REVISTA BIO CIENCIAS
http://revistabiociencias.uan.edu.mx
https://doi.org/10.15741/revbio.11.e1556

ISSN 2007-3380

Original article / Artículo original

Growth and quality indices of peach (*Prunus* spp.) plants established on different substrates under nursery conditions to be selected as rootstock

Crecimiento e índices de la calidad de plantas de durazno (*Prunus* spp.), establecidas en diferentes sustratos bajo condiciones de vivero para seleccionarse como portainjerto

Chairez-Aquino, A. Z.[1], *Velasco-Velasco, V. A.* [2*], *Enríquez-del Valle, J. R.*[2], *Rodríguez-Ortiz, G.* [2], *Ruiz-Luna, J.*[2]

[1] *Estudiante en la División de Estudios de Posgrado e Investigación. Tecnológico Nacional de México/ Instituto Tecnológico del Valle de Oaxaca. Exhacienda de Nazareno, Santa Cruz Xoxocotlán, Oaxaca. C.P. 71233, Oaxaca, México.*

[2] *Profesor-investigador en la División de Estudios de Posgrado e Investigación. Tecnológico Nacional de México/Instituto Tecnológico del Valle de Oaxaca. Exhacienda de Nazareno, Santa Cruz Xoxocotlán, Oaxaca. C.P. 71233, Oaxaca, México.*

Please cite this article as/Como citar este artículo: : Chairez-Aquino, A. Z., Velasco-Velasco, V. A., Enríquez-del Valle, J. R., Rodríguez-Ortiz, G., Ruiz-Luna, J. (2024). Growth and quality indices of peach (*Prunus* spp.) plants established on different substrates under nursery conditions to be selected as rootstock. *Revista Bio Ciencias*, 11, e1556. https://doi.org/10.15741/revbio.11.e1556

Article Info/Información del artículo
Received/Recibido: September 01th 2023.
Accepted/Aceptado: January 24th 2024.
Available on line/Publicado: February 19th 2024.

ABSTRACT

To guarantee the peach cultivation success, it is suitable to use quality rootstocks, adapted to the establishment place. In the present study, the growth and quality of *Prunus* spp. plants established in different organic substrates under nursery conditions were evaluated to be selected as rootstock. A completely randomized design and 4x4 factorial arrangement was employed, strictly speaking, peach genotype factor: yellow flesh, white flesh prisco, white flesh and white flesh veneer; substrate factor: soil 100 %, soil 60 % + chicken manure 40 %, soil 60 % + bovine manure 40 %, and soil 60 % + bush soil 40 %. The white-fleshed prune peach genotype showed significantly higher values for plant height (76.87 cm) and stem diameter (7.28 mm). The yellow-fleshed, white-fleshed prisco, and white-fleshed chape peach genotypes were classified as high morphological quality. The white-fleshed peach genotype was classified as medium quality. The soil substrate with chicken manure was the best condition for obtaining high morphological quality plants. It is possible to use the white-fleshed prune peach genotype as rootstock, since it excelled in growth and quality.

KEY WORDS: Organic fertilizers, plant quality, peach tree growth.

***Corresponding Author:**

Vicente Arturo Velasco-Velasco. División de Estudios de Posgrado e Investigación. Tecnológico Nacional de México/Instituto Tecnológico del Valle de Oaxaca. Exhacienda de Nazareno, Santa Cruz Xoxocotlán, Oaxaca. C.P. 71233, Oaxaca, México. Teléfono: (951) 117 1430. E-mail: vicente.vv@voaxaca.tecnm.mx

Revista Bio ciencias
ISSN 2007-3380

RESUMEN

Para garantizar el éxito del cultivo de durazno, es conveniente utilizar portainjertos de calidad, adaptados al lugar de establecimiento. En el presente estudio se evaluó el crecimiento y calidad de las plantas de *Prunus* spp. que se establecieron en diferentes sustratos orgánicos en condiciones de vivero, para seleccionarse como portainjerto. Se estableció un diseño completamente al azar y arreglo factorial 4x4, esto es, factor genotipo de durazno: de pulpa amarilla, prisco de pulpa blanca, pulpa blanca y chapeado de pulpa blanca; factor sustrato: suelo 100 %, suelo 60 % + gallinaza 40 %, suelo 60 % + estiércol bovino 40 %, y suelo 60 % + tierra de monte 40 %. El genotipo de durazno prisco de pulpa blanca mostró significativamente valores más altos en altura de planta (76.87 cm) y diámetro de tallo (7.28 mm). Los genotipos de durazno de pulpa amarilla, prisco de pulpa blanca y chapeado de pulpa blanca se clasificaron de alta calidad morfológica. El genotipo de durazno de pulpa blanca se clasificó de calidad media. El sustrato de suelo con gallinaza fue la mejor condición para obtener plantas de alta calidad morfológica. Es posible utilizar el genotipo de durazno prisco de pulpa blanca como portainjerto, ya que sobresalió en crecimiento y calidad.

PALABRAS CLAVE: Abonos orgánicos, calidad de la planta, crecimiento de durazneros.

Introduction

The peach tree [*Prunus persica* (L.) Batsch] is native to China and was cultivated in Persia before being introduced to Europe (Cardenas-Hernandez & Fischer, 2013). It was brought to Mexico by the Spanish over 450 years ago. The peach tree is the most important fruit species due to its wide distribution and annual per capita consumption of peaches, which is around 1.9 kg (Pérez, 2007; SIAP, 2022). It is widely used in the food, flavor, beverage, and fragrance industries (Verma *et al.,* 2017). In 2021, 33,556.30 ha were planted, 31,439.39 ha were harvested, and peach production reached 217,266 tons (SIAP, 2021). Despite Mexico achieving the most significant harvest in the last five years, growing domestic demand led to an increase in international purchases (SIAP, 2022).

In Mexico, research on rootstock production is required since many producers resort to buying plants without knowing their origin. The quality of nursery plants is a crucial factor for success in cultivation (Rodríguez, 2008; Dini *et al.,* 2021). Seeds used for rootstock production generally come from waste in the agro-industry of preserves and nearby markets, resulting in a lack of genetic identity control and influencing the low quality of the produced plants (Souza

Revista Bio ciencias
ISSN 2007-3380

et al., 2016). Additionally, there is no certainty about their adaptation to the establishment site, which could lead to future management, growth, and production issues (Alvarado & Hernández, 2020).

Rootstocks are essential for optimizing soil anchoring, tree vigor, sunlight utilization, precocity, flowering, fruiting, fruit development, water and nutrient absorption, resistance or tolerance to soil pathogens, and the metabolism of carbohydrates, lipids, and hormones (Pérez-Romero *et al.,* 2013; Seker *et al.,* 2017; Bielsa *et al.,* 2021). New varieties have been developed in countries where major stone fruit crops are grown, reaching their maximum potential primarily under their own environmental conditions (Eremin *et al.,* 2017). Alternative rootstocks are needed to induce better fruit quality, higher productivity, and cold resistance for more intensive production systems (Miloševič & Miloševič, 2012).

