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Growth and yield of mango trees at three stages of development influenced by rootstock, scion variety¹

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ABSTRACT

Research was conducted at the Fortuna Research and Development Center to study the growth and yield of mango trees at three development stages of different rootstock and scion combinations. Scion diameter varied with age but after 6 years, Palmer was thickest followed by Edward and Irwin. Eldon was the most effective rootstock in reducing scion diameter during the first 6 years; its effect disappeared after the trees were 9 years old. Scion to rootstock ratio varied with age. After 9 years of growth the combination of Edward on Manzano Tetenené showed the lowest ratio. After 6 years of growth Edward had the largest canopy, but after 9 years it was surpassed by Palmer, followed by Edward and Irwin. Eldon, as rootstock for Palmer and Irwin, produced the smallest canopy irrespective of tree age. Regardless of rootstock, the order in height was Palmer, Edward, Irwin. Eldon as rootstock produced significantly smaller Irwin and Palmer trees, although after 9 years the effect of rootstock on tree height was not significant. In varieties Edward and Palmer yield efficiency decreased with age and height, but was not significantly affected by the rootstock. However, yield decreased significantly when Irwin was grafted on Julie. Fruit production per tree and total weight of fruits were related to a reduction in size, with a significant reduction in total number and weight of fruits produced.

INTRODUCTION

The need to control tree size in mango and the progress thus obtained with other fruits served as motivation to initiate research with the intention of modifying tree size and improving yield efficiency and per acre production of mango. Part of the efforts in that direction are herein reported.

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The mango tree varies considerably in height and shape among varieties. It is normally propagated from seed or by means of grafting on unselected seedlings. These propagation practices usually result in very tall trees which are difficult to cultivate and harvest.

There is very little information in Puerto Rico or elsewhere on how to control tree size in mango. Research with temperate fruits in other countries (1, 3, 4, 5, 6) indicates that size, yield, nutrient content and survival of fruit trees can be modified through the use of rootstocks. Westwood et al. (3) reported that in three pear varieties, five rootstocks used in their experiments influenced height, spreading habit and volume of the canopy of the tree.

The influence of nine rootstocks on growth and production of two apple varieties was evaluated in Washington state (5) and demonstrated that after 16 years trees grafted on rootstocks with the least effect on tree size also produced the least efficiently.

MATERIALS AND METHODS

Research on different rootstock and scion conditions was initiated at the Fortuna Research and Development Center to study growth and yield of mango trees.

Varieties selected for the study included two tall (Edward and Palmer) and one semi-dwarf (Irwin) commercial varieties. These varieties were selected on the basis of consumer acceptance at the local markets. Variety Edward is an early bearer, whereas Palmer and Irwin produce midseason crops. One tall (Eldon) and three dwarf (Julie, Malda and Manzano Tetenené) varieties were used as rootstocks.

Trees were planted April 1973 at a 4.7 m × 6.1 m distance in randomized complete blocks including 12 treatments, four replicates and two trees per replication. In the summer of 1980, when the trees were 7 years old, one tree per treatment was removed to provide more space to remaining trees.

Since the average annual rainfall at the Fortuna Research and Development Center is 1020 mm, the experiment was grown with supplementary irrigation provided by drip irrigation. Fertilization, weed control and other management practices were performed in accordance with the recommendations of the Puerto Rico Agricultural Experiment Station (2).

Trees started to bear a few fruits the second year after transplanting but because of lack of uniform fruits, these fruits were removed at an early stage of development.

Stock and scion diameter, tree height and canopy width were measured annually in July. Number and weight of fruits per tree was obtained by weekly picking all fruits starting to ripen. Two trained laborers with

more than 10 years of experience harvesting mangoes were employed for this operation.

Canopy volume (C.V.) was calculated with the formula

$$C.V. = 4/3 \pi a^2b,$$

where $a=1/2$ the canopy width and $b=1/2$ the tree height. Yield efficiency was calculated by dividing the number and/or weight of fruits per tree by the number of cubic meters of canopy.

