Agricultura, Sociedad y Desarrollo

RESPONSE OF CHILE HUACLE (*Capsicum annuum L.*) TO WATER STRESS UNDER GREENHOUSE CONDITIONS

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ABSTRACT

Restricted water and high temperatures are limiting factors that affect plant development. In this study, the effect of water stress on black Huacle chile was evaluated at three levels of soil moisture stress (10 to 20, 21 to 30 and 31 to 40 kPa) in planting beds, with and without mulch of 0.9 m wide and 6.0 m long. A bifactorial design was used with four repetitions made up of 18 plants each. 27 variables in plant and fruit were evaluated. The greater availability of moisture in the soil with mulch increased flower buds by 85%, flowers by 89% and fruits by 61%, compared to the treatment with greater water stress without mulch; likewise, it presented the highest dry fruit yield (122.9 g), sweeter fruit (20.4%), net assimilation rate (0.11 g cm^2 d^{-1}), absolute growth rate (2.72 g d^{-1}) and relative growth rate (0.13 g g^{-1} d^{-1}). Lower moisture stress in the soil produced higher plant height (65.3 cm) and stem diameter (11 mm). Finally, greater moisture tension in the mulched soil caused 30% senescence.

Keywords: fruit quality, phenology, physiological indices.

INTRODUCTION

The *Capsicum* genus includes more than 30 species of which *C. annuum, C. frutescens, C. chinense, C. baccatum* and *C. pubescens* are domesticated and cultivated for consumption; either fresh, dried or processed; its main uses are: in food preparation, manufacture of cosmetics, pharmaceutical products and pest control (Ramchiary and Kole, 2019).

Due to varying climates, microclimates and edaphology in Mexico, we find a great variety of native chile peppers distributed throughout the country (Aguilar *et al.*, 2018). Oaxaca is one of the states with the greatest diversity of native chile peppers, among which is the black Huacle chile (*Capsicum annuum L.*) (Sanjuan *et al.*, 2020), cultivated in the Oaxacan Cañada region, that is of great value and importance as it is the main ingredient of the international black mole from Oaxaca (García *et al.*, 2017). This chile is generally cultivated in the open air and irrigated with a rotating sprinkler, paying around 200 ha^{-1} in wages for its management (López *et al.*, 2016), with an average yield of 1.0 t ha^{-1} of dehydrated fruit (Aguilar *et al.* , 2010), producing fruit 10 cm long and 8 cm wide, that is black in color when ripe (García *et al.*, 2017), and generating between 400,000 and 800,000 pesos of income, depending on the season of sale (López *et al.* , 2016). Despite the above, it has been classified as an endangered crop (Sanjuan and Martinez, 2022). This

Citation: Sanjuan-Martínez J, Ortiz-Hernández YD, Aquino-Bolaños T, Cruz-Izquierdo S, Pérez-Pacheco R. 2022. Response of chile huacle (*Capsicum annuum* L.) to water stress under greenhouse conditions.
Agricultura, Sociedad y Desarrollo
https://doi.org/10.22231/asyd.v19i4.1382

ASyD 19(4): 421-435

Editor in Chief:
Dr. Benito Ramírez Valverde

Received: November 25, 2020.
Approved: September 20, 2021.

Estimated publication date:
January 30, 2023.

is why in recent years, studies have been carried out to evaluate the effect of protective structures, localized irrigation systems and control of nutrient and pruning densities, in the cultivation of black Huacle chile, with the aim of improving crop production and quality (San Juan *et al*., 2019; Urbina *et al*., 2020; Martínez *et al*., 2022).

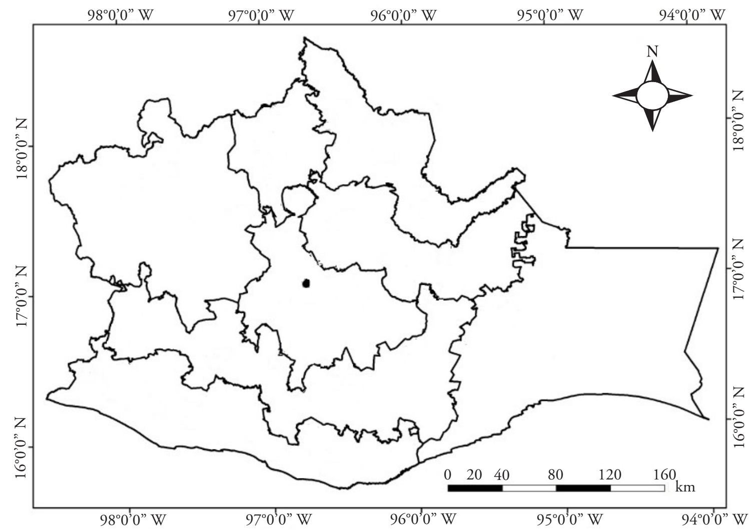
In *Capsicum* spp. it has been shown that water deficit mainly affects: plant height, extent of foliage, yield (Quintal *et al*., 2012), number of flowers and fruit quality (Quesada, 2015). Sezen *et al.* (2019) report that the phenology and physiology of plants is affected by water availability and environmental factors. Likewise, it has been shown that the use of plastic mulches and irrigation tapes, among other techniques, improve the management and use of water (Cosgrove and Rijisberman, 2014), reducing water consumption by up to 50%, and influencing plant height, leaf area index, weight and fruit quality by 10 to 15% (Dong *et al*., 2014), as it helps improve condition of soil moisture by avoiding loss of water by evaporation and reduces the presence of weeds (Bahena *et al*., 2012; Inzunza *et al*., 2017). This is very important because worldwide, agriculture consumes 70% of the fresh water that is extracted annually (Villalobos *et al*., 2017); In addition, water constitutes 80 to 95% of growth tissues in plants (Quintal *et al*., 2012).

