

Progress Report on UC Riverside Asparagus Breeding Program

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The overall objective of the breeding program at UC Riverside is to develop new asparagus cultivars for California that have higher yields of green, fresh market asparagus than existing cultivars. An emphasis is placed on high yields of export quality spears. The program involves development and identification of new parent clones; hybridization to produce new dioecious and all-male cultivars; and evaluation of these hybrids first in isolated unreplicated trials, and later in replicated trials at several locations. The field research is supported by laboratory research which is aimed toward producing and identifying supermale clones to be used as

parents for all-male cultivars, and toward developing genetic markers useful in cultivar identification and trait selection.

Field Research

Replicated Field Trials. These trials were established to evaluate the most promising advanced lines from the UCR breeding program compared with other cultivars currently available. The trials planted in 1990 and 1991 include 15-16 lines with 3 replications of 25 plants for each line. The entries include 7 promising hybrid breeding lines and one open-pollinated line from the UCR breeding program; 3 standard California cultivars, two cultivars from CAST, and 2-3 New Jersey cultivars. Similar trials were planted at UCR, in the Coachella Valley, and at two Delta locations. New replicated trials were planted in 1994, 1995, and 1996 to evaluate some new all male lines and lines which have performed well in the unreplicated portion of the 1990 trial.

UCR 1990 Replicated Trial. This trial was planted as speedling transplants in the spring of 1990. In 1996 and 1997, grading was refined to distinguish between spears that are suitable for the domestic market and those which are suitable for export to the Japanese market. Brock Special, and 2 UCR hybrids performed poorly during the first 3 years and were not harvested in subsequent years. Jersey Giant and Greenwich had high total yields during the first 3 years, but marketable yields were low due to "loose heads". These cultivars were also dropped from the trial. In 1997 we harvested 38 times between January 17 and April 14, three days per week. Spears were graded as marketable if they had reasonably tight heads, were relatively straight and unblemished. Export grade spears were defined as follows: Size - between 7/16" and 10/16" at the base of the spear; Head Tightness - very tight heads with smooth, closely appressed bracts; Color - all green, no white butt or excessive purpling of the base, bracts, or tip; Shalie - spear tip should be uniformly tapered, not bulbous or extremely bent. Shaft should be straight and without blemishes. Spears which were marketable, but lacked a quality attribute essential for export grade were graded either as small domestic (3/16-10/16") or large domestic (>10/16"). A preliminary analysis of the data (averaged over all six years) is shown in Table 1. The data should be interpreted with caution because variation among plots of some cultivars was rather large so that only large differences in marketable yield are statistically significant. Stand percentage also varies

among lines and plots - 1997 stand is shown but the average yields are not adjusted for stand because stand percentage changes over years. The most promising new line is still F 1 89 x HS 1 04 which gave a total marketable yield (3870 lb/ac), about 45% higher than that of 'UC157' (2672 lb/ac). This line also had the highest early yield (1315 lb/ac) producing 48% more spears during the early harvest period than any other line.. Atlas had the highest total yield (5863 kg/ha). Ida Lea had the highest percent marketable yield (74.2%). For average spear weight Atlas (32.6 g) was the largest followed by F189 x HS185 (31.0 g). UC157 and F597 x M1 3 8 had the lowest average spear weight, both at 22.4 grams.

1996 and 1997 average yields for the 1990 trial, categorized by marketable class, are shown in Table 2. Ida Lea and F597 x M138 had the highest export quality yield. During this 2-year period F597 x M138 produced 62% more export quality yield than UC157. Atlas and F1 89 x HS104 had the highest large domestic yield. F597 x M138 and Ida Lea had the highest small domestic yield. For some lines such as Atlas and F 1 89 x HS 104, export yield appears to be limited by large spear size. Total yields were much higher this year than in 1996, most likely due to better control of pests and maintaining a consistent harvest 3 days per week.

1994 UCR trial. A trial was planted at UCR in 1994 that includes 4 replications of 30 lines. This trial includes standard cultivars, 6 new lines from the 1990 trial, 18 promising hybrids tested previously only in an unreplicated plots, and unreplicated plots of 19 additional crosses, mostly California x European hybrids.. This trial was harvested 23 times between January 17th and March 10th, three days per week. For the 1994 trial, the 2-year production totals are shown in Table 3 for the 10 highest yielding lines, as well as the commercial cultivars and lines previously tested in the 1990 trial. Lines are ranked by total marketable yield. These results should also be interpreted with caution mainly because of problems apparently related to reduced vigor the first season after planting. Although excellent establishment was noted the year of planting, reduction of vigor apparently stems from a combination of herbicide runoff from adjacent fields and Phytophthora infestation following heavy rains in 1995. Beds were properly formed in 1995 and 1996 and the trial recovered fairly well with 80% of the plots having more than 75% stand. In comparison to the first two years of harvest from the 1990 trial, the same lines in the 1994 trial have produced very little. Differences in stand percent alone cannot account for such large differences in yield between the two trials. During the first two years' harvest from the 1994 trial UC 157 produced only 13% of its first two years' average from the 1990 trial.

