

Some Root Characteristics of Avocado (*Persea americana* Mill.) Seedlings of the West Indian and Guatemalan Races

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Summary

Using avocado seedlings, a range of characters (length, diameter, number, and fresh and dry weights) of the main and lateral roots of the first, second, and third order was evaluated. The seedlings originated from five individual trees of the West Indian and Guatemalan races. Some characters (number of shoots, leaves, twig length and diameter, and fresh and dry weights) of the above ground part were also evaluated. A large variation was found in each of the characters. The differences were present among the populations originated from the various trees as well as among races, the West Indian race giving higher values for all the characters studied. A range of correlations was found among the characters studied.

Resumen

Al nivel de plántulas se ha evaluado un rango de caracteres de la raíz principal y de las laterales del primer, segundo, y tercer orden (longitud, grosor, número, peso fresco y seco) de cinco árboles progenitores de la raza Antillana y Guatemalteca. Las variables incluyeron también la parte superior (número de tallos y hojas, longitud y grosor del tallo, peso y fresco de hojas). Se presentó una amplia variación en todos los caracteres estudiados. Se encontraron diferencias entre las poblaciones de plántulas originarias de diferentes árboles dentro de ambas razas como entre las razas, siendo mayores los valores de la raza Antillana. Se encontraron varias correlaciones entre las variables.

Introduction

Variation among root distribution has been observed many times under field conditions (13, 5).

A large variation was found among seedlings' nutritional status related to the variation of root characters (11, 15, 12a-b, 9) as well as in root size and susceptibility to aquatic stress (10). Variability in the root characteristics of the Mexican race (*P. americana* var *drymifolia*), as well as of chinini (*P. schiedeana* Nees.), in seedlings of various origin has been reported earlier (2). The aim of this paper is to report the variability found in the roots as well as in some above ground characteristics of seedlings of West Indian

and Guatemalan races and the differences among the five populations of plants from five different trees.

Materials and Methods

This research was carried out with the West Indian race in the period of July 1980 to March 1981, and with the Guatemalan race between July 1982 and March 1983. The seeds of the West Indian race were collected from five separate trees in Zempoala, Veracruz. Seeds of the Guatemalan race were got from four trees in Larrainzar and one tree in Teopisaca, Chiapas. From each tree, 32 seeds were collected. Seeds from free pollination were used. In order to germinate, the seeds were freed from the seed coat and planted in a specially designed box in order to facilitate the plants' transplantation, later on, in plastic tube (15 cm x 40 cm). The substrate was a mixture of organic and mineral soil (1:1). The plants were grown in glasshouse all the time, and were irrigated with distilled water in order to prevent salt injury.

The roots were separated from the substrate by saturating the soil mixture with water and, later on, washing out the soil particles. Length, diameter, and fresh as well as dry weights were determined with a scale, vernier, or balance of adequate sensitivity. The dry weight was determined after drying the samples at 70°C for 48 hours. Physically, it was not feasible to estimate the length of laterals of second and third order, and only the fresh and dry weights were taken. The fresh and dry weights of cotyledons were taken at the end of the experiments.

Results

The range values found for each character of the seedlings' roots are listed in Table 1. The variation found in roots' morphological characters in a sample from 180 plants for each race can be appreciated. The gap between the minimum and maximum values is very wide in both races. Other interesting features are the high values of fresh and dry weights of roots of higher order. This is due to very high numbers of rootlets of second and third order. These roots were very short; and for this reason, in this work, their length and number were not estimated. Almost half of the lateral roots were located in the basal third part of the entire root system.

In Table 2, differences among populations of plants coming from different trees can be seen. It was found that the length of the main root of the plants from five trees was similar. Similarly, no significant difference was found in dry weight of the main root among plant populations of the

Guatemalan race and length of the first order lateral roots of the West Indian race as well as dry weight of the Guatemalan race. In all the remaining cases, significant differences were found among the plant populations of both races.

In general, significant differences were present in all plant characters between the West

Indian and Guatemalan races, the first one giving higher values (Table 3). Similar differences were found between both races in the size components of the above ground part (Table 4). Several significant correlations were found between the roots' characters (Table 5), as well as between root and shoot characters (Table 6).

Discussion

The size of the root systems of avocado trees has not been determined yet, although few reports are available on the spread of avocado roots. The genetic factors of both the rootstock and the scion seem to be involved in avocado root spread and some root size components. These, as well as other aspects of avocado roots, are discussed in the review by Borys(5).