In Oaxaca, work has been carried out with native crops such as beans (*Phaseolus vulgaris* L.) (Pliego *et al*., 2013; Aguilar *et al*., 2019), in order to identify the response of these genetic materials to water availability; in similar fashion, water consumption and yield under cover have been determined for green or husk tomato (*Physalis ixocarpa*) (Ramos *et al*., 2017). For their part, Cruz *et al.* (2018) report the use of plastic mulch and macrotunnels in the production of chile de agua (*Capsicum annuum* L.). These investigations have made it possible to improve production and crop quality, as well as increase efficiency concerning water use.

Correspondingly, the objective of this research was to improve water availability for black Huacle chile, grown under plastic cover with three levels of humidity in beds with and without plastic mulch; in addition to evaluating its effect on phenological, morphological and physiological aspects and fruit quality.

METHODOLOGY

Research was carried out in a 200 m^2 tunnel-type greenhouse from January to August 2019, in Santa Cruz Xoxocotlán, Oaxaca (Figure 1), located at 1550 m. Black Huacle chile seeds were used. The seedlings were established in 200-cavity polystyrene trays; the substrate consisted of a mixture of peat-moss and agrolita (substrate) at a ratio of 2:1. The seedlings were irrigated daily with the 25% Steiner solution (Steiner, 1984) until they reached an average of 16 cm in height with eight true leaves, when they were transplanted into a double row in sowing beds 0.9 m wide and 6.0 m long; distance between plants of 0.6 m, 0.4 m between rows, with a 1.0 m wide aisle. The experimental design was completely randomized in a 3x2 bifactorial arrangement, corresponding to three moisture stress intervals (H, in kPa) and beds with mulch (WM) and without mulch (WoM) black/silver plastic (Table 1). For each treatment, four repeats were established, each repeat consisted of 18 plants; each plant was considered as an experimental unit.



Source: Prepared by Raúl Rivera García from the Laboratory of Geographic Information Systems and Remote Sensing of the IPN-CIIDIR-Oaxaca.
Figure 1. Macrolocation of the municipality of Santa Cruz Xoxocotlán, Oaxaca, Mexico.

Soil characteristics consisted of: sandy loam texture (20% silt, 10% clay and 70% sand), pH 8.55 and 626.6 mg mg kg^{-1} of NO_3^-. Nutritional requirements were covered by the 250N-200P-300K kg ha^{-1} dose used for habanero chiles by Quintal *et al.* (2012). Application of fertilizers, together with water distribution was by means of a T-Tape with drippers 20 cm apart and a unit flow of 1.0 Lh^{-1} with an operating pressure of 0.8 Kgcm^{-3}. Monitoring of soil moisture began 30 days after transplanting (dat), for which a 12" IRROMETER® brand tensiometer was placed in the central part of each treatment at a depth of 15 cm. Data were analyzed by means of an analysis of variance and comparison of means Tukey (P≤0.05) using the SAS® version 9.1 (SAS, 2004).
During culture development, microclimatic variables were recorded every hour from 07:00 to 18:00: temperature (T), relative humidity (RH) and photosynthetically active

Table 1. Treatments applied to Huacle chile plants.

Treatment	With mulch	Moisture stress in the earth (kPa)
T1	With (WM)	10-20 (H1)
T2		21-30 (H2)
T3		31-40 (H3)
T4	Without mulch (WoM)	10-20 (H1)
T5		21-30 (H2)
T6		31-40 (H3)

WM: with mulch, WoM: without mulch.
Source: eelf elaborated.

