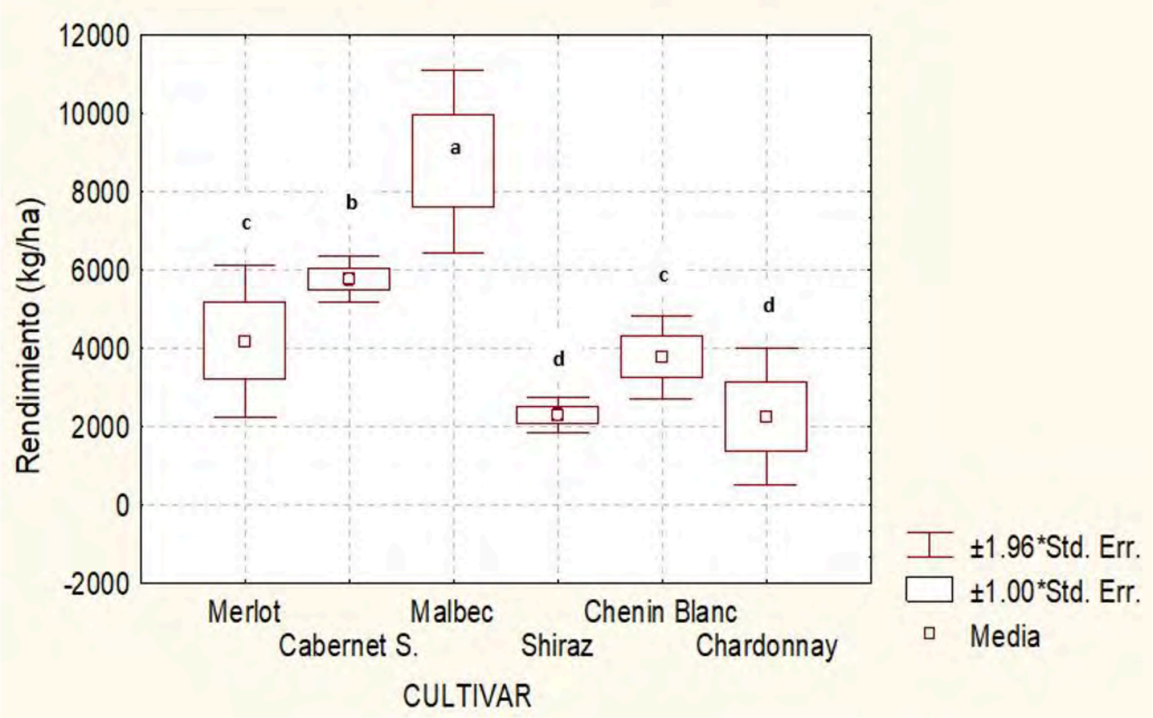
Figure 4
Yields observed by cultivar of the vines tested.



