June, 2023 Vol.7 No.12 14-25

Yahualica tree seedling chile production (*Capsicum annuum*) on different substrates and its behavior during the development of the crop

Producción de plántula de chile de arbol Yahualica (*Capsicum annuum*) en diferentes sustratos y su comportamiento durante el desarrollo del cultivo

ZEPEDA-ARIAS, José de Jesús†, ARELLANO-RODRÍGUEZ, Luis Javier*, RODRÍGUEZ-GUZMÁN, Eduardo and PADILLA-GARCIA, José Miguel

Universidad de Guadalajara. Departamento de Producción Agrícola. Centro Universitario de Ciencias Biológicas y Agropecuarias, Camino Ing. Ramón Padilla Sánchez 2100, Nextipac, 44600 Zapopan, Jalisco

ID 1st Author: *José de Jesús, Zepeda-Arias* / **ORC ID**: 0009-0006-4187-374X, **CVU CONAHCYT ID**: 846681

ID 2nd Co-author: *Luis Javier, Arellano-Rodríguez* / **ORC ID**: 0000-0002-3188-0245, **arXiv Author ID**: LuisJavier#2, **CVU CONAHCYT ID**: 65995

ID 1rd Co-author: *Eduardo, Rodriguez-Guzman* / **ORC ID**: 0000-0002-4640-7610, **Researcher ID Thomson**: T-9496-2019, **CVU CONAHCYT ID**: 67847

ID 2rd Co-author: *José Miguel, Padilla-García* / **ORC ID**: 0000-0002-5627-3986, **CVU CONAHCYT ID:** 236981

DOI: 10.35429/JANRE.2023.12.7.14.25 Received March 14, 2023; Accepted June 30, 2023

Abstract

In order to observe the differences between substrates in the production of Yahualica chili pepper (Capsicum annuum) seedling and plant, in the field and greenhouse at the University Center of Cs. Biological and Agricultural of the University of Guadalajara, this investigation was carried out, where six substrates were evaluated: Promix-GLX, Promix-FLX, Sunshine-3, Berger-BN2, Germinaza and 50% Germinaza + 50% Earthworm Humus. In seedlings, the following were evaluated: Emergence Speed, Emergence Percentage, Stem Thickness, Seedling Length, Number of Leaves, Fresh Weight Aerial Part, Fresh Weight root, aerial part dry weight and root dry weight, and during plant development in field and greenhouse: Plant height, and Fresh weight of ripe fruit. Significant differences were found between treatments (P≤0.05) in the seedling and plant quality variables. Consequently with the mixture of 50% Germinaza + 50% Earthworm Humus, Berger BN2 and Sunshine 3, the best seedling quality was obtained. And moreover the best plant development was observed in the greenhouse, with an average plant height of 139 cm and a fresh fruit yield of 651 g. When germinaza was combined with earthworm humus (50:50), the results were significant to obtain vigorous plants, high percentage of emergence.

Substrates, Emergence, Agricultural, Seedling quality, Humus, Significant, *Capsicum annuum*

Resumen

Con el objetivo de observar las diferencias entre sustratos en la producción de plántula y planta de chile Yahualica (*Capsicum annuum*), en campo e invernadero del Centro Universitario de Cs. Biológicas y Agropecuarias de la Universidad de Guadalajara se llevó a cabo esta investigación, donde se evaluaron seis sustratos: Promix-GLX, Promix-FLX, Sunshine-3, Berger-BN2, (Germinaza) y 50% Germinaza + 50% Humus de Lombriz. En plántula se evaluó: Velocidad de emergencia, Porcentaje de Emergencia, Grosor de tallo, Longitud de plántula, Numero de hojas, Peso fresco parte aérea, Peso fresco de raíz, Peso seco parte aérea y Peso seco de raíz, y durante desarrollo de planta en campo e invernadero, las variables fueron: Altura de planta, y Peso fresco de fruto maduro. Se encontraron diferencias significativas entre tratamientos (P≤0.05) en las variables de calidad de plántula y de planta. La mezcla de 50% Germinaza+50% Humus de lombriz, Berger BN2 y Sunshine-3 se obtuvo la mejor calidad de plántula. El mejor desarrollo de planta se observó en invernadero, con altura de planta promedio de 139 cm y un rendimiento de fruto fresco de 651 gr. En el tratamiento de germinaza cuando se combinó con humus de lombriz (50:50), los resultaron fueron significativos para obtener plántulas vigorosas y alto porcentaje de emergencia.

Sustrato, Emergencia, Agricultura, Calidad de plántula, Humus, Significancia, *Capsicum annuum*

Citation: ZEPEDA-ARIAS, José de Jesús, ARELLANO-RODRÍGUEZ, Luis Javier, RODRÍGUEZ-GUZMÁN, Eduardo and PADILLA-GARCIA, José Miguel. Yahualica tree seedling chile production (*Capsicum annuum*) on different substrates and its behavior during the development of the crop. Journal-Agrarian and Natural Resource Economics. 2023. 7-12: 14-25

* Correspondence to Author (e-mail: Javier.arellano@academicos.udg.mx)
† Researcher contributing as first author.

Introduction

The increase of the world population forces mainly the agricultural sector to generate new technologies in order to increase the horticultural yield per unit area and the quality of food products for the demanding market. According to Guimarães et al. (2002); Hartmann and Kester (2002), in the production of high quality vegetables, seedling production is one of the most important stages in the crop cycle, since it has a significant influence on the responses of the plant, from a nutritional and productive point of view, given that there is a direct relationship between healthy and vigorous seedlings and production in the field.

In this respect, Abad and Noguera (2000) point out that soil is the natural medium for seedling growth, due to various factors such as: availability, cost, ease of obtaining, etc. However, it is not the most suitable material for seedling growth. However, it is not the most suitable material for the production of seedlings in greenhouses. From an environmental point of view, the most important criteria for choosing a material as a substrate for soilless cultivation are: its durability and its capacity for subsequent recycling. One of the most important functions of a substrate in a soilless cultivation system is to provide an "ideal" environment for the plant for root growth and to constitute a suitable base for the anchorage or mechanical support of the plants.

