Performance Of Various Lemon Types in Southwest Arizona

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ABSTRACT

Long term comparisons of 8 types of lemons (Citrus limon Burm. F.) on Macrophylla (Alemow) (C. macrophylla) rootstock regarding yield, tree growth, and quality under the arid conditions of the Southwest were studied. 'Foothill Lisbon' showed significantly higher cumulative yield and total acid than 'Monroe Lisbon', 'Prior Lisbon', Eureka strains, and 'Villa Franca', and had larger fruit than other Lisbon strains. 'Prior Lisbon' produced larger tree canopy than all other strains. Overall, Eureka strains and 'Villa Franca' had lower relative cumulative yield, yield efficiency, canopy volume, soluble solids, total acid, and fruit seed content , but higher soluble solids to acid ratio than Lisbon strains. All factors considered, 'Foothill Lisbon' and 'Prior Lisbon' have good potential for planting in the arid climate and sandy soil of Southwest, when Macrophylla rootstock is to be used.

INTRODUCTION

Lemon is the major type of citrus produced in the southwest. Arizona orchards, with an annual production of approximately 175,000 metric tons, provides 25% of the total lemon production in the United States (2). In spite of this large production, there is no comprehensive study to compare yield, growth, and quality of various strains of lemons. Our objective in this long-term study was to compare various strains of 3 major lemon varieties regarding yield, growth, and quality in the arid climate of the southwest.

MATERIALS AND METHODS

At the time this project was started, C. macrophylla appeared to be the rootstock of choice for the area; therefore, trees were budded onto this rootstock. Seeds were collected from an indexed C. macrophylla tree and planted in the greenhouse. The seedlings were grown and budded in the greenhouse with buds of 8 lemon types from trees which were free of viruses. The strains were chosen from 'Lisbon', 'Eureka', and 'Villa Franca' lemon varieties, and consisted of: 'Foothill Lisbon', 'Monroe Lisbon', 'Frost Nucellar Lisbon' ('F. N. Lisbon'), 'Rosenberger Lisbon', 'Prior Lisbon', 'Cook Eureka', 'Frost Nucellar Eureka' ('F. N. Eureka'), and standard 'Villa Franca'.

The orchard was established in May 1970 at the Yuma Mesa Agricultural Center, in southwest Arizona, with a planting distance 8.5 x 9.1m. The experimental design was a randomized complete block with 6 blocks (replications) of 2 trees each (total of 12 trees per strain), with guard trees on the end of each row. The soil was Superstition sand (Typic Calciorthid, sandy, mixed, hyperthermic; 90% sand), with pH of 8.0. Overall, cultural practices, soil and other environmental conditions in this experimental block were similar to those of commercial blocks in the Southwest.

Yield and trunk circumference (about 15 cm above the bud union) were measured, and the trunk cross-sectional area was calculated annually for 7 years. Volume of tree canopies were measured (by the formula: width 2 x height/4 (7)) in March 1982, when trees were 12 years old. Yield efficiency was calculated as yield kg per tree/cm^2 trunk cross- sectional area for each year. The mean yield efficiency was calculated by averaging yield efficiencies over 7 years. Fruit weight, juice volume and percent juice content, soluble solid, percentage of total acid in the juice, soluble solids/acid ratio, peel thickness and fruit seed content were evaluated in 7 years. All data were analyzed statistically using SAS computer program.

RESULTS AND DISCUSSION

Effects on yield and growth

In general, Lisbon strains, particularly 'Foothill Lisbon', had higher yield than those of Eureka strains and 'Villa Franka', perhaps because the Lisbons had larger canopies (Table 1). 'Prior Lisbon' had the largest tree canopy among all strains (Table 1). While Prior and Monroe Lisbons had a similar cumulative yield, 'Monroe lisbon' had significantly higher yield efficiency than 'Prior Lisbon', Eureka strains and 'Villa Franca' because of its smaller trunk cross-sectional area (Table 1). Tree growth in most trees started to decline after 16 years of planting (in 1986), due to sieve tube necrosis (1). This decline was more severe in 'Villa Franca' and Eureka strains and least severe in 'Prior Lisbon' (Table 1).

