

Yield Growth and Fruit Quality of 'Fuerte' and 'Ettinger' Cultivars of Avocado on Four Rootstocks in Cyprus

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SUMMARY

Yield, tree growth, and fruit quality were measured for 'Fuerte' and 'Ettinger' cultivars of avocado on 'West Indian', 'Duke', 'Topa-Topa', and 'Mexicola' rootstocks. From 1981, when cultivars were 10 years old to 1990, the highest cumulative yield per tree of 'Fuerte' was recorded on 'Mexicola' rootstock and the lowest on 'Duke'; whereas for 'Ettinger', the highest cumulative yield was recorded on 'West Indian' rootstock and the lowest on 'Duke'. The individual fruits of 'Ettinger' were significantly heavier than those of 'Fuerte' on all rootstocks, but in neither cultivar did the rootstock affect mean fruit weight significantly. Although there were some small differences in the percentage of stone and oil content of fruit, these differences were not large enough to likely affect the market value of the fruit. The 'Fuerte' trees were spreading in habit on all rootstocks, whereas 'Ettinger' had an upright growth habit. Trees of both cultivars were most tolerant to lime-induced chlorosis when grown on 'West Indian' rootstock.

The avocado, *Persea americana* Miller, is a relatively new crop in many areas of the world outside its native range in the American subtropics, but it has frequently proved to be a very profitable commercial crop for both local consumption and export.

It was brought to Cyprus in 1970 for trials at the southwest coastal part of the island where soil, water, and climatic conditions appeared to be favorable for growing avocado. The first planting was successful and the enterprise started to expand. The area of avocado in 1990 was 134 hectares and avocado production in the same year reached 800t.

The performance of two cultivars on four rootstocks for ten years as measured by growth, yield, and quality are presented in this paper.

MATERIALS AND METHODS

The cultivars 'Fuerte' and 'Ettinger' were tested on 'West Indian', 'Duke', 'Topa-Topa', and 'Mexicola' rootstocks.

Seeds of 'West Indian' were obtained from the University of the West Indies in Trinidad and those of 'Duke', 'Topa-Topa', and 'Mexicola' from the University of California, Los Angeles. Seeds were sown in boxes in February 1970; and about three months later, when the seedlings were about 15cm tall, they were transplanted into a nursery row. The young rootstocks were grafted in September 1970 with buds of the cultivars 'Fuerte'

and 'Ettinger' which were obtained from Israel.

The trees were raised in the nursery by standard practice and transplanted with a ball of soil in May 1971 to the Government Farm of Kouklia, Paphos. The trees were planted in a 4x2 factorial combination arranged in a Randomized Complete Block design with four replications of single-tree plots of each rootstock/cultivar combination. There was a missing plot which was estimated. The spacing was 6x6m.

The soil was a well drained sandy-clay loam with a CaCO₃ content of 35% and pH of 8.2 (measured on a 1:2.5 soil:water suspension). The area has an average yearly rainfall of 420mm, falling mainly from October to April, and mean maximum air temperatures ranging from 17 °C in January to 33 °C in July, with mean minima from 9 °C to 21°C. Relative humidity ranges from 70% to 80% during the winter months and from 60% to 70% in summer.

A total of about 25 irrigations were applied per year at weekly intervals during each irrigation season. The irrigation was applied with microjet sprinklers, and about 700 liters of surface water per tree were given in each application. The water was obtained from a dam, had a pH of 7.6 and an electrical conductivity of 0.7 mmhos/cm, and contained an average of 450 ppm total soluble salts including 53 ppm Cl, 57 ppm Na, 58 ppm Ca, 20 ppm Mg, 134 ppm SO₄, and 128 ppm HCO₃. In spring, a month before flowering, annual applications of ammonium sulphate, triple superphosphate, and potassium sulphate were made at 3.0 Kg, 0.5Kg and 1.0 Kg per tree, respectively. The orchard was cultivated with rotavators to suppress weeds, and the trees were pruned as required.

Trunk circumference was measured in October 15cm above the bud union and expressed to trunk cross-sectional area.

