'Bowden' and 'Amoore Sweet' Nectarines

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'Bowden' and 'Amoore Sweet' are the fourth and fifth nectarines released from the University of Arkansas peach and nectarine [*Prunus persica* (L.) Batsch] breeding program. Prior nectarine releases include 'Arrington', 'Bradley', and 'Westbrook' released in 2000 (Clark et al., 2001). The program began in the 1960s (Clark et al., 1999) and included an objective to develop adapted nectarines and fresh-market peach cultivars for on-farm, local, and shipping sales. These new releases broaden grower choices for nectarines in Arkansas and for producers in similar climates.

'Bowden' is the program's first white-fleshed nectarine release. It has very firm, non-melting flesh, excellent white nectarine flavor with standard acidity, and ripens just after 'Bradley'. 'Amoore Sweet' is the first nectarine released from the program with low acid flavor and non-melting flesh. It has yellow flesh and ripens after 'Bradley'. These cultivars have very good resistance to bacterial spot [caused by *Xanthomonas arboricola* pv. *pruni* (Smith, 1903; Vauterin et al., 1995)] and should provide high-quality options for growers in areas where bacterial spot disease is a concern. These cultivars also expand options for growers in the mid- to upper-southern United States and other areas of the world with similar climatic conditions.

Origin

'Bowden' and 'Amoore Sweet' resulted from a cross of Ark. 699 × Ark. 663 nectarines (Fig. 1) made in 2001. This progeny consisted of 50 seedlings and provided a range of segregants for a number of traits including melting and non-melting flesh, a range of fruit acidities, yellow and white flesh, bacterial spot resistance, and a range in ripening dates. Seven selections were made from this population. These cultivars were selected in 2004 and were designated Ark. 764 and Ark. 765, respectively. 'Bowden' is named in honor of Henry Bowden, who served for many years in the University of Arkansas Division of

Agriculture. 'Amoore Sweet' is named in honor of distinguished professor emeritus James N. Moore, who initiated and directed the University of Arkansas fruit breeding program from 1964 to 1996.

Primary testing of these selections and comparison cultivars was at the Fruit Research Station, Clarksville, AR (FRS) [west-central Arkansas, lat. 35°31'58" N, long. 93°24'12" W; U.S. Dept. of Agriculture hardiness zone 7a; soil type Linker fine sandy loam (Typic Hapludult)]. In all testing, trees were either open-center-trained and spaced 5.5 m between trees and rows or trained to a perpendicular V system with trees spaced 1.9 m and rows spaced 5.5 m. Trees were dormant-pruned and fertilized annually with either complete or nitrogen-only fertilizers and irrigated as needed. Perpendicular V trees also received one summer pruning, consisting of removing inward-growing shoots, in mid-June of each year. Pests were managed using a program typical for commercial orchards of the area. No bactericides were applied to plantings during testing. Fruits were thinned to a distance of 12 to 15 cm between fruit after shuck split but before pit hardening each year.

A trial consisting of open-center-trained, two-tree, non-replicated observational plots of 'Bowden', 'Amoore Sweet', and comparison cultivars Arrington, Bradley, and Westbrook, all on 'Lovell' rootstock, were maintained at FRS and data were collected from these trees or the original selection (own-root) trees from 2005 through 2011 (no data for 2007 as a result of spring frost). Dates for 10% and full bloom (90% of flowers open) and first harvest were recorded along with ratings of bloom amount

(intensity) on a 1 to 5 scale with heaviest bloom receiving a 5 rating. Fruit ratings in the orchard at first harvest were taken from these years for firmness and flavor, whereas trees were rated for vigor, crop, and health with an emphasis on bacterial spot severity on leaves and/or fruit. The rating scale for these fruit and tree variables was 1 to 10 with 10 being most desirable. An exception was a rating of 7 to 8 being most desirable for vigor and a rating of 10 indicated excessive vigor. Additionally, a five-fruit sample was collected each year and average fruit weight and soluble solids content (SSC) were determined using a refractometer (Sper Scientific 300035 digital refractometer; Sper Scientific, Scottsdale, AZ). Also from this sample, percent blush on fruit skin was estimated.