The selection of the substrate is one of the most important factors in providing the appropriate conditions for root growth (Ocampo et al., 2005). In agriculture, a wide variety of substrates are used for seedling production, some of the best known being: rice husks, tree bark, coffee pulp, coconut fibre, peat, sawdust and shavings, sand, gravel, earthworm humus, leaf litter, manure, among others (Acosta et al., 2008). Finding an ideal substrate is a difficult task, because each species has different requirements, but through experiments it is possible to find an optimal substrate that meets the minimum conditions required by the species to be studied (Oliverio, 2014). According to Gomes et al. (2008) and Moreno-Resendez et al. (2008), one of the most commonly used substrates for the commercial production of vegetable seedlings is peat.

Its physical, chemical and biological characteristics allow excellent germination and seedling growth, but its high cost and unsustainable exploitation have begun to restrict its use (Fernández et al., 2006). However, in Mexico there are alternative materials with physical and chemical properties that can substitute Peat Moss, such is the case of coconut powder, whose advantages include its wide availability in Mexico and adequate physical and chemical properties (Noguera et al. 2003).

One of the main horticultural crops in Mexico is the Capsicum annuum chilli, with a production of 1.85 million tonnes (López-Baltazar et al., 2013). The development of poor quality seedlings is one of the production factors that cause the most problems for producers of Yahualica chilli de árbol in the region of the crop's denomination of origin (Yahualica, Jalisco); seedlings are generally produced in seedbeds on the ground and develop very slowly due to the poor root system. As a result, many of the plants die before they can take root in the soil once transplanted and have to be replanted, increasing production costs. Although some farmers are already producing their seedlings in trays and the problem of deficient roots has improved, there are still no studies on the best substrate available on the market to solve this problem. For this reason this work was carried out, with the aim of using the results to help growers in the selection of the best substrate for seedling production of this crop.

Objective

To evaluate the effects of six substrates on seedling production and plant productivity of Yahualica chile de árbol.

Materials and methods

The research was carried out in experimental fields and greenhouses of the CUCBA of the University of Guadalajara, in the property Las Agujas, municipality of Zapopan, Jalisco, located in the central region of the state, in the extreme coordinates of 20º25'30" to 20º57'00" north latitude and 103º19'30" to 103º39'20" west longitude, at an altitude of 1,548 metres above sea level.

The climate of the experimental site is temperate sub-humid (A) C (w1) to (e) g according to the Köppen climate classification, with an average annual temperature of 18º to 22° C, with an average rainfall of 851 mm and four days of frost in January and February (García, 2004).

Chili fruit collections. With various producers in Yahualica, a collection of dry and ripe chilli peppers was carried out, with high health and good physical appearance. The following activities were carried out in the CUCBA seed laboratory to ensure that the seed to be used had high germination power and vigour.

Obtaining pure seed: The dried fruits were threshed and the seed was separated from the impurities using sieves and wind. The seed was sorted through a pneumatic separator to obtain seed of high specific weight.

Six substrates were tested in this research:

1. Promix GLX : Canadian Sphagnum peat (90-95%/vol) 2. Vermiculite - horticultural grade; Macronutrients; Micronutrients; Dolomitic and Calcitic lime; Wetting agent. pH range 5.0 - 6.0 (SME). Electrical conductivity 0.7 - 1.1 mmhos/cm (SME). Air porosity: 6-10% by volume. Water holding capacity: 70 - 85% by volume.
2. Promix FLX: Sphagnum peat moss, limestone for pH adjustment and wetting agent.
3. Sunshine: Plug-grade Canadian Sphagnum Moss peat, plug-grade vermiculite, dolomitic limestone.
4. Berger BN2: Selected fine-grained peat moss of excellent quality, fine-grained perlite, fine-grained vermiculite, dolomitic and calcitic limestone, non-ionic humectant, initial charge of standard fertiliser for seedlings.
5. Germinaza: Ground coconut tow
6. Germinza + earthworm humus: 50% and 50%.

The research was carried out in two stages:

A. Seedling production:

The experiment was set up twice. Using 200-cavity unicel trays. Three replicates per substrate and 100 seeds per replicate were sown under a completely randomised design.

According to Reveles (2005), the seedling is ready when it has 3 to 4 pairs of true leaves and a height between 10 and 12 centimetres, which is achieved between 40 and 50 days after sowing.
Variables measured:.

– As a test of vigour, the variable speed of emergence (VE) was measured. This was obtained by counting the number of seedlings emerged daily after sowing, taking as emerged seedlings those that protrude from the substrate. The speed of emergence was calculated using the expression proposed by Maguire (1962):

$$VE = \sum_{i=1}^{n} Ni / ti$$

Where:

VE = rate of emergence; N_i= Number of seedlings emerged per day; ti=Number of days after sowing; n= Number of counts 1, 2....., n counts.

– Emergence percentage (EP): total number of normal seedlings emerged at the end of the test per treatment and replicate.

– Seedling length (LP): Measured from the insertion of the hypocotyl to the tip of the apex of the last leaf.

– Stem thickness (GT): Using a TRUPER digital vernier (CALDI-6MP), the diameter of the seedling was measured in the middle part of the hypocotyl.

– Number of leaves (NH). The number of leaves developed above the cotyledons was counted.

– Fresh weight and dry weight of aerial part and root (PFRA, PFPA, PSRA and PSPA) of the seedlings produced:

In each treatment, five subsamples of 10 seedlings per treatment were weighed to obtain both aerial and root fresh weight of the seedlings. The seedlings were carefully cleaned by separating the aerial part from the roots and weighed on an analytical balance.

For the seedling dry weight test, five subsamples of 10 seedlings per treatment (representative of each replicate) were tested. The stem was then separated from the root, and these were placed separately in small brown paper bags, then taken to the oven to dry for three days at a temperature of 70ºC. After this time they were removed from the oven, allowed to cool and weighed on an analytical balance to obtain the dry weight of each treatment of both roots and aerial part.

