Agrisost 2018, Vol.24, No.2: pages: 110-114 ISSN 1025-0247
Available at http://revistas.reduc.edu.cu/index.php/agrisost/index

Depth, Weight, and Volume of Tomato Roots (*Solanum lycopersicon) cv. Piedro* in Greenhouse Conditions

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Received: October 14, 2017

Accepted: April 17, 2018

ABSTRACT

This research was done to determine the distribution of the root system of tomatoes as a way to perform more accurate agrotechnical conditions. It was conducted in San Pedro Pinampiro Canton, province of Imbadura, Ecuador, between July 10, 2015, and the second fortnight of January 2016. Monoliths were used to determine root distribution, considering the diameter, length, mass, and volume of roots between 0.10 and 0.40 m. The largest root volume was found in the 0-10 m deep profile.

KEY WORDS:/ *Solanum lycopersicon*, roots, greenhouse, tomato

INTRODUCCION

The distribution of crop root systems is vital for effective irrigation, drainage, nutrition, and overall tilling, which lead to stable and cost-effective yields. Under favorable conditions, the root system of plants depends on its genetic condition; however, sensitive distortions may occur in the way or shape that roots are distributed in the soil when the conditions are adverse (Kramer, 1974). The volumes of water and nutrients absorbed by the root system are influenced by the physical and chemical conditions of soils (Eavis & Payne, 1968). Besides, root development depends on the characteristics of the soil medium, as well as the events that take place in the aerial parts of plants (Henin, Gras & Monnier, 1972). Normal growth and development of the root system of crops are considerably influenced by the proximity of static groundwater table toward the soil surface, the presence of compaction stratums, and the existence of toxicity (Gosnell, 1971 & Kong, 1968).

Tilling (fertilization, irrigation, herbicide use, etc.) also has a marked influence on crop root distribution (Montero & Antón, 1993). In Cuba, protected crop systems are an example of technology transference; these systems are designed to create an umbrella effect to offer protection to plants from excess of sun radiation and heavy rainfall (Casanova & Gómez, 1997).

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According to authors who published their criteria in relation to depth of *Lycopersicon esculentum* root systems in the Caribbean, South America, and Europe, root depths are varied. For instance, during flowering and fruit formation they go 0.45-0.55 cm deep (Pacheco, Alonso, Pujol & Camejo, 2006). In Canton Pimampiro (Imbambura province, Ecuador), known as the land of tomatoes, greenhouse and protected crop houses are used today to cultivate different varieties of tomatoes. The overall yields achieved, however, do not correspond to the productive potential of the crop. One of the reasons for this result is the influence of faulty application of irrigation-fertilization procedures due to the absence of actual determination of the root system in the soil.

Therefore, the aim of this paper was to determine the weight and volume distribution of the root system of tomato by profiles, to favor greater precision of the main agrotechnical applications, namely, irrigation and fertilization.

MATERIALS AND METHODS

The climatic variables of precipitation and temperature are shown in Tables 5 and 6, respectively. The root system of *Solanum Lycopersicon*, *Piedro* hybrid, with a determined growth habit, was analyzed under greenhouse conditions, with localized irrigation, drip irrigation, and planting distance (0.16 m x 0.32 m). Plantation took place on July 10, 2015 and harvest was performed on January 26, 2016, at an age of 189 days, 2.10 cm high. The experiment was made in Cantón Pimampiro, Imbaura province, Ecuador, 0°23′28’’ north latitude, and 77°56′26″ west longitude, and 2 090 m above sea level. The crop was planted on bare soil with added organic matter (Soil Institute, 1975), whose chemical composition was characterized according to ISO/IEC 17025:2015.

The root study method used was the monolith, which was modified regarding size, by Franco & Inforzato (1946), and depth, by Krautman (1959). Three plants were selected linearly, 0.48 m long and 0.32 m wide, with 0.1536 m^2 total vital space. The method included digging holes every 0.10 m, up to 0.40 m deep. The substrate and root samples were collected by 0.10 m profiles, in plastic bags, and labeled accordingly. The roots were washed, air dried, and weighed in a precision analytical balance (0.0001g) for further average calculation. The amounts present were determined, using an ocular micrometer (length and diameter by profiles); the water volume moved by the roots was calculated in a graduated flask.

