CALIFORNIA PISTACHIO ROOTSTOCK TRIALS: 1989-2001

Louise Ferguson, Extension Pomologist, University of California, Davis at Kearney Agricultural Center

Robert Beede, Farm Advisor, Kings County

Heraclio Reyes, Laboratory Assistant, University of California, Davis at Kearney Agricultural Center

Mahmoud Seydi, Graduate Student, University of Tehran, Tehran, Iran

SUMMARY

Currently, the California pistachio industry relies upon four rootstocks, two species and two interspecific hybrids, all members of the genus Pistacia. They are P. atlantica, P. integerrima (PGI), P. atlantica x P. integerrima (PGII and UCB-1). The first three are open pollinated, the last a result of closed pollination. All knowledge of these rootstocks prior to this trial was anecdotal. There is no long term data demonstrating relative rootstock effects on yield, nut quality and alternate bearing. That was the objective of this trial.

These three rootstock plots in this trial were established in three major pistachio production microclimates of California. The plots are located in Fresno, Madera and Kern Counties. The trials were established in 1989 (Table 1) and are now completing their twelfth year in the ground. Thus far, these trials demonstrated significant differences among the rootstocks in Verticillium wilt tolerance, freeze tolerance, and micronutrient uptake (Beede, et al., 1991; Epstein, et al., 1992; Ferguson, L., 1990; Ferguson, 1991; Ferguson, et al., 1991; Ferguson and Brown, 1990; Ferguson et al., 1990; Ferguson, et al., 1991, Morgan, et al., 1992). Furthermore, physiological investigations in 1992 (Ferguson, L., et al., 1993) demonstrated the observed differences in growth rate and early bearing are not the result of differences in the ability of the rootstocks to conduct water to, or affect the photosynthetic rate, of the Kerman scion.

Results through this final year, from 1989 though 2001, demonstrate rootstock has a significant effect on mature tree yield. The differences in yield among the rootstocks is a function of number of clusters per tree. The other components of yield, number of nuts per cluster, stable at 12-18 nuts per cluster, and nut size are unaffected by rootstock. Similarly rootstock does not affect the percentage of splits and blanks, or nut size. Nor does rootstock affect alternate bearing. Thus, if future breeding efforts include improving nut size, increasing splitting or decreasing blanking, or minimizing alternate bearing, the efforts should focus on scion breeding.

The data now conclusively demonstrates trees on UCB-1 rootstocks consistently produce significantly better yields than trees on any of the other three rootstocks. Trees on other hybrid rootstock, PGII, and trees on PGI, produce equally well. Both produce significantly lower yields than trees on UCB1 rootstocks. Trees on UCB1, PGI and PGII rootstocks all produce significantly better yields than trees on Atlantica rootstocks.

Further, these trials demonstrate trees grown on the west side of the southern San Joaquin Valley will consistently produce higher early yields than trees grown in the central San Joaquin Valley, irrespective of rootstock.

PROCEDURES

When these trials were planted and budded, is detailed in Table 1. There are 400 trees, divided into 100, four-tree plots containing one of each of the four rootstocks. Ten of these four-tree plots are grouped into a 40-tree irrigation set. This is to facilitate later irrigation, fungicide, growth regulator, pesticide, biocontrol, or nutrition trials. All of the trees are budded with the same female and male. With these locations, and this design, we are attempting to observe the behavior of the different rootstocks under a range of climatic conditions. This is particularly facilitated by budding with the same clonal material. The same female and male tree was used as a bud source for all the trees in all the plots.

Table 1.

Location	**Planted**	**Budded**
Madera County	5/28/88+	+
KAC	2/22/89	7/10/89
Kern County	3/4/89	8/14/89

+This demonstration plot was established independently a year before this trial using budded trees, and a different field design.

RESULTS AND DISCUSSION

Yield and Nut Quality

Early bearing was determined by individual tree harvest and grading of all trees. Starting in 2000 nuts were graded using USDA standards at Paramount Farming Companies grading facility. The results are given in Table 2. From this table it can be seen that trees on UCB-1 rootstocks produced significantly higher, early cumulative yields than trees on the other three rootstocks. Over the life of this trial there have been exceptions within individual years and plot locations. Generally, rootstock effect on yield ranked as follows: UCB-1 > PGI = PGII > Atlantica. As these plots age the differences in yield among rootstocks with _P. integerrima_ parentage may dissipate. However, these trees are now considered mature, and thus far, trees on UCB-1 rootstocks have produced the highest early yields. This is consistent over all three plot locations.

Earlier than expected, in the tenth year of the trial, 1999, trees in all three trial locations began to alternate bear sharply. This is true for trees on all four rootstocks. This will make it possible to have a calculated alternate bearing index within four years, by 2003. Three, two-year cycles, are required to calculate a reliable alternate bearing index. The 1998 through 2000 yields have provided the first half of the data required for this calculation.

