Reprinted from
Proc. Fla. State Hort. Soc. 103:294-298. 1990.

POTENTIAL FOR LOW-CHILL JAPANESE PLUMS IN FLORIDA

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Additional index words. Prunus salicina, selection, cultivars, evaluation, fruit breeding.

Abstract. **Low-chill cultivars and selections of Japanese-type plum (*P. salicina* Lindl. and hybrids) from the University of Florida breeding program were evaluated for fruit and tree characteristics at Gainesville, Florida in 1990. Information is provided on chilling requirement, ripe date, fruit development period (FDP), fruit size, fruit quality traits and field resistance to bacterial spot and plum leaf scald. The earliest ripening clone (Fla. 85-3) ripened on 31 March and the latest clone (Fla. 87-11) on 29 May. Chilling requirement was estimated to range from 200 to 450 chill units and FDP ranged from 76 to 125 days. The best of these clones have the potential to significantly extend the availability of fresh, early season plums in the USA when grown in appropriate regions of Florida, other areas with similar low-chill winters, and in colder locations in the absence of spring freezes.**

The University of Florida Japanese-type plum (*Prunus salicina* Lindl. and hybrids) breeding program aims to produce low-chill, early ripening, cultivars with high fruit quality and disease resistance (10). Growing these cultivars in Florida should be economically attractive because the

Florida Agricultural Experiment Station Journal Series No. N-00301.

fruit will ripen 4 to 6 weeks before the earliest, high-chill plums from California and so will obtain high prices. Low chilling germplasm was obtained via *P. salicina* seed importation from Taiwan and was crossed with 'Ozark Premier', 'Burbank', 'Methley', 'Beauty', and 'Bruce' to produce an F_1 (first generation hybrid) seedling population (8). This was followed by 4 cycles of phenotypic recurrent mass selection and infusions of plum germplasm from Auburn University, Alabama and USDA Byron, Georgia, which had resistance to bacterial spot incited by *Xanthomonas campestris* pv. *pruni* (Sm) Young et al. and plum leaf scald incited by *Xylella fastidiosa* Wells et al. (12). The selected individuals from each cycle have been polycrossed according to a system used by breeders of self-incompatible forage crops (1). To date over 4000 seedlings have been evaluated and the 25 selections which remain represent the genetic improvement obtained during 4 generations of breeding. This paper reports on the performance of these selections and their potential as commercial cultivars.

Materials and Methods

The clones evaluated in this study consist of 23 numbered selections from the University of Florida breeding program and 3 cultivars. The cultivars are 'Wade' from Clemson University in South Carolina (2) and 'Gulfgold' (formerly Fla. 3-4) and 'Gulfruby' (formerly Fla. 8-2) which were bred at the University of Florida and named by a Florida nursery person (8). Clones were budded on low-chill, peach seedling rootstocks which have resistance to rootknot nematodes (*Meloidogyne* spp.) and planted at 20 foot x 10 foot spacings with 2 to 6 ramets per clone at the IFAS orchard in Gainesville, Florida. Orchard management involved overhead irrigation and fertilizer, herbicide and pest control similar to the recommendations for Florida low-chill peaches (4). Evaluations in 1990 were from fourth leaf (average) trees that were pruned but not fruit thinned.

Fruit were harvested when first eating ripe and evaluated on a 1 (least desirable) to 5 (most desirable) scale for amount of red skin color, attractiveness, flavor, firmness, juiciness, and stone freedom. Fruit shape was rated using the International Board of Plant Genetic Resources plum descriptor scale of 1 rounded flat, 2 rounded, 3 elliptic, 4 ovate, 5 heart, and 6 oblong (3). Fruit sweetness was evaluated by hand refractometer measurement of total soluble solids (TSS). Bacterial spot incidence on fruit was evaluated by sampling 20 fruit per tree at harvest and measuring the percentage of infected fruit. Average fruit weight and the diameter range were measured on a 20-fruit-sample. Harvest date was the date of picking the first ripe fruit.