RESULTS AND DISCUSSION

Scion diameter

Table 1 indicates that scion diameter increased with age for all varieties. After 3 years of growth Edward variety tended to be a thicker tree than Palmer or Irwin. However, Palmer had a thicker scion than the other varieties after 6 years of growth.

Eldon was the rootstock that produced the thinnest scion. However, this effect was more dramatic when the trees were 3 and 6 years old, but disappeared when the trees were 9 years old.

Canopy width and volume

Table 2 indicates that canopy width varied for the different varieties when the trees were 3 and 6 years old, with size decreasing most in this order: Edward, Palmer and Irwin. However, after 9 years, Palmer had the largest canopy, followed by Edward and Irwin. Eldon as rootstock for Palmer and Irwin produced the smallest canopy, irrespective of tree age.

Scion to rootstock ratio

When the trees were 3 years old there was no significant difference in scion/rootstock ratio in any of the varieties studied. However, when the trees were 6 years old, Palmer on Julie and Irwin on Eldon had a scion/stock ratio of 0.84, which was significantly lower than ratios in the other varieties. After 6 years of development, Edward on Manzano Tetenene had a 0.62 ratio, which was the lowest ratio for all the scion/rootstock combinations (table 3). A low scion/rootstock ratio was associated with a small tree.

Tree height and yield efficiency

Table 4 indicates that irrespective of the rootstock, the order of tree height was Palmer, Edward and Irwin, and that the height increased continuously with tree age.

Results also indicate that when the trees were 3, 6 and 9 years old, Eldon as rootstock produced significantly smallest Irwin and Palmer trees. Edward trees grafted on Eldon and Manzano Tetenene were smaller at the ninth than at the sixth year after planting. This result is possi-

TABLE 1.—Scion diameter at 3, 6 and 9 years after transplanting of Edward, Palmer and Irwin mango varieties grafted on Julie, Malda, Manzano Tetenené and Eldon rootstocks

Rootstock	Scion diameter (cm)		
	Years after transplanting		
	3	6	9
		<i>Edward</i>	
Julie	11.6 ab ¹	21.0 abc	27.3 ab
Malda	12.0 a	20.4 bc	26.0 ab
Manzano Tetenené	13.2 a	22.0 ab	24.8 ab
Eldon	11.2 abc	20.3 bc	20.0 b
		<i>Palmer</i>	
Julie	11.1 bc	24.5 a	31.8 a
Malda	10.6 bc	20.3 bc	31.3 a
Manzano Tetenené	11.6 ab	21.7 ab	27.5 ab
Eldon	9.4 c	19.5 cde	26.0 ab
		<i>Irwin</i>	
Julie	10.7 bc	18.6 cde	22.5 ab
Malda	11.1 bc	16.9 de	22.5 ab
Manzano Tetenené	10.6 bc	17.3 cde	20.0 b
Eldon	10.1 bc	16.4 e	21.8 ab
		<i>Edward</i>	
Julie	11.0 ab	19.2 ab	25.0 ab
Malda	11.5 a	19.9 ab	27.5 ab
Manzano Tetenené	12.4 a	21.2 a	20.3 ab
Eldon	10.7 bc	19.5 ab	18.8 ab
		<i>Palmer</i>	
Julie	10.1 bc	20.3 a	28.0 ab
Malda	10.0 bc	18.3 abc	29.0 a
Manzano Tetenené	11.0 a	18.7 ab	26.3 ab
Eldon	8.7 e	16.7 bed	22.5 ab
		<i>Irwin</i>	
Julie	9.4 bc	16.2 cd	22.0 ab
Malda	10.4 bc	16.4 cd	21.8 ab
Manzano Tetenené	10.1 bc	16.6 bed	19.5 ab
Eldon	8.7 e	13.6 d	17.3 b

¹Means in columns, for all tables, followed by the same letters do not differ significantly at the 0.05 probability level.

ble because of the significantly smaller scion to rootstock ratio of this variety on those rootstocks (table 3). These results demonstrate a dwarfing effect produced by these two rootstocks.