58% of all lines in the trial had M256 as their male parent. Among the 10 highest yielding lines all but one (F597 x M138) were hybrids with M256. The high yielding M256 hybrids also generally had high percent marketable yield. F600 x M256 had the highest marketable yield (1027 lb/ac) as well as the third highest total yield (1503 lb/ac). Lines from the 1990 trial generally performed poorly, all ranking in the lower 50% of lines. Large average spear sizes were evident for F586 x M256 (22.3 g) and Atlas (22.2 g).

1994 Coachella Trial. The trial planted in 1990 at Coachella was removed due to severe Fusarium damage. It was replaced with a new trial on a different plot of land in 1994. Plant establishment was good, but asparagus aphid was noted toward the end of 1995. The trial was harvested for 5 weeks in 1996, but spear size was very small throughout the harvest period. In

1997 the trial was harvested 15 times between January 24th and February 26th, three days per week. Spear size was normal this year. Although total yield and spear counts were taken at each harvest, grading was only done weekly on Wednesday's harvest. To obtain graded data representing all harvests we used an estimation method: the total yield data for the Monday and Friday harvests was adjusted using the graded data from Wednesday to determine the percentage of each grading class for each week.

1995 trials. Additional trials were planted at UCR in the spring of 1995 using speedling transplants. The varieties included were similar to those in the 1994 trial. One trial, with two replications of 29 lines was on a field that has been used for asparagus for many years. The other, with two replications of 18 lines, is on a field that has not been used for asparagus and which is expected to have low Fusarium pressure. Both trials include unreplicated plots of several additional lines, including the all-male hybrids described below. In 1996, the stand in both trials was nearly 100% except for a few plots damaged by rabbits. Fences that give good rabbit control have now been constructed around all trials planted since 1994.

1996 trial . A new trial was planted at UCR in the spring of 1996 using speedling transplants. The purpose of this trial is to evaluate five supermales not previously tested as potential parents of all-male cultivars. These supermales were crossed with eight promising females, including F109 and F189 (the parents of 'UC 157' and 'Ida Lea', RF110 (the female parent of one of the lines from the 1990 replicated trial), and five female parents of some of the top producers in the 1990 unreplicated trial. This trial has two replications of 19 lines and I replication of 2 lines. 'UC157' has 4 replicates in each of the statistical blocks. Most trials since the 1990 trial were planted using an 18-foot plot length. This trial uses a larger, 30-foot plot length. Establishment in this trial is nearly 100%. We will harvest this trial for the first time in 1998.

Seed Production. In order to provide larger amounts of seed of experimental hybrids for evaluation by growers, we expanded the size of seed production plots in 1996 and 1997 and plan to further expand these next year using male and female clones propagated through tissue culture and crown division. Between 0.5 and 1.8 lb. of seed of each of 6 lines was to sent Ed Zuckerman for planting in a crown nursery. Also, small amounts of twenty additional hybrids having M256 as their common male parent which did well in the 1990 unreplicated trial, were sent to Bob Mullen to plant in further trials.

Development of All-Male Hybrids. The next generation of new hybrids derive from putative supermales and should be all-male cultivars. We identified 6 supermale plants from selfpollination of hermaphrodite (bisexual) plants from California germplasm and are evaluating them as parents of supermale cultivars.

Breeding. In 1994 we identified a plant from European germplasm that produces almost exclusively bisexual flowers and are now studying inheritance of this trait. This trait could be used to develop alternative breeding methods depending on how it is transmitted to progeny.

During the spring of 1996 we planted 1440 plants for future single-plant selections in the field. These consist of the following: 720 seedlings from seven open-pollinated California-European

hybrid females from the 1994 Riverside trial, selected for high branching and vigor; 276 seedlings from hand pollinations between two California-European hybrid males and F109 and F189; and 444 hand-pollinated seedlings (F1 hybrids between various European varieties and some of our best breeding parents (F189, F109, M256, M120). Some early selections have been made out of this material: one male seedling from an open-pollinated California-European hybrid female from the 1994 Riverside trial appears to be either rust tolerant or resistant; and several female seedlings from hand pollination between a California-European hybrid male and F109 are quite vigorous and have good spear quality. We plan to use these individuals as parents for future crosses with some of our best breeding parents.

Branching Height Study The purpose of this study is to determine the extent of genetic influence over branching height in asparagus. Branching height appears to be highly correlated with head tightness in harvested asparagus, thus we plan on measuring this trait as an indication of the tendency of spears to feather. European asparagus varieties generally tend to have a low branching height when grown in California. We have produced three families (European backcross, California backcross, and F2) from each of two California-European crosses: one cross is F189 crossed with a French line and the other is M120 crossed with a line from Spain. Between 50 and 80 plants of each family were planted in Riverside during the spring of 1996. These were evaluated in the spring of 1997 by measuring the basal cane diameter, the height and the number of nodes to the first branch and the sex of all individuals in each family.