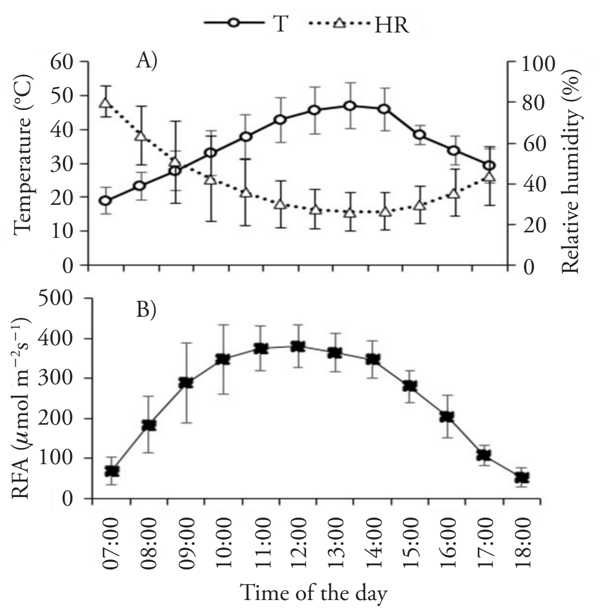
radiation (PAR) using a data logger mod. HOBO® U12 placed at a height of 0.8 m from the ground in the central part of the greenhouse.

Following transplantation, the number of buds (BU), flowers (FL) and fruits (FR) were recorded every 30 days, for six plants taken at random from each treatment, as well as plant height (PH) from the base of the stem to the highest part of the plant, a Truper® brand metal flexometer was used (3 m with a minimum scale of 1 mm); stem diameter (SD) at five centimeters above the ground, using a digital vernier caliper micrometer (0.1 mm resolution); leaf area (LA), using an Epson L555 scanner (Epson America), the leaves of each plant were digitized and analyzed, using the ImageJ 1.5 program (National Institutes of Health, USA). Subsequently, the plants were separated in terms of leaves (L), stem (S), root (R) and fruit (F); these were deposited in paper bags and dried in a forced-air oven at 65 ºC until reaching constant weight, recording dry weight (DW) with an electronic balance (Ohaus®, USA). Taking these values, we calculated the following: leaf area index (LAI) according to Hunt (1978). We calculated net assimilation rate (NAR), absolute growth rate (AGR) and relative growth rate (RGR), as indicated by Cortés *et al*. (2016).

At 60 dat, the number of dead plants per treatment were counted and converted to a percentage. At 120 dat, six fresh ripe fruits from different plants of each treatment were randomly selected in order to determine the following: total soluble solids (TSS in °Brix) using a refractometer (ATAGO scale 0 to 30°), pH using a potentiometer (Hanna Instruments, model Hi98130) and titratable acidity (TA) according to AOAC (1990). With the values obtained, the maturity index (MI) was calculated as the result of the quotient between the TSS and TA %. Also, 20 dried commercial fruits from different plants in each treatment were randomly selected and the length, width, dry weight, number and weight of seeds (NS and WS) were determined. The commercial yield (CY) was obtained by averaging the dry weight of fruits from six plants, randomly selected from each treatment (only considering fruits at least 3.0 cm wide and 4.0 cm long). The number of commercial fruits per plant (NCFP) was obtained by averaging the number of commercial fruits from six plants, randomly selected from each treatment. The harvest index (HI) was obtained, as the ratio between fruit yield and the aerial biomass of each plant (Garrido *et al*., 2013)

RESULTS AND DISCUSSION

In Figure 2, we present average microclimatic data per hour that prevailed during crop development. According to Lorenzo (2012), it is necessary to be aware of the behavior of T and RH inside the greenhouses because in agriculture, once these two variables are accounted for, they intervene in transpiration processes and consequently result in greater or lesser consumption of water. The maximum average PAR exceeded 300 μmol m^{-2} s^{-1} and the average RH was less than 30% during the same time period (Figure 2). These results are similar to certain values obtained by Zermeño *et al*. (2019), who reported PAR values of 200 to 600 μmol m^{-2} s^{-1} at 12:00 h under three different red, blue and translucent polycarbonate covers for cultivation of chile poblano of the Ebony variety (*Capsicum annuum* L.); however, the type of structure they evaluated may have caused the higher



Source: self-elaborated.

Figure 2. Average values of A) temperature and relative humidity, B) photosynthetically active radiation recorded inside the greenhouse.

PAR values that were not recorded in this experiment carried out using a conventional plastic cover for a black Huacle chile (*Capsicum annuum* L.) crop, due to the fact that the transmission of solar radiation through each cover is different, as reported by Paredes *et al.* (2018). In contrast, between 10:00 a.m. and 6:00 p.m., average temperatures exceeded 30 °C; in this regard, Baxevanou *et al.* (2008), mention that the increase in temperature under cover depends on the total radiation, for their part, Escalante *et a*l. (2008) mention that photosynthesis and temperature in most cases are closely related, as increasing the temperature increases the photosynthetic rate. Finally, the highest RH of the day was 80% and was recorded at 7:00 a.m., which gradually decreased until reaching 29%, recorded between 1:00 p.m. and 3:00 p.m.

