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Rootstock and Pruning Influence on Yield and Fruit Quality of 'Lisbon' Lemon

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Abstract

Effects of three rootstocks and five methods of pruning on the "first harvest yield", total yield and fruit quality of 'Lisbon' lemon (*Citrus limon* (L.) Burm) were studied over the 1986-88 seasons. The pruning treatments were applied in April 1986. Trees on Indian rough lemon had a higher first harvest yield and total yield than the those on other rootstocks. Trees on rough lemon (*C. Jambhiri* Lush) had significantly higher soluble solids concentrations (SSC) than those on Volkamer lemon (*C. limon* Burm f.) in 1987 and those on Indian rough lemon in both 1986 and 1987. In 1986 and 1988, trees which weve moderately cut on one side and the top had a higher first harvest yield than the trees that received severe or moderate cuts on both sides and the top. However, uncut (control) trees had a higher total cumulative yield than the trees that were severely or moderately cut on both sides and the top. Fruit size in 1986 increased as the severity of branch-cutting increased. Fruit from trees with moderate or severe pruning on two sides and the top had thicker rind than those from trees with other treatments.

Introduction

Rootstocks affect yield and fruit quality in various types of citrus (3, 4, 5, 6, 7, 12, 14). Most of the previous studies with lemon have focused on tree decline (1, 10), on soluble solids concentrations and titratable acid of juice (9, 13) or citrus pectins (11). The influence of rootstock on various aspects of lemon tree performance including growth and yield has been reported (8).

Lemon is the major type of citrus produced in Arizona, where annual production is about 175,000 t, which constitutes 25% of total lemon production in the United States (2). However, little attention has been paid to the responses of different rootstocks of lemon to various pruning regimes. The objective of this research is to study the influence of three rootstocks and five pruning techniques on the first harvest yield (commercially acceptable fruit in early harvest), total yield, and fruit quality over 1986-88 growing seasons.

Materials and Methods

'Frost Nucellar Lisbon' lemon trees were budded onto three rootstocks — Indian rough lemon, rough lemon and Volkamer lemon in containers in the greenhouse. One-year-old trees were planted at 8.5 x 9.1 m spacing at the University of Arizona Yuma Mesa Agricultural Center in southwestern Arizona on April 21, 1973 Tree rows were oriented on an east-west direction. The soil was a Superstition sand (Typic Calciorthid, sandy, mixed, hyperthermic; 85% sand) and soil pH was 8.0. The trees were flood irrigated twice each month during April through September and monthly during October through March. Ammonium nitrate was applied in five equal applications in October, December, February, March, and April every year at the total annual rate of 0.5 to 1.5 kg N/tree, depending on the age of trees. Pesticides were applied twice annuall} for thrip control and the orchard was disked for weed control as needed. Overall, cultural practices, soil, and other environmental conditions in this experimental block were similar to those of commercial orchards, in Arizona, where mean annual precipitation is about 63.5 mm.

The experimental design was a randomized complete block split plot with five pruning methods and uncut control as the main plots and three rootstocks as subplots with four replications. Treatments were as follows: 1) Severe cuts on two sides and top: trees were severely cut

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down to 1.5 to 2 m from the main crown (main frame of the tree) from both sides (north and south) and from the top; 2) Moderate cuts on two sides and top: trees were moderately cut down to 2.5 to 3 m from the main crown from both sides (north and south) and from the top; 3) Moderate cuts on two sides only: moderate cuts (2.5 to 3 m from the main crown) were made on north and south sides; 4) Moderate cuts on one side and the top: moderate cuts (2.5 to 3 m from the main crown) were made only on the south side and the top; 5) Select cuts: only 3 to 4 limbs were eliminated entirely to allow more light penetration through the tree canopy; 6) Control (uncut): trees received no cuts.

Pruning was done by a rotating blade commercial citrus pruner in April 1986. Yield data from the first harvest and total yield for each year were recorded. In the first harvest, only fruit which were commercially acceptable were harvested in late November. Fruit should have a minimum diametev of 5.6 cm (ring size 7) to be commercially acceptable for the first harvest while in the general harvest, all of the remaining fruit were harvested in mid-February to mid-March of the following crop year.

Fruit weight, juice volume (total juice per fruit), percent juice content (percent by fruit weight), soluble solid concentrations (SSC), total titratable acid (TA), SSC:TA ratio, and rind thickness of fruit from the first harvest were evaluated in 1986 and 1987. Twenty-four fruit per tree were collected randomly in late November of each year. Fruit were weighed, cut in half, and rind thickness was measured with a digital caliper. Juice was extracted by pushing each half of the fruit against the rotating blades of an electric juicer until only rind remained. The juice was passed through a strainer to remove the pulp and to extract pure juice. Total juice volume per fruit was measured in a graduated cylinder. A 500-ml aliquot of each composite juice from all fruit of each sample was weighed, and per cent juice content of each fruit was calculated. Soluble solid concentration was measured with a temperature-compensated refractometer (Atago N1). Total titratable acid was determined by titration with 0.39 N NaOH to a pH of 8.0, using an automated Fisher Titralizer (Model 41; Fisher Scientific Co., Pittsburgh) and TA was expressed as citric acid. Analyses of variance for first harvest yield and total yield in each individual year, cumulative yield over 3 years, and analyses of variance for each quality factor are reported. Mean separations were computed with Duncan's multiple range test when a significant F value existed.