The various rootstock cultivars have different efficiencies in the absorption and use of mineral elements from the substrate, leading to growth differences during the early stages of development (Menegatti *et al.,* 2019b). Rootstocks may respond positively to organic fertilization as it improves the physical, chemical, and biological soil conditions under an agroecological system (Pérez-Romero *et al.,* 2013; Petry *et al.,* 2016), and it is considered economically viable (Ortiz-Rivera *et al.,* 2020).

Hence, improving the quality of nursery-produced plants involves using selected rootstocks originating from seeds in good sanitary conditions, in addition to providing good sources of nutrition, influencing the lifespan of the future orchard (Souza *et al.,* 2016, 2017). Given this background, the objective was to evaluate the growth and quality of *Prunus* spp. plants established in different organic substrates under nursery conditions for selection as rootstock.

Materials and Methods

Study Area

The research was conducted in the locality of Benito Juárez, Santa Catarina Lachatao, Oaxaca, Mexico, located in the Sierra Norte region, Ixtlán de Juárez district. It is situated at 17°16’ N and 96°28’ W, at an altitude of 2908 m. Covering an area of 100.21 km², it represents 0.11% of the total surface area of Oaxaca state (INEGI, 2010). The plot where the work was carried out is at an altitude of 2830 m.

Peach trees propagation

Plants were propagated by seed germination, according to the methodology described by Pérez (2007):

Seed acquisition: Seeds were collected in July and August 2021 in Santa Martha Latuvi, belonging to the municipality of Santa Catarina Lachatao. The orchard was located at coordinates

Revista Bio ciencias ISSN 2007-3380

17°09’15.9” N and 96°29’44.3” W, at an altitude of 2450 m. Sixty yellow-fleshed peach (DPA) fruits, 60 white-fleshed prisco (DPPB), 60 white-fleshed (DPB), and 60 veneered white-fleshed (DCPB) fruits were obtained. The pulp was removed from each fruit, the endocarp (stone or pit) was extracted, washed with running water, and dried in the shade.

Scarification and seed disinfection: The seed (kernel) was extracted by carefully breaking the endocarp to avoid damage to its structure. Subsequently, the kernels were immersed in distilled water for 1 hour, discarding the kernels that floated. They were disinfected by immersion for 5 minutes in a solution of sodium hypochlorite at a rate of 1.0 mL of commercial product containing 6 % NaClO per L^{-1} of water, followed by rinsing with distilled water.

Stratification: Once the seeds were disinfected, they were placed on plastic trays (25 x 30 cm) covered with absorbent paper moistened with a suspension of 3.0 g L^{-1} of commercial fungicide (active ingredient: carboxamide). The trays were stacked and placed in a translucent bag to observe the germination process. They were placed in the middle section of a domestic refrigerator (Whirlpool ®, WSS505Q) at 5 °C to promote seed germination.

Experimental design and seeding

A completely randomized design (CRD) with a 4x4 factorial arrangement was employed, comprising the genotype factor: DPA peaches, DPPB, DCPB, and DPB; and the substrate factor: substrate 0, 100 % local soil; substrate 1, 40 % chicken manure + 60 % local soil; substrate 2, 40 % bovine manure + 60 % local soil; substrate 3, 40 % bush soil + 60 % local soil. Sixteen treatments with 12 replications were considered, resulting in a total of 192 experimental units.

Once the seeds germinated (between 53 and 62 days after sowing), 48 seeds of each genotype were sown individually in 25 cm x 30 cm polyethylene bags and placed in a nursery with a 50 % shade net cover. The soil used was analyzed for pH, electrical conductivity (EC) (dS m^{-1}), organic matter (OM) (%) through organic carbon (OC) (%) content by the Walkley and Black method, and texture by the Bouyoucos method. pH and EC were determined for bush soil, chicken manure, and bovine manure using a Conductronic ® PC45 model. The specified analyses were carried out following NOM-021-RECNAT-2000.

Variables evaluated during 8 months

The first data collection was carried out at 45 days after sowing (DDS), followed by assessments every 30 days. Over 8 months, the following plant parameters were evaluated: height (A; cm) from the substrate level to the last apical leaf, with a flexometer (maxtool ®); stem diameter (DT; mm) at 10 cm height, with a digital caliper (Avedistante ®, accuracy ±0.2 mm); number of leaves (NH) and ramifications (RAM); then the monthly relative growth rate (RGR) [(final size-initial size)/8] was calculated for each variable.

Revista Bio ciencias
ISSN 2007-3380

Variables evaluated at 10 months

At 10 months after sowing, four plants per treatment were assessed for the following variables: collar diameter (mm) with a digital Vernier (Avedistante®, accuracy ± 0.2 mm); height (cm) from substrate level to the last apical leaf with a flexometer (maxtool ®, model FLEX-5M-R-MX); root length (cm) with a scalimeter; leaf area (m^2) was determined with a scanner (Brother ®, DCP-300) and the ImageJ Java 8 Software; fresh and dry weight (g) of leaves, branches, stems and roots was determined with a scale (kokorox-17028). For plant drying, their organs were placed in paper bags and placed in an oven (Memmert ® model 100-800) with forced air circulation at 70°C for 72 h. Quality indices were calculated according to Rodriguez (2008): Robustness index or slenderness index = $\frac{\text{Heigth (cm)}}{\text{Diameter (mm)}}$; Root height/root length ratio (AL/LR) = $\frac{\text{Heigth (cm)}}{\text{Root length (cm)}}$ Dickson quality index (DQI) = ; Root height to root length ratio (RL/RL) =; Dickson quality index (DQI) = $\frac{\text{Total dry weight (g)}}{\frac{\text{Height (cm)}}{\text{Diameter (mm)}}+\frac{\text{Above-ground dry biomass (g)}}{\text{Root dry biomass (g)}}}$ Ratio of aerial dry biomass to root dry biomass (R Bsa/Bsr) = $\frac{\text{Above-ground dry biomass (g)}}{\text{Root dry biomass (g)}}$.

Statistical analysis

The data underwent Bartlett's homogeneity test and Shapiro-Wilk's normality test. Variables that did not meet these assumptions (stem diameter, number of leaves, branches, root dry weight, stem, leaf, total dry weight, leaf area, and Dickson index) were transformed using log (*x+1*), and analysis of variance was performed. Subsequently, with the non-transformed data, Duncan's multiple range test ($p \leq 0.05$) was conducted for morphological variables and growth rates, and the Tukey test ($p \leq 0.05$) was applied for plant quality variables. All analyses were conducted using SAS (Statistical Analysis System) version 9.4 (SAS Institute, 2016).