With the exception of T4, at 60 dat, the highest number of BU and FL showed significant differences (P≤0.05), significantly exceeding the T1 values (Table 2). The reduction of BU and FL between treatments can mainly be attributed to water stress, an effect reported for the genus *Capsicum* by Rao *et al.* (2016), because water intervenes in physical-chemical integrity and cell expansion, as indicated by Quesada (2015). Likewise, the temperatures registered inside the greenhouse (Figure 2), exceeded 30 °C, referring to this, Chaves and Gutiérrez (2017) mention that exposure of the genus *Capsicum* to temperatures above 33 °C during the day and 20 °C during the night, which affects viability of pollen and fertilization, increases the abortion of flowers and decreases fruit set. Similarly, the oscillation in relative humidity (40-80%) may be the cause of the reduction in the number of flowers; in this regard, Amador *et al.* (2014) reported that stabilizing relative humidity

Table 2. Number of buds, flowers and fruits during the development of the Huacle chile.

	Number of buds (dat)			Number of flowers (dat)			Number of fruits (dat)		
	60	90	120	60	90	120	60	90	120
T1	75 a	0 c	0 c	29 a	2 ab	0 b	16 a	59 a	52 a
T2	37 b	11a	40 ab	10 bc	5 a	2 b	4 b	31 b	31 b
T3	41 b	6 b	0 c	16 b	1 b	0 b	3 b	27 b	31 b
T4	35 b	0 c	60 a	5 c	0 b	27 a	3 b	20 b	31 b
T5	34 b	0 c	17 bc	5 c	0 b	6 b	3 b	31 b	29 b
T6	14 c	1 c	1 c	3 c	2 ab	0 b	2 b	21 b	20 b

Means with different letters in the column present a significant difference (Tukey, 0.05); dat=days after transplantation.
Source: self-elaborated.

close to 70% increased the number of flowers and fruits in the mirasol chile (*Capsicum annuum* L.). Similarly, low PAR (Figure 2) may induce negative effects on the distribution of photoassimilates and fruit growth as reported by Paredes *et al.* (2018) for chile piquín (*Capsicum annuum* L.) cultivated under colored netting, where the size and number of fruits were affected by PAR.

At 90 and 120 dat, T1 presented an increase of 195% and 67% respectively in the number of fruits, compared to T4 (Table 2), thus indicating a favorable effect on the part of plastic mulch, as both treatments maintained a tension in soil moisture (from 10 to 20 kPa); however, this effect was not reflected in T2 and T3 as it did not show significant differences with T5 and T6 respectively. In this regard, Bahena *et al.* (2012) mention that the placement of plastic mulch prevents moisture loss through evaporation and reduces the presence of weeds, limiting competition for light and nutrients; in addition, it maintains soil moisture and because the greatest absorption of nutrients and water is by the root system within the first 0.5 m of depth, this possibly covers the demand for photoassimilates for the fruiting stage (Álvarez and Pino, 2018).

T1 and T4 demonstrated significant differences ($P \leq 0.05$) in PH and DWT with respect to the rest of the treatments (Table 3). This indicates that maintaining a soil moisture tension range of 10 to 20 kPa positively influences PH and DWT regardless of mulch, as reported by Quintal *et al.* (2012) as water availability increased the height of Habanero chile (*Capsicum chinense* Jacq.) grown under cover. However, Lopez *et al.* (2016) show 55% higher values in the PH of the Huacle chile produced in the open and with rotating irrigation, compared to those obtained in this study with T1 and T4

In contrast, T1 presented a higher significant value for the variables, DWF, DWH, LAI and LA (Table 3). In this regard, it has been reported that the reduction in LA is a response to water stress, whereby the plant avoids the loss of water through transpiration (Moreno and Liz, 2009); however, this response also directly affects the ability of plants to generate photoassimilates, because leaves represent the organ responsible for this function (Quesada, 2015), directly affecting the accumulation of dry matter and its physiological indices.

Table 3. Morphological characteristics of Huacle chile plants at 120 dat.

