HortScience 51(6):761–765. 2016.

# 'Baby Blues' Highbush Blueberry

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*Additional index words.* processing, machine harvest, small fruit, fruit breeding, *Vaccinium corymbosum*, *Vaccinium darrowii*

'Baby Blues' is a new highbush blueberry (*Vaccinium* hybrid: 75% *Vaccinium corymbosum* L. and 25% *Vaccinium darrowii* Camp) from the U.S. Department of Agriculture–Agricultural Research Service (USDA-ARS) breeding program in Corvallis, OR, released in cooperation with Oregon State University's Agricultural Experiment Station. 'Baby Blues' is a vigorous, high-yielding, very-small-fruited, machine-harvestable highbush blueberry with outstanding fruit quality that will be primarily suited for the processing market where small fruit size is desirable. 'Baby Blues' should offer growers and processors an alternative to the low-yielding 'Rubel' highbush blueberry and to the lowbush blueberry (*Vaccinium angustifolium* Ait.) that, by the nature of its production and harvest, is a mixture of many variable genotypes. 'Baby Blues' should be a potential cultivar in the milder areas where northern highbush blueberries are grown.

## Origin

'Baby Blues', tested as ORUS 10-1, was selected in Corvallis, OR, in 1999 from a cross made in 1993 by J.F. Hancock at Michigan State University (East Lansing, MI) of US 647 (US 75 × G 362) × US 645 (US 75 × G 362) (Fig. 1). The two parents were selections made by A. Draper, formerly from the USDA-ARS (Beltsville, MD), in his work to broaden the germplasm base of the highbush blueberry. The parents were included in a multistate trial to characterize germplasm that might be tolerant of mineral soils (Scheerens et al., 1999a, 1999b). In that research, US 645 had been identified as a superior parent for plant height, plant volume, growth rate (volume increase), adaptation to mineral soils, early bloom date, and yield, while US 647 was superior for adaptation to mineral soils, early bloom date, and large berry size. One parent listed by Scheerens et al. (1999a) for US 645 and US 647 was incorrect, whereas the US 75 parent was correct, the second parent was G 362 and not US 226 (J.C. Scheerens, personal communication).

'Baby Blues' was evaluated most extensively in trials at Oregon State University's North Willamette Research and Extension Center (OSU-NWREC; Aurora, OR), but single multiplant plots were also grown in Corvallis, OR; Benton Harbor, MI; Lowell, OR; Prosser, WA; and Agassiz, B.C., Canada. In the trial plantings, standard cultural practices for blueberry production were used, including annual dormant season pruning to balance vegetative growth with cropping potential, drip irrigation (Strik et al., 1993), and fertilization with 90 kg·ha$^{-1}$ of urea divided into equal portions and applied annually from bloom to mid-June (Hart et al., 2006). Pre- and postemergent herbicides were applied annually and fungicides, particularly for protection against gray mold (*Botrytis cinerea* Pers.), and insecticides, particularly for control of winter moth (*Operophtera brumata* L.), were applied as recommended