Results and Discussion

Physical and chemical characteristics of substrates

The substrates used exhibited a pH ranging from moderately acidic to neutral (Table 1). These results align with Loewe *et al*. (2001), who recommend using substrates with a moderately acidic to neutral pH for Prunus avium. In Zacatecas, the largest peach producer in Mexico (SIAP, 2022), the soil pH where peaches grow ranges between 6.8 to 7.8 (Fernández *et al.,* 2016). This variation is due to the fact that each species demands different soil conditions. The EC of the soil used without mixing was acceptable for peach cultivation according to Hirzel (2017). Arribillaga (2002) mentions that optimal EC ranges from 3.5 to 4.0 dS m^{-1}. The organic matter (OM) content found is considered suitable (Fernández *et al.,* 2016; Hirzel, 2017) and high (NOM-021-RECNAT-2000, 2002). The high OM content can be attributed to the experimental proximity to the coniferous forest (roughly 50 m).

The soil exhibited a loamy sandy texture, which is deemed suitable for the proper development of *Prunus* plants (Loewe *et al.,* 2001; Hirzel, 2017). Peach trees adapt well to deep, well-draining soils (García-Gallegos *et al.,* 2020), in contrast to establishing in clayey soils, which are highly compact and retain excessive moisture (Carrasco *et al.,* 2017).

Table 1. Some physical and chemical characteristics of substrates.

Analysis			Soil		Reference
O.M. (%)			4.22		[§+]4-5%
O.C. (%)			2.45		
Texture			Sandy loam		[§§+]Sandy to sandy loam
			Substrates		
	S0= 100 % of soil	S1=60 % of soil + 40 % of chicken manure	S2=60 % soil + 40 % bovine manure	S3=60 % of soil + 40 % of forest land	
pH	5.7	6.1	7.1	5.9	[§§+]5.1-7.3
EC (dS m)$^{-1}$	1.16	2.97	4.66	1.57	[++]<1.5 FA

pH = hydrogen potential, EC = electrical conductivity, OM = organic matter, OC = organic carbon. S0 = Substrate 0, S1 = Substrate 1, S2 = Substrate 2, S3 = Substrate 3. [§](Fernández *et al.,* 2016), [§§](Loewe *et al.,* 2001), +(NOM-021-RECNAT-2000, 2002), [++](Hirzel, 2017), FA = in loamy sandy soils.

Morphologic variables and relative growth rates at 8 months DDS

The analysis of variance (Table 2) for the morphological variables and relative growth rates, showed highly significant differences ($p \leq 0.01$) for the substrate factor in all variables and relative growth rates; the genotype factor presented highly significant differences ($p \leq 0.01$) in height, diameter, number of leaves, branching, relative growth rate (RGR) of diameter, RGR of number of leaves and RGR of branching, the RGR of height presented significant differences ($p \leq 0.05$); the interaction of substrate with genotype had highly significant effect ($p \leq 0.01$) in all variables, RGR of diameter, RGR of number of leaves and RGR of branching, the RGR of height did not present significant differences ($p \leq 0.05$).

The coefficient of variation in height (AL), diameter (D), number of leaves (NH), branches (RAM), and relative growth rates (AL, D, NH, RAM) is considered low, as it was less than 8 % (Gomez & Gomez, 1984). However, the relative growth rate of branches was higher than 8 %, attributed to the heterogeneity in the behavior of each plant, influenced by the substrates used.

Revista Bio ciencias ISSN 2007-3380

Menegatti *et al*. (2019b) found highly significant differences ($p \leq 0.01$) in growth variables based on the growth period of three rootstocks: Flordaguard, Capdeboscq, and Okinawa Roxo.

For a peach tree to be grafted, a stem diameter (DT) of 5 to 6 mm is required (Alvarado & Hernández, 2020; Pérez, 2007). All peach genotypes reached diameters exceeding 5 mm at 195 days after sowing (DDS), with the white-flesh prisco peach genotype (DPPB) achieving the specified DT at 165 DDS (Figure 1).

In other studies, it was reported that peach plants of the Capdeboscq cultivar reached the appropriate DT for grafting up to 240 DDS in a traditional system (Fischer *et al.,* 2016). Meanwhile, the Capdeboscq and Okinawa Roxo cultivars reached the required DT (7.14 mm and 6.23 mm) for grafting at 154 DDS (Schmitz *et al.,* 2014). This shorter time may be attributed to the plants being developed in larger pots (4.5 L) compared to the 3 L volume used in that study. DDS were even shorter, as reported by Menegatti *et al*. (2019b), for the Flordaguard, Capdeboscq, and Okinawa Roxo cultivars, reaching the required DT (7.2 mm, 6.9 mm, and 6.3 mm) at 104 DDS due to the use of chemical fertilization. The results from this study, when compared with those of other researchers, suggest that the DT can be achieved in a shorter or longer time (100-200 days), depending on the cultivar, substrate, container volume, fertilization, among other factors.

Table 2. Analysis of variance of growth variables at 8 months of age of peach trees, as a function of the factors substrate, genotype and their interaction.

Variable	Mean squares			C.V (%)	$\sqrt{CME}$
	Genotype (G)	Substrate (S)	G x S		
DF	3	3	9		
Height (AL; cm)	264.45**	919.67**	103.9**	5.72	4.24
Diameter (DT; mm)$^{+}$	0.06**	0.47**	0.02**	0.83	0.01
Number of leaves (NH)$^{+}$	0.02**	2.81**	0.02**	0.62	0.02
Ramifications (RAM)$^{+}$	0.20**	11.00**	0.02**	1.93	0.05
RGR-AL (cm/month)	1.89*	7.71**	0.54^{ns}	7.78	0.55
RGR-DT (mm/month)	0.08**	0.32**	0.02**	4.11	0.02
RGR-NH (NH/month)	3.19**	120.27**	1.40**	6.18	0.36
RGR-RAM (RAM/month)	1.98**	77.70**	1.12**	9.82	0.26

GL=degrees of freedom, CV=coefficient of variation, √CME = root mean square error, **highly significant ($P \leq 0.01$), *significant ($p \leq 0.05$),^{ns} not significant ($p > 0.05$). RGR=Relative growth rate. Transformed data + ln (x+1).