There is one report published (1) on the avocado seedling root system of the Mexican race (*P. americana* Mill.) and of the chinini (*P. schiedeana* Nees.) and one report on the West Indian race (2). Some other data can be found in the paper by Mácias, *et al.*, (10). A wide range of root sizes in eight-months old seedlings was reported in those papers. Those results, as well as the results presently given, seem to justify the opinion of Jones, *et al.*, (8) on the possible relation between the variation in productivity among the avocado trees and rootstock characteristics. This opinion was supported by the studies of Gillespie (6). Our results seem to suggest that, in part, this variation can result from size variation of roots as well as roots' morphological components (root length - main and lateral roots, diameter, and number). The depth of rooting and the number of roots are some of the components determining the yielding in some other fruits (4). Avocado seems to be susceptible to shallow soil. It has been found that the productivity of cvs, Fuerte and Hass, grafted to the Mexican race, is related to the depth of available soil (16).

The West Indian rootstocks are recommended by Solares (14) for very deep soils, the Guatemalan for intermediate ones, and the Mexican for soils of lower depth. These recommendations have no experimental evidence. On the other hand, it is known from the data from Israel that avocados on the West Indian rootstocks are giving higher yields than those on Mexican race (3). Among the root's size components, the water content can be an important factor in the productivity of the avocado tree. The water content judged from the difference between fresh and dry weight of roots and above ground parts, and diameter differences, indicate that the water capacitancy of those parts is higher in the West Indian stocks than in the Guatemalan ones. Similar differences were present in the West Indian and the Mexican races, in favor of the first one, in the experimental work of Maclas, *et al.*,(10). This, perhaps, as well as better rooting characteristics of the West Indian race, will in part explain the better performance of avocado plantations established on this stock, than the Mexican one, under the conditions of Israel. The higher root capacitance, at least, probably will buffer the effects of periodic water stress of avocados established on West Indian stock.

The roots were grown in plastic tubes of 40 cm of height. It seems that this was perhaps one of the factors giving restricted size of the main root and larger dimensions of lateral

roots of the first and higher orders. In the future, longer tubes should be used in order to eliminate the obstacle for main root growth. It seems that the growth of lateral roots was not restricted, although the main root mass was concentrated near the tube walls.

The presence of a negative correlation between the total length of lateral roots of the first order and their diameter as well as between their number and the diameter of first order lateral roots, seems interesting (Table 5.) These data point out the thicker roots result in shorter ones and with lower branching capacity.

A positive correlation between the seeds and seedlings' height and diameter for the Mexican race and chinini has been found (7). The correlation values between the residual cotyledon size and lateral roots were negative with the exception of lateral roots' dry and fresh weight which gave positive, very high correlation (Table 6). At present, this discrepancy between the residual cotyledons' fresh and dry weight relations with the roots' characters cannot be explained.

The West Indian seedlings, in all the characters studied, appeared to be superior to the Guatemalan race. Wide variation between races and among the progenies of Mexican and West Indian races were also found in the root volume as well as fresh and dry weight of the whole root, the West Indian race giving higher values (10). The differences in the root size of both races in that study showed a tendency to be lower with the rise of water deficit in the soil (10). The same tendency showed the root water content. The plant populations did not present differences in the size of main roots, but they were present in other root characteristics. The West Indian and Guatemalan parent trees from which the seeds for the present studies were collected were grown in farmyard orchards. This, possibly, was a factor limiting the main root variability. Differences among plant populations were very high in the case of the Mexican race (*P. americana* Mill.) and of chinini in all the characters evaluated (2). The seeds for this study were collected from wild places where the pre-selection surely did not take place.

The data of this study, as well as of the former reports, present a very wide variation in root size and its components, use of water, as well as in the capacity to absorb and translocate nutrients to the above ground parts (1, 2,10,11, 12, 15). These variations are giving genotypes of stocks adapting the cultivars to various soil conditions. The only way to assure that material will be useful is to propagate the selected material vegetatively.

There are several reasons justifying the studies of the root size components in avocado. The lack of information is one of them. The basic one is to define the relation between the size of rootstock and/or of its components and the scion productivity. This will be the next step in our research,

Literature Cited

Barrera Guerra, J. L., M. W. Borys, Martínez Méndez H. Root systems of *Persea americana* Mill. and *Persea schiedeana* Nees. 21st International Horticultural Congress, Hamburg, FRG, abstracts. 1981.