A replicated trial of perpendicular V-trained trees on 'Lovell' rootstock was also established at FRS that included comparison cultivars Arrington and Bradley in 2007. Data collected in this planting were yield and average fruit weight. Data were collected only for the fruiting year 2010 as a result of the planting encountering health limitations in subsequent years and tree performance not representative of the genotypes after 2010. In this planting, four single-tree replications arranged in a randomized complete block design were used, and data were analyzed by analysis of variance and means separated by least significant difference (SAS Institute, 2012).

An additional component to the peach breeding program was added in 2011, that being cold storage of selections and cultivars for postharvest/storage performance potential. Previously, storage potential was only estimated for releases based on firmness of flesh at harvest. In 2011 and 2012, fruit used in the study were selected from midcanopy and only those fruit exhibiting uniform shape and color, and lacking any insect, disease, and hail damage were selected. To evaluate storage performance, 15 fruit from two trees (two replicates) from each genotype were harvested at the well-mature stage, determined by skin color showing less than 5% green ground color and a slight decrease in firmness based on finger-feel. All fruit were hand-harvested directly into 0.24-L corrugated trays (FormTex Plastics Corp., Houston, TX). After harvest,

Fig. 1. 'Amoore Sweet' and 'Bowden' pedigree.

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Table 1. Fruit and plant characteristics of 'Bowden' and 'Amoore Sweet' nectarines compared with three other nectarine cultivars from two-tree observational plots, University of Arkansas Fruit Research Station, Clarksville 2005–11 (missing 2007 data resulting from frost).^z

		Bowden	Amoore Sweet	Arrington	Bradley	Westbrook
Fruit	First harvest date	4 July ± 7	6 July ± 7	30 June ± 8	1 July ± 7	15 June ± 6
	Days bloom to harvest ^y	104 ± 9	106 ± 8	98 ± 9	99 ± 7	83 ± 6
	Fruit weight (g)	144 ± 20 ^x	145 ± 23 ^x	113 ± 20 ^x	154 ± 31	116 ± 9 ^y
	Soluble solids (%)	13.8 ± 2.3 ^x	15.2 ± 2.6 ^x	13.6 ± 4.0 ^x	12.2 ± 2.4	9.3 ± 3.7
	Firmness rating ^w	8.0 ± 0.0	9.0 ± 0.3	8.2 ± 0.2	8.5 ± 0.2	6.2 ± 0
	Percent blush	75 ± 13	78 ± 9	69 ± 11	72 ± 4	93 ± 3
Plant	10% bloom date ^y	19 Mar. ± 6	19 Mar. ± 6	20 Mar. ± 6	21 Mar. ± 7	21 Mar. ± 7
	Full bloom date ^y	22 Mar. ± 7	22 Mar. ± 7	23 Mar. ± 7	24 Mar. ± 6	24 Mar. ± 6
	Bloom amount rating ^{y,v}	3.4 ± 0.9	3.2 ± 0.4	3.0 ± 0.0	3.4 ± 0.5	3.0 ± 1.0

^zData for fruit weight, soluble solids, firmness, and percent blush based on a five-fruit sample collected each year at first harvest date. Data are mean values ± SD.

^yMissing 2007 and 2009 data.

^xMissing 2005 and 2007 data.

^wFirmness rating based on a 1 to 10 scale with 10 being very firm.

^vBased on observation of mature trees at full bloom using a scale of 1 to 5 with 5 being very heavy bloom.

all fruit were pre-conditioned in room temperature storage ($\approx 20^\circ\text{C}$) for 24 h. All fruit were then placed in a walk-in cooler for cold storage. Cooler temperature was maintained between 1 and 4 $^\circ\text{C}$. After 1, 2, and 3 weeks, one fruit from both replications from all genotypes was removed from storage. After removal from cold storage, all fruit were held at room temperature ($\approx 20^\circ\text{C}$) for ≈ 24 h. Skin and flesh quality, skin and flesh color, juiciness, browning, mealiness, and taste were subjectively rated on a scale from 0 (worst) to 10 (best). Photographs were taken of all fruit evaluated using a Beseler CS-14 copy stand (Charles Beseler Co., Stroudsburg, PA) and a Nikon D70s digital camera (Nikon Corporation, Tokyo, Japan). Skin and flesh color and quality, browning, juiciness, mealiness, and taste ratings were totaled for each genotype to establish a storage performance score. An overall ranking based on the grouping of performance score was determined for each genotype [0 (0.00–40.99), 1 (41.00–50.99), 2 (51.00–60.99), 3 (61.00–70.99), 4 (71.00–75.99), and 5 (76.00–80.00), with 0 being unacceptable and 5 being exceptional storage performance]. Cultivar performance rankings were presented by weeks as well as averaged to establish an overall ranking for each genotype.