Revista Bio ciencias
ISSN 2007-3380

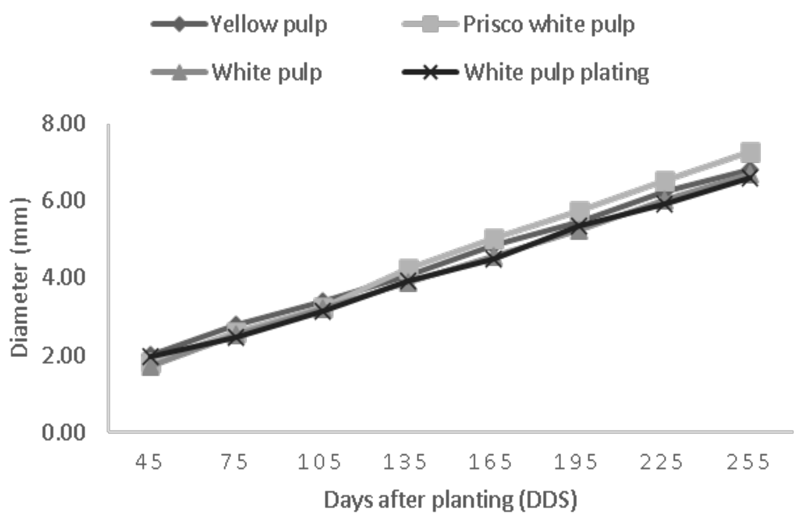

Figure 1. Stem diameter (at 10 cm height) of different peach genotypes during 8 months of age.

The substrate resulting from the mixture of soil with chicken manure allowed the highest stem diameter (at 10 cm height) of 7.67 mm at 255 days after sowing (DDS) (Figure 2). Plants established in substrates of soil with chicken manure and soil with bovine manure were the ones that developed stems with diameters exceeding 5 mm at 165 DDS; consequently, the plants were ready for grafting (Pérez, 2007; Alvarado & Hernández, 2020).

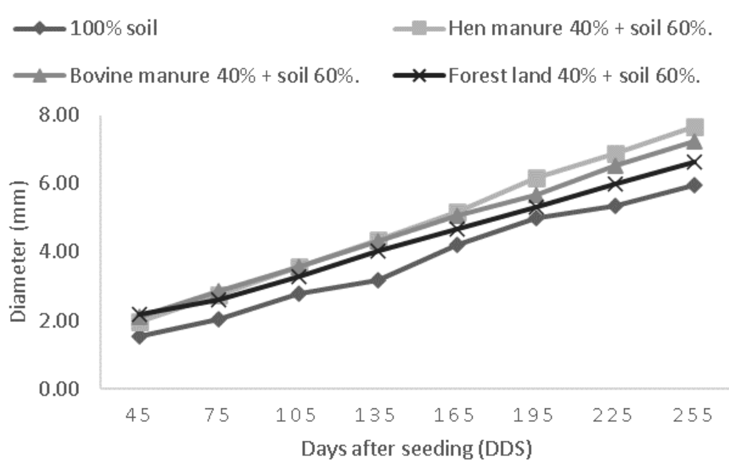

Figure 2. Effect of substrates on stem diameter (at 10 cm height) of different Prunus genotypes during 8 months of age.

Revista Bio Ciencias
ISSN 2007-3380

The DPA and DPPB genotypes reached higher values in height (Table 3), which is a convenient characteristic when these plants are established in the field, making them more competitive with surrounding weeds (Prieto *et al*., 2009; Muñoz *et al*., 2014). The peach genotypes reached more than 70 cm at 255 days after sowing (DDS), but it is estimated that they can reach 80 cm or very close to this value in the subsequent 30 days, as observed by Alvarado & Hernández (2020) in the Nemaguard rootstock at 365 DDS.

The DPB genotype obtained the highest number of leaves; the DPPB genotype presented the highest stem diameter (DT) at 10 cm height and the number of branches at 8 months of age. On the other hand, when relating height to branches in the evaluated genotypes, it was observed that there are few branches in the genotypes, which will be reflected in a reduction in production costs and less stress on the plants at the time of grafting (Schmitz *et al*., 2014). The DPPB genotype showed the highest monthly relative growth rates in height, diameter, number of leaves, and branches (Table 3). Thus, it had a greater biomass generation, favoring the growth of plants when established in the field (Prieto *et al*., 2009).

The plants established in substrates of soil with chicken manure and soil with bush soil showed the greatest height (Table 4); the soil-chicken manure mixture had the greatest effect on diameter, number of leaves, branches, and the relative growth rates of the plants. On the other hand, the plants established in soil had lower effects on the evaluated variables, perhaps due to having a pH of 5.7, making the availability of essential nutrients more difficult.

Table 3. Growth variables of four *Prunus* genotypes at 8 months after sowing.

Variable	Peach genotype			
	Yellow pulp	Prisco white pulp	White pulp	White pulp plating
Height (A; cm)	75.42 ± 0.69ᵃ	76.87 ± 1.16ᵃ	72.77 ± 0.81ᵇ	71.77 ± 0.75ᵇ
Diameter (DT; mm)	6.81 ± 0.09ᵇ	7.28 ± 0.14ᵃ	6.71 ± 0.08ᶜ	6.61 ± 0.10ᵈ
Number of leaves (NH)	57.72 ± 1.79ᵇ	61.04 ± 2.12ᵇ	58.31 ± 1.65ᵃ	58.10 ± 1.64bᵇ
Ramifications (RAM)	15.17 ± 0.83ᵇ	17.37 ± 1.03ᵃ	14.82 ± 0.83ᵇ	15.16 ± 0.82bᵇ
RGR-AL (cm/month)	7.17 ± 0.08ᵇ	7.43 ± 0.11ᵃ	7.04 ± 0.09ᵇ	6.98 ± 0.08bᵇ
RGR-DT (mm/month)	0.68 ± 0.01ᵇ	0.76 ± 0.02ᵃ	0.68 ± 0.01ᵇ	0.67 ± 0.01bᵇ
RGR-NH (NH/month)	5.59 ± 0.21ᶜ	6.21 ± 0.18ᵃ	6.04 ± 0.24ᵇ	6.00 ± 0.19bᵇ
RGR-RAM (RAM/month)	2.63 ± 0.16ᵇᶜ	3.00 ± 0.20ᵃ	2.53 ± 0.15ᶜ	2.64 ± 0.15bᵇ

RGR= Relative growth rate. Values with different letters in rows present statistically significant differences (Duncan, $p \leq 0.05$). Mean ± standard error.

Revista Bio ciencias
ISSN 2007-3380

Morphological variables and quality indexes at 10 months of nursery growth

In the analysis of variance (Table 5) for morphological variables and quality indices, highly significant differences ($p \leq 0.01$) were found for the substrate factor in all variables and plant quality indices. For the genotype factor, there were highly significant differences ($p \leq 0.01$) in all variables and quality indices, except for the lignification index ($p > 0.05$). For the interaction between substrate and genotype, significant differences ($p \leq 0.01$) were observed in all variables and plant quality indices. The coefficient of variation is considered low in all variables as it is less than 8 % (Gomez & Gomez, 1984).

Table 4. Effect of substrates on the growth of different genotypes.