Results and Discussion

Rootstock Effect:

Trees on Indian rough lemon had a higher yield at first harvest than the other rootstocks in all three years of evaluation (Table 1). This difference was not significant in 1986 because fruit in 1986 for the first harvest was picked only after five months of pruning; thus, rootstock differences were minimized by pruning. However, the first harvest cumulative yield of trees on Indian rough lemon was also significantly higher than that on the other rootstocks (Table 1). Total yield (yield of first harvest and second harvest) in each year and total cumulative yield over 1986-88 seasons in trees on Indian rough lemon was significantly higher than those on other rootstocks.

There was no significant rootstock effect on fruit weight, rind thickness, juice per fruit, percentage juice, or specific gravity (date not shown). However, fruit from trees on rough lemon had higher average SSC than those from trees on Indian rough lemon and Volkamer lemon rootstocks (Table 1).

Pruning Effects:

In 1986, first harvest yield from trees which received moderate cuts on one side and the top was significantly higher than those in trees with moderate or severe cuts on two sides and the top (Table 2). This is because a considerable amount of fruiting surface on the moderate cut and severe cut trees were eliminated. In 1981,

Table 1. Effects of rootstock on first harvest yield and total production of 'Lisbon' lemon over 3 years.[z]

	First harvest yield (kg/tree)				Total yield (kg/tree)				Soluble solids		
Rootstock	1986	1987	1988	Cum.	1986	1987	1988	Cum.	1986	1987	Avg.
Indian rough lemon	121.1 a	79.9 a	147.3 a	348.3 a	289.2 a	228.1 a	256.2 a	773.5 a	6.94 b	7.15 b	7.05 b
Rough lemon	101.0 a	55.4 b	128.2 b	284.6 b	237.1 b	182.9 b	228.3 b	648.3 b	7.04 a	7.28 a	7.16 a
Volkamer lemon	106.2 a	59.3 b	110.9 b	276.5 b	249.6 b	175.6 b	197.4 b	622.6 b	7.00 ab	7.15 b	7.08 b

[z]Mean separation within columns by Duncan's Multiple Range Test at 0.05%.

the first harvest crop in trees with any type of side and/or top cut had significantly higher yield than uncut trees (Table 2). A better light penetration and higher leaf/fruit ratio perhaps resulted in a larger number of fruit in the harvestable category (the first harvest yield) in the pruned trees. In 1988, trees that received moderate cut on one side and the top and those with moderate cuts on two sides had significantly higher crops at first harvest than trees with moderate or severe cuts on two sides and the top (Table 2), because excessive growth in the trees with moderate to severe cuts on two sides and the top produced shaded canopies, resulting in a reduced production of marketable fruit for the first harvest. The 3-year cumulative yield for the first harvest in the trees which received a moderate cut on one side and the top was significantly larger than trees that were cut severely on two sides and the top. Cumulative total yields (total of first harvest and other harvests) over three years in uncut trees were higher than those of trees with moderate or severe cuts on two sides and the top (Table).

In 1986, fruit size increased as the severity of branch-cutting increased; thus, severe cut trees had the largest fruit among all treatments. In 1986, trees with moderate cuts on two sides and the top had significantly larger fruit size than all treatments except those with severe cuts on two side and the top (Table 3). Average fruit weight over 1986 and 1987 seasons in uncut trees and select cuts trees was smaller than most other treatments (Table 3).

In 1986, fruit from trees with moderate or severe cuts on two sides and the top had thicker rinds than those from all other treatments" (Table, 3). Average rind thickness over 1986 and 1987 in these two treatments was significantly higher than that of uncut trees (Table 3). Fruit from trees with moderate or severe cuts on two sides and the top yielded higher

Table 2. Influence of pruning on first harvest yield and total yield of 'Lisbon' lemon over three years.[z]

	First harvest yield (kg/tree)				Total yield (kg/tree)			
Pruning treatment	1986	1987	1988	Cum.	1986	1987	1988	Cum.
Severe cuts on two sides and top	73.8 c	71.2 a	105.7 b	250.7 b	137.4 d	217.2 a	189.3 c	544.0 c
Moderate cuts on two sides and top	94.0 bc	66.0 a	107.8 b	267.8 ab	192.2 c	219.8 a	212.1 bc	624.0 bc
Moderate cuts on two sides onl}	121.2 ab	72.3 a	139.7 a	333.2 ab	303.4 ab	179.0 a	235.6 ab	718.0 ab
Moderate cuts on one side and top	133.4 a	75.2 a	146.7 a	355.3 a	293.6 b	209.8 a	232.7 ab	736.1 ab
Select cuts	111.7 ab	57.9 ab	140.9 a	310.5 ab	278.1 b	170.9 a	255.9 a	704.8 ab
Control (uncut)	122.4 ab	46.8 b	132.0 ab	301.2 ab	347.1 a	176.6 a	238.0 ab	761.7 a

[z]Mean separation within columns by Duncan's Multiple Range Test at 0.05%.