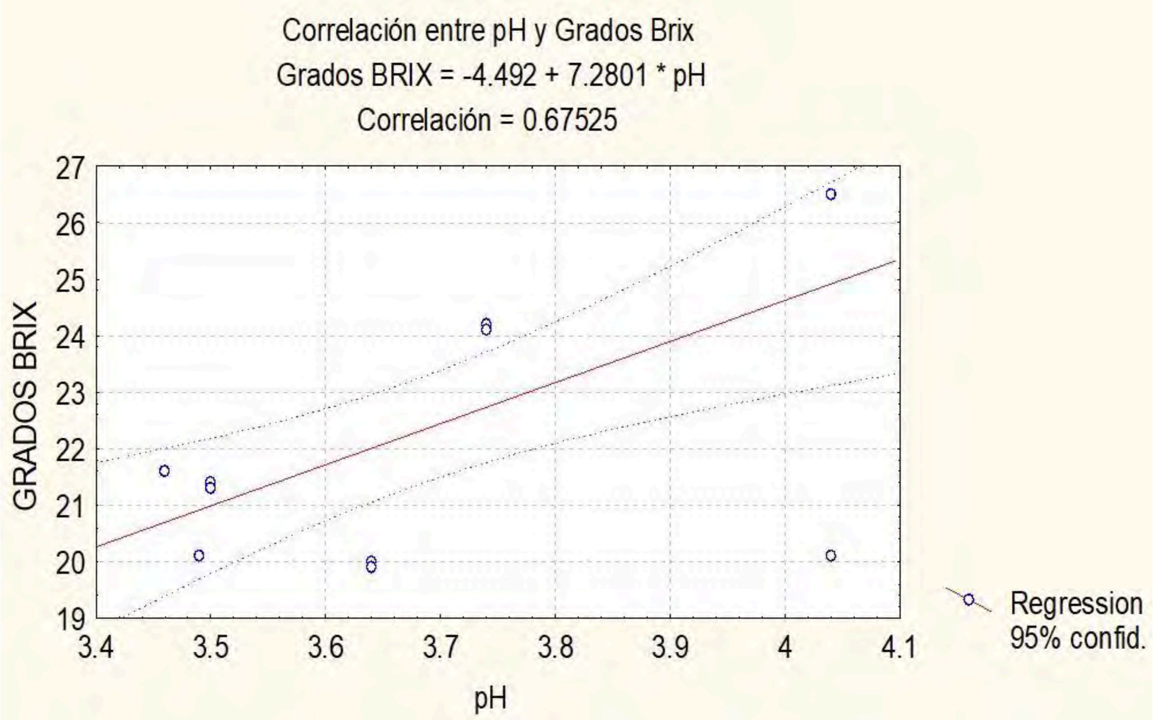
Studies indicate different yields for the varieties: Vargas (1994) had a productivity between 2 500 and 4 000 kg ha^{-1} for the Merlot variety and higher productivity for Shiraz (6 000 kg ha^{-1}); Ortega (2002) obtains 73% higher yield (8 457 kg ha^{-1}) for the Chardonnay variety and 23% for Cabernet Sauvignon (7 503 kg ha^{-1}); Huerta (2021) obtains yields of 9 027 kg ha^{-1} for the Malbec variety and Flores (2022) reports the best yields on average per year with 1 099 kg ha^{-1} for Cabernet Sauvignon and 1 074 kg ha^{-1} for Chenin Blanc.

The yield results suggest the rapid adaptation of Cabernet Sauvignon, being the most planted in the world (340 000 ha), and Merlot, ranked fourth with (266 000 ha), so an adequate agroecological management (pruning, fertilization, and phytosanitary control practices) favors their high yields.

There is a positive correlation, r= 0.67, between the pH of the fruits and the degrees Brix in the varieties tested (Figure 5), which indicates that the higher the pH, the higher the degrees Brix. Ramos *et al*. (2020) suggests that, due to high temperatures, phenolic ripeness, anthocyanins, and sugar have suffered an imbalance and acidity has decreased. The rise in temperature does not affect the concentration of tartaric acid but that of malic acid decreases considerably (Chaves *et al*., 2010).

DOI: https://doi.org/10.29312/remexca.v16i3.3605

Figure 5
Behavior of degrees Brix compared to the pH of the fruits.



Conclusions

Of the six vine varieties tested in the vineyard of the municipality of Linares, Nuevo León, as a crop alternative, for red wine, the Malbec or Cabernet Sauvignon cultivars are suggested due to their productive yield, and for white wine, the Chenin Blanc cultivar due to the sugar content (°Brix), the Shiraz and Chennin Blanc cultivars had the highest values. In terms of pH, all six varieties remain in the suggested range of 3-4. Therefore, the study will contribute as a source of information and technology transfer for producers in the southern region of the state who seek to implement vine (*Vitis vinifera*) as an alternative crop; it will depend on the ecological and soil conditions and needs or interests they have on their farms for the selection of the variety.

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Journal Information
Journal ID (publisher-id): remexca
Title: Revista mexicana de ciencias agrícolas
Abbreviated Title: Rev. Mex. Cienc. Agríc
ISSN (print): 2007-0934
Publisher: Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias

Article/Issue Information
Date received: 01 January 2025
Date accepted: 01 April 2025
Publication date: 03 May 2025
Publication date: Apr-May 2025
Volume: 16
Issue: 3
Electronic Location Identifier: e3605
DOI: 10.29312/remexca.v16i3.3605

Categories

Subject: Articles

Keywords:

Keywords:

Vitis vinifera

degrees Brix

yield

Counts

Figures: 5

Tables: 2

Equations: 0

References: 32

Pages: 0