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# The grapevine root growth under the tropical condition (10º 01’ N) of Tarabana, Lara State, Venezuela

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## Abstract

To evaluate grapevine root growth, under tropical conditions during the season, is important to properly schedule different vineyard labors. With the objective of quantifying the development of new rootlets, soil samples were periodically collected around plants of the rootstock "Criolla Negra" in *Tarabana* (10º01’N, 510 m above sea level), Lara State, Venezuela. Samplings were performed at 15 cm intervals from surface to 75 cm deep in alleys and vine rows. The experiment was arranged in a factorial set of treatments with five depths and two sites per sampling. The highest root length density was found at the beginning of the season, previous to flowering, bearing a decreasing growth pattern with the lowest values during the rest of the period, following the harvest. However, two months after the high initial activity, there was a slight flush of new growth. This suggests that grapevine root that growth in the tropics has a different pattern as compared to that in temperate regions. Root length density decreased with depth but no differences were found between site samplings. No effect was detected on specific root length indicating that there was no define pattern on spatial distribution of roots with different thickness.
**Key words:** *Vitis* sp., grape, roots, seasonal growth

## Introduction

Studies about quantification of roots, about their interaction with soil, are less than those that refer to the aerial part of the plant and its interaction with the atmosphere. It is evident that this is due to the time and effort that represents the sample or the observation towards this subterrain organ, located, normally, out of the reach and sight of the researcher.

In some places, the temperate climate in both hemispheres, such as, Australia, Bulgaria and Southafrica,

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it is been determined that the growth of vineroots begin after vineshoots and the aerial parts of the plant begin to grow at the beginning of spring, and it shows at the end of the cycle of the plant one or two aditional ups of growth (8, 13, 24).

These studies have been carried out under different conditions, for example, in labs of roots (8), plants into pots (5), lisimeters (23), chambers with transparent walls (17) and in furrows (25). Likewise, factors that effect this activity of growth (7) have been checked. However, in tropic conditions, studies have evaluated the distribution of vineroots in some moment of their phenological cycle (1, 3, 18) but in available bibliography, there are no researches that quantity the growth of roots during the complete cycle of development of plant.

Determination of growth invloves the measure of those with a small diameter, it means, the rootlets. They constitute just a little fraction of the total root mass, thus, the best parameter that represents this process of growth is the length of rootlets more than their mass (4). In this sense, Marsh (16) simplified the method of lines interception on a plan that allow estimating the length of roots accurately. Similarly, nowadays, there are special equipments to quantify roots through image digitalization (2), even, recently, techniques have been applied to study formation ans growth of vineroots in fuction to their capacity to obtain oxygen in the apical meristems (15).

In previous researches in Venezuelan vineyards, Pire (19) obtained cuantitative results of the distribution of the roots system in a stateg of the development of the rootstock "Criolla Negra", a native hybrid used as cleft graft in the country. However, the exact variation of growth of plant's roots is not known yet. This information may lead to the elaboration of more efficient management programs for vineyards, particularly to mechanize soil, location of providers of irrigation system and choose representative places for samples, among others.

The objective of this research, was to determine growth of the roots of the rootstck "Criolla Negra" in different distances and depths of soil during different stages of its cycle of development.

## Materials and methods

The study was carried out on lands that own the Institute of Grape (Instituto de la Uva) that belongs to the Western University Lisandro Alvarado (Universidad Centrocidental Lisandro Alvarado), in *TarabanaI* (10º01'N, 510 msnm), *Lara* State, Venezuela. The zone is characterized by a semiarid climate with evaporation of 2085 mm, precipitation of 812 mm and an average annual temperature of 25,3ºC (19,8 y 30,8ºC Min-Max). It has a loamy-clay-sandy soil with a great permeability and with an intermediate natural fertility (table 1).

The vegetal material consist of 40 plants of about 15 years old from the rootstock "Criolla Negra" trained with a distance of 3x3 m. Since many factors may affect the growth of the vine roots (21), all the plants received similar cultural procedures in regard to irrigation, fertilization and fitosanitary controls, and they were selected from a set that had a homogeneous vegetative development.

Irrigation was applied every week through furrows located next to the plantation row. When precipitation values exceeded 30 mm, irrigation was not performed. Fertilization was done through applying on soil 1 kg of a complete formula 12-12-17/2 (N- $P_2O_5$-$K_2O$/Mg) at the beginning of the cycle. The weed control of the vine was performed using a rotary mower. The rest of the cultural activities, as chemic plague control and sicknesses, was carried out only when was strictly necessary.