In addition to storage evaluations, fruits from Day 0 of the storage study in 2011 and 2012 were used to measure SSC, pH, and titratable acidity (TA). Two fruit from each of two trees (four fruits total) for each genotype were included in the measurements. Juice from the fruits was extracted by hand-squeezing and filtered through a metal kitchen strainer. Soluble solids content was measured using a Sper Scientific 300035 digital refractometer (Sper Scientific) and pH and TA were measured using a Metrohm 877 Titrino Plus automatic titrator with a LL Unitrode combination pH (Metrohm AG, Herisau, Switzerland). Titratable acidity was expressed as percent malic acid.

Description and Performance

'Bowden' was first ripe on average 4 July at FRS (average 104 d after full bloom) in observational plots (Table 1). 'Amoore

Sweet' first ripe date averaged 6 July (average 106 d after full bloom). It should be noted that first ripe date varied for all genotypes by 6 to 7 d reflecting seasonal variation for harvest date.

Cropload ratings on a 10-point scale on observational trees for 'Bowden' averaged 9.0, whereas 'Amoore Sweet' averaged 8.7 for the 6 years of observation (data not shown). These ratings were comparable to or higher than those for 'Arrington' (8.5), 'Bradley' (8.0), and 'Westbrook' (7.3) (data not shown). Yields for 'Bowden' and 'Amoore Sweet' in the replicated trial were good, comparable to 'Arrington' and 'Bradley' (Table 2).

Average fruit weight for 'Bowden' was 144 g and 'Amoore Sweet' 145 g on samples from observational trees, near that of 'Bradley' but larger than 'Arrington' and 'Westbrook' (Table 1). In the replicated trial, 'Amoore Sweet' was the largest entry with average weight of 147.3 g and was significantly larger than comparison cultivars (Table 2).

Fruits of 'Bowden' and 'Amoore Sweet' are clingstone and have non-melting flesh. This flesh type is derived from processing peaches with this trait coming from their grandparent, 'Bradley'. This flesh type provides for firm fruit at harvest and is also excellent for canning. With an additional two generations of crossing after 'Bradley', the processing peach flavor and distinct rubbery texture were further reduced in these new nectarines. The flavor of 'Bowden' is standard acid with a distinct white nectarine flavor. The flavor of 'Amoore Sweet' is very sweet, low acid, and quite unique, often commented to be "mango-like." Flavor rating averaged 7.8 for 'Bowden' and 7.3 for 'Amoore Sweet', comparable to or higher than comparison cultivars (data not shown). Soluble solids for 'Bowden' averaged 13.8% in the observational tree samples (Table 1) and was 14.9% in the samples collected with the storage-study fruits (Table 3). 'Amoore Sweet' by comparison averaged 15.2% and 17.3%, respectively. 'Bowden' was comparable to 'Arrington' and 'Bradley', whereas 'Amoore Sweet' was higher in SSC than other genotypes (Tables 1 and 3). Juice pH and TA were distinctly different among the cultivars with 'Amoore Sweet' higher in pH and lower in TA than the

Table 2. Production characteristics for 2010 of replicated 'Bowden', 'Amoore Sweet', 'Arrington', and 'Bradley' nectarine cultivars established in 2007 at the University of Arkansas Fruit Research Station, Clarksville.

Cultivar	Yield/tree (kg)	Fruit wt (g)
Bowden	14.4 a ^z	121.1 b
Amoore Sweet	14.5 a	147.3 a
Arrington	11.2 a	105.5 b
Bradley	13.2 a	116.6 b

^zMean separation by least significant difference, 0.05.