Effects on quality

'Foothill Lisbon', strains of Eureka, and 'Villa Franca' larger fruit with higher juice content than other strains of Lisbon (Table 2). Fruit peel in 'Cook Eureka' fruit was significantly thicker than those of 'F. N. Lisbon' and 'Prior Lisbon' (Table 2). Most of the strains having larger and juicier fruit also had thicker peel (Table 2). Therefore, no significant differences was found in the percent juice content among strains, as percent juice is affected by fruit wieght, peel thickness and total juice volume (Table 2).

Lisbon strains had generally higher soluble solids and total acid, but they had lower soluble solid/acid ratio than strains of Eureka and 'Villa Franca' (Table 2). In contrast to Batchelor and Bitters (3), no significant differences was found in total acid among Eureka strains and 'Villa Franca' lemons. (Table 2). Among all strains, 'Foothill Lisbon' ranked highest in percent total acid and soluble solids, but ranked lowest in solid/acid ratio (Table 2). Since yield, fruit weight and acid content are high in 'Foothill Lisbon', total juice and acid production per tree in Foothill should also be higher than other strains. Juice specific gravity was proportional to soluble solids in all strains (data not shown). Fruits of 'Foothill Lisbon', 'Prior Lisbon', and 'F. N. Lisbon' had smoother skin and less internal granulation than other strains (data not shown). Fruit of 'F. N. Lisbon', Eureka strains, and 'Villa Franca' had fewer seeds, while 'Monroe,' 'Rosenberger,' and 'Prior' Lisbons had higher number of seeds (Table 2).

Relationships between yield and quality

Various yield and quality factors were interrelated. For example, larger fruit generally had thicker peel ($r = 0.77$). Crop load is reported to influence various quality factors by altering fruit size (5). However, this was not the case in our experiment. As an example, 'Foothill Lisbon' which had the highest yield (Table 1) also had larger fruit than other strains of 'Lisbon' (Table 2). Higher yield showed significantly positive correlations with percent acid in the juice ($r = 0.55$). This relationship deserves further studies.

Overall, 'Foothill Lisbon' was a superior strain in our long-term experiment. Although it is difficult to select a single strain with all of the desirable characteristics, 'Foothill Lisbon' is superior to others in yield, fruit size, acid content and fruit skin smoothness. However, it should be noted that both 'Foothill Lisbon' and 'Monroe Lisbon' are suceptible to exocortis, a mycoplasma-like organism, which can be transmitted by budding and pruning tools (4 , 6). Therefore, sanitary budding, nursery and field precautionary practices must be followed, and suceptible rootstocks, such as trifoliate orange (Poncirus trifoliata Raf.), citrange (P. trifoliata x c. sinensis) and Rangpur lime (C. aurantifolia L.), must be avoided.

Based on this experiment, 'Cook Eureka', 'F. N. Eureka' and 'Villa Franca' are not desirable for planting under the arid climate and sandy soil of the southwest because of their low yield and poor tree growth. Even if rootstocks other than Macrophylla are used to improve the tree growth in these strains, the low acid content of these strains is undesirable.

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Table 1. Comparison of yield, yield efficiency and tree growth in different strains of lemon[z].

