California Avocado Society 1991 Yearbook 75:87-92

Performance of Ettinger, Fuerte, and Hass Cultivars of Avocado on Two Rootstocks in Cyprus

C. Gregoriou and C. V. Economides
Agricultural Research Institute, Nicosia, Cyprus.

Summary

In a trial conducted in Cyprus, during the first twelve years of production there were no significant differences in the cumulative yields per tree of the avocado cultivars 'Ettinger', 'Fuerte', and 'Hass' on 'Lula' and 'West Indian' rootstocks. Also, rootstocks did not significantly affect the average tree size and average fruit weight of the three cultivars, but fruits of all cultivars had significantly higher weight of stone on 'Lula' than on 'West Indian' rootstocks. Fruits of 'Ettinger' had significantly higher oil content on 'Lula' than on 'West Indian' rootstock, but rootstock did not affect significantly oil content of 'Fuerte' and 'Hass'. The trees of 'Fuerte' and 'Hass' were spreading in habit on both rootstocks, whereas trees of 'Ettinger' had an upright growth habit. Trees of all cultivars were most tolerant to lime-induced chlorosis when grown on 'West Indian' rootstock.

Introduction

The avocado *(Persea americana* Miller) is a relatively new crop in areas of the world outside its native range in the American tropics, but it has frequently proved to be a very profitable commercial crop for both local consumption and export. Hence, in recent years there has been an interest in the establishment of plantations of avocado in many countries where conditions are favorable for its growth and production.

Avocado is already grown in countries of the Mediterranean area, mainly in Spain, Portugal, Sicily, Israel, Greece, Morocco, Algeria, Egypt, and the Canary Islands (Gustafson, 1976). It was introduced in Cyprus for trial in 1970 where soil, water, and climatic conditions in the southwest coastal part of the island 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 ha and avocado production in the same year reached 800t.

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

Materials and Methods

The cultivars 'Fuerte', 'Ettinger', and 'Hass' were tested on 'West Indian' and 'Lula' rootstocks. Seeds of 'West Indian' were obtained from the University of the West Indies in Trinidad and those of 'Lula', from the University of California, Los Angeles. Seeds were sown in boxes in February 1974, and about three months later, when seedlings

were about 15 cm tall, they were transplanted into a nursery row. The young rootstocks were worked in October 1974 with buds of the cultivars 'Ettinger', 'Fuerte', and 'Hass' which were obtained from each single tree, respectively. The scions of all the trees of each variety were thus of the same clonal strain.

The trees were raised in the nursery by standard practice and transplanted each with a ball of soil in April 1974 in the Government Farm of Kouklia, Paphos. The 2X3 factorial combinations were arranged in a Randomized Complete Block design with six replications of three-tree plots of each rootstock/cultivar combination. The spacing was 6X6m.

The soil was a well drained sandy-clay loam with a $CaCO_3$ content of 35% and pH of 8.2 (measured on a 1:2.5 soil:water suspension). The specific conductivity of a saturated soil extract at 25°C was 0.80, 1.10, and 2.00 mmhos/cm at depths of 30, 60, and 90cm, respectively. 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 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, the amount increasing progressively each year to reach 700 liters of water per tree in each application. The water was obtained from a dam, and 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 Mg, 134 ppm SO_4, and 128 ppm HCO_3. In spring, a month before flowering, annual applications of ammonium sulphate, triple superphosphate, and potassium sulphate were applied, the amounts increasing progressively each year to reach 3.0 kgs, 0.5 kg, and 1.0 kg per tree, respectively. The orchard was cultivated with rotavators to suppress weeds, and the trees were pruned as required.

Tree size was recorded per tree from 1979 to 1990 and always harvested in the end of November for the 'Fuerte' and 'Ettinger' and after the middle of December for 'Hass'. Composite fruit samples for fruit weight, weight of stone, and oil content in 1987 to 1990 consisted of 90 fruits picked at random from all trees of each rootstock-cultivar combination. These parameters were determined by standard methods.