Table 3. Average of 2011 and 2012 soluble solids content, pH, and titratable acidity (% malic acid) for 'Bowden' and 'Amoore Sweet' nectarines and standard nectarine and peach cultivars.

Genotype	SSC (%)	pH	Percent acid
Souvenirs	14.1	4.5	0.24
Bowden	14.9	3.4	0.84
Amoore Sweet	17.3	4.1	0.29
White County	15.5	4.2	0.29
Bradley	14.8	3.4	0.95
Redhaven	13.6	3.5	0.70
White Rock	14.3	4.4	0.26

SSC = soluble solids content.

nectarine cultivars 'Bowden' and 'Bradley' but similar to the low-acid peaches 'Souvenirs', 'White County', and 'White Rock' (Table 3). Firmness rating for 'Bowden' averaged 8.0 and 'Amoore Sweet' 9.0, near or higher than that of the non-melting flesh 'Arrington' and 'Bradley' and higher than the melting-flesh 'Westbrook' (Table 1). Fruit skin averaged 75% and 78% blush for 'Bowden' and 'Amoore Sweet', respectively, providing for an attractive fruit. Skin finish is a key characteristic of nectarines, because they are much more subject to skin defects and abrasions than the pubescent peach of the same species. Finish rating of 'Bowden' averaged 6.2, near that of 'Bradley' and 'Arrington', and in some years, the finish was noted to have some spots and occasional skin splits (data not shown). This limitation could be a factor for retail market sales but should not be as substantial of an issue for local markets. 'Amoore Sweet' had an average finish rating of 7.8 and was routinely one of the more attractive nectarines in the program (data not shown).

In 2011 postharvest evaluations, the overall ranking for 'Bowden' was 3.7, similar to 'Bradley' and superior to 'Arrington' (Table 4). Further ratings for storage characteristics

for 'Bowden' indicated exceptional performance for lack of browning and mealiness throughout storage with very good ratings also for taste, flesh color, and quality (Table 6;

Fig. 2). In 2012 postharvest evaluations, the overall ranking for 'Bowden' increased from 3.7 in 2011 to 4.3 (Table 5) with repeated exceptional performance for lack of browning and mealiness throughout storage (Table 7). In 2011, 'Amoore Sweet' had an overall ranking in storage of 3.0 (Table 4) with very good ratings for most variables for 0 to 2 weeks but had lower ratings for almost all variables for 3 weeks (Table 8). This trend was not seen in 2012 with 'Amoore Sweet' demonstrating superior storage performance to all genotypes tested with an overall ranking of 4.7 (Table 5). Further ratings for storage characteristics for 'Amoore Sweet' indicated exceptional performance for all variables, specifically lack of browning and mealiness along with flesh color and quality throughout storage (Table 9; Fig. 3). Both cultivars should allow for longer storage than melting flesh nectarine cultivars, although none were compared in these evaluations.

Flowers of 'Bowden' and 'Amoore Sweet' are non-showy and self-fertile. Average 10% bloom and full bloom dates for both 'Bowden' and 'Amoore Sweet' were 19 and 22 of Mar., respectively, 1 to 2 d earlier than the comparison nectarine cultivars (Table 1). Bloom amount (intensity) rating averaged 3.4 (on a 5-point scale) for 'Bowden' (among the highest ratings), whereas 'Amoore Sweet' averaged 3.2 (Table 1).

'Bowden' and 'Amoore Sweet' leaf glands were all reniform and located near the base of the leaf blade on the top of the petiole. 'Bowden' leaf glands measured 0.8 mm wide and 1.4 mm long and 'Amoore Sweet' leaf glands measured 1.0 mm wide and 1.7 mm long.

Tree vigor ratings on observational trees averaged 7.0 for 'Bowden' and 6.8 for 'Amoore Sweet'. Tree health rating for 'Bowden' averaged 8.7 and 'Amoore Sweet'

Table 4. Nectarine storage performance^a overview ranking for 3 weeks of cold storage in 2011 for 'Bowden' and 'Amoore Sweet' and the cultivars Bradley and Arrington.