Evaluation of tree characteristics consisted of measurements of bacterial leaf spot and plum leaf scald on a scale of 1 (no symptoms) to 5 (severe symptoms) in late June 1990. Crop load was assessed at time of harvest on a scale of 1 (light) to 6 (very heavy). Chilling requirement was estimated as chill units (cu) by comparison of the clone's flowering time to that of known standard peach and nectarine cultivars i.e. 'Okinawa' 150 cu, 'Sunred' 250 cu, 'Early Amber' 350 cu, 'Sunlite' 450 cu and 'Sungold' 550 cu (11).

Table 1. Tree characteristics of low-chill plum clones tested at Gainesville in 1990.

Clone	Chill[z] units	Crop[y] load	Bacterial[x] leaf spot	Bacterial[w] fruit spot (%)	Leaf[x] scald
Fla. 8-1	–	4	4	–	–
Fla. 79-3	200	5	2	0	1
Fla. 83-1	–	6	1	–	–
Fla. 85-1	250	5	2	0	3
Fla. 85-2	200	5	1	0	3
Fla. 85-3	–	2	2	–	–
Fla. 86-1	250	5	1	4	2
Fla. 86-2	350	3	4	35	1
Fla. 86-3	300	6	2	0	3
Fla. 86-4	350	3	3	5	2
Fla. 86-5	400	6	5	3	1
Fla. 86-6	300	5	2	0	2
Fla. 86-7	250	5	1	3	2
Fla. 86-8	300	6	1	0	2
Fla. 87-1	300	1	2	20	1
Fla. 87-2	300	5	3	5	3
Fla. 87-3	350	2	4	22	1
Fla. 87-4	350	5	1	0	3
Fla. 87-6	450	5	1	–	4
Fla. 87-7	325	5	2	5	2
Fla. 87-8	350	5	4	28	1
Fla. 87-10	300	5	1	0	2
Fla. 87-11	350	–	1	–	1
Gulfgold (3-4)	–	6	1	9	4
Gulfruby (8-2)	350	4	2	9	2
Wade	–	2	1	6	5

[z]Estimated from bloom date (see text for details).
[y]Rated 1 light, 3 medium, 5 heavy, 6 very heavy.
[x]Rated 1 (no symptoms) to 5 (severe symptoms).
[w]% of fruit infected at harvest with *X. campestris* pv. *pruni*.

Results and Discussion

Table 1 lists the chilling requirement, crop load and incidence of major diseases of the clones. Tree characteristics are important in determining the level of adaptation of a particular clone to an environment. Locations with summer rainfall, strong winds and sandy soils, as found in many regions of Florida, are likely to experience problems with bacterial spot (5,7). Plum leaf scald is also likely to be prevalent in Florida due to the large number of natural hosts and incidence of the insect vector (6,12). Selection of clones for Florida should therefore avoid the most susceptible genotypes (clones with ratings of 4 and 5). Selections such as Fla. 86-2, Fla. 87-8, Fla. 87-3 and Fla. 87-1 may only be suited to dry climates due to the high level of *X. campestris* pv. *pruni* infection on the fruit (Table 1).

Chilling requirement of the University of Florida clones varied from 200 cu to 450 cu. This corresponded to a 2 week range in flowering times (January 22 to February 4) in Gainesville in 1990. Chilling requirement determines the suitability of clones for different climatic zones. Clones with low chilling requirements will flower earlier than those with high chilling requirements. Clones planted where winter cold is inadequate to satisfy their chilling requirement will flower erratically and set light crops; in areas where they receive excess winter cold, they may blossom early and suffer freeze damage to flowers or young fruitlets (11). The optimum climatic zone in Florida for each range of clonal chilling requirements has been published by Sherman and Rodriquez-Alcazar (9). For example, clones with chilling requirements from 300 to 400 cu are recommended for Gainesville.

Table 2. Fruit characteristics of low-chill plum clones tested at Gainesville in 1990.