RESULTS AND DISCUSSION

The results of dry root distribution by monolith (summarized per soil horizon) are shown in Table 1

Table 1. Depth, weight, and percentage of roots in the soil profile

Depth (m)	Weight (g)	%
0–0.10	128.0	61.83
0.11–0.27	79.0	38.17
>0.27-0.40	No roots were found	

Agrisost 2018, Vol.24, No.2: pages: 110-114 ISSN 1025-0247
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Table 1 shows the root weight values; the deeper the roots were in the soil, the lower the value observed. The absence of roots in the 0.27-0.40 m profile was significant; most roots were observed in the 0.10 m profile (61.83%).

The depth values achieved did not coincide with the values reported by Fuentes (2003), which may have been influenced by different research under various edaphic conditions, varieties, cycles, and agrotechniques.

The pivoting root is conical (8 mm diameter in the upper side and 3 mm in the lower area), and it is surrounded by a large amount of smaller roots of various diameters and lengths.

The abundance of roots in the top soil layer and their quick reduction as they go deeper (0.27-0.40 m) may be attributed, among other factors, to difficulties in the penetration of roots in the soil, due to unfavorable conditions, like apparent density, porosity limitations, restrictions, inner drainage, and possible oxygen restriction issues.

Table 2. Diameter, length, and number of roots in the profile

Depth	Diameter	Length	Amount
m	m	M	One
0-0.10	<0.001–0.001	0.006–0.013	137
	>0.001-0.003	0.007-0.008	45
	>0.003-0.005	0.013-0.015	19
			Total…… 201
>0.10-0.27	>0.001–0.002	0.001-0.008	337
	>0.002–0.003	0.008–0.010	103
	>0.003–0.006	0.010-0.014	37
	>0.006	11-15	22
			Total…. 489
>0.27	00	00	

Table 2 shows characterization of diameter, length, and number of roots in the profile. The 0.10 m profile had the thinnest roots. The total amounts by profiles were higher in the corresponding largest profile (0.10 m-0.27 m). No roots were observed in the +0.20-0.40 m profile. The water volume moved by the roots in the soil profile is shown in Table 3. The 0-0.10 m soil profile, with thinner roots and lower numbers, were heavier.

Table 3. Root distribution and percentage in the soil profile

Depth m	Volume cm^3	Per cent (%)
0–0.10	56.6	56.6
0.11–0.27	43.4	43.4
>0.27–0.40	0.0	
	Σ 100	

According to J. Pineda (personal communication, February 7, 2015), knowing the total depth of the root system at harvesting allows to determine the value of the active layer's depth over time, according to the equation below,

$$Dp=1.8\left(\frac{t}{tc}\right)\left(1.5-\frac{t}{tc}\right)p$$

Dp=Depth of the root system (m)

t=Time desired to know the depth of the root system (days)

tc=Duration of the crop cycle (days)

p=Total depth of roots (m)

This information facilitates a more accurate irrigation and drainage, since the depth of the root system can be determined over time or at a given crop's stage.

CONCLUSIONS

Solanum Lycopersicon, *Piedro hybrid* only showed a root system in the 0-0.27 m profile in protected crop conditions.

The 0-0.10 m substrate profile showed fewer, thinner roots when compared to the 0.11-0.27 m profile, though they were heavier, which was evidenced by moving a greater water volume.

RECOMMENDATIONS

To further the study the root system of *Solanum Lycopersicon* in its various stages, which will allow for more accurate agrotechnical actions with the ensued economic benefits.

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APPENDIXES

Table 4. Precipitations

Months	J	F	M	Ap	My	Jn	Jl	Ag	S	O	N	D
Precipitations (mm)	17.2	41.7	38.2	131.9	99.2	29.4	48.0	31.8	72.2	49.5	116.4	82.9

Legend

J: January..................F: February M: March Ap: April

My: May Jn: June Jl: July Ag: August

S: September O: October N: November D: December

Table 5. Outdoor air temperature-Celsius degrees

Months	J	F	M	Ap	My	Jn	Jl	Ag	S	O	N	D
Temperature in Celsius degrees	16.9	17.0	17.1	17.1	17.1	16.8	16.8	16.7	17.1	17.3	16.9	17.0