Although we have not analyzed all of the data, it is evident that female plants had significantly higher branching heights, larger cane diameters, and more nodes to the first branch than males in all except population 4 where there was no significant difference between sexes and population 6 where branching height did not differ significantly. We also plan to use additional data that we have taken on temperature and earliness to better examine genetic factors which determine spear quality and earliness.

Laboratory Research.

A major objective in the laboratory research is to develop supermale clones. Supermales are used to produce seed of "all-male" cultivars which often have higher yield than standard hybrids. Although we continue to work on producing supermales through anther culture, most of our efforts lately have been to produce supermales through selling hermaphroditic plants

We recently obtained, from a laboratory in Italy, a DNA clone (547). We found that in some crosses with our breeding material the RFLP marker which is produced with the clone can distinguish between normal males and supermales. In order to simplify the RFLP test procedure we sequenced the clone and designed primers to produce a SCAR marker "Sequence Characterized Amplified Region". The SCAR marker has been shown to be as informative as the RFLP marker, even though it is much easier to produce. We anticipate that this new marker will save us a lot of time, by greatly reducing the amount of effort needed to make test crosses.

Table 1.

Average production (1992-1997) of the Riverside asparagus trial, planted 1990

Line	Total Yield lbs/ac	Marketable Yield		Early Yield* lbs/ac	Stand % June, 1997	Avg. Spear Wt. grams
		lbs/ac	%			
F189 x HS104	5723	3870	67.5	1315	97.3	29.1
Atlas	5863	3577	61.0	727	98.7	32.6
Ida Lea	4353	3228	74.2	891	86.7	25.7
F609 x M138	4045	2840	69.5	801	77.3	25.6
UC157	3922	2672	67.6	725	91.7	22.4
F597 x M138	3724	2609	69.9	897	73.3	22.4
F189 x HS185	4100	1914	46.1	527	97.3	31.0
RF110 x M138	3444	1830	53.0	352	94.7	23.3
LSD (.05)	1352	1101	7.7	380	12.9	3.9

*Early yield is the average marketable yield of those harvests during which UC157 produced the first 25 % of its annual marketable yield

Table 2.

Average production (1996-1997) categorized by marketable quality of the Riverside asparagus trial, planted 1990

LINE	Small Domestic Yield, lbs/ac *	Large Domestic Yield, lbs/ac *	Export Yield, lbs/ac	Marketable Yield, lbs/ac	Total Yield, lbs/ac
F189 x HS104	805	1426	898	3129	6894
Ida Lea	902	707	1218	2827	5127
Atlas	487	1600	672	2759	7200
F597 x M138	963	488	1044	2494	4748
F609 x M138	726	688	696	2111	4462
UC157	697	323	645	1665	3951
RF110 x M138	456	626	479	1560	4513
F189 x HS185	256	340	151	747	4054
LSD (.05)	396	402	463	1021	1699

*Domestic grade spears were categorized into small domestic (less than or equal to export size) and large domestic (greater than export size)

Table 3.

Total production (1996-1997) for the Riverside asparagus trial, planted 1994

Line	Total Yield lbs/ac	Marketable		Stand %*	Spear Wt. grams	Rank
		lbs/ac	%			
F600 x M256	1503	1027	68.4	92.0	14.7	1
F184 x M256	1663	1017	60.4	97.5	15.0	2
F586 x M256	1491	1001	68.6	72.3	22.3	3
F141 x M256	1517	977	62.6	93.5	17.8	4
F82-2 x M256	1333	836	62.4	86.5	17.1	5
F609 x M256	1114	645	56.5	75.0	14.4	6
F212 x M256	934	589	56.5	73.5	15.7	7
F597 x M138	889	584	64.4	73.5	17.7	8
F133 x M256	1112	578	51.0	80.0	16.8	9
F145 x M256	982	568	58.1	86.8	16.8	10
Ida Lea	880	565	62.0	76.5	14.6	11
UC157 Lot 1	938	513	54.1	85.5	16.6	13
Atlas	992	454	44.3	91.8	22.2	15
F609 x M138	818	449	54.1	82.8	16.3	16
UC157 Lot 2	702	427	58.3	89.0	16.5	18
F608 x M138	625	416	69.6	69.8	15.4	20
F189 x HS104	801	389	48.0	77.8	19.5	24
F189 x HS 185	901	243	26.7	88.3	14.3	27
RF110 x M138	319	131	39.4	89.5	17.9	31
LSD (.05)	558	369	17.0	22.7	5.4	

*Stand percent was measured in June, 1997