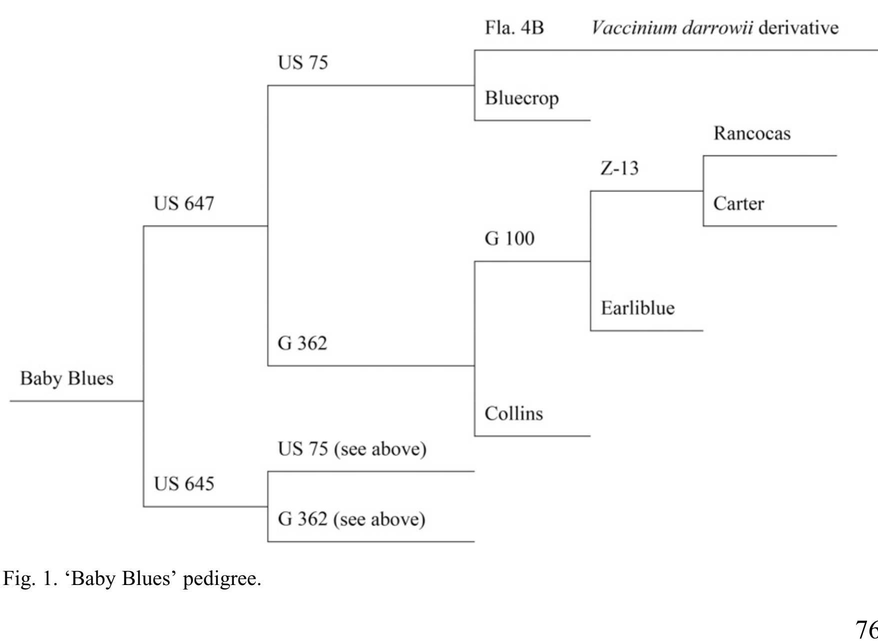


Fig. 1. 'Baby Blues' pedigree.

Received for publication 23 Feb. 2016. Accepted for publication 1 Apr. 2016.
This research was funded by the Oregon Blueberry and Washington Blueberry Commissions, a grant through the Northwest Center for Small Fruits Research, and USDA-ARS CRIS projects 2072-21220-002-00D and 2072-21000-047-00D.
We gratefully acknowledge Connie Pace, Nino Adams, Kimmie Ernst, Gil Buller, Patrick Jones, Michael Dossett, Tom Walters, Adam Wagner, and Peter Boches for their assistance in the evaluation of 'Baby Blues'; Fall Creek Farm and Nursery, Inc. (Lowell, OR) for testing 'Baby Blues' and for propagating test quantities of plants; and Nola Mosier for efforts to free the nuclear material of known viruses.
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(DeFrancesco et al., 2013). After performing well in an observation plot that was planted in 2000 and harvested from 2003 to 2006, 'Baby Blues' was then included in a replicated trial planted in 2006 with the standards 'Aurora', 'Bluecrop', 'Draper', and 'Liberty'; the trial was a randomized complete block design with three, 3-plant replications. In 2006, 'Bluecrop' was the most important cultivar in the Pacific Northwest but has since been supplanted by 'Duke' and 'Draper' for the midharvest season. 'Liberty' and 'Aurora' have become the standards for the late midseason and late season, respectively.

Plots were harvested by hand once per week from 2008 to 2012 to determine harvest season, yield, and average fruit weight (based on a randomly selected subsample from each harvest). A weighted mean fruit weight was calculated. In addition, each spring during the flowering period, the percentage of flowers that died from *Blueberry shock virus* (BlShV) was estimated on each plant, and the yield adjusted accordingly to account for the estimated crop loss. This pollen-borne virus is somewhat unique in that the portion of the plant infected by the virus shows the flower shock symptom only once, but it may take several years to move through the plant. Once BlShV has moved through the plant, the plant will be asymptomatic for flowering-/fruiting-related traits for its life, but may show some leaf spotting (Bristow and Martin, 1999).

The data, collected from 2008 to 2012, were analyzed as a split plot in time with cultivar as the main plot and year as the subplot with mean separation by least significant difference. The cultivar × year interaction was significant for yield but not fruit weight. The means for the final harvest year and the overall means are presented and compared (Table 1). Subjective fruit evaluations were made during the 2011–13 fruiting seasons using a 1 to 9 scale (9 = the best expression of each trait) and included picking ease (rating of how easily the ripe fruit were separated from the plant), color (ideal is light blue due to the surface wax or bloom), picking scar (evaluation of the scar where shallow and dry are ideal but deep or torn skin are unacceptable), firmness (as measured subjectively by hand when pressing thumb and forefinger together on the fruit), and flavor (rated by tasting fruit in the field) are presented (Table 2). Plant ratings were conducted one time each year to assess plant vigor (1 = dead to 9 = extremely vigorous) (Table 2).

The fruit ripening season in Oregon was characterized by the dates on which 5%, 50%, and 95% of the total fruit were harvested (Table 3). A handheld, machine harvest simulator (B.E.I. International, Kalamazoo, MI) was used in 2013 to compare 'Baby Blues' and 'Draper' for machine harvestability at OSU-NWREC.