Barrera Guerra, J. L., M. W. Borys, Martínez Méndez H. Desarrollo radical en plantas jóvenes de aguacate *Persea americana* Mill. de la raza Antillana. XXIX Congreso Anual

de Sociedad Americana Ciencias Hortícolas Regiao Tropical, Campinas, SP, Brazil. Resúmenes No. 4. 1982.

Ben-Ya'acov, A. Avocado rootstock-scion relationships: a long-term, large-scale field research project. II. Data collected from fruit-bearing orchards. Calif. Avocado Soc. Ybk. 56: 130-134. 1973.

Borys, M. W. Fisiología de la raíz. Manuscrito de apuntes del curso. Colegio de Postgraduados, Chapingo, México. 1981.

Borys, M. W. Raíces y patrones de aguacate (in preparation).

Gillespie, H. L. Asexual reproduction of rootstock from heavy producing Fuerte avocado trees. Calif. Avocado Soc. Ybk. 37: 97-101. 1952.

Hernandez-Montoya, M. Compatibilidad y vigor en injertos entre razas de aguacate (*P. americana*) y chinini (*P. schiedeana*). M. C. tesis, Colegio de Postgraduados, Chapingo, México. 1980.

Jones, W. W., T. W. Embleton, C. B. Cree. Number of replications and plot sizes required for reliable evaluation of nutritional studies and yield relationships with citrus and avocado. Proc. Amer. Soc. Hortic. Sci. 69: 208-216, 1957.

Lopez, Jiménez A., M. W. Borys, J. L. Barrera Guerra. Respuesta de plantas jóvenes de aguacate (*Persea americana* Mill.) en suelos calcáreos. IX Congreso Nal Fitogenética, Somefí, Buenavista, Saltillo. Resúmenes, 105. 1982.

Macías G-, J. L., M. W. Borys, A. Muñoz O., A. García V. Respuesta de plantas de aguacate, *Persea americana* Mill. a tres regímenes de humedad. I, II, III, IV, III Congreso Nacional de Fruticultura, Guadalajara, Jalisco. Resúmenes No. 50, 51, 150, 86, respectively, 1981.

Macías González, J. L., M. W. Borys. Toxicidad de cloro en plantillas de *Persea americana* var *drymifolia* y *P. schiedeana*. Fitotecnia 4 (5): 139-146. 1983.

Mendoza Mondragón C., M. W. Borys, S. Alcalde B., A Muñoz Orozco, J. L. Barrera-Guerra. Respuesta de plántulas de aguacate (*Persea americana* Mill.) a diferentes niveles de zinc en soluciones nutritivas; I. Diferencias entre poblaciones; II. Diferencias genotípicas entre plantas. IX Congreso Nacional Fitogenética, Somefi, Buenavista, Saltillo; p. 106. 1982.

Sandoval Heredia, J., M. W. Borys. Distribución del sistema radical de aguacate (*Persea americana* Mili.) en el suelo volcánico del Paricutín. XVI Congreso Nacional de la Ciencia del Suelo, Soc. Mex., Oaxaca. Resúmenes p. 60. 1983.

Solares M. Cultivo moderno y rentable del aguacate. Editores Mexicanos Unidos, S. A., México. 1976.

Solares Morales R. F. de J., Herrera Guadarrama A., Salazar García S., M. W. Borys. Tolerancia de aguacate (*Persea americana* Mill. y *P. schiedeana* Nees.) a condiciones de salinidad progresiva. I, II, III. XVI Congreso Nacional de la Ciencia del Suelo, Soc. Méx., Oaxaca. Resúmenes pps. 71, 72, 73, respectively. 1983.

Vázquez Valdivia V., S. Salazar García, M. W. Borys. Resultados preliminares sobre el

comportamiento de aguacates cv Fuerte y Hass en suelos delgados y profundos de la región de Atlixco, Pue. XVI Congreso Nacional de la Ciencia del Suelo, Soc. Méx., Oaxaca. Resúmenes, p. 70. 1983.

Table 1. Root characteristics of native avocado seedlings populations of the West Indian and Guatemalan races.