A. Plant production in the field and greenhouse

Under field conditions, 30 seedlings per treatment/repetition were sown in a randomised block design with three replications.

In the greenhouse, 12 plants per treatment/repetition and with three replicates were transplanted into 10 litre pots using 75% jal and 25% worm castings as substrate, under a completely randomised design.

In these two environments, the 100% Stainer solution, which was prepared from calcium nitrate, potassium nitrate, magnesium sulphate, potassium sulphate and micronutrients, was fertilised using a venturi.

Both in field and greenhouse conditions, the following variables were considered: plant height (PA) sampled in two and three phases respectively, considering the measurement from the base of insertion in the substrate to the tip of the last leaves. Total fresh fruit weight (TFFW): The sample consisted of 10 plants per treatment and repetition, considering that the plant had one hundred percent of red fruits.

Statistical analysis: An analysis of variance (ANOVA) was carried out on all the variables and, where statistical differences were found, a multiple mean test was carried out using Tukey's test at 0.05 probability. The SAS 1981 statistical package was used for this purpose.

Results and discussion

Seedling production. In research carried out by Momirovic et al. (2000), Guzmán and Sánchez (2003) and Díaz et al. (2008), the variables germination percentage, seedling length, root dry weight and aerial part dry weight are considered as important variables to evaluate the quality of seedlings in chilli. Statistical differences ($P \leq 0.01$) were observed in the variables speed of emergence (VE) and percentage of emergence (PE) evaluated during two stages. This indicates that at least one substrate showed differences with the rest of the substrates. With a mean of 83 and 82% in the variable percentage of emergence within the two evaluations. And a coefficient of variation of 3.31% and 4.93% respectively considered as very good, which gives us an idea of high reliability in the results. On the other hand, the coefficients of variation of 19.6% and 15.2% were obtained for the speed of emergence during the two evaluations, and due to the nature of this variable, they can be considered as having good reliability.

In the variables stem thickness (GT), seedling length (LON), aerial part fresh weight (PFPA), root fresh weight (PFRA), aerial part dry weight (PSPA) and root dry weight (PSRA), statistical differences were found ($P \leq 0.01$) between the substrates evaluated, only in the variable number of leaves (NH) there were no statistical differences.

Means of 2.1 g, 11.45 mm, 9.7, 6.26 g, 2.97 g, 0865 g, and 0.291g respectively were observed in the variables stem thickness, seedling length, number of leaves, aerial part fresh weight, root fresh weight, aerial part dry weight, and root dry weight. And with coefficients of variation that give reliability to the results.

Mean test:

a) Variable speed of emergence (as a measure of vigour) and percentage of emergence

In table 1 for the variable speed of emergence, it was observed that the greatest vigour was presented with the combined substrate of 50% germination and 50% earthworm humus in the two tests carried out.

This was followed by the sunshine, Berger BN2 and germination treatments. It was observed that the substrate Promix FLX and Promix GTX had a negative effect on the speed of seedling emergence by obtaining very low vigour values (Table 1).

In the two tests for the variable percentage of emergence, the substrates 50% germination + 50% earthworm humus, Berger BN2 and germination (Table 1) stood out, with emergence percentages of over 88%, while the lowest number of emerged plants corresponded to Promix FLX and Promix GTX, with germination averages of 56 and 74%. These two variables evaluated are the basis of horticultural crop production, as seedlings of high vigour and germination are needed to ensure high yields in the field. As reported by Andrade-Rodriguez et al. (2008) when using different substrates for papaya seedling production, they found that substrates in which earthworm humus was used produced better seedling growth.

b). Variable seedling length, stem thickness and number of leaves

In the variable stem length, according to graph 1, a marked difference is observed between the six substrates evaluated, where the best substrate corresponded to 50% germination + 50% earthworm humus and Berger BN2; while the germination substrate had the smallest seedlings. These results are in contrast to García et al. (2001), who tested substrates with rice husk, coconut fibre, pine bark, peat, and garden compost combined with inorganic materials, and found higher productivity and quality of Epipremnum aureum and Spathiphyllum wallisii plants when using coconut fibre, peat and peat with agrolite.

On this point, Velasco-Velasco et al. (2001) point out that the improvement observed in the growth of seedlings by adding earthworm humus to the germination substrate suggests that it can be used as a biofertiliser, thus reducing the use of chemical fertilisers. It is also considered to improve the soil as it provides organic matter and modifies physical and chemical properties (López-Moctezuma et al., 2005).

Ortega-Martínez et al. (2010), found that the variable seedling length in tomato, the information obtained at 30 days expressed significant differences.

The seedlings with the greatest height were obtained in earthworm humus (17 cm) and peat (15 cm) followed by those grown in sawdust (12 cm). On the other hand, the treatment 50% germinza + 50% earthworm humus compared to the treatment with only germinza (where small and chlorotic seedlings were obtained) showed that the addition of earthworm humus to the latter had a significant effect on seedling growth and seedling colouring.

Andrade-Rodriguez et al. (2008), in a study of papaya seedling production, the smallest seedlings were obtained when grown on coconut fibre/sawdust/agrolite (5:2.5:2.5) and coconut fibre/sawdust (7:3), where the seedlings showed general chlorosis due to the phenols released by the coconut fibre.

In the variable stem thickness, the highest value of the seedling was observed in the Promix FLX treatment (2.51 mm); and the lowest thickness was observed in the germination substrate (Figure 1), showing a value of 1.83 mm; which when compared with the substrate where worm castings were added, an increase in stem thickness of 2.2 mm was obtained (Figure 1). In this regard, Ortega-Martínez et al. (2010) found that the substrates worm castings, peat and sawdust significantly favoured a greater development in stem thickness. As for the number of leaves, as shown in graph 2, the lowest value was found in the germination treatment. However, when worm castings were added to this treatment, there was an increase in the number of leaves (from 8.6 to 11.07).