Fruit titratable acidity, percent soluble solids, and pH were determined at each harvest date in each year from fresh hand-harvested fruit (Table 4). Fruit samples of 'Baby Blues', 'Rubel', 'Draper', and 'Bluecrop' from the 2015 growing season were analyzed for anthocyanins using previously described procedures (Lee and Finn, 2007) and with a longer high-performance liquid chromatography column (Synergi Hydro-RP 80Å, 250 × 2 mm, 4 µm; Phenomenex Inc., Torrance, CA) (Table 5) (Lee et al., 2004). Fruit were processed as individually quick frozen fruit and were thawed before being informally evaluated by growers, processors, and researchers in each year to determine whether they were commercially acceptable; traits including appearance, color, shape, flavor, firmness etc. were taken into account.

Table 1. Berry weight and yield in the final year of harvest when the plants were fully mature and averaged over the 2008–12 harvest seasons for 'Aurora', 'Baby Blues', 'Bluecrop', 'Draper', and 'Liberty' blueberry at Oregon State University's North Willamette Research and Extension Center (Aurora, OR); grown in a replicated trial (three 3-plant plots) in 2006. Plants were scored for percentage of the plant showing *Blueberry shock virus* symptoms at bloom and yield was adjusted by that percentage to determine a "shock adjusted" yield.

| | Berry wt (g) | | Yield (kg/plant) | |
|---|---|---|---|---|
| Cultivar | 2012 | 2008–12 | 2012 | 2008–12 |
| Aurora | 2.7 a[z] | 2.2 a | 4.83 ab | 1.54 b |
| Baby Blues | 0.9 b | 0.8 c | 5.93 a | 1.67 b |
| Bluecrop | 2.4 a | 2.0 b | 4.38 b | 2.06 a |
| Draper | 2.7 a | 2.2 a | 3.71 b | 1.63 b |
| Liberty | 2.7 a | 1.9 b | 6.10 a | 2.35 a |

[z]Mean separation within columns by least significant difference, $P \leq 0.05$.

## Description and Performance

Fruit size was greater with each successive year; however, there were no cultivar × year interactions for fruit size (Table 1). The fruit of 'Baby Blues' was very small, only 38% to 42% of the weight of the next largest cultivar over the study years. Yield increased with each successive year, and there was a cultivar × year interaction for yield. The mean yield for 'Baby Blues' in 2008–12 was less than for 'Liberty' and 'Bluecrop' but comparable to that of 'Aurora' and 'Draper'. In the final year of harvest (2012), when the plants were largest, the yield of 'Baby Blues' was similar to 'Liberty' and 'Aurora' and greater than 'Bluecrop' and 'Draper'.

The most common cultivar currently planted specifically for the commercial small-fruit market is 'Rubel' (Darrow and Scott, 1966). While 'Baby Blues' and 'Rubel' were not in the same trials where they might be directly compared, their performance relative to 'Bluecrop' in two separate trials can be compared. In a trial planted in 2000 and harvested through 2006, 'Rubel' fruit were 40% the weight of 'Bluecrop'. 'Rubel' yielded significantly less than 'Bluecrop' (2.2 vs. 5.8 kg/plant) (data not shown). In contrast, in the trial planted in 2006 (Table 1), the yield of 'Baby Blues' was slightly less (5-year mean) or greater (mean of last year of harvest) than that of 'Bluecrop'. 'Rubel' had a yield that was about half that of 'Bluecrop'. 'Rubel' and 'Baby Blues' each had a fruit size that was ≈40% that of 'Bluecrop'. While impossible to completely characterize the environmental differences over these two different trials, 2000–11 were considered typical years, and plant growth in each trial was excellent.

There were differences among the tested cultivars for all subjectively evaluated traits (Table 2), among years only for fruit color and fruit firmness, and there were cultivar × year interactions for each trait except firmness (data not shown). 'Baby Blues' was similar to the other cultivars and better than 'Aurora' for the ease of picking. The reason for the significant cultivar × year interaction was not clear, but the scores were less erratic and more consistent in the last 3 years of the trial as the bushes reached maturity and were consistently carrying a full crop load.

When assessing cultivar suitability for machine harvest using a handheld vibrating simulator, 'Baby Blues' had a higher yield than 'Draper' (8.9 vs. 6.9 kg/plant), higher quality scores, and was very easy to harvest (data not shown). After simulated machine harvest, 'Draper' fruit had a considerable number of pedicels attached ("stemmy"), whereas there were very few fruit of 'Baby Blues' with the pedicel attached (B.C. Strik, personal observation).