Among all the selected plants, samples were extracted from depths of 0-15, 15-30, 30-45, 45-60 and 60-75 cm, knowing that previous observations indicated that the biggest part of the vine roots system in these soils were at depths under 80 cm. Every sampling was performed at the end of an irrigation cycle at 60 cm of distance from the axis of the trunk in two directions: one to the neighbor row the other one to the adjacent plant inside the same row (south and east side of the plant). These samplings were done every three or four weeks after the total coming up of the plant until recollection of fruits. An additional sampling was carried out during the resting period, two months after harvest, to complete a total of eight evaluations in the cycle. In every case there were used five replications, using a plant as experimental unit. Before the beginning of samplings and during the development cycle of plants, soil was kept weed free manually, to avoid interferences with results.

The used procedure to obtain and quantify roots consisted of the following stages: 1) samples; 2) samples washing and roots drying and 3) determining the length of rootlets. After dividing this length and the volume of recollected soil, the roots length density was obtained.

1) Samples: Samples of soil were obtained using a cylindric blasthole to obtain portions of soil to reach roots.

2) Samples washing and roots drying: Each sample was put in water and stirred to obtain an adequate suspension of soil. Separation of roots was performed successively with a sieve of 248 holes $cm^{-2}$ (0.35 mm each hole). The recollected rootlets, after being chosen and separated manually away from bigger roots, were dried in a stove at 75ºC and weighted.

3) Determining the length of rootlets: after getting rid of organic residues and other strange particles, rootlets were put on a flat surface and its image was digitalized using the program SkyeRoot from computerized equipment Skye Instruments PAL-CCIR that allows the quantification of the total length, through adding all the segments of the root in the sample. Precision and calibration of the equipment was controlled by

countings following the method of Marsh (16) in twenty samples of rootlets selected at random.

Additionally, the specific length of roots was determined (this means, the length of a specific segment of the root per unit of mass) which was obtained after dividing the evaluated length of the root and its dry mass (6).

The trial was analyzed as a design completely at random with a factorial arrangement of five treatments of depth and two cardinal orientations to each sample. Analysis of variance was used and separation of means according to Duncan's test through statistical program CoStat 6.003.

## Results and discussion

The biggest activity of roots growth was detected at the beginning of the cycle of the plant, previous days to blooming in February. This caused a pattern of growth of new roots that was diminishing slowly until it reached the lowest values of the resting period, subsequent to fruits harvest. This diminishing tendency, changed literally at the end of April, when a slight growth was observed (figure 1).

The fact that in this study the biggest growth in roots was found at the beginning of the cycle, contrast to results obtained in studies carried out under temperate climate conditions, where the roots growth happened after sprouting began (21). Freeman and Smart (8) mentioned that the fast vine root growth in Griffith, Australia, began ten weeks after sprouting and reached the maximum point in the middle of the plant cycle. Likewise, Lilov and Andanova (13), in hormonal studies of the new vine roots in Sophia, Bulgaria, found similar results, eventhough, they pointed out that formation of roots began 3 weeks after the beginning in relation to buds sprouting day.

The delay in growth of new roots on template zones might be due to the low temperatures of soil that persist at the beginning of spring (18). It also exist evidence that may happen a cyclic growth of roots in perennial plants, as a consequence of soils temperatures, at least in part (14). However, according to the climatic register of the zone where the trial was developed, temperature of soil, at 1 m deep, was over 24ºC during the whole year (with an average slightly superior to 30ºC in the first 30 cm in the morning), appropriate conditions for roots growth of most of cultivated plants (9). More specifically, Richards (21) mentioned that the optimal temperature for vine root growth was close to 30ºC, which contribute to explain why beginning of root growth happened faster in tropical conditions than in template zones.

Independently to the cause that originated the differences between moments of roots growth, it can be inferred that in template zones the vine depends on old and roots to receive water, nutrients and maybe hormones, whereas in the tropic, additional help from the new roots are evidenced. It is unknown if this might have any implication in metabolic aspects during initial development of the plant, however, there are no doubts that in the tropic and in template zones, when climatic conditions are appropriate, blooming processes that follow sprouting, happen normally.

Behavior of vine roots under our conditions could be comparable to other fruit trees of template zones. Such as, apple trees (*Malus domestica*) and peach (*Prunus persica*) which coincided with buds sprouting of plants (21).

As mentioned before, a slight sprout or increase of growth was evidenced at the end of April (figure 1), coinciding, approx., with the moment when fruit growth slowed down before the beginning of maturation; when the demand of photoassimilated by the aerial part of the plant might be decreased, leaving more nourishing products for the root. Nevertheless, the same interpretation could not be applied for the roots growth at the beginning o the cycle, because at that moment, this growth would have been produced under disadvantageous conditions, since it existed a strong competition for photoassimilated between the roots and the upper part of the plant, where a fast vegetative mass growth was being observed.