	Yield (kg/tree)							Cumulative yield 1976-82	Trunk cross-sectional area in 1982 (cm^2)	Mean yield efficiency (kg/cm^2)	Canopy volume in 1982 (m^3)
	1976	1977	1978	1979	1980	1981	1982				
Fo. Lisbon[y]	41 ab[x]	84 a	64 a	158 a	66 b	110 a	78 a	601 a	282 ab	.56 abc	19.9 b
Mo. Lisbon	41 ab	50 bcd	56 ab	117 b	57 b	87 b	43 b	451 bc	198 d	.63 a	14.2 c
F.N. Lisbon	45 ab	75 ab	62 ab	106 bc	87 a	104 a	80 a	559 ab	272 abc	.52 abcd	18.7 bc
Ro. Lisbon	56 a	63 abc	65 a	118 b	60 b	98 a	67 ab	527 ab	226 cd	.61 ab	17.9 bc
Pr. Lisbon	42 ab	58 bc	56 ab	86 bcd	51 b	92 b	61 ab	446 bc	292 ab	.42 bcd	27.3 a
Co. Eureka	30 b	30 d	45 ab	71 cd	55 b	96 b	80 a	406 c	321 a	.32 d	14.1 c
F.N. Eureka	40 ab	46 cd	42 b	67 cd	64 b	92 b	77 a	429 bc	266 bc	.39 cd	13.9 c
Vi. Franca	25 b	39 cd	53 ab	60 d	63 b	84 b	64 ab	388 c	227 cd	.40 cd	13.0 c

[z]Trunk cross sec. = Trunk cross sectional area after 12 years of planting; Mean yield efficiency = Mean yield efficiency over 7 years; Canopy volume = volume of each tree canopy 12 years after planting.

[y]Abbreviations for strains: Fo. Lisbon = 'Foothil Lisbon'; Mo. Lisbon = 'Monroe Lisbon'; F.N. Lisbon = 'Frost Nucellar Lisbon'; Ro. Lisbon = 'Rosenberger Lisbon'; Pr. Lisbon = 'Prior Lisbon' ; Co. Eureka = 'Cook Eureka'; F.N. Eureka = 'Frost Nucellar Eureka'; Vi. Franca = 'Villa Franca'.

[x]Mean separation within columns by Duncan's Multiple Range Test, 5% leve.

Table 2. Influence of different strains on lemon fruit quality[z].

Strain[y]	Fruit wt. (g/fruit)	Fruit volume (ml/fruit)	% Juice (w/w)	Peel Thickness (mm)	Soluble Solids (Brix)	Total acid (% juice)	Sugar/acid ratio	Number of seeds per fruit
Fo. Lisbon	105.4 a[x]	42.6 ab	41.4 a	3.9 ab	7.66 a	5.4 a	1.42 c	6 bc
Mo. Lisbon	97.0 b	39.9 bc	42.2 a	3.8 ab	7.60 a	5.2 b	1.50 bc	8 ab
F.N. Lisbon	97.5 b	41.3 abc	43.4 a	3.6 b	7.61 a	5.3 ab	1.48 bc	4 cd
Ro. Lisbon	97.6 b	40.0 bc	41.9 a	3.8 ab	7.54 ab	5.3 ab	1.46 c	9 a
Pr. Lisbon	95.3 b	39.1 c	41.8 a	3.5 b	7.54 ab	5.2 b	1.49 bc	7 ab
Co. Eureka	106.5 a	41.6 ab	40.5 a	4.1 a	7.26 d	4.8 c	1.56 a	3 d
F.N. Eureka	105.5 a	44.4 a	43.1 a	3.8 ab	7.33 cd	4.9 c	1.53 ab	2 d
Vi. Franca	104.2 a	43.7 a	43.0 a	3.8 ab	7.41 bc	4.9 c	1.56 a	4 cd

[z]Each value in the table represents an average of 7 years of data with 6 blocks (replications) per strain per year and 2 trees per replication.

[y]Abbreviations for strains: Fo. Lisbon = 'Foothill Lisbon; Mo. Lisbon = 'Monroe Lisbon'; F.N. Lisbon = 'Frost Nucellar Lisbon'; Ro. Lisbon = 'Rosenberger Lisbon'; Pr. Lisbon = 'Prior Lisbon' ; Co. Eureka = 'Cook Eureka'; F.N. Eureka = 'Frost Nucellar Eureka'; Vi. Franca = 'Villa Franca'.

[x]Mean separation within columns by Duncan's Multiple Range Test, 5% level.