Results and Discussion

Yearly mean yields per tree of the three cultivars on the different rootstocks are presented on Table I. There were no significant differences among the annual yields of the three cultivars on the two rootstocks during the first twelve years of production. The annual yields of all three cultivars seem to lack consistency, and in some years the yield was negligible. This variability in production of the three cultivars is probably reflecting a tendency to biennial bearing.

Also, there were no statistically significant differences among the cumulative yields of 'Ettinger', 'Fuerte', and 'Hass' over the first twelve years (1979-1990) of production on each one of the two rootstocks (Table II). On the other hand, there were statistically significant differences in the cumulative yields among the three cultivars over the two rootstocks. The highest cumulative yield was obtained from 'Fuerte' and the lowest, from 'Hass'. Cumulative yield of 'Ettinger' was intermediate but did not significantly differ from that of 'Fuerte'.

The average size of the trees of the three cultivars on the two rootstocks in 1990, as indicated by the trunk cross-sectional areas, is given in Table II. After twelve years of growth the two rootstocks did not significantly affect the size of trees of three cultivars, although the largest trees of 'Fuerte' were on 'West Indian' and of 'Hass', on 'Lula' rootstock.

The 'Fuerte' and 'Hass' trees on both 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 trees of all three cultivars were more tolerant to lime-induced chlorosis on 'West Indian' than on 'Lula' rootstock. This observation supports that 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.

Average fruit weight, weight of stone, and oil content of fruit for the years 1987-1990 is shown in Table II. Rootstock did not significantly affect average weight of fruit, although trees of 'Fuerte' and 'Ettinger' produced the heaviest fruit on 'West Indian' and trees of 'Hass', on 'Lula' rootstock. On the other hand, there were significant differences in the average fruit weight among the three cultivars over the two rootstocks. Fruits of 'Ettinger' had the highest weight and fruits of 'Hass,' the lowest. Rootstock significantly affected the average stone weight of fruit. Fruits of all three varieties had significantly heavier stone on 'Lula' than on 'West Indian' rootstock. Also, there were significant differences in the average weight of stone of the three cultivars over the two rootstocks. Fruits of 'Ettinger' had the highest stone weight and fruits of 'Hass', the lowest. Rootstock did not significantly affect the oil content of fruit with the exception of 'Ettinger', where fruits on 'Lula' had significantly higher oil content than fruits on 'West Indian' rootstock. There were significant differences in the average fruit oil content among the three cultivars over the two rootstocks. Fruits of 'Hass' had the highest oil content (14%) and fruits of 'Fuerte', the lowest (11.2%)

Although there were some small differences in fruit weight, percentage of stone, and oil content of fruits, these differences were not large enough to likely affect the market value of the fruit. Unlike other fruits, avocados ripen after they have been picked. The stage of maturity at harvest is very important, because immature fruits will not ripen properly and will not attain acceptable eating quality after harvest. In Cyprus, 'Fuerte' and 'Ettinger' fruits matured after the middle of October (early varieties), whereas 'Hass' fruits matured after the middle of December and it is considered as a late cultivar (Vakis, et al, 1985). It was observed that fruits of 'Fuerte' and 'Hass' 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' and 'Hass' stored well for three weeks at 4.4°C, whereas fruits of 'Ettinger' stored well only for one week at the same temperature.

References

Bergh, B. O. (1975). Avocado research in Israel. Yearbook. California Avocado Society, 58, 108-26.

Gustafson, C. D. (1976). World avocado production. In: Proceedings of the First International Tropical Fruit Short Course. The Avocado, (ed. J. W. Sauls, R. L. Philips, and L. K.Jackson), pp. 1-9. University of Florida, Gainesville, Florida.

Kadman, A. (1985). Selection of avocado and mango rootstocks for calcareous soils. Acta Horticulturae. No. 158, 63-67.