Variable	Substrate			
	100% soil	Suelo 60 % + gallinaza 40 %	100% soil	Suelo 60 % + tierra de monte 40 %
Height (A; cm)	68.95 ± 0.56[c]	77.09 ± 1.03[a]	72.25 ± 0.59[b]	78.50 ± 0.69[a]
Diameter (DT; mm)	5.86 ± 0.01[d]	7.67 ± 0.10[a]	7.24 ± 0.03[b]	6.63 ± 0.05[c]
Number of leaves (NH)	41.29 ± 0.18[d]	75.68 ± 0.61[a]	60.18 ± 0.43[b]	58.04 ± 0.35[c]
Ramifications (RAM)	6.81 ± 0.11[d]	23.46 ± 0.40[a]	15.35 ± 0.16[c]	16.91 ± 0.14[b]
TR-CAL (cm/month)	6.81 ± 0.06[c]	7.68 ± 0.09[a]	6.87 ± 0.09[c]	7.28 ± 0.08[b]
RGR-DT (mm/month)	0.62 ± 0.01[d]	0.81 ± 0.01[a]	0.73 ± 0.01[b]	0.65 ± 0.01[c]
RGR-NH (NH/month)	4.48 ± 0.07[d]	8.21 ± 0.06[a]	5.85 ± 0.07[b]	5.31 ± 0.06[c]
RGR-RAM (RAM/month)	1.00 ± 0.01[d]	4.11 ± 0.09[a]	2.71 ± 0.06[c]	3.00 ± 0.01[b]

Relative growth rate. Values with different letters in rows present statistically significant differences (Duncan, $p \leq 0.05$). Mean ± standard error.

Revista Biociencias
ISSN 2007-3380

Table 5. Effect of mixtures of substrates, the genotype and their interaction on the quality of the plants.

Variable	Mean squares			C.V (%)	$\sqrt{CME}$
	Substrate (S)	Genotype (G)	S x G		
DF	3	3	9		
Height (AL)	2216.90**	353.22**	175.37**	1.93	1.68
Diameter (DC)	28.74**	2.35**	0.74**	1.62	0.12
Root length (RL)	355.39**	117.97**	50.94**	3.73	1.35
Stem biomass $^{+}$	6.06**	0.17**	0.11**	2.47	0.05
Biomass from branches	250.12**	9.45**	12.50**	5.5	0.31
Leaf biomass $^{+}$	4.86**	0.13**	0.11**	4.61	0.08
Root biomass (BR) $^{+}$	3.75**	0.25**	0.20**	1.37	0.03
Aerial biomass (BA)	2807.97**	158.72**	119.44**	5.32	1.05
Total biomass (BT) $^{+}$	6.26**	0.17**	0.14**	1.14	0.03
Slenderness ratio (A/DC)	15.01**	5.53**	3.75**	2.53	0.27
A/LR ratio	0.74**	0.26**	0.16**	4.71	0.11
BA/BR ratio	1.39**	0.13**	0.11**	3.9	0.05
Dickson Index $^{+}$	2.78**	0.06**	0.05**	1.93	0.03
ÍL= BT/PFT	13.54**	2.62^{ns}	26.28**	3.29	1.2
Leaf area (cm) $^{2+}$	13.17**	0.45**	0.51**	0.11	0.01

ÍL= lignification index, PFT= total fresh weight of the plant, DF= degrees of freedom, CV= coefficient of variation, √CME = root mean square error, **highly significant ($p \leq 0.01$),^{ns} not significant ($p > 0.05$). Transformed data^{+} ln (x+1).

To ensure good survival and plantation vigor, only healthy plants with worthy growth and a balance between biomasses should be established in the field (Rodríguez, 2008; Menegatti *et al.,* 2021). For the genotype factor (Table 6), DPB showed the greatest height (A), which may make it more competitive with herbaceous and shrubby vegetation, but this does not guarantee survival in the field (Prieto *et al.,* 2009; Muñoz *et al.,* 2014). In turn, Sáenz *et al*. (2014) found that plants with a tussock growth habit with heights ≥ 6.0 cm are considered of high quality in forest nurseries, and all evaluated genotypes had a greater height; this height will change when the plants are grafted, depending on the size of the grafting stick.

The root collar diameter (DC) is the most important quality characteristic, allowing the prediction of plant survival in the field and defining the stem's robustness (Muñoz *et al.,* 2014). All studied genotypes had values above 5 mm, which can ensure greater resistance to bending and tolerance to damage by pests (Sáenz *et al.,* 2014). The genotype of white-fleshed prisco peach

Revista Bio Ciencias ISSN 2007-3380

(DPPB) showed the longest root length (LR); however, there must be a balance between larger above-ground and radical parts, and a great capacity for the formation of new roots for better survival and growth (Rodríguez, 2008; Muñoz *et al.,* 2014; Rodríguez-Ortiz *et al.,* 2021).

The DPPB genotype generated the highest above-ground biomass (BA) and radical biomass (BR), reflecting the plant's successful development in the nursery. In this regard, Prieto *et al*. (2009) state that biomass is correlated with plant survival and growth in the field. The slenderness index (IE) is an indicator of the plant's resistance to wind desiccation, survival, and growth in dry sites (Prieto *et al.,* 2009).

Sáenz *et al*. (2014) mentioned that high-quality plants with a tussock growth habit in forest species should have a ratio of A/DC ≥ 8.0, BA/BR ≥ 0.15, and A/LR ≤ 2.5; all peach genotypes achieved a ratio higher in A/DC and BA/BR, so they are considered of high quality according to the mentioned indicators. However, with the A/LR indicator, only the DPA, DPPB, and DCPB genotypes were considered of high quality, presenting values ≤ 2.5, at the same time, the DPB genotype presented a higher value, reflecting disproportionate growth between the above-ground part and the root system of the plant, so it was classified as low quality.

The Dickson quality index (ID) combines several morphological attributes into a single value and is used as a quality index; the higher the index value, the better the plant quality (Muñoz *et al.,* 2014), reducing the time for grafting the rootstocks (Menegatti *et al.,* 2019a). Sáenz *et al*. (2014) mention that high-quality plants with a tussock growth habit in forest species should have ID values ≥ 0.50, and all evaluated genotypes had higher values, so they are considered of high quality. The lignification index relates the total dry weight to the total wet weight of the plant, and it showed no differences between peach genotypes. The DPPB genotype showed a larger leaf area (1293 cm^2).

The substrate of soil with chicken manure showed a more significant effect on height, diameter, and biomass production (Table 7). According to the criteria mentioned by Sáenz *et al*. (2014), the aforementioned substrate influenced obtaining high-quality plants in the indicators: A/DC, A/LR, BA/BR, and ID. The plants that were in this substrate grew proportionally between the above-ground part and the root system, so they can be established in the field (Menegatti *et al.,* 2021).

