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EFFECT OF SIMULATED STONEY LAYER AND HIGH WATER TABLE ON SHOOT AND ROOT GROWTH OF AVOCADO (Persea americana Mill.) AND MANGO (Mangifera indica L.)

C. Gregoriou and D. Raj Kumar[1/]

INTRODUCTION

Throughout the West Indies there is interest in covering denuded mountain ranges with forest, often fruit forests. Among the fruit species considered are mango and avocado. However, on these hillsides there is frequently only a thin layer of soil overlying rocky layers, while on the lower slopes and valleys there may be high water tables, especially during the rainy seasons. These factors, among others, influence root and consequently shoot growth of perennial plants (Rogers and Head, 1969).

Khan (1960) examined the root system of an 18 year old mango tree growing in a soil which had a compact stoney layer at 90 to 120 cm depth, overlain by loam and sandy loam and overlying a sandy subsoil. He found this compact, stoney layer acted as an obstacle to root growth and only few roots passed beyond this layer.

Avilan (1974) also found that the presence of regular-sized stones at 110 cm depth prevented root penetration of a 7-year-old mango tree. Observations at the St. Michael Hillside Station of the Ministry of Agriculture, Trinidad and Tobago indicated that mango plants grew well on the upper hillsides where there was only a thin layer of top soil over a rocky subsoil, whereas avocado plants did not thrive under these conditions.

Poor soil aeration, due to water saturation, prevented root and consequently shoot growth of avocado plants (Haas, 1940; Valoras et al. 1964). Avilan (1974), Ghosh (1974), Singh (1960) and Stephens (1949) also reported that the water table limited the spread of mango root system vertically.

It was of interest therefore, to determine the effects of a stoney layer and a simulated high water table on the growth of young mango and avocado plants.

MATERIALS AND METHODS

Three treatments viz. stoney layer, simulated water table (s.w.t.) and a control were applied to each species. The experiment was laid out

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1/ Faculty of Agriculture, University of the West Indies, St. Augustine, Trinidad.

in randomized complete blocks and there were six replicates. Grafted avocado (cv. 'Pollock' on unknown West Indian rootstocks) and mango (cv. 'Julie' on cv. 'Rose' rootstock) plants, six and nine months old respectively, were transplanted into pots 25 x 25 x 70 cm containing River Estate Loam (Brown and Bally, 1970). The stoney layer consisted of a 10 cm layer of stones 40cm below the top of the pot. The stones were 3-5 cm in diameter. The high water table was simulated by placing the pot in a larger container with free water which was maintained at a depth of 20cm.

All the plants were harvested 14 months after planting by cutting off the tops at soil level. The soil and roots were divided into three layers: A = 0-40 cm, B = 40-50cm and C = 50-70cm deep, and the roots from each layer carefully collected and washed. Dry weights of roots and shoots were recorded after oven drying at 80°C to constant weight.

RESULTS

Avocado

The stoney layer significantly ($p < 0.05$) reduced shoot and total root dry weight. The s.w.t. treatment also reduced shoot and total root dry weight, but not significantly (Table 1).

However, the treatments significantly influenced root distribution. In the A layer there was significantly ($p < 0.05$) less root dry weight in the stoney layer treatment than in the control whereas the s.w.t. treatment had no effect on root dry weight in this layer. In layer B the stoney layer significantly ($P < 0.05$) reduced root growth, but the reduction in root dry weight due to the simulated water table was much greater ($p < 0.01$). A similar pattern was evident in layer C, where there was almost no root in the s.w.t. treatment.

When expressed as percentage of total root dry weight it appears that the stoney layer had little effect on the distribution of roots in the three layers and in both the treatment with the stoney layer and the control approximately 80 percent of the total dry weight of root was found in the top 40 cm of soil. In contrast, 99 percent of the root dry weight was found in the top 40 cm of the s.w.t. treatment.

Mango

There were small differences in shoot dry weight between the three treatments with the control producing the highest and the s.w.t. treatment the lowest. However, these differences were not significant (Table 2). Similarly the differences in total root dry weight were small and not significant. The s.w.t. treatment produced the highest and the stoney layer treatment the lowest total root dry weight.

Table 1.--Effects of a stoney layer and simulated high water table on shoot and root growth of young avocado plants cv. 'Pollock' on unknown West Indian rootstock

	Stoney layer	Simulated water table	Control	S.E. of difference	C.V.
					%
Shoot dry weight (g)	381.4 b[1]	409.3 ab	491.3 a	36.97	14.99
Total root dry weight (g)	218.1 b	280.1 ab	364.4 a	40.43	24.36
Root dry weight (g) in					
Layer A[2]	175.2 b	277.4 a	286.2 a	38.01	26.74
Layer B[3]	17.4 b	1.8 c	29.7 a	1.82	55.03
Layer C[4]	25.4 b	0.9 c	48.6 a	2.28	45.58
Percentage of root dry weight in					
Layer A	80.3	99.0	78.6		
Layer B	8.0	0.7	8.1		
Layer C	11.7	0.3	13.3		

[1]Means in the same line with the same letter are not significantly different ($p < 0.05$).
[2]Layer A = 0-40 cm deep.
[3]Layer B = 40-50 cm deep.
[4]Layer C = 50-70 cm deep.