Lopez Jimenez, A.; Alcade Blanco, A.; Borys, M. W.; Barrera Guerra, J. L. (1985). Response of Mexican, West Indian, and Guatemalan avocados to soils with different calcium carbonate contents. Horticulture Mexicana. 1 (1), 51-62.

Vakis, J. N. (1982). Storage behaviour of Ettinger, Fuerte, and Hass avocados grown on Mexican rootstock in Cyprus. Journal of Horticultural Science, 57 (2), 221-26.

Vakis, N. J.; Gregoriou, C.; and Papademetriou, M. (1985). Maturity and picking dates of avocados under Cyprus conditions. California Avocado Society Yearbook, Vol. 69:81-88.

Table 1. Effect of rootstock on annual yields of 'Ettinger', 'Fuerte', and 'Hass' cultivars of avocado.

	Yearly mean yield per tree (kg)											
Cultivar / rootstock	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Ettinger												
Lula	1.0	0.3	1.5	8.3	21.1	29.7	34.6	28.4	29.3	25.8	47.5	32.2
West Indian	2.5	0.4	2.2	9.5	13.4	31.3	40.2	46.5	29.1	23.8	42.3	19.1
Mean	1.7	0.3	1.9	8.9	17.2	30.5	37.4	37.4	29.2	24.8	45.0	25.6
Fuerte												
Lula	6.1	2.7	13.4	20.9	34.1	34.2	42.5	20.8	27.7	24.7	76.9	3.0
West Indian	6.1	4.5	12.4	23.5	36.5	29.7	50.0	26.6	26.5	17.1	54.1	6.0
Mean	6.1	3.6	12.9	22.2	35.3	31.9	46.2	23.7	27.1	20.9	65.5	4.5
Hass												
Lula	0.0	0.2	0.0	7.0	25.7	12.0	24.5	4.5	31.8	27.2	29.6	46.1
West Indian	0.0	1.3	3.6	17.3	18.7	8.3	33.2	13.3	,31.6	20.8	28.0	14.1
Mean	0.0	0.7	1.8	12.1	22.4	10.1	28.8	8.9	31.7	24.0	28.8	30.1
MEAN	2.6	1.6	5.5	14.4	24.9	24.2	37.5	23.3	29.4	25.9	46.4	20.1
S.E. for cultivar	0.66	0.50	1.21	3.01	4.29	3.40	4.35	3.84	5.94	4.15	6.36	6.19
S.E. for rootstock	0.54	0.40	0.99	2.46	3.50	2.78	3.55	3.13	4.85	3.39	5.19	4.75
S.E. for rootstock within cultivar	0.93	0.70	1.72	4.26	6.07	4.82	6.16	5.43	8.40	5.87	9.0	8.75

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

Cultivar / rootstock	Cumulative yield per tree (kg/tree) (1979 - 1990)	Average tree size in 1990 (cm^2)	Average fruit weight (1987 - 1990)	Average weight of stone %	Average oil content of fruit %
Ettinger					
Lula	260.0	202.1	298.1	22.2 a++	13.1 a
West Indian	260.3	236.7	322.8	21.3 b	12.6 b
Mean	260.2	219.4	310.5	21.7	12.8
Fuerte					
Lula	307.2	266.2	245.4	18.0 a	11.1 a
West Indian	293.1	292.5	252.1	16.6 b	11.2 a
Mean	300.1	279.3	248.7	17.3	11.2
Hass					
Lula	208.7	267.4	221.1	16.2 a	14.0 a
West Indian	190.1	258.2	210.0	15.3 b	14.0 a
Mean	199.4	262.8	215.5	15.7	14.0
MEAN	253.2	253.8	258.2	18.3	12.7
S.E. for cultivar	15.83	12.96	6.36	0.07	0.07
S.E. for rootstock	12.92	10.59	5.17	0.06	0.59
S.E. for rootstock within cultivar	23.38	18.34	8.96	0.10	0.10

+ Relative tree size indicated by area of cross section of trunk 15cm above bud union.
++ 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.