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Root Distribution of Mature Avocado Trees Growing in Soils of Different Texture

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ABSTRACT

Following the Kolesnikov's method to study root distribution of fruit trees in the field, it was found that the root system of mature avocado trees, cv. Fuerte, established in a sandy soil is better distributed either horizontally or vertically as compared with that in a clay soil. The amount of roots in the sandy soil (8,646 g dry weight) is almost four times the amount in the clay one (2,650 g). In both soils, most of fine roots are located from 0-60 cm depth and a high percentage of roots (40%) is outside the individual basin for irrigation, particularly in the sandy soil.

INTRODUCTION

In fruit production, deciduous fruit trees have received much of the attention on management practices such as time and rates of fertilization, irrigation, and planting distances, as compared with subtropical and tropical fruit trees even though their performance in the field is affected in a similar way by such practices. In Mexico, the avocado is very important because Mexico is considered as the original home of this species; and, with a growing area of 51,530 ha, plays an outstanding role in the economy of the country. However, so far little is known about the functioning of its root system which is determinant in feeding the tree efficiently. Hence, this paper deals with the results of root distribution of avocado mature trees, cv. Fuerte, growing in soils of different texture.

LITERATURE REVIEW

Among the main factors which influence root development and distribution in both vertical and horizontal directions are soil texture, compaction, air space, soil moisture, and genetic characteristics of the plant.

In fruit trees, the influence of soil texture has been well established. Root systems of fruit trees in clay soils are less developed and located a few centimeters from the surface, as compared with those in sandy soils which present the maximum root density at 30 cm from the trunk (1, 8, 13). In regard to the degree of soil compaction, there is a threshold level for root growth, the soil strength being the limiting factor (4, 6). Apple

roots penetrated well if the soil strength was less than 30 kg/cm2; but in a soil with a value between 30 and 60 kg/cm2, only few roots went through it, and zero roots penetrated if the soil strength was greater than 60 kg/cm2 (6).

On the other hand, vigorous root systems well ramified and with a great amount of fine roots are developed only in soils well aerated (5, 12). As the air space is reduced, rootlets rapidly die or are unable to develop, leading to a root system much less ramified with thicker and shorter roots.

In compacted soils, it is common to have an inadequate level of oxygen mainly in the deep layers, which reduces root growth of fruit trees during the period of intensive growth (3). It has been reported that the critical level of air space at field capacity in relation to root density of citrus trees is 9-10% at a depth of 25-75 cm (11).

Soil depth is an important factor in establishing an avocado orchard (2). When trees grow in the presence of compacted layers which lie close to the surface, their growth is retarded. The problem can be worsened if water through irrigation or rainfall is not handled adequately, leading to anaerobic conditions. Therefore, as a general rule a deeper soil produces higher yields because the root system has a greater volume with which it can obtain water, nutrients, and oxygen (7, 9),

The avocado tree is a species whose root system tends to grow close to the surface with a dense proliferation of fine roots. This is enhanced if the soil surface is covered with a thick layer of leaves well moistened.

Root distribution of avocado also is affected by the scion. The performance of cvs. Fuerte, Hass, Corona, and Edranol eight years old in a soil sandy loam was: a) cv. Fuerte>Hass>Corona>Edranol in regard to amount of roots and better distribution either vertically or horizontally, and b) the root : top ratio was: Edranol 1.45, Fuerte 1.2, Hass 1.1, and Corona 1.0 (8).

MATHERIALS AND METHODS

Two orchards with avocado trees, cv. Fuerte, established on soils of different texture were selected. One is located at Tenextepec (Site 1), Municipio de Atlixco, and the other at Las Bocas (Site 2), Municipio de Izucar de Matamoros, in the state of Puebla. Site 1 is at 1,800 m above sea level and Site 2 at 1,300 m.