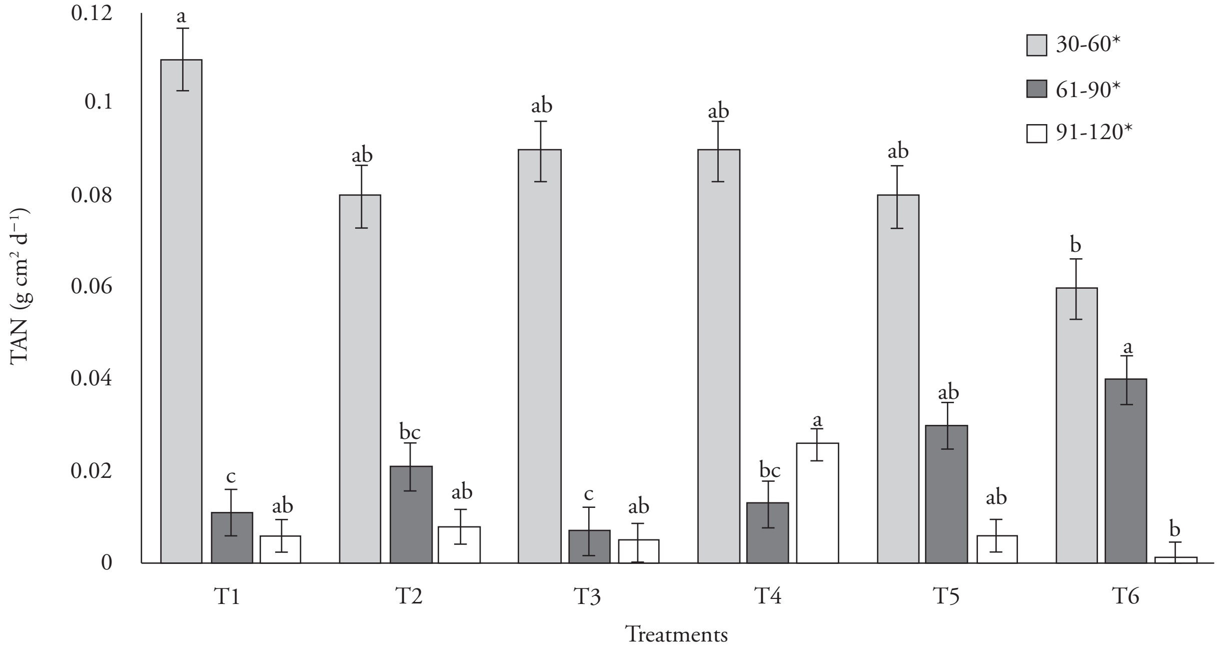
	PH (cm)	SD (mm)	Dry weight (g)				LA (m^2 $plant^{-1}$)	LAI
			Fruit	Leaves	Stalks	Root		
T1	65.3 a	11.0 a	122.9 a	38.0 a	36.0 a	1.8 bc	6.06 a	2.24 a
T2	54.9 bc	9.6 b	94.1 ab	27.3 b	24.9 b	1.1 c	4.00 b	1.48b
T3	50.6 c	9.2 bc	67.2 bc	19.2 c	21.3 bc	1.6 bc	2.80 c	1.03 c
T4	63.5 ab	10.9 a	48.4 c	26.7 b	41.1 a	2.5 a	4.01 b	1.48 b
T5	50.7 c	10.1 ab	47.9 c	21.9 bc	25.5 b	2.1 ab	3.15 bc	1.16 bc
T6	47.6 c	8.3 c	45.8 c	15.2 c	15.0 c	1.5 bc	2.02 c	0.74 c

Means with different letters in columns present a significant difference (Tukey, 0.05); PH: plant height; SD: stem diameter; LA: leaf area; LAI: leaf area index. Source: self-elaborated.

Finally, the highest value (2.5 g) for DWR was obtained with T4. In this regard, Inzunza *et al.* (2010) report that the application of plastic mulch can cause an increase of up to 6 ºC in soil temperature, which can generate root stress, affecting its development. Besides this, it has been reported that in situations of water stress some plants reduce growth in the aerial part and increase root development in order to seek moisture at greater depth (Florido and Bao, 2014), a situation which may have occurred in this experiment, as the highest values were found in unmulched beds (T4 and T5). In this regard, Hernández *et al.* (2021) state that the application of mulches reduces the loss of water by evaporation and increases the retention of moisture in the soil.

Regarding the physiological indices, the highest NAR occurred from 30 to 60 dat with T1 manifesting significant differences of ($P \leq 0.05$) compared to T6. (Figure 3), mainly attributable to the difference of 66.6% between the values of the leaf area between T6 and T1 (Table 3), which is attributable to water stress caused by the irrigation of 31 to 40 kPa of T6, causing a reduction in the availability of water and nutrients, which was thus not available to the plant for the accumulation of dry matter (Rodríguez *et al.*, 2014), because at the beginning of the crop cycle this mainly contributes towards the formation of leaves. This may also be due to the phenological change of the crop going from a vegetative to a reproductive stage, directing the photoassimilates towards the formation of fruits, from 60 dat (Table 2). Likewise, it has been reported that temperatures higher than 33 °C cause senescence and abscission of leaves (Chaves and Gutiérrez, 2017). This reduces the leaf area of the crop, directly affecting the NAR.