During the resting period of the plant after the harvest, no noticeable increasing on the root growth valuation was perceived (figure 1). Apparently, stimulus to begin growth was produced after the beginning of the next cycle. As known, under tropical conditions, the new cycle begins after the pruning and the irrigation process to the plant (20), contrary to template zones where buds sprouting occur spontaneously during spring.

Lateral roots growth provides an

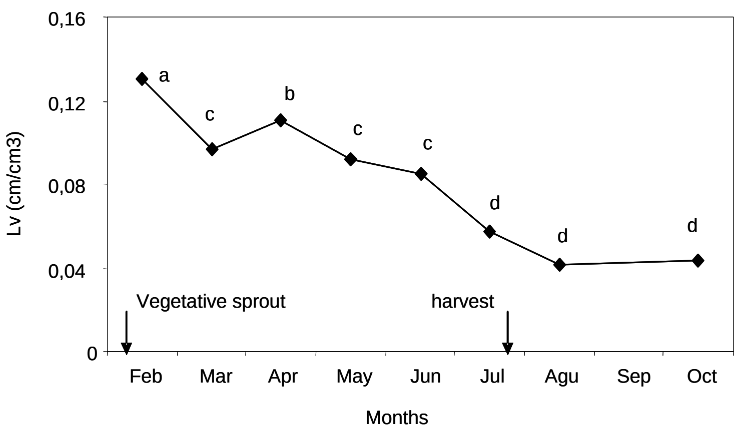


**Figure 1. Length of roots (L) into profile 0-75 cm during the growth cycle of rootstock "Criolla Negra" in Tarabana, Lara State, Vanezuela. Points with different fonts are statistically different between them, ccording to Duncan's Test (P≤0,05).**

important means to increase the possibility of absorption of water and nutrients. Likewise, roots may increment their effectiveness as a source of hormone, specially cytokines and gibberellins that regulate processes of growth of the aerial part of the plant (10, 11).

Independently from depth and sample time, diameter of most of rootlets oscillated between 0.1 and 1.5 mm, predominating the value 0.2-0.6 mm. Richards (21) found that in these vines, thin roots are abundant and pointed out that a plant of the cv. "*Shiraz*" with 15 years old may have close to 10.000 rootlets smaller than 1 mm of diameter. This abundance of thin roots let a better exploration of volume of soil, but its length is smaller than length of thicker roots, for this reason they should be replaced continuously, demanding a more important consume of energy of the plant (6).

In concordance with the previously said, this study determined a noticeable increasing in the number of rootlets during the growth cycle of the plant, which suggests that a great quantity of them dye in a short period of time, excepting those that reach a secondary growth and subsequently will be part of the permanent structure of roots.

Fitter (6) indicated that presenting abundant thin roots, is a characteristic of plants that do not have the tendency to associate themselves in a symbiotic way with mycorrhizas, which have favored capacity of the plant to absorb nutrients of soil.

The trial allowed the observation of a well-defined pattern of roots' density in relation to depth into the profile of soil (figure 2). The highest density of rots occurred in the superior stratum of soil (0-15 cm), observing a progressive increasing deeper into the profile. For each stratum significant differences were showed, but for the corresponding at 30-45 and 45-60 cm of depth. The presence of a certain number of roots (more than 10% of the total) at the deepest point of soil indicated that they could descend more than 75 cm into the profile. However, small quantities in soils and the decreasing marked pattern related to depth, suggest that density of roots should be really small at higher depths.

Important texture changes were not observed in the profile or physical barriers, such as, compact layers or sand lenses that could limit the descendant growth of roots. However, Richards (21) pointed out that in soils of different origin and structure, the biggest part of vine roots were placed in the first meter of the profile, even though, some isolated roots could descend even several meters down. On their behalf, Stevens and Douglas (22), working with vine "Colombard", found that independently from the used type of irrigation, length of roots was highly related to soil depth.