Table 2. Effect of rootstock on crop year 2001 yield and grade out. *

	County	UCB	PGII	PGI	Atlantica
2001 Yield/Tree Total Edible Weight **2001 Yield/Acre Total Edible Weight @ 112/Bearing Trees/Acre** (kg dry inshell split/)	Fresno	6.1a 683	5.7a 638	3.5b 381	2.0b 224
	Kern (NS)	14.0 1568	12.0 1344	11.3 1266	10.5 1176
	Madera+				
Alternate Bearing Index	Fresno(NS)	0.63	0.62	0.66	0.70
	Kern	0.55b	0.61ab	0.61ab	0.64a
	Madera+	0.79	0.65	0.79	0.70
% Total Edible Split Inshell; USDA Sample	Fresno(NS)	57	55	54	51
	Kern	66b	69a	67ab	67ab
	Madera* (NS)				
# Nuts per Ounce	Fresno	20b	21ab	22a	21ab
	Kern (NS)	21	21	21	20
	Madera+				
Cumulative Yield to 2001 (lbs/acre @ 112 trees/acre)	Fresno	11,095a	9,539b	9,442b	7,394c
	Kern	15,258a	13,301b	13,052b	11,418c
	Madera+	7,106a	6,285b	5,643c	4,258d

*Values within a row followed by different letters are significantly different. Lack of letters indicates no significant differences within a horizontal row.
+Estimated yield less than 40 pounds per acre, or essentially no yield.

The results given in Table 2 clearly demonstrate Kerman trees on UCB1 rootstocks produce significantly better yields than trees on any of the other three rootstocks in the trial. Trees on PGII and PGI rootstocks produce equally well. And trees on all three of these rootstocks produce significantly better yields than trees on Atlantica rootstocks.

The component of yield responsible for these significant differences in yield is number of clusters per tree. The number of nuts per cluster, 12-18, and nut size, number of nuts per ounce, remained stable through the trial. In all locations there were no consistent, significant differences in the percentage of total edible split inshell nuts, or blanks, among the four rootstocks.

CONCLUSIONS

As the trees in these plots were budded with Kerman and Peters buds from the same trees all growth and yield differences can be attributed to the rootstock. However, there no demonstrated effects of rootstock on the percentage of split or blank nuts, or nut size. Alternate bearing intensity was similarly unaffected by rootstock. Therefore, any future attempts to improve these factors should be done with the scion cultivars, not restock.

Recent evidence being developed by Dr. Lynne Epstein (Epstein et al, 2000, 2001) increasingly demonstrates trees on UCB-1 rootstocks possess Verticillium tolerance equal to that of trees grown on PGI rootstocks. Thus far trees on both rootstocks have had no mortality, trees on UCB-1 are producing better yields, and trees on both rootstocks both are rated equally well in terms of general vigor. Cumulatively, this evidence demonstrates trees on PGI rootstocks possess no clear advantage over trees on UCB-1 rootstocks in terms of Verticillium tolerance.

Trees on UCB-1 rootstocks are also clearly more cold tolerant than trees on PGI rootstocks. An evaluation of young tree mortality, and freeze damage, after the December 1989 freeze clearly demonstrated trees on UCB-1 are significantly more cold tolerant (Ferguson, 1991).

Trees on UCB-1 rootstocks are as tolerant of saline conditions as trees grown on PGI rootstocks. In the currently ongoing field trials trees on UCB-1 rootstocks are as tolerant of saline irrigation water up to 8 dS/m as trees on PGI rootstocks (Ferguson et al, 2000b). Tank trials produced a similar result with trees on UCB-1 being more tolerant, but not significantly so, of higher salinity levels than trees on PGI rootstocks (Ferguson, et al, 2000a).

The combination of significantly better yields, better cold tolerance, and equal Verticillium and salinity tolerance, of trees on UCB-1 rootstocks versus trees on PGI rootstocks suggests UCB-1 would be the more productive rootstock for most locations and climates. Grower observations also indicate it is more tolerant of saturated soils.

Individual, cumulative yield records have been used to identify three apparently superior UCB1 rootstocks. Vegetatively propagated material these specific individual UCB1 rootstocks will be released to the nursery industry through Office of Technology Transfer at UC Davis. It must be remembered that these are individual trees. As such there are no statistics to prove superiority, just individual tree performance. Three superior PGII rootstocks have also been identified.

These trials have also confirmed that the climate and soil conditions in the West Side of the southern San Joaquin Valley are better for production of pistachios than those in the central portion of the valley. This is most likely a result of higher cumulative heat units, high boron content of southern San Joaquin Valley soils and the generally more even, better quality, deeper soils without hardpan layers. The first condition ensures a higher percentage of the crop will ripen and split, the second, a higher percentage of fruit set, and the last is better for good production.

Thus far, from 1989 through 2001, these rootstock trials have demonstrated significant differences in growth, productivity, cold tolerance, micronutrient uptake, salinity and Verticillium tolerance among the four pistachio rootstocks (Beede, et al., 1990; Epstein, et al., 1992;

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