Data in Table 1 shows that Site 1 has a soil texture of sandy loam and Site 2 in the first 30 cm is clay loam and clay in the rest of the profile. Soil pH in both sites is above 7.6, organic matter, phosphorus, and calcium contents are higher in Site 2 and potassium and micronutrients contents are higher in Site 1.

Trees in both orchards are irrigated through individual basins connected in a herring bone pattern. The area between rows in Site 1 is always under grass, and in Site 2 is under clean cultivation.

Table 1. Analytical results of soil samples taken at several depths in both sites under study.

Depth (cm)	pH saturated paste (mmhos/cm)	E.C.	O.M. (%)	Nutrient Content									Mechanical Analysis			Soil Texture
				N (%)	P Olsen (ppm)	K (Saturated paste (meq/l))	Ca	Mg	Fe (Extractable in 0.1N HCl (ppm))	Zn	Cu	Mn	Sand (%)	Silt	Clay	
Site 1																
0-30	8.0	0.41	0.75	0.04	12.05	5.77	1.84	1.68	13.0	2.17	3.0	14.9	70	14	16	Sandy loam
30-60	8.1	0.45	0.50	0.02	9.80	5.80	1.80	1.66	15.5	1.10	1.7	11.2	66	16	18	" "
60-90	8.0	0.60	0.56	0.01	7.70	4.07	2.97	2.31	18.2	0.57	2.0	8.2	68	17	16	" "
90-120	8.1	0.70	0.47	0.01	4.05	4.76	3.22	2.93	24.5	0.74	2.4	5.6	68	17	15	" "
120-140	8.1	1.17	0.55	0.03	4.30	3.91	5.15	5.43	23.5	0.65	2.0	9.0	68	17	15	" "
Site 2																
0-30	7.7	0.55	2.97	0.11	12.30	0.78	2.85	1.88	Traces	Traces	Traces	Traces	32	25	43	Clay loam
30-60	7.7	0.75	1.78	0.07	11.50	5.11	4.49	1.88	"	"	"	"	27	23	50	Clay
60-90	7.7	0.89	1.54	0.05	11.30	6.10	4.45	2.40	"	"	"	"	25	24	51	"
90-120	7.7	0.99	1.28	0.05	8.00	2.10	4.92	3.11	"	"	"	"	22	22	56	"

Root distribution was evaluated in two trees at each site following the Kolesnikov's method (7) by digging a sector of the root systems with an angle of 55° at five and six distances (Sites 2 and 1, respectively) starting 50 cm away from the trunk: 50-90, 90-130, 130-170, 170-210, 210-250, and 250-290 cm; and at seven soil depths: 0-20, 20-40, 40-60, 60-80, 80-100, 100-120, and 120-140 cm. Each layer of soil was extracted, then deposited in a wire mesh where water was applied in order to separate the roots according to their diameter in four groups: < 2, 2-5, 5-8, and >8 mm. Each group was kept in plastic bags previously identified and stored in a cooler to determine later on the volume and dry weight of the roots. Volume displacement and an oven at 70°C with air forced were the methods to obtain these root parameters.

RESULTS

1. Horizontal root distribution. Tables 2 and 3 present the results of this distribution on the basis of volume (cc) and dry weight (g), respectively. The data in these tables show that 55% of the roots in the clay soil are located in the first two distances away from the trunk (50-90 and 90-130 cm), and in the sandy soil this same amount is distributed up to the distance 130-170 cm.

It is observed that in general, horizontal root distribution is more uniform in the sandy soil than in the clay one. Looking at root thickness (Tables 2 and 3), the results indicate that approximately 40% of total volume or weight of roots corresponds to roots with a diameter < 2 mm which are distributed in a fashion more or less uniform in the clay soil, and with a diminishing distribution from the trunk in the sandy soil. Roots with a thickness between 5-8 mm were the less abundant.

Data in Tables 2 and 3 also show clearly that trees growing in the sandy soil have almost four times the amount of roots of trees in the clay soil.