In this regard, Velasco-Velasco et al. (2001), studied the effect of the incorporation of earthworm humus and observed that it had a positive effect on the photosynthesis rate, dry matter accumulation and yield of tomato husk. According to Larqué-Saavedra et al. (2010), Parra-Terraza et al. (2010), and Berrospe-Ochoa et al. (2012), tomato seedlings at 31 to 35 d of age presented on average between three and eight leaves. Ortega-Martínez et al. (2010). They point out that in an investigation with tomato, the number of leaves produced by the seedlings in the period analysed, had significant differences caused by the treatments under study, of which the worm humus substrate achieved the highest number of leaves (7).

Thus, the results obtained, as well as previous research, indicate the need to use in the substrates some component that provides nutrients for plant growth, in addition to adequate support.

c). Variables Fresh weight and dry weight of the aerial part and roots

In these variables, the sunshine substrate presented the highest values in comparison with the others, followed by the substrates Promix FLX, Berger BM2, Promix GTX and worm castings 50% + germinaza 50% (Table 2). While the substrate germinaza showed the lowest values in these four variables. In this regard, Ortega-Martínez et al. (2010), in an investigation with various substrates and in tomato cultivation, the dry weight of tomato seedlings showed significant statistical differences, where the best substrates were peat and earthworm humus followed by sawdust.

Higher dry matter accumulation indicates better seedling quality for transplanting and higher rooting percentage (Herrera et al., 2008; Rosca, 2009). According to Muñoz (2002), it seems that one of the best parameters is the dry matter (DM) content, so the higher the dry matter content, the more resistant the plant is to stress. It is clear that the D.M. content has a significant influence on the rooting of the plant. This will favour the development and proper growth of the other vegetative structures of the seedlings, such as leaf area weight, number of leaves and stem thickness.

Plant production and development under greenhouse and field conditions: In the analysis of variance, statistical differences were found in all the variables studied. In terms of plant height in the greenhouse, a greater average was achieved than in the field (135 cm and 109 cm respectively), and a greater yield of fresh fruit compared to that obtained in the field (651 g to 588 g respectively). In this regard, Bowman and Paul (1983) point out that there are differences between a plant grown in the field compared to one grown in a pot, which is generally exposed to a more stressful and constantly changing environment. Where the volume of a pot is limited, the substrate and its components must possess physical and chemical characteristics which, combined with a comprehensive management programme, allow optimum growth.

Comparative test of means

a) Plant height

Greenhouse: In the greenhouse area, two samples of plant height were taken in June (beginning of flowering) and in October (harvest). In the field, three samples were taken. Two in June and one in October (harvest).

As can be seen in graph 3, the plants from the substrates 50% Germinaza + 50% earthworm humus, Sunshine and Berger BN2 obtained the greatest heights (145, 145 and 140 cm respectively). While the Germinaza and Promix GTX treatments had the lowest plant heights (123 and 121 cm respectively).

Field

During the first two sampling dates the plant height of the six treatments remained constant (very similar data), but on the third date we found a marked difference between Germinaza and Promix FLX with values of 113 and 99 cm respectively. While, Promix FLX, Berger BN2, 50% Germinaza + 50% earthworm humus, Promix GTX, and Sunshine and showed the highest and very similar values in plant height at harvest (113, 113, 112, 109, and 109 cm respectively) (Figure 4).

Comparison of greenhouse and field plant height

When comparing the heights at harvest (fresh fruit) between greenhouse and field conditions, a marked difference is observed in the values obtained (Figure 5). Here, higher values can be seen in this variable under greenhouse conditions. Three groups of significance were formed: A AB and B, where the highest value corresponds to 50% Germinaza + 50% worm humus, Sunshine and Berger BN2, grouped in significance group A, and in group B the lowest value corresponds to Promix GTX and Germinaza. Under field conditions, three significance groups were also formed: A AB and B. The Germinaza treatment was placed in group B, it was the treatment with the lowest height (Figure 5). The highest values in the field were found in group A with the substrates Promix FLX, Berger BN2, and 50% Germinaza+50% earthworm humus. These last two treatments showed the most stable behaviour in the two test environments.

According to Muñoz (2002), the environmental conditions inside the greenhouse are relatively homogeneous and controlled, but outside in the final environment they will be very heterogeneous and not very or not at all controllable. This is demonstrated by the fact that a lower coefficient of variation was obtained in the greenhouse than in the field (4.2% and 5.2% respectively).

Fresh fruit weight: In this variable under field conditions, the best treatment corresponded to Berger BN2 (855 g), 50% Germinaza + 50% earthworm humus (840 g), and Promix GTX (614 g), and the lowest harvest value (420 g) was observed in the Sunshine substrate. While, in the greenhouse, the highest value (1163 g) was observed in the 50% germination and 50% worm castings treatment, followed by Sunshine (1011 g), and Berger BN2 (937 g). The lowest weights were observed in the plants from the Germinaza and Promix GTX substrates (Figure 6). In both environments, the 50% Germinaza+50% worm castings treatment stood out. In this regard, Domínguez et al. (2010) point out that it has been shown that the addition of earthworm humus to soils and substrates considerably increases the growth and productivity of a large number of horticultural crops.

According to graph 6, there are marked differences in fresh fruit weight in the two environments. In the greenhouse, yields were much higher than those obtained in field conditions, due to the fact that greenhouse crop production reduces the effects of extreme climates, allows the production of vegetables throughout the year and increases quality and yield (Rojas and Paniagua, 2015).

In graph 6, it is observed that the Sunshine treatment, despite showing a high weight in the greenhouse, had a significant drop when produced in the field. In this regard, Bowman and Paul (1983) point out that there are many differences in a field crop and another in greenhouses and pots. In greenhouses, temperatures and humidity are controlled, favouring yields and crop development. Nesmith and Duval (1998), point out that the variability of models associated with the use of certain substrates implies different morphological and physiological responses in the field or in the greenhouse.