FEATURE	WEST INDIAN			GUATEMALAN		
	MINIMUM	MAXIMUM	AVERAGE	MINIMUM	MAXIMUM	AVERAGE
	RACE: WEST INDIAN			GUATEMALAN		
	Main Root			Lateral roots - 1st order		
Length, cm	1.60	69.50	48.68	10.0	63.50	36.81
Diameter, mm	5.40	20.20	10.79	1.4	13.50	8.52
Fresh weight, g	1.60	30.10	11.97	1.8	17.60	7.03
Dry weight, g	0.15	9.05	2.78	0.3	5.80	2.08
	Lateral roots - 2nd+3rd order			Lateral roots on the basal 1/3 part of the main root		
Total length, cm	133.40	1948.70	1055.30	29.80	986.75	400.52
Diameter, mm	0.70	7.60	1.94	0.46	2.90	1.15
Number	4.0	116.0	72.6	2.00	99.0	48.2
Fresh weight, g	1.3	28.7	14.09	0.60	11.50	4.46
Dry weight, g	0.2	1.59	1.59	0.10	2.90	0.81
	Lateral roots - 2nd+3rd order			Lateral roots on the basal 1/3 part of the main root		
Fresh weight, g	1.4	66.30	24.34	0.3	34.30	7.23
Dry weight, g	0.1	6.71	2.09	0.1	5.0	1.20
	Lateral roots on the basal 1/3 part of the main root			Lateral roots on the basal 1/3 part of the main root		
Number	2.0	60.0	35.46	1.0	58.0	22.54
Length, cm	71.2	1167.0	607.68	2.5	747.9	216.93

Table 3. Root characters of comparison of avocado seedlings of the West Indian [WI] and Guatemalan [G] races.

RACE	FEATURE	VALUE
WI	Main roots; Longitud,cm	48.6a
G	Main roots; Longitud,cm	36.8b
WI	Main root; Diameter,mm	10.79a
G	Main root; Diameter,mm	8.52b
WI	Main root; Fresh weight,g	11.97a
G	Main root; Fresh weight,g	7.03b
WI	Main root; Dry weight,g	2.78a
G	Main root; Dry weight,g	2.08b
WI	Lateral roots-1st Order; Longitud,cm	1055.3a
G	Lateral roots-1st Order; Longitud,cm	400.5b
WI	Lateral roots-1st Order; Diameter,mm	1.94a
G	Lateral roots-1st Order; Diameter,mm	1.15b
WI	Lateral roots-1st Order; Number	72.65a
G	Lateral roots-1st Order; Number	48.23b
WI	Lateral roots-1st Order; Fresh weight,g	14.09a
G	Lateral roots-1st Order; Fresh weight,g	4.46b
WI	Lateral roots-1st Order; Dry weight,g	1.59a
G	Lateral roots-1st Order; Dry weight,g	0.81b
WI	Lateral roots-2nd+3rd order; Fresh weight,g	24.34a
G	Lateral roots-2nd+3rd order; Fresh weight,g	7.23b
WI	Lateral roots-2nd+3rd order; Dry weight,g	2.09a
G	Lateral roots-2nd+3rd order; Dry weight,g	1.20b
WI	1st Order Laterals on 1/3 basal part of	607.6a
G	Length of the main root;cm,	216.9b
WI	1st Order Laterals on 1/3 basal part of Longitud of the main root; Number	35.4a
G	1st Order Laterals on 1/3 basal part of Longitud of the main root; Number	22.5b

Table 4. Shoot characters of comparison of avocado seedlings of the West Indian [WI] and Guatemalan [G] races.

RACE	FEATURE	VALUE
WI	Stem, Length, cm	80.6a
G	Stem, Length, cm	65.4b
WI	Stem, Diameter, mm	11.0a
G	Stem, Diameter, mm	8.8b
WI	Stem, Fresh weight, g	38.2a
G	Stem, Fresh weight, g	21.3b
WI	Stem, Dry weight, g	8.5a
G	Stem, Dry weight, g	6.5b
WI	Leaves, Number	25.1a
G	Leaves, Number	22.6b
WI	Leaves, Fresh weight, g	37.4a
G	Leaves, Fresh weight, g	23.8b
WI	Leaves, Dry weight, g	9.98a
G	Leaves, Dry weight, g	7.47b
WI	Cotyledons, Fresh weight, g	58.8a
G	Cotyledons, Fresh weight, g	22.7b
WI	Cotyledons, Dry weight, g	6.89a
G	Cotyledons, Dry weight, g	5.81b