Specific length of roots did not showed significant differences between diverse depths (table 2). Since by definition thin roots have a bigger specific length than the thick ones, this result indicated that there was not a definite pattern of thickness

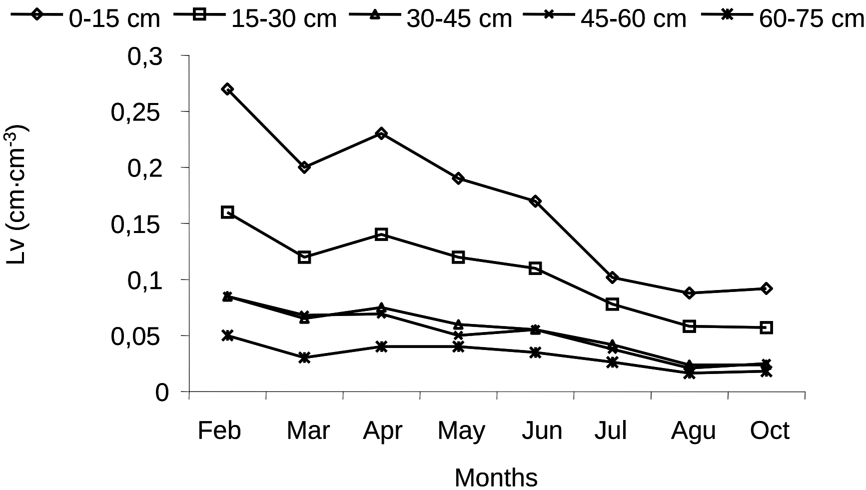


**Figure 2. Length of roots (L) in stratums of 15 cm in the rpfile during the growth cycle of rootstock "Criolla Negra" in Tarabana, Lara State, Venezuela. Different fonts at the beginning of each curve indicate statistical differences between stratums according to Duncan's Test (P≤0,05).**

**Table 1. Texture and fertility characteristics of the profile soil until 75 cm depth in the Grape Institute (Instituto de la Uva), *Tarabana,* Lara State, Venezuela.**

| | Depth (cm) | | |
|---|---|---|---|
| | 0-25 | 25-50 | 50-75 |
| Sand (%) | 51 | 48 | 47 |
| Slime (%) | 27 | 29 | 28 |
| Clay (%) | 22 | 23 | 25 |
| MO ($mg \cdot g^{-1}$) | 22,8 | 17,6 | 14,3 |
| P ($mg \cdot kg^{-1}$) | 12 | 18 | 15 |
| K ($mg \cdot kg^{-1}$) | 190 | 100 | 100 |
| Ca ($mg \cdot kg^{-1}$) | 4850 | 4800 | 4950 |
| Mg ($mg \cdot kg^{-1}$) | 155 | 150 | 115 |
| pH | 8,1 | 8,1 | 7,9 |
| CE ($dS \cdot m^{-1}$) | 1,4 | 1,7 | 1,9 |

MO: Organic Material
CE: Electrical Conductivity
Source: Soil Lab. Agronomy Deanery. Western University "Lisandro Alvarado" (Laboratorio de Suelos. Decanato de Agronomía. Universidad Centroccidental "Lisandro Alvarado")

**Table 2. Specific length (SL) and length (L)of rootstock "Criolla Negra" in trabana, Lara State, Venezuela, into different depths an orientations in soil profile. Avergae values of the growth cycle.**

| Depth (cm) | SL ($cm \cdot g^{-1}$) | L($cm \cdot cm^{-3}$) | |
|---|---|---|---|
| | | Row | Alley |
| 0-15 | 1424[a] | 0.162[Aa] | 0.174[Aa] |
| 15-30 | 1259[a] | 0.111[Ab] | 0.099[Ab] |
| 30-45 | 1310[a] | 0.057[Ac] | 0.051[Ac] |
| 45-60 | 1456[a] | 0.056[Ac] | 0.046[Ac] |
| 60-75 | 1365[a] | 0.029[Ad] | 0.035[Ad] |
| V.C. | 14.9 | 24.1 | 24.7 |

Capital and small letters to compare between columns and rows, respectively, according to Duncan's Test (P≤0,05). Values transformed through Log function (x).
V.C. Variation Coeficcient (%).

distribution of roots in relation to depth or location into the profile. This means that in every corner of the sample were roots of different diameter and there was a definite tendency in special distribution of different sizes rootlets.

There were no differences detected in roots length from the plantation row or alleys between rows (table 2), which indicated a uniform development of roots in both directions, at least until 60 cm from the trunk of the plant (the biggest distance of sample). Liedgens and Richner (12) detected that depth of soil affected in a stronger way length of corn roots than the distance of row. Similarly, in a previous study (19), there were no differences in the lateral distribution of the vine roots system until a distance of 135 cm of the plant, which was attributed to the lateral growth of roots, differently from growth into depth, conditions of the terrain do not affect it frequently.

## Conclusions

Vine roots presented a higher activity of growth at the beginning of the cycle of the plant development, which contrast with the pattern of growth that occurs in template latitudes. This activity decreased with the time, until it reached the minimal value during the resting time, even though approx. two months after the initial high activity, there was an up in growth. Length of roots diminished with depth but showed a uniform lateral development, whereas thickness was not determined by depth into the soil profile.

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