Table 3. Influence of pruning on fruit quality of 'Lisbon' lemon over two years.[z]

Treatment	Fruit weight (g)			Rind thickness (mm)			Juice per fruit (ml)			Soluble solids conc.			Titratable acids		
	1986	1987	Avg.	1986	1987	Avg.	1986	1987	Avg.	1986	1987	Avg.	1986	1987	Avg.
Severe cuts on two sides and top	107.7 a	94.0 b	100.9 a	3.99 a	3.78 a	3.88 a	43.1 a	35.7 a	39.4 a	6.78 b	7.15 a	6.96 c	4.64 a	5.04 a	4.84 a
Moderate cuts on two sides and top	102.0 b	97.3 ab	99.6 a	3.85 a	3.91 a	3.88 a	41.4 a	36.4 a	38.9 a	6.98 a	7.10 a	7.04 bc	4.63 a	5.12 a	4.88 a
Moderate Cuts on two sides only	90.0 c	99.1 ab	94.6 ab	3.61 b	3.85 a	3.73 ab	36.4 b	38.0 a	37.2 ab	7.04 a	7.23 a	7.13 ab	4.68 a	5.12 a	4.90 a
Moderate cuts on one side and top	90.7 c	107.8 a	99.2 a	3.61 b	3.89 a	3.75 ab	37.2 b	38.1 a	37.7 ab	7.01 a	7.18 a	7.09 ab	4.70 a	5.01 a	4.86 a
Select cuts	86.0 c	96.3 ab	91.2 b	3.63 b	3.84 a	3.73 ab	34.0 b	37.0 a	35.5 b	7.09 a	7.27 a	7.18 a	4.59 a	5.27 a	4.93 a
Control (uncut)	86.4 c	95.5 b	91.0 b	3.47 b	3.77 a	3.62 b	35.1 b	36.3 a	5.7 b	7.08 a	7.23 a	7.16 a	4.61 a	4.98 a	4.80 a

[z]Mean separation within columns by Duncan's Multiple Range Test at 0.05%.

juice volume per fruit due to their larger sizes in 1986 (Table 3) However, percentage of juice (based on fruit weight) and specific gravity of juice were not affected by any pruning treatments because percent juice is correlated positively with total juice per fruit and negatively with rind thickness. Although larger fruit from trees with moderate or severe cuts on two sides and the top had higher juice volume per fruit in 1986, they also had thicker rind (Table 3), thus resulting in a similar percentage juice. Fruit from trees with severe cuts on two sides and the top had lower SSC in 1986. Reduction of yield (Table 2) leads to a decreased competition for photosynthates and water among fruit, resulting in a higher leaf/fruit ratio and larger fruit in pruned trees. Since the larger fruit resulting from severe cut trees also had higher rind thickness but lower SSC, it is possible that the larger fruit size in those trees is a result of both thicker rinds and a higher water content rather than other factors.

No significant pruning-rootstock interaction was observed in this experiment.

Conclusion

Both rootstock and type of pruning have a major impact on lemon yield and fruit quality in the first year that pruning treatments are applied. Trees which received a cut on one side and the top had overall better yield and fruit quality. Severe cuts on two sides and the top reduces yield without a major improvement in fruit quality; this practice, therefore is not recommended. It may be beneficial to alternate the side of pruning every few years by moderately cutting one side and the top in one year and cutting the other side within the following two seasons.

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Linkage and Correlation Analysis of Some Traits in Peach

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Abstract

Segregating F_2 peach populations in the University of Florida breeding program were analyzed to determine linkage relationships among five qualitative traits: non-showy/showy flower (*Sh*), melting/non-melting fruit flesh (*M*), white/yellow fruit flesh color (*Y*), reniform/globose/absent leaf gland (*E*), and pubescent/glabrous fruit surface (*G*). Independent segregation was confirmed between the loci for fruit flesh color and leaf gland type, pubescence and flesh color, and flower type and pubescence. Independent segregation was found between the loci for leaf gland type and fruit flesh type and between the loci for pubescence and leaf gland type in our populations. The comparisons between the last two pairs have not been documented previously and should be investigated in other breeding populations. No reliable correlation was found between fruit development period and fruit flesh type. No correlation was found between chilling requirement and fruit flesh type nor between fruit flesh color and chilling requirement.

Introduction

Generally, breeding populations in tree fruit crops are highly heterozygous which interferes with effective segregation and linkage studies. Genetic studies of morphological traits are also hampered by long juvenile periods seen in most tree fruit species (8). The diploid, self pollinated peach [*Prunus persica* (L.) Batsch), which has a relatively short juvenile period, has attracted more genetic studies than most fruit crops (13). However, even with the relatively large amount of work done on peach, only a small number of single gene traits have been identified and little information on linkage relationships exists (8). Of the approximately 40 morphological and isozyme markers identified, seven linkage groups have been identified (5, 8, 15, 16). In order to identify possible linkage relationships among five qualitative traits of peach, inheritance data from 14 hybrid populations were analyzed.

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