A quality seedling is one that has good root development, a vigorous stem, no chlorosis, and is free of pests and diseases. To overcome transplanting stress, it must have adequate root capacity for water and nutrient uptake, as well as the ability to generate new roots. The growth rate is reduced when low quality seedlings are used (Leskovar, 2001). In this regard, Pérez et al. (2007), in a study with maize varieties, observed a positive correlation between vigour variables and grain yield and its components. The variables best correlated with vigour were speed of emergence, length and mesocotyl dry weight. In this greenhouse study, jal and worm humus were used as substrate (75% and 25%, respectively).

The addition of worm humus in the growth medium and the consequent increase of nutrients in the tissue has been observed in studies with various vegetables, attributing this increase to the presence of nutrients in the worm humus, as well as to the high cation exchange capacity it possesses, in addition to high moisture retention (Pérez-Murcia et al, 2006; Grigatti et al., 2007). Due to these properties attributed to the composted materials, the addition of 100% Steiner's nutrient solution improved plant development. For their part, Ramos et al. (2011) report that the application of worm humus, in addition to adding organic matter, which influences aeration, humidity and resistance of degrading soils, improves the capacity to regulate pH and CEC, as well as favouring the availability of phosphorus, potassium, iron and manganese in the crop.

Conclusions

Differences were found in the behaviour of the substrates with respect to Yahualica chilli seedling quality, where the highest seedling quality was achieved with the substrates 50% germination + 50% earthworm humus, Sunshine, and Berger BN2.

In the greenhouse, plant development reached the highest values for plant height and fresh fruit weight. Under greenhouse conditions, mean plant height values of 135 cm and fresh fruit weight of 652 g were obtained. In the field, mean plant height values were 109 cm. And with an average fresh fruit weight of 588 g.

In the greenhouse, the plants produced in the substrates 50% Germinaza+50% worm castings, Sunshine and Berger BN2 stood out for their height. In field conditions, seedlings produced on the substrates Promix FLX, Berger BN2 and 50% Germinaza + 50% earthworm humus stood out.

In terms of fresh fruit yield, the plants produced from the substrates 50% Germinaza + 50% earthworm humus, Sunshine and Berger BN2 achieved the highest yields under greenhouse conditions. In the field, the substrates Berger BN2 and 50% Germinaza+50% worm castings stood out.

Annexes

Treatments	Emergency Speed (1)	Emergency Speed (2)	Emergency Percentage (1)	Emergency Percentage (2)
Promix GLX	22.61 a	22.66 c	74.00 c	75.33 c
Promix FLX	8.38 b	9.64 d	60.00 d	52.00 d
Sunshine	31.56 a	31.33 abc	86.00 b	86.00 bc
BergerBN2	31.46 a	34.80 ab	93.00 ab	93.33 ab
Germinaza	27.25 a	25.92 bc	88.33 b	88.33 ab
Germinaza 50%+Wormwormworm compost 50%.	36.75 a	39.75 a	97.67 a	97.67 a
DMS	14.18	11.41	7.56	11.01

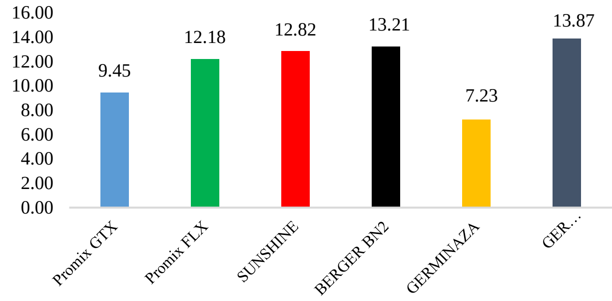
Where: Means with the same letter within columns are statistically equal, according to Tukey's test (p≤ 0.05), LSD= Least Significant Difference.

Table 1 Comparative test of means (Tukey at 0.05 probability) for the variables speed of emergence (first and second evaluation) and the variable percentage of emergence (first and second evaluation) in the six substrates evaluated

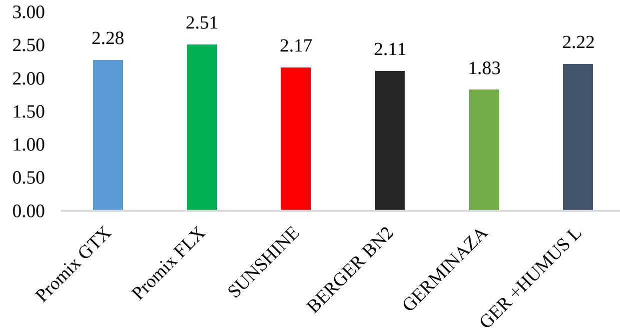
Tratamientos	PFPA	PFRA	PSPA	PSRA
Promix GLX	5.54 bc	2.36 b	0.628 c	0.212 b
Promix FLX	6.26 abc	2.74 b	0.766 bc	0.262 b
Sunshine	7.70 a	4.7 a	1.130 a	0.412 a
BergerBN2	7.10 ab	2.84 b	0.958 ab	0.280 b
Germinaza	2.80 d	1.00 c	0.453 d	0.185 c
Germinaza 50%+Humus lombriz 50%	4.64 c	2.22 b	0.856 b	0.290 b
DMS	1.85	0.99	0.20	0.08

Where: Means with the same letter within columns are statistically equal, according to Tukey's test (p≤ 0.05), LSD= Least Significant Difference.