Three years after planting, Malda rootstock produced significantly smaller Edward trees than the other rootstocks, and after 6 years Edward trees grafted on Malda and Eldon were significantly shorter than those on other rootstocks. Tree height after 9 years was not much different among rootstocks, indicating the need of further research to obtain rootstocks to reduce the size of Edward trees.

TABLE 2.—*Canopy width after 3, 6 and 9 years after transplanting of Edward, Palmer and Irwin mango varieties grafted on Julie, Malda, Manzano Tetenené and Eldon rootstocks*

Rootstock	Canopy width (m)		
	Years after transplanting		
	3	6	9
		<i>Edward</i>	
Julie	2.9 bc	5.2 ab	6.3
Malda	3.0 ab	5.1 abc	7.0
Manzano Tetenené	3.2 a	5.5 a	5.7
Eldon	2.6 bcd	4.9 abc	5.6
		<i>Palmer</i>	
Julie	2.3 ed	4.9 abc	7.0
Malda	2.4 cd	5.0 abc	6.7
Manzano Tetenené	2.6 bcd	4.5 bcd	6.5
Eldon	1.8 e	4.3 bcd	5.9
		<i>Irwin</i>	
Julie	2.2 ed	4.3 bcd	5.6
Malda	2.5 cd	4.1 de	5.5
Manzano Tetenené	2.3 ed	4.1 de	5.4
Eldon	1.8 e	3.4 e	4.5

TABLE 3.—*Scion/rootstock ratio of trees at 3, 6 and 9 years after transplanting on Edward, Palmer and Irwin mango varieties grafted on Julie, Malda, Manzano Tetenené and Eldon rootstocks*

Rootstock	Scion rootstock ratio		
	Years after transplanting		
	3	6	9
		<i>Edward</i>	
Julie	0.95	0.91 abc	0.92 abc
Malda	0.96	0.98 a	1.06 a
Manzano Tetenené	0.94	0.97 ab	0.62 c
Eldon	0.96	0.96 b	0.70 bc
		<i>Palmer</i>	
Julie	0.91	0.84 d	0.90 abc
Malda	0.94	0.90 ab	0.91 abc
Manzano Tetenené	0.95	0.86 bc	0.95 ab
Eldon	0.92	0.85 cd	0.86 abc
		<i>Irwin</i>	
Julie	0.88	0.87 abc	0.97 ab
Malda	0.93	0.97 ab	0.96 ab
Manzano Tetenené	0.95	0.96 ab	0.98 ab
Eldon	0.86	0.84 d	0.79 abc

TABLE 4.—Tree height at 3, 6 and 9 years after transplanting of Edward, Palmer and Irwin mango varieties grafted on Julie, Malda, Manzano Tetenené and Eldon rootstocks

Rootstock	Tree height (m)		
	Years after transplanting		
	3	6	9
		<i>Edward</i>	
Julie	2.8 ab	3.9 b	4.8 ab
Malda	2.4 c	3.6 c	4.6 abc
Manzano Tetenené	2.9 ab	4.2 b	3.7 bcd
Eldon	2.7 bcd	3.7 c	3.6 bcd
		<i>Palmer</i>	
Julie	3.0 a	4.8 a	5.5 a
Malda	2.9 a	4.8 a	6.2 a
Manzano Tetenené	2.8 ab	4.6 a	5.8 a
Eldon	2.4 cd	4.2 b	5.1 ab
		<i>Irwin</i>	
Julie	2.4 cd	3.1 d	3.6 bcd
Malda	2.2 d	2.9 d	3.1 cd
Manzano Tetenené	2.1 de	3.0 d	3.1 cd
Eldon	2.0 e	2.5 e	2.9 d

Yield efficiency, measured as the number of fruits produced per cubic meter of canopy, decreased with tree age and height. Therefore, pruning or other size control should be practiced as the trees get older.

Rootstock effects on yield efficiency were not significant for Edward and Palmer at the three ages measured. Efficiency is apparently influenced more by the environment than by the rootstock.

Irwin grafted on Julie was significantly less efficient at the third and ninth year. There was no significant difference among rootstocks for yield efficiency of Irwin variety when the trees were 6 years old.