Clone	Harvest date	FDP[z] (days)	Av. wt. (g)	Diameter range (mm)	Red[y] skin color	Attractiveness	Shape[x]	Flesh[w] color	Flavor[y]	TTS[v] (%)	Firmness[y]	Juicyness[y]	Stone-freedom[y]	Skin bitterness[y]
Fla. 8-1	10 Apr	–	26	34-41	5	3	1	Y	3	14.6	4	3	1	3
Fla. 79-3	29 May	125	47	39-46	4	1	2	R	4	14.7	4	3	1	5
Fla. 83-1[u]	17 May	–	19	31-33	4	3	2	Y	3	–	4	3	1	4
Fla. 85-1	13 Apr	77	34	35-43	5	3	4	Y	3	13.3	3	3	1	2
Fla. 85-2	10 Apr	76	35	36-45	5	4	2	Y	2	14.7	2	2	1	1
Fla. 85-3	31 Mar	–	26	35-42	5	3	5	Y	3	15.8	3	3	1	2
Fla. 86-1	24 Apr	89	46	37-51	5	2	5	Y	1	10.2	2	2	1	1
Fla. 86-2	7 May	97	76	42-58	4	3	2	Y	2	13.0	5	1	1	1
Fla. 86-3[u]	19 Apr	82	38	34-45	3	1.	2	Y	1	9.5	1	2	1	1
Fla. 86-4	30 Apr	90	51	34-50	5	3	2	R	3	11.3	1	4	1	1
Fla. 86-5[u]	4 May	92	25	32-41	5	3	2	Y	3	14.6	2	1	1	1
Fla. 86-6	14 May	106	50	37-48	4	3	5	YR	4	14.3	4	3	1	3
Fla. 86-7	27 Apr	92	59	38-53	4	3	3	Y	2	13.5	1	2	1	1
Fla. 86-8[u]	4 May	97	29	32-41	4	3	2	Y	3	13.9	3	3	3	4
Fla. 87-1	24 Apr	87	53	39-51	4	2	5	Y	3	14.2	3	–	–	3
Fla. 87-2	24 Apr	86	41	37-59	5	4	2	Y	3	14.6	4	2	1	4
Fla. 87-3	19 Apr	79	40	38-45	4	3	3	Y	3	14.9	4	3	1	3
Fla. 87-4	17 Apr	77	37	35-45	5	3	5	Y	3	14.7	3	1	1	3
Fla. 87-6	24 Apr	79	51	40-56	4	3	5	Y	2	9.9	1	2	–	4
Fla. 87-7	4 May	95	57	36-55	5	5	2	Y	3	12.8	5	3	2	1
Fla. 87-8	24 Apr	84	42	35-45	5	3	5	Y	2	15.5	1	2	1	1
Fla. 87-10	29 May	121	40	–	5	3	4	Y	3	19.0	3	3	1	4
Fla. 87-11	29 May	119	49	39-47	1	3	2	Y	4	15.5	4	3	3	4
Gulfgold[u] (3-4)	10 May	–	28	32-42	1	3	5	Y	3	11.1	3	3	3	4
Gulfruby (8-2)	19 Apr	79	41	39-48	4	3	5	Y	3	13.2	3	3	1	1
Wade	24 Apr	79	39	36-47	3	1	2	YR	–	–	–	–	3	–

[z]Fruit development period from 50% bloom to ripe fruit.
[y]Rated 1 (least desirable) to 5 (most desirable). The following were rated most desirable: 100% red skin color, high flavor, high firmness, high juiciness, freestone, and non-bitter skin.
[x]Rated 1 = rounded-flat, 2 = rounded, 3 = elliptic, 4 = ovate, 5 = heart, 6 = oblong.
[w]R = red; y = yellow.
[v]Total soluble solids; mean of 1 reading on each of 3 firm-ripe fruit.
[u]Clones that were overcropped in 1990—fruit size should increase.