The substrates showed significant differences (Tukey, $p \leq 0.05$) in the slenderness index (IL) and leaf area, with the substrates of soil with chicken manure and soil with mountain soil showing greater effects on IL; and the substrate of soil with chicken manure having a greater effect on leaf area.

Revista Bio ciencias ISSN 2007-3380

Table 6. Effect of genotype factor on morphological variables of peach trees at 10 months of nursery growth.

Variable	Peach genotype			
	Yellow pulp	Prisco white pulp	White pulp	White pulp plating
Height (A; cm)	84.59 ± 1.50^{c}	88.71 ± 3.63^{b}	92.78 ± 3.82^{a}	82.09 ± 2.18^{d}
Diameter (DC; mm)	7.62 ± 0.23^{c}	8.51 ± 0.34^{a}	7.87 ± 0.27^{b}	7.86 ± 0.37^{b}
Root length (LR; cm)	34.50 ± 0.92^{c}	40.06 ± 1.89^{a}	36.12 ± 1.21^{b}	34.12 ± 0.88^{c}
Stem biomass (g)	6.75 ± 0.76^{d}	10.06 ± 1.89^{a}	9.12 ± 1.36^{b}	7.37 ± 0.99^{c}
Biomass of branches (g)	4.68 ± 0.63^{c}	6.56 ± 1.12^{a}	5.50 ± 1.12^{b}	5.50 ± 0.83^{b}
Leaf biomass (g)	4.87 ± 0.47^{b}	6.62 ± 1.24^{a}	6.87 ± 1.11^{a}	5.25 ± 0.64^{b}
Root biomass (BR; g)	11.37 ± 0.87^{d}	17.00 ± 2.35^{a}	14.06 ± 1.95^{b}	12.25 ± 1.47^{c}
Aerial biomass (BA; g)	16.31 ± 1.78^{d}	23.25 ± 4.21^{a}	21.50 ± 3.57^{b}	18.12 ± 2.46^{c}
Total biomass (BT; g)	27.68 ± 2.52^{d}	40.25 ± 6.53^{a}	35.56 ± 5.53^{b}	30.37 ± 3.93^{c}
Slenderness index (A/DC)	11.21 ± 0.29^{b}	10.44 ± 0.19^{c}	11.76 ± 0.24^{a}	10.67 ± 0.40^{c}
A/LR ratio	2.41 ± 0.04^{ab}	2.25 ± 0.09^{c}	2.56 ± 0.07^{a}	2.41 ± 0.04^{b}
BA/BR ratio	1.36 ± 0.10^{a}	1.23 ± 0.07^{b}	1.42 ± 0.06^{a}	1.43 ± 0.04^{a}
Dickson Index	3.95 ± 0.34^{c}	5.09 ± 0.68^{a}	4.43 ± 0.51^{b}	4.51 ± 0.53^{b}
IL= BT/PFT	36.15 ± 0.67^{a}	36.78 ± 0.54^{a}	36.85 ± 0.78^{a}	36.08 ± 0.27^{a}
Leaf area (cm)^{2}	836 ± 96^{c}	1293 ± 240^{a}	1153 ± 292^{b}	774 ± 124^{d}

ÍL= lignification index, PFT= total fresh weight of the plant. Different letters in the same row represent significant differences (Tukey, $p \leq 0.05$). The mean is included ± standard error.

Revista Bio ciencias ISSN 2007-3380

Table 7. Effect of substrate factor on morphological variables of peach trees at 10 months of age.

Variable	Substrate			
	100 % soil	Soil 60 % + chicken manure 40 %.	Soil 60 % + bovine manure 40 %.	Soil 60 % + bush land 40 %.
Height (A; cm)	72.56 ± 0.87[d]	99.87 ± 2.72[a]	83.21 ± 1.48[c]	92.34 ± 1.07[b]
Diameter (DC; mm)	6.39 ± 0.07[d]	9.59 ± 0.20[a]	8.31 ± 0.07[b]	7.58 ± 0.08[c]
Root length (LR; cm)	34.12 ± 1.31[c]	42.93 ± 1.21[a]	32.12 ± 0.61[d]	35.62 ± 0.41[b]
Stem biomass (g)	2.68 ± 0.11[c]	16.00 ± 1.08[a]	7.25 ± 0.19[b]	7.37 ± 0.25[b]
Biomass of branches (g)	1.31 ± 0.11[d]	10.87 ± 0.62[a]	5.18 ± 0.26[b]	4.87 ± 0.36[c]
Leaf biomass (g)	2.00 ± 0.01[c]	11.00 ± 0.84[a]	5.50 ± 0.12[b]	5.12 ± 0.25[b]
Root biomass (BR; g)	5.93 ± 0.06[d]	22.68 ± 1.81[a]	12.50 ± 0.39[c]	13.56 ± 0.77[b]
Aerial biomass (BA; g)	6.00 ± 0.20[c]	37.87 ± 2.48[a]	17.93 ± 0.19[b]	17.37 ± 0.63[b]
Total biomass (BT; g)	11.93 ± 0.23[c]	60.56 ± 4.28[a]	30.43 ± 0.58[b]	30.93 ± 1.33[b]
Slenderness index (A/DC)	11.38 ± 0.22[b]	10.45 ± 0.29[c]	10.04 ± 0.19[d]	12.21 ± 0.22[a]
A/LR ratio	2.16 ± 0.07[c]	2.50 ± 0.03[a]	2.60 ± 0.04[a]	2.60 ± 0.05[a]
BA/BR ratio	1.01 ± 0.03[d]	1.72 ± 0.05[a]	1.45 ± 0.03[b]	1.31 ± 0.04[c]
Dickson Index	2.06 ± 0.05[d]	7.54 ± 0.35[a]	4.49 ± 0.06[b]	3.87 ± 0.12[c]
IL= BT/PFT	36.03 ± 0.49[b]	37.29 ± 0.39[a]	35.38 ± 0.69[b]	37.17 ± 0.65[a]
Leaf area (cm)^2	224 ± 7[d]	2147 ± 199[a]	916 ± 9[b]	768 ± 93[c]

Different letters in the same row represent significant differences (Tukey, $p \leq 0.05$). The mean is included ± standard error. AL= height, LR= root length, BA= aerial biomass, BR= radical biomass.

The previous results were evaluated according to the suitability criteria of Sáenz *et al*. (2014), who consider plants of high quality as those that show an absolute absence of undesirable characteristics; plants of medium quality accept one variable with an undesirable rating, and plants of low quality are those that exhibit two or more undesirable values.