2. Vertical root distribution. The depth with the greater amount of roots in the clay soil is 20-40 cm with 34% (Tables 4 and 5), and in the sandy soil is 0-20 cm with 47%. In both soils, roots with a thickness <2 mm are the most abundant (39% in the clay soil and

42% in the sandy soil) which are contained in the layer 0-20 cm: following are roots with a diameter >8 mm concentrated in the layer 20-40 cm in the clay soil, and thoroughly distributed from 0 to 100 cm depth in the sandy soil. The third important group of roots are those with a thickness between 2-5 mm. In the clay soil, 76% of these roots are located from 0 to 60 cm depth; but in the sandy soil, 58% of them are in the 0-20 cm layer.

Finally, it was observed that trees in sandy soil were taller, with a greater cross sectional area of the trunk and diameter of top and root system with a root : top ratio of 0.7, as compared with trees in the clay soil which presented a root:top ratio of 0.9.

Table 2. Horizontal root distribution [root volume in cc]* of avocado trees cv. Fuerte that are growing in soils of different texture.

Soil Texture	Root thickness (mm)	Distance away from the trunk (cm)						Total	% of total
		50-90	90-130	130-170	170-210	210-250	250-290		
Clay	<2	639.0	898.5	701.5	612.5	461.5		3313.0	39.9
	2-5	346.5	511.0	524.0	401.0	354.5		2137.0	25.7
	5-8	141.0	182.5	151.0	148.5	67.5		690.5	8.3
	>8	1179.0	700.0	166.0	94.0	28.5		2167.5	26.1
	Total	2105.5	2292.0	1542.0	1256.0	912.0		8308.0	
	% of total	27.7	27.6	18.6	15.1	11.0			100%
Sandy loam	<2	1417.5	1993.0	2189.0	2729.0	2600.0	2897.5	13826.0	41.8
	2-5	469.0	1889.0	1025.0	975.5	1092.5	819.0	6270.0	18.9
	5-8	404.0	404.0	865.5	567.5	451.5	357.5	3050.0	9.2
	>8	3006.5	3030.0	1995.5	1080.0	555.0	317.5	9980.5	30.1
	Total	5297.0	7316.0	6071.0	5352.0	4699.0	4391.5	33126.5	
	% of total	16.0	22.1	18.3	16.2	14.2	13.2		100%

* Mean of two observations (two trees in each soil type).

Table 3. Horizontal root distribution [root dry weight in g]* of avocado trees cv. Fuerte that are growing in soils of different texture.

Soil Texture	Root thickness (mm)	Distance away from the trunk (cm)						Total	% of Total
		50-90	90-130	130-170	170-210	210-250	250-290		
Clay	<2	175.2	183.3	197.4	186.9	133.6		876.4	33.0
	2-5	121.4	130.4	179.1	125.0	103.2		659.1	24.9
	5-8	53.1	72.4	49.0	47.6	16.0		238.1	9.0
	>8	490.7	277.0	66.4	32.9	10.6		877.6	33.1
	Total	840.4	663.1	491.9	392.4	263.4		2651.2	
	% of total	31.7	25.0	18.6	14.8	9.9			100%
Sandy loam	<2	303.8	506.7	647.6	662.7	610.5	553.8	3285.1	38.0
	2-5	140.1	279.8	321.3	291.7	320.4	199.2	1552.5	18.0
	5-8	117.6	159.6	157.8	173.9	132.5	100.1	841.5	9.7
	>8	957.2	819.4	568.3	351.1	172.5	98.3	2966.8	34.3
	Total	1518.7	1765.5	1695.0	1479.0	1235.9	951.4	8645.9	
	% of total	17.6	20.4	19.6	17.1	14.3	11.0		100%

* Mean of two observations (two trees in each soil type).

Table 4. Vertical root distribution [root volume in cc] of avocado trees cv. Fuerte that are growing in soils of different texture.