The University of Florida plum germplasm has been selected for heavy flowering and heavy fruit set at an early age. Most of the plums will set fruit on 1 year old whips as well as on spurs. This precocious and heavy cropping is beneficial for early returns to growers and provides a margin of safety when damage by spring feezes occurs. However, it also means that in locations or years in which freezes do not occur the trees must be thinned heavily. Failure to thin adequately results in small fruit and reduced prices. The clones rated 6 (very heavy) for crop load in Table 1 were overcropped and the fruit size is therefore smaller than would be expected with optimum management. Clones rated 5 (heavy) for crop load would also have larger fruit if thinned more severely.

Table 2 lists ratings of fruit characteristics which affect marketability. The most important traits determining fruit value are size, attractiveness, and harvest date. There is variation among clones for fruit size; generally the clones having shorter fruit development periods (FDPs) produce smaller fruit (Table 2). A single clone can also vary in fruit size depending on management (thinning, irrigation, etc.) and location. Higher growing season temperatures result in shorter FDPs and smaller fruit size in peach (13) and similar results could be expected in plum. Attractiveness is a composite subjective appraisal of the fruit's external appearance based on size, shape, and brightness of the skin color. Attractiveness of the clones was generally acceptable with only 4 clones receiving unacceptable ratings, i.e. values of 1 and 2 on the 1-5 scale (Table 2).

Harvest date depends on date of flowering, growing season temperatures, and the relative FDP. For a given location, clones which flower early (i.e. have a low chilling requirement) and have a short FDP will ripen first. Harvest date for a single clone can vary with year and location. The 1990 season was 3 weeks earlier than an "average" year and the harvest dates in Table 2 should be adjusted accordingly. The early 1990 season resulted from a rapid accumulation of winter chilling units during December and early January, and then a rapid accumulation of growing degree hours in mid to late January. The FDPs were similar to "average" years. Harvest date will also depend on location, and has been shown in peach to decrease by 5 days for each 1°C increase in mean growing season temperature (14). Flowering date will also change with location, but the change may not be great within a zone of chilling adaptation (14).

The date of first harvest has been critical in determining fruit prices in traditional high chilling regions. In these areas, the flowering time varies little among clones, so the clones with the shortest FDP are the earliest ripening and receive high prices. Growing low-chill plums in warm locations is a different situation. In this case, the mid-season fruit will still ripen ahead of the early fruit from traditional high chilling locations so growers need not be concerned with planting the earliest ripening of the low-chill clones. It is more important to choose among the clones that produce the largest fruit that is acceptably attractive. In this respect, the outstanding clones are Fla. 86-2 and Fla. 87-7. Fla. 86-2 appears susceptible to *X. campestris* pv. *pruni* so will probably only be suited to dry climates.

Choice of the best clone is not quite as simple as described above. Internal fruit characteristics, such as flavor and firmness, must also be considered as they are important for consumer satisfaction and ease of handling. For example, clone Fla. 86-7 produces large fruit averaging 59 g weight with acceptable external attractiveness (Table 2), but the fruit flavor is marred by a bitter skin, and the fruit softens rapidly. Hence, all the characteristics in Table 2 must be considered in selecting clones to test.

Most Japanese plums have some bitterness in the skin or around the stone, and the University of Florida plum germplasm contains some segregants for extreme bitterness. Generally the sweetness of the flesh balances the bitter skin and results in a pleasant flavor. Most of the clones have moderate to high sugar levels (Table 2). Seven clones were rated by us as unsatisfactory for flavor, i.e. values of 1 or 2 on the 1-5 scale. Three of the 7 had the lowest TSS values but the other 4 had high TSS values and were rated low for flavor due to excessively bitter skins. For example, Fla. 86-7 and Fla. 87-8 had 13.5% and 15.5% TSS, yet both were rated 2 for flavor. We had some apprehension concerning the palatability of several of the large and visually attractive plums because of their bitter skins, so an informal survey of 6 consumers was conducted on what we considered 5 promising clones. The clones comprised 3 red-skin selections with yellow flesh (Fla. 86-2, Fla. 86-6, Fla. 87-7), the yellow skin cultivar 'Gulfgld' and the blood plum Fla. 79-3. The overall rating of desirability on a 1 (very poor) to 9 (very good) scale includes appraisal of external appearance as well as internal organoleptic characteristics. The ranking of clones was Fla. 87-7 (7.8), Fla. 86-2 (7.2), Fla. 86-6 (6.8), 'Gulfgold' (5.8), and Fla. 79-3 (5.6). It appears that these selections were all acceptable in this limited test, and the 3 larger red-skinned, yellow-fleshed selections were especially popular. It also seems likely that our ratings of flavor are more harsh than those of consumers.