Table 2.--Effects of a stoney layer and simulated high water table on shoot and root growth of young mango plants, cv. 'Julie' on 'Rose' rootstock

	Stoney Layer	Simulated water table	Control	S.E. of difference	C.V.
					%
Shoot dry weight (g)	333.7 a[1]	306.1 a	372.4 a	48.71	25.01
Total root dry weight (g)	187.1 a	201.6 a	195.8 a	24.89	22.12
Root dry weight (g) in:					
Layer A[2]	160.0 a	201.2 a	160.0 a	21.84	21.78
Layer B[3]	8.4 a	0.4 b	11.8 a	2.43	60.00
Layer C[4]	18.7 a	0.0 b	24.0 a	4.87	59.33
Percentage of root dry weight in:					
Layer A	85.5	99.8	81.7		
Layer B	4.5	0.2	6.1		
Layer C	10.0	0.0	12.2		

[1]Means in the same line with the same letter are not significantly different ($p < 0.05$).
[2]Layer A = 0-40 cm deep.
[3]Layer B = 40-50 cm deep.
[4]Layer C = 50-70 cm deep.

As in avocado, the s.w.t. treatment had a profound effect on root distribution, resulting in 99.8 percent of the total root dry weight being in the top 40 cm of soil, compared to 81.7 percent in the control. There was very little difference in root distribution between the control and the stoney layer treatment.

DISCUSSION

The presence of a stoney layer significantly reduced both shoot and total root dry weight of avocado. Moreover, the presence of this layer reduced root dry weight in all three layers of soil. It appears that a stoney layer retards the development not only of avocado roots in that layer but of the entire root system of the plant. This may explain why avocado plants do not thrive on the rocky, denuded hillsides of the Northern Range of Trinidad.

The main effect of the simulated water table on avocado growth was a reduction (almost to non-existence) of root growth in the B and C soil layers (Table 1). This was probably due to poor aeration caused by water saturation, as reported by Haas (1940) and Valoras et al. (1964). It is interesting that there was very poor root growth in layer B, the 10cm layer above the water level. This layer must have remained nearly saturated by capillarity, in which case the air content of the layer may have been too low for adequate growth of avocado roots. It is possible that in preparing the soil and filling the pots the soil structure was completely destroyed or that over the 14 months of the experiment the soil compacted thereby eliminating most of the macropores and increasing the degree of saturation by capillarity.

The water table acted as an effective barrier to avocado root growth, reducing its growth in the two lower soil layers but not significantly reducing total root dry weight as the stoney layer did.

In contrast, the stoney layer had no significant effect on total root dry weight of mango (Table 2). It also had no effect on the root distribution of mango. Again these results are in agreement with observations at the Northern Range of Trinidad where mango plants grow well on denuded, rocky hillsides. On the other hand Avilan (1974) and Khan (1960) investigated tree root distribution of mango plants *in situ* and found that a stoney layer acted as an obstacle to root growth and only a few roots were found beyond this layer. The differences in results may be due to, among other things, the type and extent of the stoney layer, the depth at which it was located and the age and vigour of the plant.

The s.w.t. treatment slightly reduced total shoot dry weight of mango, but had no effect on total root dry weight. However, the water table completely inhibited root development in the saturated soil layers. This agrees with the reports of Avilan (1974), Ghosh (1974), Singh (1960) and Stephens (1949). Nevertheless, under such conditions the plants developed as much root in the upper 40 cm of soil as did the control plants in the entire 70 cm depth of soil.

From the results of this study it is clear that avocado plants grow faster than mango plants. Even though the avocado plants were three months younger than the mango plants the former had greater shoot and root dry weights (Tables 1 and 2). However, the root distribution of the two species, as shown by the percentage of total root dry weight of the controls in each layer, was very similar. Nevertheless it is apparent that the two species respond differently to different soil conditions and that mango is less affected than is avocado.

SUMMARY

A simulated water table 50cm below the soil surface severely limited root penetration of both mango and avocado plants growing in pots. Approximately 99 percent of the root systems were found in the top 40cm of soil compared to approximately 80 percent in the controls. This simulated water table tended to reduce both shoot and root growth of avocado but not of mango. The presence of a stoney layer 40cm below the soil surface significantly reduced shoot and root growth of avocado but not of mango and had little effect on the distribution of roots of either species.

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