In this regard, Aleman *et al.* (2018) recorded a value exceeding 2 g cm^2 d^{-1} for chiles grown in a greenhouse; whereas for their part, Quezada *et al.* (2011) reported that the NAR for chile manifests decreasing attributes, with value diminishing in line with the development stage of the crop, similar to what was found in this study except for T4, which presented an increase in NAR during the interval of 61 - 90 to 91 - 120 dat (Figure 3). This behavior may be the result of a longer vegetative stage, as the greatest number of buds and flowers in T4 appeared at 120 dat, in contrast to the rest of the treatments, which showed the highest value for the same variables at 60 dat (Table 2). In this regard, López *et al.* (2015),



Source: self-elaborated.

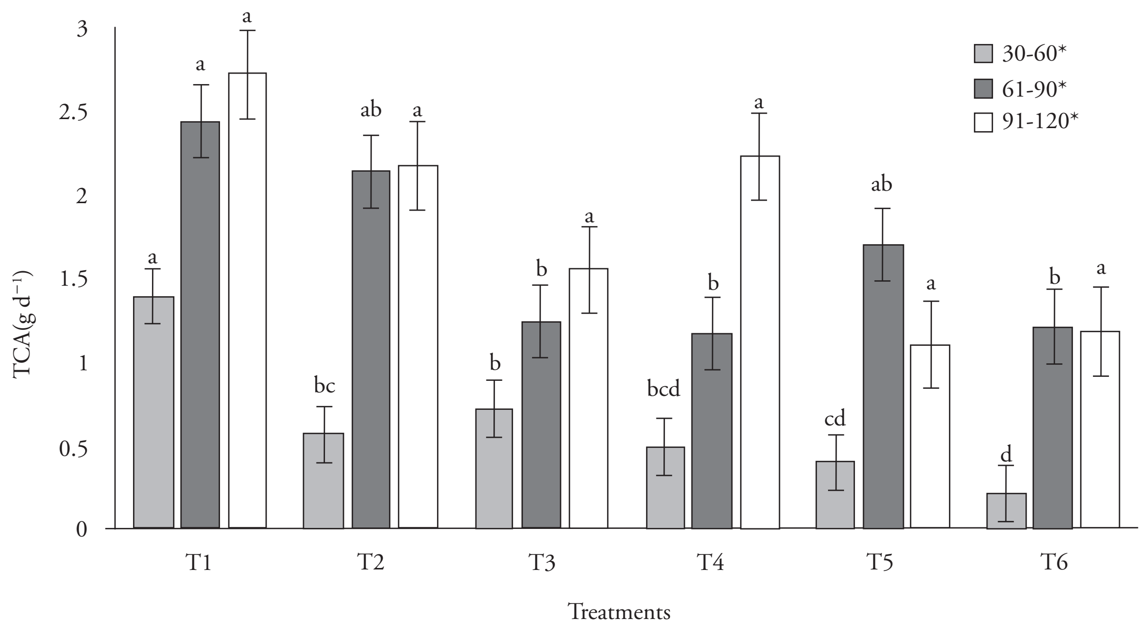
Figure *3*. Net Assimilation Rate (NAR) of Huacle chile plants. *days after transplant. Means with different letters in the same period present a significant difference (Tukey, 0.05).

report that the application of plastic mulch induces early production on the part of the Habanero chile (*Capsicum chinense* Jacq.); for their part, Moreno and Liz (2009) mention that when faced with a water deficit, plants increase the production of abscisic acid (ABA), a phytohormone that regulates flowering time and other physiological and phenological processes.