Conclusions

The genotype of white-fleshed prisco peach exhibited the fastest relative growth rate, standing out at 255 DDS in height, stem diameter, number of leaves, and branching; emphasizing its readiness for grafting at 165 DDS. The white-fleshed peach genotype reached the greatest height at 315 DDS. The white-fleshed prisco peach genotype excelled in root collar diameter,

Revista Bio ciencias ISSN 2007-3380

root length, leaf area, and generated the most biomass, with the root being the organ with the highest biomass. The genotypes of yellow-fleshed peach, white-fleshed prisco, and white-fleshed chapeado were classified as having high morphological quality, particularly excelling in quality indices. The white-fleshed peach genotype was classified as having medium quality.

The substrate of soil with chicken manure favored the growth of the evaluated peach genotypes. This substrate benefited plants in root collar diameter, root length, leaf area, total biomass formation, as well as quality indices, reflecting plants of high morphological quality.

The implementation of organic fertilizers promotes the growth and quality of *Prunus* plants. Based on the results of this study, it is suggested to use soil with chicken manure as a substrate for peach plant growth in nurseries and consider the white-fleshed prisco peach genotype as a rootstock, as it outperformed others in growth and quality.

Author contribution

Conceptualization of the work, AZCA, VAVVV, JREV, GRO; methodology development, AZCA, VAVV, GRO, JRL; software management, AZCA, GRO, VAVV; experimental validation, VAVV, GRO, JRL; analysis of results, AZCA, VAVV; data management, AZCA, GRO, VAVV; manuscript writing and preparation, AZCA, VAVV; writing, revising and editing, AZCA, VAVV, JREV.

All authors of this manuscript have read and accepted the published version of the manuscript.

Financing

This research did not receive external funding.

Acknowledgments

To the Consejo Nacional de Humanidades, Ciencias y Tecnologías (CONAHCYT-Mexico) for the scholarship awarded to Arcelia Zurani Chairez Aquino (grant number 1154236) for her master degree in science.

Conflict of interest

The authors declare that they have no conflicts of interest.

Revista Bio ciencias ISSN 2007-3380

Referencias

Alvarado, Q. H., & Hernández, A. A. A. (2020). Comportamiento de nueve portainjertos de melocotoneros (*Prunus persica*), de la germinación a la injertación. https://online.fliphtml5.com/riws/nesu/#p=1

Arribillaga, G. D. (2002). Antecedentes técnicos del cultivo del cerezo en Aysén (*Prunus avium*). Instituto de Investigaciones Agropecuarias (INIA). https://frutales.files.wordpress.com/2011/01/ce-17-antecedentes-tecnicos-del-cultivo-del-cerezo.pdf

Bielsa, B., Sanz, M. Á., & Rubio-Cabetas, M. J. (2021). 'Garnem' and Myrobalan 'P.2175': Two Different Drought Responses and Their Implications in Drought Tolerance. *Horticulturae*, 7(9). https://doi.org/10.3390/horticulturae7090299

Cardenas-Hernandez, J. F., & Fischer, G. (2013). Clasificación botánica y morfología de manzano, peral, duraznero y ciruelo. In Miranda, D., Fischer, G., & Carranza, C. Los frutales caducifolios en Colombia. Situación actual, sistemas de cultivo y plan de desarrollo. (1a ed., pp. 21–29). 2013. https://www.researchgate.net/publication/256495323

Carrasco, J. J., Riquelme, S. J., & Abarca, R. P. (2017). Manejo de suelos para el establecimiento y cultivo del duraznero. In Manual de manejo del cultivo de duraznero (pp. 29–48). https://biblioteca.inia.cl/bitstream/handle/20.500.14001/6702/Bolet%C3%ADn%20INIA%20N%C2%B0%20373?sequence=1&isAllowed=y

Dini, M., Raseira, M., Valentini, G., & Zoppolo, R. (2021). Duraznero: Situación actual en Uruguay, Brasil y Argentina. *Agrociencia Uruguay*, 25(NE1), e394. https://doi.org/10.31285/agro.25.394

Eremin, G. V., Podorozhniy, V. N., & Eremina, O. V. (2017). Use of genetic diversity of the genus *Prunus* L. in selection of clonal rootstocks for stone fruit crops and features of their reproduction. *Proceedings of the Latvian Academy of Sciences, Section B: Natural, Exact, and Applied Sciences*, 71(3), 173–177. https://doi.org/10.1515/prolas-2017-0029

Fernández, M. M. R., Pérez-González Salvador, & Mondragón Jacobo, C. (2016). Guía para cultivar duraznero en Tlaxcala. Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias (INIFAP). (Vol. 41). https://docplayer.es/70516896-Guia-para-cultivar-duraznero-en-tlaxcala.html

Fischer, D. L. de O., Picolotto, L., Rocha, M. S., Souza, A. das G., & Bianchi, V. J. (2016). Influência do período de estratificação em frio úmido sobre a emergência e produção de porta-enxertos de pessegueiro a campo. *Revista Da Jornada Da Pós-Graduação E Pesquisa*, 1–11. http://revista.urcamp.tche.br/index.php/rcjpgp/article/view/1827

García-Gallegos, E., Vázquez-Cuecuecha, O. G., Chávez-Gómez, J. A., Hernández-Acosta, E., & López-López, A. (2020). Relación entre parámetros edáficos y criterios de calidad postcosecha de frutos de *Prunus persica* (L.) Batsch por análisis multivariado. *Scientia Agropecuaria*, 11(4), 565–573. https://doi.org/10.17268/SCI.AGROPECU.2020.04.12

Gomez, K. A., & Gomez, A. A. (1984). Statistical procedures for agricultural research (JOHN WILEY & SONS, Ed.; 2nd ed.). https://pdf.usaid.gov/pdf_docs/PNAAR208.pdf

Hirzel, J. (2017). Fertilización en cultivo de duraznero. In Manual de manejo del cultivo de duraznero (pp. 104–113). https://biblioteca.inia.cl/bitstream/handle/20.500.14001/6702/Bolet%C3%ADn%20INIA%20N%C2%B0%20373?sequence=1&isAllowed=y

Revista Bio ciencias ISSN 2007-3380

Instituto Nacional de Estadística y geografía [INEGI]. (2010). Compendio de información geográfica municipal 2010. https://www.inegi.org.mx/contenidos/app/mexicocifras/datos_geograficos/20/20365.pdf

Loewe, M. V., Pineda, B. G., & Delard, R. C. (2001). Cerezo común (*Prunus avium*) : una alternativa para producir madera de alto valor. INFOR. https://bibliotecadigital.ciren.cl/handle/20.500.13082/26348

Menegatti, R. D., Souza, A. das G., & Bianchi, V. J. (2021). Nutritional efficiency for nitrogen, phosphorus and potassium in peach rootstocks. *Journal of Plant Nutrition*, 44(2), 228–237. https://doi.org/10.1080/01904167.2020.1806306