Table 2 Comparative test of means (Tukey at 0.05 probability) for the variables fresh weight of aerial part (PFPA), fresh weight of root (PFRA), dry weight of aerial part (PSPA), and dry weight of root (PSRA) in the six substrates evaluated

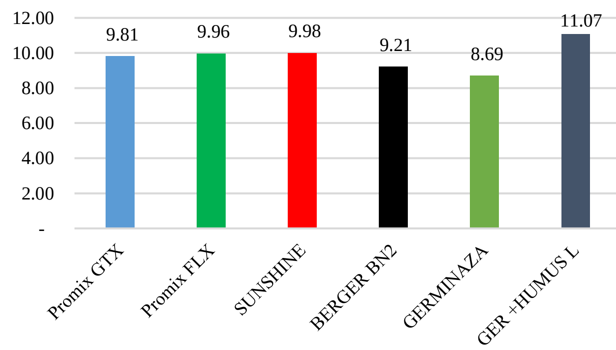


a

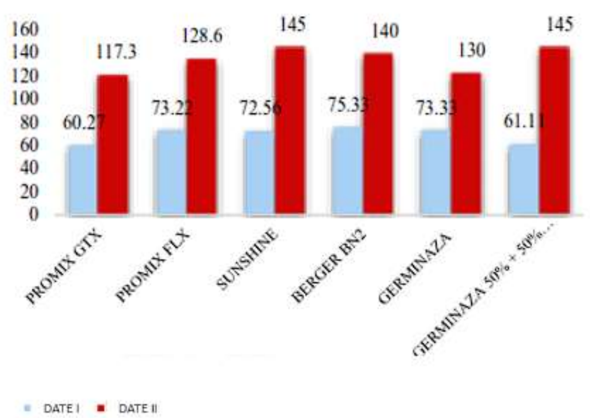


b

Graph 1. a) Variable seedling length (cm) and b) variable stem thickness (mm) in the six treatments evaluated

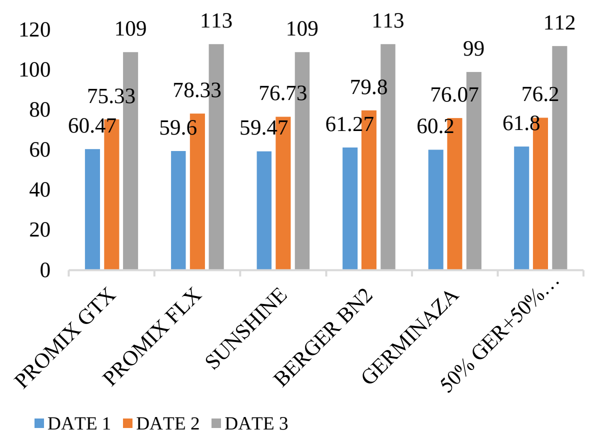


Graph 2 Variable number of leaves in the six treatments evaluated in Yahualica chile seedlings

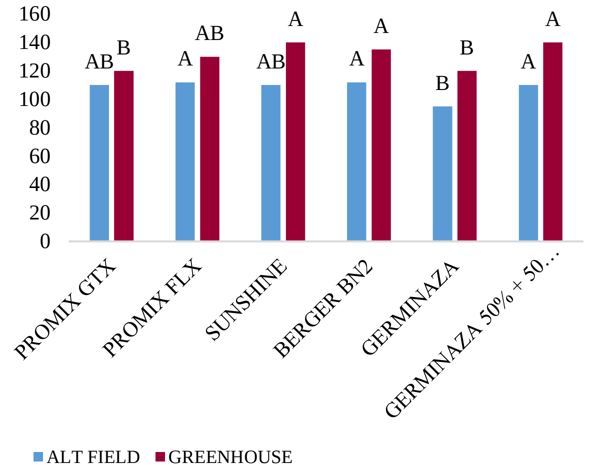


Graph 3 Variable plant height (cm) on two sampling dates for the six substrates evaluated under greenhouse conditions

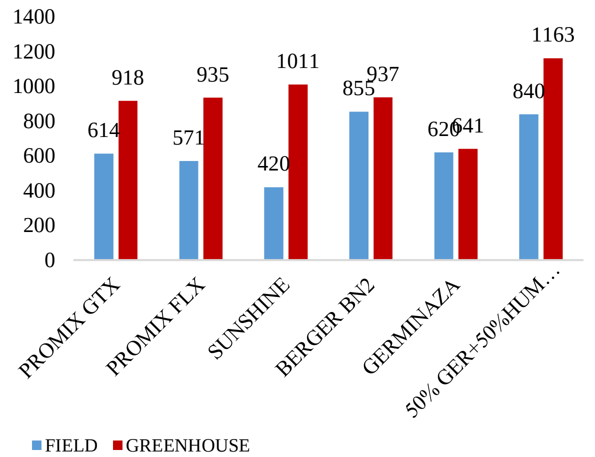
ISSN 2524-2091



Graph 4 Variable plant height (cm) during three dates in the six substrates evaluated in the field



Graph 5 Comparison of the variable plant height (cm) at harvest between greenhouse and field for the six treatments evaluated. Means with the same letter within columns are statistically equal



Graph 6 Variable fresh fruit weight (gr) at harvest for the six treatments evaluated under field and greenhouse conditions

References

Abad, M. y Noguera, P. (2000). Los sustratos en los cultivos sin suelo. En Manual del cultivo sin suelo. Universidad de Almería- Mundi-Prensa, Madrid, 137-183 p. URL: https://www.scirp.org/(S(351jmbntvnsjt1aadkozje))/reference/referencespapers.aspx?referenceid=1837630

Acosta-Durán, C. M.; Gallardo, C. S.; Kämpf, A. N. y Bezerra, F. C. (2008). Materiales regionales utilizados en Latinoamérica para la preparación de sustratos. Investigación Agropecuaria, 5(2): 93-106. URL: https://www.academia.edu/3244556/ Materiales regionales utilizados_en_Latinoamerica_para_la_preparación_de _ sustratos.

Andrade-Rodríguez, M; Ayala-Hernández, J.J; Alia-Tejacal, I; Rodríguez-Mendoza, H; Acosta-Durán, C.M. y López-Martínez, V. (2008). Efecto de promotores de la germinación y sustratos en el desarrollo de plántulas de papayo. *Revista de la Facultad de Agronomía*. *25*(4): 617-635. URL: http://ve.scielo.org/scielo.php?script=sci_arttext&pid=S0378-78182008000400002 & lng=es&tlng=es.