Number and weight of fruits per tree

Table 5 indicates the natural tendency of trees to increase in fruit number and total weight as trees become older. This effect was least in the Edward variety. Results show that those trees whose size was reduced significantly due to the rootstock on which they were grafted, such as Edward on Malda, Edward on Eldon, Palmer on Eldon, and Irwin on Eldon, also yielded significantly less fruit.

This result indicates that Eldon and Malda, when used as rootstocks, may reduce tree size and yield per tree. A similar situation has been reported for apple (1) in which fruit yields were negatively correlated with tree size. To compensate for this situation in mango, the possibility of closer planting distances should be explored.

TABLE 5.—*Number and weight of fruits per tree at 3, 6 and 9 years after transplanting of Edward, Palmer and Irwin mango varieties grafted on Julie, Malda, Manzano Tetenené and Eldon rootstocks*

Rootstock	Years after transplanting		
	3	6	9
		Number	
		<i>Edward</i>	
Julie	39 bed	167 bc	140 cde
Malda	24 d	130 bed	184 bcde
Manzano Tetenené	52 bcd	150 bc	102 e
Eldon	33 cd	104 bed	106 e
		<i>Palmer</i>	
Julie	34 cd	141 bc	501 a
Malda	38 bed	87 cd	171 bcde
Manzano Tetenené	64 bc	76 c	360 abcd
Eldon	19 d	37 d	193 bcde
		<i>Irwin</i>	
Julie	107 a	277 a	387 ab
Malda	121 a	194 ab	380 abc
Manzano Tetenené	106 a	189 ab	132 de
Eldon	72 b	123 bed	166 bcde
		Weight (kg)	
		<i>Edward</i>	
Julie	17 bc	71 ab	67 c
Malda	11 c	54 bc	84 bc
Manzano Tetenené	24 abc	67 ab	49 c
Eldon	16 bc	50 bc	43 c
		<i>Palmer</i>	
Julie	18 bc	69 ab	236 a
Malda	19 bc	47 bc	98 bc
Manzano Tetenené	33 a	38 bc	168 ab
Eldon	9 c	19 c	84 bc
		<i>Irwin</i>	
Julie	30 ab	88 a	121 bc
Malda	32 a	71 ab	121 bc
Manzano Tetenené	33 a	70 ab	42 c
Eldon	20 abc	45 bc	55 c

RESUMEN

Cómo la relación patrón-esqueje influye el crecimiento y la producción de árboles de mango

En el Centro de Investigación y Desarrollo de Fortuna, en la costa semiárida del sur, se estudió el crecimiento y el rendimiento de mangoteros en tres edades usando diferentes combinaciones de patrones e injertos. Se encontró que el diámetro de los árboles injertados varió según su edad, pero que después de 6 años la variedad Palmer tenía el tronco más grueso. Le seguieron las variedades Edward e Irwin. Eldon fue el patrón más eficaz

en reducir el diámetro del injerto durante los primeros 6 años de crecimiento, pero su efecto desapareció después de 9 años. La razón injerto/patrón varió con la edad, pero después de 9 años era menor en la Edward injertada sobre Tetenene. A los 6 años de crecimiento, la variedad Palmer tenía la copa más ancha; le siguieron las variedades Edward e Irwin. Eldon, como patrón para las variedades Palmer e Irwin, causó la formación del diámetro y el volumen de copa más pequeños independientemente de la edad de los árboles. Asimismo, los árboles de la variedad Palmer fueron más altos que los Edward e Irwin sin importar la edad de los árboles.

Con Eldon como patrón los árboles de las variedades Irwin y Palmer fueron significativamente más pequeños, aunque después de 9 años el efecto del patrón sobre la altura no fue significativo. La eficiencia de rendimiento no se afectó significativamente por el patrón en las variedades Edward y Palmer, pero se afectó significativamente cuando la variedad Julie se injertó sobre Julie. La producción y el peso de las frutas por árbol estuvieron relacionados con el tamaño de los árboles, encontrándose que una reducción en tamaño reducía significativamente el número total y el peso de las frutas.

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