Menegatti, R. D., Souza, D. G. A., & Bianchi, V. J. (2019a). Estimating genetic divergence between peach rootstock cultivars using multivariate techniques based on characteristics associated with seeds. *Genetics and Molecular Research*, 18(3). https://doi.org/10.4238/gmr18345

Menegatti, R. D., Souza, D. G. A., & Bianchi, V. J. (2019b). Growth and nutrient accumulation in three peach rootstocks until the grafting stage. *Comunicata Scientiae*, 10(4), 467–476. https://doi.org/10.14295/cs.v10i4.3211

Miloševič, T., & Miloševič, N. (2012). Rootstock-induced changes in the dry matter and carbohydrate contents of bearing shoots and flower buds in two Serbian plum cultivars. *The Journal of Horticultural Science and Biotechnology*, 87(4), 347–352. https://doi.org/10.1080/14620316.2012.11512875

Muñoz, F. H. J., Sáenz, R. J. T., Coria, A. V. M., García, M. J. de J., Hernández, R. J., & Manzanilla, Q. G. E. (2014). Calidad de planta en el vivero forestal La Dieta, Municipio Zitácuaro, Michoacán. *Revista Mexicana de Ciencias Forestales*, 6(27), 72–89. https://www.scielo.org.mx/pdf/remcf/v6n27/v6n27a7.pdf

NOM-021-RECNAT-2000. (2002). NORMA Oficial Mexicana NOM-021-RECNAT-2000, que establece las especificaciones de fertilidad, salinidad y clasificación de suelos. Estudio, muestreo y análisis. http://www.ordenjuridico.gob.mx/Documentos/Federal/wo69255.pdf

Ortiz-Rivera, M. I., Brambila-Paz, J. de J., Barrera-Islas, D., Arjona-Suárez, E. de J., Torres-Hernández, G., López-Reyna, Ma. del C., & Hernández-Martínez, J. (2020). Opciones técnicas y económicas para mejorar el ingreso de los productores de durazno [*Prunus persica* (L.) Batsch] en el Estado de México. *Agrociencia*, 54(2), 279–293. https://dialnet.unirioja.es/servlet/articulo?codigo=7306088

Pérez-Romero, L. F., Arroyo, F. T., Santamaría, C., Herencia, J. F., & Daza, A. (2013). Growth, phenology and fruit set of *Prunus armeniaca* L. (cv. Ninfa) grafted on two rootstocks in organic and conventional management. *Horticultural Science*, 41(3), 101–106. https://doi.org/https://doi.org/10.17221/46/2014-HORTSCI

Pérez, S. (2007). Duraznero. Ecofisiología, Mejoramiento genético y Manual para su cultivo. (1a ed.). 2007.

Petry, H. B., Mazurana, M., Marodin, G. A. B., Levien, R., Anghinoni, I., Gianello, C., & Schwarz, S. F. (2016). Root distribution of peach rootstocks affected by soil compaction and acidity. *Revista Brasileira de Ciencia Do Solo*, 40. https://doi.org/10.1590/18069657rbcs20150135

Prieto, R. J. Á., García, R. J. L., Mejía, B. J. M., Huchín, A. S., & Aguilar, V. J. L. (2009). Producción de planta del género *Pinus* en vivero en clima templado frío (INIFAP-SAGARPA, Ed.; 1a ed., Vol. 48). http://sivicoff.cnf.gob.mx/ContenidoPublico/09%20Manuales%20t%C3%A9cnicos/

Lista%20de%20documentos/Viveros%20forestales/Manual%20Produccion%20de%20planta%20de%20Pinus%20en%20vivero.pdf

Rodríguez-Ortiz, G., José-Hernández, Y., Enríquez-Del-Valle, J. R., & Campos-Angeles, G. V. (2021). Calidad de plántula de árboles seleccionados de *Leucaena esculenta* en sistema agroforestal. *CIENCIA Ergo-Sum*, 28(1). https://doi.org/https://doi.org/10.30878/ces.v28n1a7

Rodríguez, T. D. A. (2008). Indicadores de calidad de planta forestal. 1a ed. Mundi-Prensa.

Sáenz, R. J. T., Muñoz, F. H. J., Pérez, D. C. M. Á., Rueda, S. A., & Hernández, R. J. (2014). Calidad de planta de tres especies de pino en el vivero “Morelia”, estado de Michoacán. Rev. Mex. de Cienc. For., 5(26), 98–111. https://www.scielo.org.mx/pdf/remcf/v5n26/v5n26a8.pdf

SAS Institute. (2016). Base SAS 9.4 Procedures Guide: Statistical Procedures (Sixth Edition). https://go.documentation.sas.com/api/collections/pgmsascdc/9.4_3.5/docsets/procstat/content/procstat.pdf?locale=en#nameddest=titlepage

Schmitz, J. D., Pasa, M. da S., Fischer, D. L. de O., Fachinello, J. C., & Bianchi, V. J. (2014). Desempenho de porta-enxertos em diferentes sistemas de cultivo na produção de mudas do pessegueiro ‘Chimarrita.’ *Revista Ceres*, 61, 293–297. https://agris.fao.org/agris-search/search.do?recordID=XS2021005851

Seker, M., Ekinci, N., & Gür, E. (2017). Effects of different rootstocks on aroma volatile constituents in the fruits of peach (*Prunus persica* L. Batsch cv. ‘Cresthaven’). *New Zealand Journal of Crop and Horticultural Science*, 45(1), 1–13. https://doi.org/10.1080/01140671.2016.1223148

Servicio de Información Agroalimentaria y Pesquera [SIAP]. (2021). Cierre de la producción agrícola. https://nube.siap.gob.mx/cierreagricola/

Servicio de Información Agroalimentaria y Pesquera [SIAP]. (2022). Panorama agroalimentario. https://www.gob.mx/siap/acciones-y-programas/panorama-agroalimentario-258035

Souza, A. das G., Smiderle, O. J., Spinelli, V. M., De Souza, R. O., & Bianchi, V. J. (2016). Correlation of biometrical characteristics of fruit and seed with twinning and vigor of *Prunus persica* rootstocks. *Journal of Seed Science*, 38(4), 322–328. https://doi.org/10.1590/2317-1545v38n4164650

Souza, A. das G., Spinelli, V. M., De Souza, R. O., Smiderle, O. J., & Bianchi, V. J. (2017). Optimization of germination and initial quality of seedlings of *Prunus persica* tree rootstocks. *Journal of Seed Science*, 39(2), 166–173. https://doi.org/10.1590/2317-1545v39n2171687

Verma, R. S., Padalia, R. C., Singh, V. R., Goswami, P., Chauhan, A., & Bhukya, B. (2017). Natural benzaldehyde from *Prunus persica* (L.) Batsch. *International Journal of Food Properties*, 20(sup2), 1259–1263. https://doi.org/10.1080/10942912.2017.1338728