Cultivar	Week 0	Week 1	Week 2	Week 3	Overall ranking
Bowden	4	5	3	3	3.7
Amoore Sweet	5	4	3	2	3.0
Bradley	4	5	4	3	3.7
Arrington	3	3	2	0	1.7

^aTotal ranking is based on the grouping of total score on a scale of 0 (0.00–40.99), 1 (41.00–50.99), 2 (51.00–60.99), 3 (61.00–70.99), 4 (71.00–75.99), and 5 (76.00–80.00), with 0 being unacceptable and 5 being exceptional storage performance.

Table 5. Postharvest storage performance^a for 'Bowden', 'Amoore Sweet', and 'Bradley' during 3 weeks of cold storage in 2012.

Cultivar	Week 0	Week 1	Week 2	Week 3	Overall ranking
Bowden	5	5	4	4	4.3
Amoore Sweet	5	5	5	4	4.7
Bradley	5	4	4	3	3.7

^aTotal ranking is based on the grouping of total score on a scale of 0 (0.00–40.99), 1 (41.00–50.99), 2 (51.00–60.99), 3 (61.00–70.99), 4 (71.00–75.99), and 5 (76.00–80.00), with 0 being unacceptable and 5 being exceptional storage performance.

Fig. 2. Whole and half-fruit images of non-melting flesh nectarine 'Bowden' before cold storage and after 3 weeks in storage in 2011.

Table 6. Storage performance overview for 3 weeks of cold storage in 2011 including all ratings means of two replicates of non-melting nectarine 'Bowden', which had an overall performance score^a of 212.50 and group 3.7 ranking.^y

Week	Skin color ^x	Skin quality ^x	Flesh color ^x	Flesh quality ^x	Browning ^x	Juiciness ^x	Mealiness ^x	Taste ^x	Total score ^w	Weekly total ranking ^y
0	8.0	8.0	9.0	10.0	10.0	9.0	10.0	10.0	74.00 ± 0.00	4
1	9.0	9.0	9.0	10.0	10.0	9.0	10.0	10.0	76.00 ± 0.00	5
2	7.0	6.5	9.0	9.0	10.0	9.0	10.0	9.0	69.50 ± 0.50	3
3	7.0	7.0	8.0	8.0	10.0	9.0	10.0	8.0	67.00 ± 0.00	3

^aPerformance score is the sum of Week 1, 2, and 3 total score.

^yGroup ranking is the average of Week 1, 2, and 3 total ranking.

^xRatings are on a scale from 0 (worst) to 10 (best).

^wTotal score is the sum of ratings of all variables (± SD).

^yTotal ranking is based on the grouping of total score on a scale of 0 (0.00–40.99), 1 (41.00–50.99), 2 (51.00–60.99), 3 (61.00–70.99), 4 (71.00–75.99), and 5 (76.00–80.00), with 0 being unacceptable and 5 being exceptional storage performance.

Table 7. Storage performance overview for 3 weeks of cold storage in 2012 including all ratings means of two replicates of non-melting nectarine 'Bowden', which had an overall performance score^a of 222.50 and group 4.3 ranking.^y

Week	Skin color ^x	Skin quality ^x	Flesh color ^x	Flesh quality ^x	Browning ^x	Juiciness ^x	Mealiness ^x	Taste ^x	Total score ^w	Weekly total ranking ^y
0	8.0	10.0	9.0	10.0	10.0	9.0	10.0	10.0	76.00 ± 0.00	5
1	8.5	10.0	10.0	10.0	10.0	9.5	10.0	10.0	77.00 ± 1.50	5
2	8.0	10.0	10.0	9.0	10.0	9.5	10.0	9.0	74.50 ± 0.50	4
3	8.0	9.0	9.0	9.0	9.0	8.0	10.0	9.0	71.00 ± 0.00	4

^aPerformance score is the sum of Week 1, 2, and 3 total score.

^yGroup ranking is the average of Week 1, 2, and 3 total ranking.

^xRatings are on a scale from 0 (worst) to 10 (best).

^wTotal score is the sum of ratings of all variables (± SD).

^yTotal ranking is based on the grouping of total score on a scale of 0 (0.00–40.99), 1 (41.00–50.99), 2 (51.00–60.99), 3 (61.00–70.99), 4 (71.00–75.99), and 5 (76.00–80.00), with 0 being unacceptable and 5 being exceptional storage performance.

