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Sunflower culture response under different water table depths

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Abstract

The water availability in soil is an important factor that influences the plant development. Thus, this study aimed to evaluate the initial development rate of the sunflower culture (*Helianthus annuus* L.) under different levels of water table depth. In this study 200 mm diameter lysimeters were allocated in three columns, each one containing 6 different depths: 10, 20, 30, 40, 50 and 60 cm. The work was conducted in an experimental greenhouse at Universidade Estadual do Oeste do Paraná, in Cascavel's city, from April to August of 2013. The parameters evaluated were: stem diameter and plant height, dry and fresh mass of the aerial part.

Key words: *Helianthus annuus,* water stress, phyto mass.

Introduction

The sunflower (*Helianthus annuus* L.) belongs to Asteraceae family. It is an herbaceous and annual culture that can reach from 1 to 6 m height, normally with just a single head. Its leaves reach until 30 cm length. The sunflower is originated from the south western of the US and its seeds were used by Indians in their feed. It is the third most important crop in production of comestible oil. The ability to adapt in different agro-climatic conditions is the main reason that made this culture spread to all continents [6].

The sunflower is a culture with low water requirements and tolerant to water stress. In Brazilian semiarid region, the water is a limiting factor in agricultural development due to low and irregular rainfall. Hence, a promising and cost effective alternative for this region would be the use of this culture [11].

Despite of the water deficit tolerance when compared to another cultures, researches show the importance of water availability for growth and vegetative development of the sunflower [14]. Heckler [5] affirms that the production of sunflower seeds without irrigation can range from 1800 to 2200 kg·ha^{-1}, generating from 400 to 1000 kg·ha^{-1} of oil. When irrigated, its productivity can range from 2200 to 3000 kg·ha^{-1}, having an oil productivity rate from 700 to 2200 kg·ha^{-1}.

According to Prado and Leal [8], the sunflower is responsible by approximately 13% of all vegetable oil produced worldwide and is the fifth largest producer culture of comestible vegetable oil. In Brazil, the sunflower is being cultivated mainly for the biofuel production.

In the regions where water precipitation occur few times in the year, the only type of available water is present in soil and subsoil, but not every crop can extract efficiently this water. According to Bremner *et al.* [1], the sunflower can extract 92% of the available water until 2 m depth, this efficiency is increasing under water deficit conditions.

The water table (LF) serves as water supply for human activities. Thus, a better understanding around the factors connected to it is necessary, that can generate technology to enhance the sustainable use of water resources and minimize impacts on them [10].

According to Raij [9], the rooting is essential for vegetable development, because roots act as water and nutrient collection points. This way, extensive root systems are vital for cultivations without irrigation. The annual cultures concentrate around 90% of their roots in a depth of 0-20 cm, but this soil layer may represent an insufficient volume of water and nutrients, forcing the plant to search for these in deeper soil layers.

The aeration is an important aspect of the physical soil quality, because part of biological activities requires oxygen for their good development. For a satisfactory aeration, gas exchange between soil and atmosphere is necessary [16]. The soil aeration is an important limiting factor for root system development, growth and culture productivity [3].

In this light, the present work aimed to evaluate the initial response of sunflower culture under different depths of water table (PLF). The variables analysed were: stem diameter, plant height and fresh and dry mass of aerial part.

Materials and Methods

The study was conducted in an experimental greenhouse located at Universidade Estadual do Oeste do Paraná (UNIOESTE), in the city of Cascavel. The soil used in the experiment is classified as dystrofic Red Latosol, having an annual precipitation of 1640 mm and an average temperature of 19°C, with a super humid and temperate mesothermal climate [4].

To perform this study, 18 lysimeters of 200 mm diameter were arranged in 3 columns, each one simulating six different depths of water table (PLF): 10, 20, 30, 40, 50 and 60 cm. The study was conducted from April to August 2013.

Experimental: The lysimeters were filled until their upper edge with the prepared soil. To obtain a water depth at the bottom of the lysimeters, plastic recipients of 3 cm in height were introduced, containing geotextile mat to avoid soil and nutrient loss. The recipes kept constantly full with water, simulating the PLF.

The sowing was on April 16, 2013, in a 2 cm depth of soil surface. The analyses were performed on August 14, 2013, and to do this the plants were harvested close to the ground through a cut in their stems.

For stem diameter analysis, a calliper gauge was used and for plant height, a millimetre ruler was used. After these analyses, the aerial plant parts were inserted into envelopes marked and placed in a greenhouse at 60°C until constant weight. The fresh and dry mass were determined using an analytical balance.

For data analyses, the Tukey's test was used at 1 and 5% significance level to determine the statistical difference between the data collected. The software ASSISTAT 7.5 beta was used [13].

Results and Discussion

The increase in PLF influenced significantly in plant height, stem diameter, fresh and dry mass from aerial part, in quadratic form ($p < 0.01$ and $p < 0.05$, respectively).

The variable plant height showed a slight increase in plants with PLF of 20 and 30 cm, if compared with 10 cm PLF plants Fig. 1. LF levels above 40 cm showed an expressive plant growing when compared with a PLF below 30 cm. These results may occur due to O_2 deficit caused by water saturation in soil, impairing gas exchange and causing a CO_2 accumulation.