The ripening sequence of the 12 most promising selections and the cultivars 'Gulfgold' and 'Gulfruby' are presented in Figure 1. It should be noted that the data are for 1 year and 1 location and are only a guide to future performance at other locations.

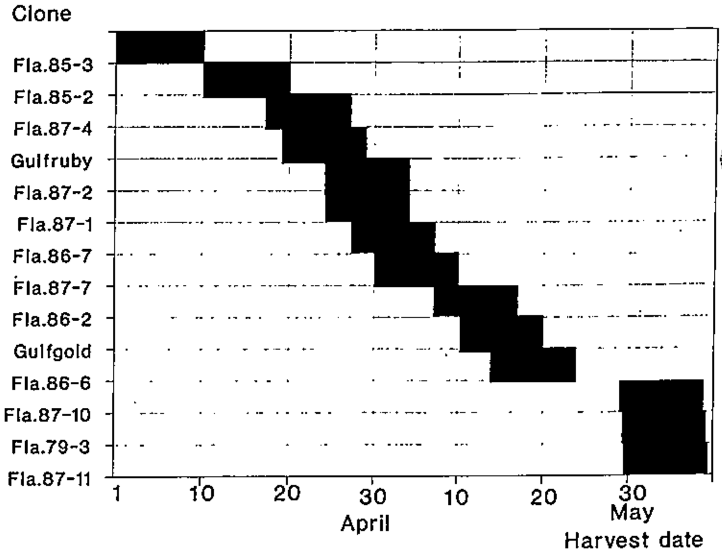

Fig. 1. Ripening sequence of the 12 most promising plum clones at Gainesville in 1990.

Comments on Each Clone

The following comments on each clone are a summary of the good and bad traits already noted in Tables 1 and 2, but also include some additional information.

Fla. 8-1—early, but too small and dull color; pollenizer for 'Gulfruby'.

Fla. 79-3—firm red flesh, prominent green lenticels on skin.

Fla. 83-1—overcropped in 1990, cannot assess properly.

Fla. 85-1—early, with moderate size, dull skin color.

Fla. 85-2—promising early plum, but softens and skin is tart.

Fla. 85-3—earliest in 1990, some end-cracking.

Fla. 86-1—good size but poor flavor.

Fla. 86-2—very large fruit, bacterial spot on fruit, bitter skin, prominent suture fold; looks promising for dry locations.

Fla. 86-3—poor flavor, uneven ripening.

Fla. 86-4—good size, but softens quickly and bitter skin.

Fla. 86-5—most susceptible clone to bacterial spot.

Fla. 86-6—good shelf life, tastes like Santa Rosa, looks promising.

Fla. 86-7—large fruit, but softens and has thin skin, weeping habit.

Fla. 86-8—overcropped so poor test of size.

Fla. 87-1—attractive, large fruit, but with very light crop in 1990; requires further observation.

Fla. 87-2—firm flesh, attractive, low juiciness.

Fla. 87-3—nothing special.

Fla. 87-4—fruit OK, but tree vigor low.

Fla. 87-6—good size and color, but soft and poor flavor.

Fla. 87-7—excellent appearance and size; looks promising.

Fla. 87-8—softens too quickly.

Fla. 87-10—size OK for crop load, good flavor.

Fla. 87-11—late ripening 'Shiro' type.

Gulfgold—yellow-skinned type, requires heavy thinning.

Gulfruby—is now the standard low-chill plum by default; grown commercially in Australia.

Wade—at the lower end of the high-chill cultivar range; unsuited to Gainesville, and poor fruit quality.

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