Table 8. Storage performance overview for 3 weeks of cold storage in 2011 including all ratings means of two replicates of non-melting nectarine ‘Amoore Sweet’, which had an overall performance score^z of 194.00 and group 3.0 ranking^y.

Week	Skin color ^x	Skin quality ^x	Flesh color ^x	Flesh quality ^x	Browning ^x	Juiciness ^x	Mealiness ^x	Taste ^x	Total score ^w	Weekly total ranking ^v
0	9.0	9.0	9.0	10.0	10.0	9.0	10.0	10.0	77.00 ± 0.00	5
1	8.5	8.0	9.0	10.0	10.0	9.0	10.0	10.0	75.50 ± 0.50	4
2	7.0	7.0	7.5	9.0	9.0	7.5	10.0	9.0	66.00 ± 3.00	3
3	6.0	6.0	5.0	6.0	6.5	7.0	10.0	6.0	52.50 ± 8.50	2

^xPerformance score is the sum of Week 1, 2, and 3 total score.

^yGroup ranking is the average of Week 1, 2, and 3 total ranking.

^zRatings are on a scale from 0 (worst) to 10 (best).

^wTotal score is the sum of ratings of all variables (± sd).

^vTotal ranking is based on the grouping of total score on a scale of 0 (0.00–40.99), 1 (41.00–50.99), 2 (51.00–60.99), 3 (61.00–70.99), 4 (71.00–75.99), and 5 (76.00–80.00), with 0 being unacceptable and 5 being exceptional storage performance.

Table 9. Postharvest storage performance overview for non-melting nectarine ‘Amoore Sweet’ during 3 weeks of cold storage in 2012 including all ratings means of two replicates which had an overall performance score^z of 225.50 and group 4.7 ranking^y.

Week	Skin color ^x	Skin quality ^x	Flesh color ^x	Flesh quality ^x	Browning ^x	Juiciness ^x	Mealiness ^x	Taste ^x	Total score ^w	Weekly total ranking ^v
0	9.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	79.00 ± 0.00	5
1	9.0	10.0	10.0	10.0	10.0	9.5	10.0	10.0	78.50 ± 0.50	5
2	9.0	9.0	10.0	10.0	10.0	9.0	10.0	9.0	76.00 ± 0.00	5
3	8.0	7.0	10.0	9.0	10.0	9.0	10.0	8.0	71.00 ± 1.50	4

^xPerformance score is the sum of Week 1, 2, and 3 total score.

^yGroup ranking is the average of Week 1, 2, and 3 total ranking.

^zRatings are on a scale from 0 (worst) to 10 (best).

^wTotal score is the sum of ratings of all variables (± sd).

^vTotal ranking is based on the grouping of total score on a scale of 0 (0.00–40.99), 1 (41.00–50.99), 2 (51.00–60.99), 3 (61.00–70.99), 4 (71.00–75.99), and 5 (76.00–80.00), with 0 being unacceptable and 5 being exceptional storage performance.

Fig. 3. Whole and half-fruit images of non-melting-flesh nectarine ‘Amoore Sweet’ before cold storage and after 3 weeks in storage in 2011.

9.0, comparable to the comparison cultivars (data not shown). A major component of the tree health rating is resistance to bacterial spot, a disease that can be severe at FRS. ‘Bowden’ and ‘Amoore Sweet’ were found to seldom show any leaf or fruit lesions resulting from bacterial spot although not fully immune in all years. The other disease seen on ‘Bowden’ and ‘Amoore Sweet’ was occasional brown rot

[caused by *Monilinia fructicola* (G. Wint.) Honey]. These cultivars are not anticipated to be different in susceptibility to brown rot compared with most nectarine cultivars. A commercial fungicide program is required for disease control on all Arkansas nectarine cultivars in areas where brown rot occurs.

Chilling requirement of these cultivars has not been determined but is probably near

800 h below 7 °C based on observations of budbreak and bloom in comparative plantings with test cultivars of known chill requirement. These cultivars have not been tested in colder locations than Arkansas; thus, ultimate bud hardiness has not been determined. However, good flower bud survival for all cultivars was experienced with mid-winter lows of –16 and –17 °C in 2010 and 2011, respectively.

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