Yield was measured in the first week of November each year as kg of fruit per tree from 1981, when cultivars were 10 years old, to 1990. Composite samples to determine fruit weight, weight of stone, and oil content were collected from 1987 to 1990 and consisted of 80 fruits picked at random from all trees of each rootstock-cultivar combination. These parameters were determined by standard methods.

RESULTS AND DISCUSSION

Annual and cumulative yields per tree of the two cultivars on the different rootstocks are presented in Table I. The annual yields of both cultivars seem to lack consistency. The yield of 'Ettinger' in 1987 and the yield of 'Fuerte' in 1980 were negligible. This variability in production of the two cultivars probably reflects a tendency to alternate bearing.

There were statistically significant differences between the cumulative yields of 'Fuerte' and 'Ettinger' over the last ten years (1981-90) of production on the different rootstocks. The highest cumulative yield per tree of 'Fuerte' was recorded on 'Mexicola' rootstock and the lowest on 'Duke'; whereas for 'Ettinger', the highest cumulative yield was recorded on 'West Indian' rootstock and the lowest on 'Duke'. There were no statistically significant differences between the cumulative yields of the two cultivars on the four rootstocks during the first seven years of production (1974-80) [Economides and Gregoriou, 1982]. Ben-Ya'acov [1976] has reported better yields from both 'Fuerte' and

'Ettinger' on 'West Indian' rootstock. The average cumulative yields of the two cultivars over all rootstocks were not significantly different from each other.

Table I. Effect of rootstock on yield of 'Fuerte' and Ettinger' cultivars of avocado.

Cultivar/ rootstock	Yearly mean yields per tree (Kg)										Cumulative yield per tree 1981-90 (kg)
	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	
Fuerte											
West Indian	39.9 a*	30.6 a	47.3 a	47.0 a	65.3 ab	70.9 a	53.7 a	42.6 ab	62.8 a	7.9 a	468.3 b
Duke	30.6 a	21.5 a	48.7 a	43.7 a	70.0 ab	43.6 a	21.8 a	21.8 b	68.5 a	2.2 a	372.5 c
Topa-Topa	32.1 a	20.0 a	30.4 a	60.1 a	42.7 b	70.4 a	28.9 a	43.5 ab	136.1 a	2.1 a	466.5 b
Mexicola	44.6 a	12.9 a	50.3 a	61.5 a	95.2 a	71.4 a	50.2 a	77.0 a	110.5 a	11.7 a	585.3 a
Mean	36.8	21.3	44.2	53.1	68.3	64.1	38.6	46.2	94.5	6.0	473.2
Ettinger											
West Indian	35.4 ab	67.9 a	55.5 a	79.7 a	57.1 a	128.0 a	12.7 a	76.8 a	59.2 a	46.6 a	619.0 a
Duke	9.7 b	56.5 a	23.5 a	88.4 a	11.1 b	51.2 b	9.5 a	32.6 a	24.0 a	27.0 a	336.6 b
Topa-Topa	40.2 a	82.5 a	42.0 a	88.5 a	28.7 ab	114.2 a	4.7 a	70.1 a	74.5 a	21.2 a	567.0 a
Mexicola	11.5 b	12.2 b	63.7 a	9.4 b	41.7 ab	38.5 b	20.6 a	33.0 a	55.3 a	59.3 a	345.3 b
Mean	25.1	57.6	45.0	70.3	34.2	86.0	11.3	54.5	53.1	37.2	474.3
MEAN	31.1	38.8	44.6	61.4	51.8	74.7	25.4	50.2	74.5	21.1	473.7
S.E for cultivar	4.5	7.0	6.7	7.3	7.2	10.5	5.1	7.6	13.9	6.1	32.6
S.E for rootstock	6.4	10.0	9.8	10.3	10.2	14.8	7.2	10.8	19.7	8.7	46.1
S.E for rootstock within cultivar	9.1	14.1	13.9	14.6	14.4	21.0	10.1	15.2	27.9	12.3	65.2

+ Means within the same column followed by the same letter for each cultivar do not differ significantly at P=0.05 according to the Duncan's multiple-range test.