Soil Texture	Depth (cm)	Root thickness (mm) <2	2-5	5-8	>8	Total	% of Total
Clay	0-20	1359.5	515.0	50.0	216.0	2050.5	24.7
	20-40	776.5	676.5	205.0	1135.0	2790.0	33.6
	40-60	533.0	432.5	246.0	721.0	1933.0	23.3
	60-80	304.0	244.5	65.0	137.5	751.0	9.0
	80-100	183.5	134.0	55.0	33.0	405.5	4.9
	100-120	156.5	134.5	69.5	14.5	375.0	4.5
	Total	3313.0	2137.0	690.5	2167.5	8308.00	
	% of total	39.9	25.7	8.3	26.1		100%
Sandy loam	0-20	8790.0	3615.0	1366.5	1627.5	15407.0	46.5
	20-40	464.0	592.0	185.5	1155.0	2396.5	7.2
	40-60	997.5	586.5	416.5	2924.0	4924.5	14.9
	60-80	981.5	652.5	540.0	2357.5	4531.5	13.7
	80-100	1150.0	474.0	391.5	1594.0	3609.5	10.9
	100-120	682.5	224.0	92.5	282.5	1281.5	3.9
	120-140	752.5	126.0	57.5	40.0	976.0	3.0
	Total	13826.0	6270.0	3050.0	9980.0	33126.5	
	% of total	41.8	18.9	9.2	30.1		100%

Table 5. Vertical root distribution [root dry weight in g] of avocado trees cv. Fuerte that are growing in soils of different texture.

Soil Texture	Depth (cm)	Root thickness (mm) <2	2-5	5-8	>8	Total	% of Total
Clay	0-20	329.7	139.4	32.1	50.1	551.3	20.8
	20-40	222.7	232.5	65.0	470.5	990.7	37.4
	40-60	156.4	139.0	81.0	284.2	660.6	24.9
	60-80	89.1	70.2	17.2	58.3	234.8	8.8
	80-100	45.0	37.6	20.1	11.3	114.0	4.3
	100-120	33.5	40.4	22.7	3.2	99.8	3.8
	Total	876.4	659.1	238.1	877.6	2651.2	
	% of total	33.0	24.9	9.0	33.1		100%
Sandy loam	0-20	1946.8	887.5	347.1	547.7	3729.1	43.1
	20-40	140.0	84.6	59.0	375.7	659.3	7.6
	40-60	301.1	175.7	128.0	794.4	1399.2	16.2
	60-80	268.8	175.8	167.7	666.1	1278.4	14.8
	80-100	310.2	141.8	106.6	486.3	1044.9	12.1
	100-120	159.5	51.5	19.0	84.7	314.7	3.6
	120-140	158.7	35.7	14.1	11.9	220.4	2.6
	Total	3285.1	1552.6	841.5	2966.8	8646.0	
	% of total	38.0	18.0	9.7	34.3		100%

DISCUSSION

The finding that the root system of trees growing in the clay soil is less developed in both directions (horizontal and vertical) is in agreement with previous reports (1,13). An explanation for this could be the better oxygen level in the sandy soil (12) and the higher degree of soil compaction in the clay soil which stresses root growth (3). Nevertheless, it is necessary to point out that the differences in root distribution here reported are also affected by the differences in soil management practices in both orchards, mainly weed control, as well as by irrigation time and manuring and fertilization practices. Hence, it is

advisable to keep in mind also these elements to define or modify the way to handle root system of avocado trees.

CONCLUSIONS AND RECOMMENDATIONS

1. Trees in sandy soil had almost four times the amount of roots of trees in clay soil.

2. Roots with a thickness <2 mm were the predominant and the less abundant were those with a diameter between 5-8 mm.

3. A high percentage of the root system is outside the individual basin for irrigation. Modification of the irrigation method is suggested in order to reduce injury by water stress during the dry season.

4. Most of the fine roots in both sites are concentrated in the first 60 cm of soil. Therefore, it is convenient to consider this finding in the application of cultural practices as well as for soil sampling to determine rates of fertilization and to define irrigation schedule.

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