Berrospe-Ochoa, E. A.; V. M. Ordaz-Chaparro; M. N. Rodríguez-Mendoza y R. Quintero-Lisaola. (2012). Cachaza como sustrato para la producción de plántula de tomate. Rev. Chapingo Ser. Hortic. 18: 141-156. URL: http://www.scielo.org.mx/scielo.php?script=sci_arttext&pid=S1027-152X2012000100010&lng=es&tlng=es.

Bowman, D.C., Paul, J.L. (1983). Understanding of container media vital knowledge for growing successful plants. Pacific Coast Nurseryman and Garden Supply Dealer. March Issue. https://doi.org/:10.21930/agrosavia.manual.7405682

Díaz, P. J. C; Granberry, D.M.; Germishuizen, P. (2008). Transplant growth and stand establishment of bell pepper (Capsicum annuum L.) plants as affected by compost-amended substrate. Acta Hort. 782: 223- 228. https://doi.org/: 10.17660/ActaHortic.2008.782.26

Domínguez, J.; Lazcano, C. y Gómez-Brandón, M. (2010). Influencia del vermicomposta en el crecimiento de las plantas. Aportes para la elaboración de un concepto objetivo. Acta Zoológica Mexicana. Número Especial 2: 359-371. https://doi.org/:10.21829/azm.2010.262900

Fernández, B. C; Urdanet, N. y Silva, W. (2006). Germinación de semillas de tomate (*Lycopersicum esculentum* Mill.) Cv Río Grande sembradas en bandejas plásticas, utilizando distintos sustratos. Rev. Fac. Agron.23 (2): 188-196.URL: http://ve.scielo.org/scielo.php?script=sci_arttext&pid=S0378-78182006000200006&lng=es&tlng=es.

García, C.O.; Alcántar, G.G.; Cabrera, R.I.; F. Gavi R. y V. Volke, H. (2001). Evaluación de sustratos para la producción de *Epipremnum aureum* y *Spathiphyllum wallissi* cultivadas en maceta. Terra latinoamericana 19 (3): 249-258. URL: https://www.redalyc.org/articulo.oa?id=57319306

García, H. 2004. Modificación al sistema de clasificación climática de Koppen. Instituto de geografía, Universidad Nacional Autónoma de México. Quinta edición. Núm. 6. URL: http://www.publicaciones.igg.unam.mx/index.php/ig/catalog/book/83

Gomes, L. A. A.; Rodríguez, A. A.; Collier, L. S. e Feitosa, S. S. (2008). Produjao de mudas de alface em substrato alternativo com adubajao. Horticultura Brasileira. 26: p 359-363. URL: https://www.scielo.br/j/hb/a/TN4PQz85nZkyGWDB4psmvkL/?format=pdf&lang=pt

Grigatti, M.; Giorgioni, M. E. and Ciavatta, C. (2007). Compost-based growing media: influence on growth and nutrient use of bedding plants. Bioresour. Technol. 98:3526-3534. https://doi.org/: 10.1016/j.biortech.2006.11.016

Guimarães, V.F.; M.M. Echer y K. Minami, (2002). Métodos de produção de mudas, distribuição de matéria seca produtividade de plântulas de beterraba. Hortic. Bras. 20 (3), 505-509. https:// doi.org/:10.1590/S0102-05362002000300022

Guzman, M. and Sánchez, A. (2003). Influence of nitrate and calcium increments on development, growth and early yield in sweet pepper plants. Acta Hort. 609: 207-211. https://doi.org/:10.17660/ActaHortic.2003.609.29

Hartmann, H. y Kester, D. (2002). Plant propagation. Principles and practices. Prentice Hall. New Jersey. P 880. URL: https://books.google.com.mx/books/about/Hartmann_and_Kester_s_Plant_Propagation.html?id=SNtXAAAAYAAJ&redir_esc=y

Herrera, F.; Castillo, J. E.; Chica, A. F.; L. López Bellido (2008). Use of municipal solid waste compost (MSWC) as a growing medium in the nursery production of tomato plants. Bioresource Technol. 99 (2): 287–296. https://doi.org/:10.1016/j.biortech.2006.12.042. Epub 2007 Mar 6. PMID: 17344043.

Larqué-Saavedra, A.; Martín-Mex, R.; Nexticapan-Garcéz, A; Vergara-Yoisura, S. y Gutiérrez-Rendón, M. (2010). Efecto del ácido salicílico en el crecimiento de plántulas de tomate. Rev. Chapingo Ser. Hortic. 16 (3): 183-187. URL: http://www. scielo.org.mx/scielo.php?script=sci_arttext&pid=S1027-152X2010000300006&lng=es&tlng=es.

Leskovar, D.I. (2001). Producción y ecofisiología del trasplante hortícola. Buena Vista, Saltillo, Coahuila. Curso. P 1-24. URL: https://es.scribd.com/document/25499246/Produccion-y-ecofisiologia-del-trasplante-horticola

López-Baltazar, J.; Méndez-Matías, A.; Pliego-Marín, L.; Aragón-Robles, E. y Robles-Martínez, M. L. (2013). Evaluación agronómica de sustratos en plántulas de chile 'onza' (*Capsicum annuum*) en invernadero. *Revista mexicana de ciencias agrícolas*, 4(6):1139-1150. https://doi.org/:10.29312/remexca.v0i6.1278

López-Moctezuma, H.; Ferrera-Cerrato, R.; Farias-Larios, J.; Aguilar-Espinosa, S.; F. Bello, Ma. del R; López-Aguirre, J.G.. (2005). Micorriza arbuscular, bacillus y sustrato enriquecido con vermicomposta en el desarrollo de plantas de papayo. Terra Latinoamericana 23 (4): 523-531. URL: https://www.redalyc.org/pdf/573/57311146011.pdf

Maguire, J.D. (1962). Speed of germination-aid in selection and evaluation for Seedling Emergence and Vigor. Crop Science 2 (2): 176-177. URL: https://acsess.onlinelibrary.wiley.com/doi/10.2135/cropsci1962.0011183X000200020033x

Momirovic, N.; Misovic, M.; Cvetkovic, R. (2000). Effect of different substrates on sweet pepper (*Capsicum annuum* L. cv. Macvanka) transplants quality in organic farming production. Acta Hort. 533: 135-139. https://doi.org/:10.17660/ActaHortic.2000.533.15

Moreno-Reséndez, A.; Gómez-Fuentes, L.; Cano-Ruíz, P., Martínez-Cueto, V.; Reyes Carrillo, J. L.; Puente-Manríquez, J. L. y Rodríguez-Dimas, N. (2008). Genotipos de tomate en mezclas de vermicompostas: arena en invernadero. Terra Latinoamericana 26 (2): 103-109. URL: http://www.scielo.org.mx/scielo.php?script=sci_arttext&pid=S0187-57792008000200002&lng=es&tlng=es.