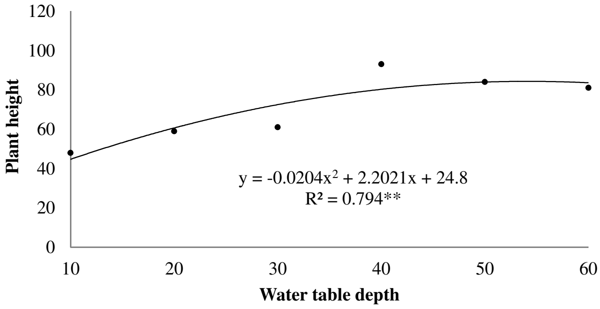

Figure 1. Plant height.
** = significant at 1% of probability and *= significant at 5% of probability.

The variable "plant height" showed a significant quadratic effect, according to PLF's increase. According to a derived mathematical equation, the sunflower culture height was of 54 cm of depth, being possible to reach a plant height of 84 cm.

According to Silva *et al.* [14] who worked with the application of different depth levels of water blades in sunflower irrigation, the culture had a better response with an application of higher levels of water depths. The plant height is negatively influenced by water deficit, which is increased when this deficit occurs in the vegetative stage [12].

Tomich *et al.* [15] reports that the variable "plant height" is a desirable and very important characteristic for the sunflower culture, because it is normally associated to a gain in grain production.

The stem diameter suffered a significant quadratic interference, according to the regression equation tested (Fig. 2). The best PLF for sunflower culture is 43 cm, in which the plant diameter can reach 0.65 cm. In the study by Silva *et al.* [12], the sunflower stem diameter had a negative influence when subjected to water stress, in which the worst results were found when the water stress occurred during the vegetative plant stage. Nezami *et al.* [7] related that one of the effects caused by water deficit in the sunflower morphology is the reduction of stem diameter, due to the slower growth of the stem radius, with a smaller participation of dry mass on the stem.

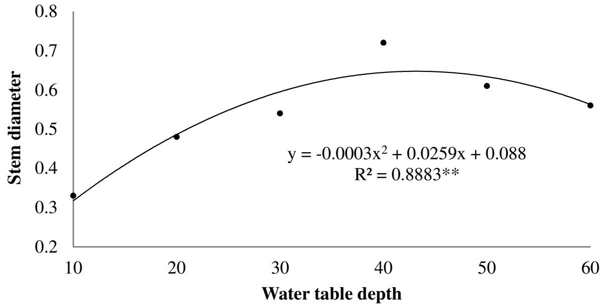

Figure 2. Stem diameter.
** = significant at 1% of probability and *= significant at 5% of probability.

Biscaro *et al.* [2] reports that the increase of the stem diameter in sunflower culture is a positive characteristic, giving more weathering condition resistance, less lodging vulnerability, management practices' increasing and cultural treatments.

The fresh mass of the aerial part, as the stem diameter, had a linear development until 40 cm of PLF, suffering a slight fall after 50 cm of PLF, being the O_2 and nutrients deficits in the shallow soils, the probably reason of the moderated development (Fig. 3). The cultures where the PLF was between 50 and 60 cm, had a decrease in their development due to difficulty in absorbing water in deeper parts of the soil.

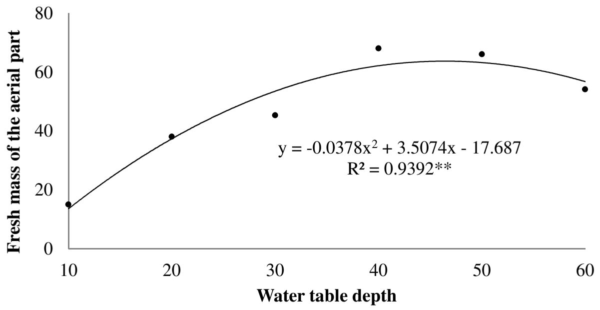

Figure 3. Fresh mass of the aerial part.
** = significant at 1% of probability and *= significant at 5% of probability.

The fresh mass of the aerial part represented a significant quadratic effect with 99% of probability. According to a derived mathematical equation, the maximum fresh mass was found at a depth of 42 cm, reaching a mass of 63 g.

The dry mass of the aerial part showed a linear development until 40 cm of PLF. The main limiting factor in plant development in shallower soil was the deficit of O_2 and nutrients, being this the main factor that contributed to the lower development of the plants. The plants with PLF between 50 and 60 cm showed a slight drop in its development when compared with plants in 40 cm depth, due to the difficulty in absorbing deeper water.

The dry mass of the aerial part (Fig. 4) showed a significant

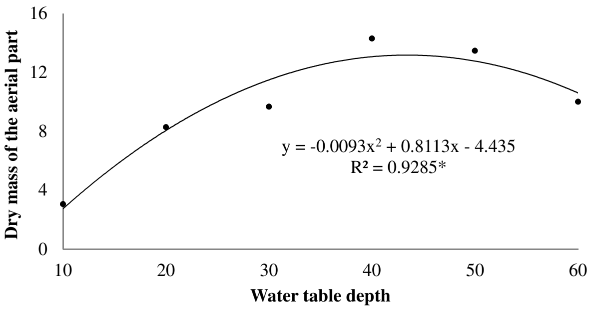

Figure 4. Dry mass of the aerial part.
** = significant at 1% of probability and *= significant at 5% of probability.

quadratic effect, with 95% of probability. According to the mathematical equation, the maximum point of dry mass in aerial part meets with a depth of 43 cm, reaching 13 g of mass.

Conclusions

The sunflower culture showed better development in a PLF above 40 cm, the deficit of O_2 and nutrients being the main limiting factors in the culture development. The plants that were in deeper soils developed axial roots that reached more profundity, providing more nutrients and oxygen to the plant. Plants localized in shallow soils developed fasciculate roots that limited their supply of oxygen and nutrients.

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