The average sizes in 1990 of the trees on the different rootstocks, as indicated by the trunk cross-sectional areas, are given in Table II. After twenty years of growth, the four rootstocks did not significantly affect the size of 'Fuerte' trees, although the largest trees of 'Fuerte' were on 'West Indian' rootstock and the smallest on 'Duke'. On the other hand rootstocks significantly affected the size of 'Ettinger' trees, the largest being on 'Topa-Topa' and the smallest on 'Mexicola' rootstock. Eleven years ago, Economides and Gregoriou [1982] reported that in the same experiment the largest trees of 'Fuerte' and 'Ettinger' were also on 'West Indian' rootstock. The correlation coefficient between average size of tree and cumulative yield was not significant ($r=0.55$, $P=0.15$).

The 'Fuerte' trees on all four rootstocks had a spreading habit of growth, whereas 'Ettinger' had an upright habit with little spreading. The upright growth of 'Ettinger' was a disadvantage during harvest. It was noted that the trees of both cultivars on 'West Indian' rootstock were more tolerant to lime-induced chlorosis than those on other rootstocks. This observation supports those of Bergh [1975], Kadman [1985], and Lopez [1985] who stated that the 'West Indian' avocado is the most tolerant race to lime-induced chlorosis. In Cyprus, such chlorosis is a serious problem because most soils are alkaline. The chlorosis was corrected by soil application of Fe EDDHA, known commercially as Sequestrene 138, at the rate of 150g per tree. This compound was applied annually in spring inside the drip-line of each tree and washed down to the root zone by irrigation given soon afterwards.

Average fruit weight, weight of stone, and oil content of fruit for the years 1987-90 are

shown in Table II. The individual fruits of 'Ettinger' were significantly heavier than those of 'Fuerte' on all rootstocks, but in neither cultivar did the rootstocks affect mean fruit weight significantly. Similarly, rootstocks did not significantly affect the stone percentage of the fruits of the two cultivars, but the weight of stone of 'Ettinger' fruit was significantly higher than that of 'Fuerte' over all rootstocks. Rootstocks did not significantly affect the oil content of fruits of 'Fuerte', but oil content of fruits of 'Ettinger' was significantly higher on 'West Indian', 'Mexicola', and 'Duke' than on 'Topa-Topa' rootstock. Over all rootstocks, fruits of 'Ettinger' had significantly higher oil content than fruits of 'Fuerte'.

Table II. Effect of rootstock on tree size, fruit weight, percentage of stone, and oil content of 'Fuerte' and 'Ettinger' cultivars of avocado.

Cultivar/ rootstock	Average tree size in 1990 (cm ²)	Average fruit weight (1987-90) (g)	Average weight of stone (1987-90) (%)	Average oil content of fruit (1987-90) (%)
<u>Fuerte</u>				
West Indian	396.9 a	262.8 a	16.3 a	11.6 a
Duke	320.1 a	241.2 a	18.8 a	12.2 a
Topa-Topa	363.1 a	266.0 a	17.3 a	11.8 a
Mexicola	337.1 a	266.5 a	18.2 a	12.1 a
Mean	355.4	259.1	17.7	11.9
<u>Ettinger</u>				
West Indian	508.4 b	315.7 a	21.0 a	13.9 a
Duke	383.2 c	338.5 a	22.2 a	13.3 ab
Topa-Topa	791.1 a	339.2 a	23.7 a	12.7 b
Mexicola	288.7 d	318.0 a	21.4 a	13.6 a
Mean	506.3	328.5	22.1	13.4
MEAN	428.3	293.8	19.9	12.6
S.E for cultivar	30.7	5.4	0.3	0.09
S.E for rootstock	43.5	7.7	0.4	0.13
S.E for rootstock within cultivar	61.5	10.8	0.6	0.2

+ Means within the same column followed by the same letter for each cultivar do not differ significantly at P=0.05 according to the Duncan's multiple -range test.

Although there were some small differences in fruit weight, percentage of stone, and oil content of fruit, these differences were not large enough to likely affect the market value of the fruit. It was observed that fruits of 'Fuerte' had longer storage life than those of 'Ettinger', and this could be an advantage in long-distance transport. This is in

agreement with Vakis [1982] who reported that fruits of 'Fuerte' stored well for three weeks at 4.4°C, whereas fruits of 'Ettinger' stored well only for one week at the same temperature.

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