Muñoz, R. J. J. (2002). Acondicionamiento nutritivo de plántulas de tomate y pimiento en semillero y su respuesta postransplante. Tesis doctoral Universidad de Almería. España. URL: https://dialnet.unirioja.es/servlet/tesis?codigo=222718

Nesmith, D.S.; Duval, J.R. (1998). The effect of container size. HortTechnology. 8(4): 495-498. URL: https://swfrec.ifas.ufl.edu/docs/pdf/veg-hort/transplant/trans_cs1.pdf

Noguera, P.; Abad, M.; Puchades, R.; Maquieira, A.; Noguera, V. (2003). Influence of particle size on physical and chemical properties of coconut coir dust as container medium. Communications in Soil Science and Plant Analysis 34(3-4): 593–605. https://doi.org/:10.1081/CSS/120017842

Ocampo, M. J.; Caballero, M. R.; y Tornero, C. M. A. (2005). Los sustratos en cultivos hortícolas y ornamentales. En: Agricultura, Ganadería, Ambiente y Desarrollo Sustentable. Tornero C. M. A., Silva G. S. E., Pérez A. R. Y Bonilla F. N. (Eds.). Publicación especial de la Benemérita Universidad Autónoma de Puebla, México. pp. 55-73. ISBN: 968 863 913 3.

Oliverio T. S. (2014). Evaluación de cinco sustratos para la producción en vivero de palo blanco (*Tabebuia donnell-smithii Rose*). Tesis de Grado. Universidad Rafael Landívar, Facultad de Ciencias Ambientales y Agrícolas. Licenciatura en Ingeniería Forestal con énfasis en Silvicultura y Manejo de Bosques. Guatemala. P 68. URL:http://biblio3.url.edu.gt/Tesario/2014/06/22/Tut-Maynor.pdf

Ortega-Martínez, L. D.; Sánchez-Olarte, J.; Díaz-Ruiz, R. y Ocampo-Mendoza, J. (2010). Efecto de diferentes sustratos en el crecimiento de plántulas de tomate (*Lycopersicum esculentum* Mill). Ra Ximhai, 6(3):365-372. https://doi.org/:10.35197/rx.06.03.2010.05.1o

Parra-Terraza, S., Salas-Núñez, E.; Villareal-Romero, R.; Hernández-Verdugo, S. y Sánchez-Peña, P. (2010). Relaciones nitrato/ amonio/ urea y concentraciones de potasio en la producción de plántulas de tomate. Rev. Chapingo Ser. Hortic. 16 (1): p 37-47. URL: http://www.scielo.org.mx/scielo.php?script=sci_arttext&pid=S1027-152X2010000100006 lng=es&tlng=es.

Pérez de la C., F.J.; Córdova, T. L.; Santacruz, V. A.; Castillo, G. F.; Cárdenas, S. E. y Delgado A. A. (2007). Relación entre vigor inicial, rendimiento y sus componentes en poblaciones de maíz chalqueño. Agric. Téc. Méx.33 (1):5-16. URL: https://www.redalyc.org/pdf/608/60833101.pdf

Pérez-Murcia, M. D.; Moral, R.; Moreno-Caselles, J.; Pérez-Espinosa, A.; Paredes, C. (2006). Use of composted sewage sludge in growth media for broccoli. Bioresour. Technol. 97 (1): 123-130. https://doi.org/: 10.1016/j.biortech.2005.02.005

Ramos, G. F.; Aguilar-Rubalcaba, J. A.; López-Gutiérrez, M.A.; Ochoa-Fuentes M.; y Vázquez-Martínez, O. (2011). Efecto de abonos orgánicos en el rendimiento del cultivo de chile ancho (*Capsicum annuum L.*) sobre las características química del suelo de la parcela experimental. Investigación y Ciencia de la Universidad Autónoma de Aguascalientes 51: 3-9. URL: https://www.redalyc.org/pdf/674/67418397001.pdf

Reveles H., M. (2005). Apuntes del curso producción de plántula en invernadero. Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias, Centro de Investigación Regional Norte Centro, Campo Experimental Zacatecas. México. Documento de trabajo, p 6.

Rojas, J; Paniagua, F. (2015). Comportamiento agronómico de *Capsicum annuum* L., *Lycopersicon esculentum* M. y *Cucumis melo* L. bajo cultivo protegido hidropónico utilizando la solución universal de Steiner. Tesis Lic. San Carlos, Costa Rica, Tecnológico de Costa Rica. P 98. URL: https://repositoriotec.tec.ac.cr/bitstream/handle/2238/6413/comportamiento_agronomico_capsicum_annuum.pdf?sequence=1&isAllowed=y

Rosca, V (2009). Optimization of nitrogen concentration in the fertilization solution for production of seedlings in cell trays. Acta Hort. 807_91: 613-618. https://doi.org/: 10.17660/ActaHortic.2009.807.91

Velasco-Velasco,V. J.;Ferrera-Cerrato,R.; Almaraz-Suarez, J.J.(2001). Vermicomposta, micorriza arbuscular y *Azospirillum brasilense* en tomate de cáscara. Terra latinoamericana19 (3): 241-248. URL: https://www.redalyc.org/pdf/573/57319305.pdf

ISSN 2524-2091