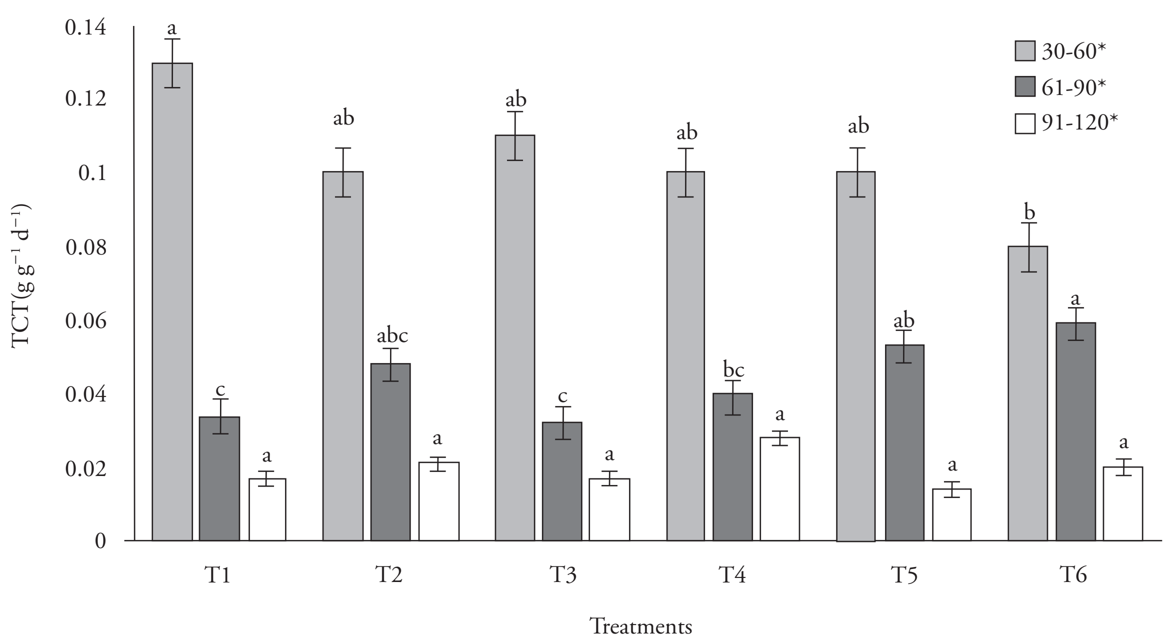
In this experiment, AGR presented inverse behavior to NAR (Figure 4), where values increased as the development of the crop advanced, mainly due to the presence of fruit and the accumulation of dry matter in these organs. T1 showed the highest value (2.72 g d^{-1}) with significant differences ($P \leq 0.05$) compared to T3, T4 and T6 during the period from 31 to 60 dat, attributable to greater availability of water and greater number of fruits per plant (Table 2).

The RGR manifested a decrease from 60 dat; the highest values occurred during the period between 30 and 60 dat (Figure 5), with significant differences ($P \leq 0.05$) between T1 and T6. From 60 dat, the value of the RGR decreased by 50%, which indicates that the accumulation of dry matter by the plants decreased, mainly attributable to the maturation of the fruit and senescence of the plant. In general, physiological indices were not influenced by the type of mulching, but instead related to the stage and age of the culture.

At 60 dat, the values for senescence variable were: T3 (30%), T2 and T6 (15%), T1 and T5 (5%) and T4 (0%); this variation may be the consequence of scarce water availability



*days after transplant. Means with different letters in the same period present a significant difference (Tukey, 0.05).
Source: self-elaborated.
Figure 4. Absolute Growth Rate (AGR) of Huacle chile plants.



Source: self-elaborated.
*days after transplanting. Means with different letters in the same period present a significant difference (Tukey, 0.05).
Figure 5. Relative Growth Rate (RGR) of Huacle chile plants

and an increase in soil temperature caused by plastic mulch. According to Quezada *et al*. (2011) if this exceeds 30 °C it generates negative damage; besides this, temperatures inside the greenhouse (Figure 2) exceeded the optimum range (22-25 °C) cited by Kaur *et al.* (2017) for the development of the *Capsicum annuum* L. crop.

The average pH of the fruits was 5.2 (Table 4), which indicates that this parameter was not influenced by either water restriction, or mulch, but rather determined by the genotype of the crop. This value was similar to the range (4.8 to 5.5) reported by Yin *et al.* (2011) for *Capsicum annuum* produced under greenhouse conditions with different types of mulch; also, at 6.4 and 5.5 obtained by Mendoza *et al*. (2015) for green and red jalapeño chiles, but lower than the range of 6.43 to 7.0 reported by Flores *et al.* (2018) for wild chiltepin chiles from Nuevo León, Mexico. The same authors and Figueroa *et al*. (2015), reported values of 5.2 to 9.8 in total soluble solids for the genus *Capsicum*, values lower than those obtained for fruit in this experiment (Table 4).

Regarding the percentage of titratable acidity, an interval from 1.47 to 2.49 was presented (Table 4), showing significant differences ($P \leq 0.05$) between the treatments without mulch, compared to treatments with mulch, as these did not present differences between them. Despite this, all the values were higher than those found by Medeiros *et a*l. (2018) and Manikharda *et al*. (2018) for eight genotypes of *C. baccatum var. pendulum* and at three stages of maturity of a *C. frutescens* genotype.

The maturity index showed significant differences ($P \leq 0.05$), with T3 standing out at a higher value of 50.7% compared to T6 (Table 4) both with the lowest level of water availability.

Significant differences of ($P \leq 0.05$) were found in the CY of dried fruit and HI (Table 5). The CY values in T4 and T5 were reduced by more than 50% compared to T1 and T2 respectively; similarly, the NCFP decreased by 33.8% (T4) and 55.5% (T5) compared to T1 and T2. This effect was attributable to plastic mulch as T1-T4 and T2-T5 were subjected to the same level of soil moisture (Table 1). Values of CY were directly affected by HI, concurring with what was reported by Quintal *et al.* (2012) and Inzunza *et al*. (2017) who mention that water stress in chile plants decreases yield by 30 to 70 %, reporting the highest yield with greater water availability and with the use of mulch in Habanero chile (*Capsicum chinense* Jacq.) and tomato (*Solanum lycop*ersicum).

Table 4. Chemical characteristics of Huacle chile fruits.

	pH	Total Soluble Solids (°Brix)	Titrable Acidity (%)	Maturity Index
T1	5.28 a	15.3 a	1.90 bc	8.18 b
T2	5.25 a	13.6 ab	1.83 bc	7.69 b
T3	5.18 a	15.3 a	1.47 c	10.41 a
T4	5.28 a	11.6 bc	1.62 cd	7.27 b
T5	5.30 a	12.3 bc	2.49 a	5.03 c
T6	5.23 a	11.3 c	2.15 b	5.28 c

Means with different letters in the column present a significant difference (Tukey, 0.05).
Source: self-elaborated.

Table 5. Commercial yield, HI and physical characteristics of dried commercial fruits of Huacle chile at 120 dat.

	CY (g $plant^{-1}$)	NCFP	HI	Fruit				
				Length (cm)	Width (cm)	Weight (g)	NSF	DWF (g)
T1	67.8 a	13.0 a	3.22 a	6.62 a	4.0 a	5.20 a	171 a	1.23 a
T2	59.8 ab	12.6 a	3.53 a	6.03 ab	3.7 ab	4.74 a	152 ab	1.27 a
T3	42.6 abc	11.5 ab	3.40 a	5.37 bcd	3.4 b	3.71 b	116 b	0.76 b
T4	30.8 bc	8.6 c	1.78 c	5.80 abc	3.3 b	3.58 b	109 b	0.57 b
T5	13.0 c	5.6 d	2.20 bc	5.01 cd	3.4 b	2.19 bc	129 ab	0.70 b
T6	24.1 c	10.5 bc	2.97 ab	4.52 d	3.3 b	2.30 c	113 b	0.72 b

Means with different letters in the column present a significant difference (Tukey, 0.05); CY: commercial yield; NCFP: number of commercial fruits per plant; HI: harvest index; NSF: number of seeds per fruit; DWF: weight of seeds per fruit.
Source: self-elaborated.

T1 presented the longest and widest fruit. Despite this, fruit size decreased approximately 50% compared to the measurements described by García *et al*. (2017), who report an average of 10 cm long and 8 cm wide. This effect for *Capsicuum*, is attributed by Rao *et al.* (2016) to water availability, which affects cell elongation and division.

The dry weight of the fruit was affected by the use of plastic mulch, the weight of the fruit obtained from T1 exceeding that of T4, both with the same water level, showing a value similar to that reported by San Juan *et al*. (2019), when evaluating the concentration of nutrient solutions for the same crop. However, the increase in water stress caused a 28.6% decrease in the accumulation of dry matter in the fruit, comparing T1 and T3 (Table 5). Likewise, the values shown in Table 5 for NSF and DWF show that these parameters are more influenced by the level of water stress than by the type of mulch, presenting significant differences ($P \leq 0.05$) for T1 and T2 compared to the rest of the treatments. In this regard, Tran and Murakami (2015) mention that exposure of the genus *Capsicum* to high temperatures affects the weight, size and number of seeds per fruit.

CONCLUSIONS

The combination of plastic mulch and greater soil moisture generated a positive effect by increasing the number of buds by 57%, flowers by 83%, fruits by 45%, the dry weight of leaves by 41.9%, the dry weight of fruit by 50.6%, the leaf area and the leaf area index by 47%, compared to the rest of the treatments. Water stress influenced the variables in terms of plant height, stem diameter, stem dry weight and fruit length, with T1 and T4 showing the highest values.

The dry weight of commercial fruit seems to be influenced by the plastic mulch because T1, T2 and T3 presented statistically higher values with respect to the treatments without mulch. Likewise, the presence of mulch in T1 and T2 promoted an increase in commercial yield, number of commercial fruits per plant and harvest index compared to T4 and T5 respectively. However, considering the same variables T3 and T6 did not manifest this behavior.

From 30 to 60 dat, all treatments presented higher values for net assimilation rate and relative growth rate (0.11 g cm^2 d^{-1} and 0.13 g g^{-1} d^{-1}), later they manifested declining behavior in terms of crop development, while absolute growth rate manifested opposite behavior, presenting the highest value (2.72 g d^{-1}) during the period from 90 to 120 dat.

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