'Baby Blues' reliably had a heavily waxed (bloomed), bright-blue fruit that was scored better than all of the other cultivars (Table 2; Figs. 2–4). While there were differences among years, the mean color scores were all acceptable as a fresh product (data not shown). The significant cultivar × year interaction for color appears to be due to the generally declining scores for 'Bluecrop' and the rising scores for 'Aurora', while the other three cultivars consistently rose and declined together (data not shown). The declining color scores for 'Bluecrop' are likely

Table 2. Subjectively evaluated fruit quality and plant vigor for 'Aurora', 'Baby Blues', 'Bluecrop', 'Draper', and 'Liberty' blueberry grown in a replicated trial (three 3-plant plots) planted in 2006 and evaluated from 2008 to 2013 at Oregon State University's North Willamette Research and Extension Center (Aurora, OR).[z]

| | Fruit quality | | | | | |
|---|---|---|---|---|---|---|
| Cultivar | Picking ease | Color | Scar | Firmness | Flavor | Plant vigor |
| Aurora | 7.2 b[y] | 6.4 e | 7.8 a | 6.8 c | 6.6 c | 6.8 c |
| Baby Blues | 7.7 a | 8.5 a | 7.1 b | 7.7 b | 8.6 a | 7.8 ab |
| Bluecrop | 7.7 a | 7.2 d | 7.1 b | 6.9 c | 6.6 c | 7.9 a |
| Draper | 7.6 a | 7.9 c | 8.1 a | 8.6 a | 6.7 c | 6.4 d |
| Liberty | 7.8 a | 8.1 b | 7.9 a | 7.6 b | 7.2 b | 7.5 b |

[z]A 1 to 9 scale was used where 9 = the best expression of each trait and 1 = the worst.
[y]Mean separation within columns by least significant difference, $P \leq 0.05$.

reflective of this cultivar becoming less ideal as new high-quality cultivars have been released over the past decade (data not shown). The picking scars for 'Baby Blues' was comparable to 'Bluecrop' but not as dry and shallow as the scars for 'Draper', 'Liberty', and 'Aurora' (Table 2). The significant cultivar × year interaction reflects a tremendous amount of variability for this trait when the crop was light on young plants, but it stabilized as the plants began carrying a full crop (data not shown). 'Draper' fruit were rated the firmest and 'Bluecrop' and 'Aurora' the softest with 'Liberty' and 'Baby Blues' being intermediate. While there were differences over years, fruit firmness was considered marginal only in 2013.

High flavor is one of 'Baby Blues' most outstanding characteristics. It was not only significantly different from the other cultivars, but also had a nearly two point higher score than all of the cultivars except 'Liberty'. Not only does 'Baby Blues' have a very good acid/sweet balance, but also it has the aroma that people associate with wild blueberries. The significant cultivar × year interaction is interesting as most of the scores follow a consistent pattern. 'Aurora', 'Draper', and 'Liberty' each had 1 or 2 years where they were much better or worse than the other 4 to 5 years when their scores were consistent (data not shown). In numerous informal evaluations of thawed frozen fruit, 'Baby Blues' was identified by the expert panels as having outstanding fruit flavor.

Table 3. Ripening season was estimated as the date at which yield passed the given percentage of total yield for 'Aurora', 'Baby Blues', 'Bluecrop', 'Draper', and 'Liberty' blueberry in a trial planted in 2006 and evaluated from 2008 to 2012 at Oregon State University's North Willamette Research and Extension Center (Aurora, OR).

| | Harvest season | | |
|---|---|---|---|
| Cultivar | 5% | 50% | 95% |
| Draper | 11 July | 18 July | 31 July |
| Bluecrop | 18 July | 18 July | 2 Aug. |
| Baby Blues | 21 July | 21 July | 5 Aug. |
| Liberty | 28 July | 1 Aug. | 12 Aug. |
| Aurora | 11 Aug. | 15 Aug. | 1 Sept. |

'Baby Blues' fruit harvested in 2010–12 differed from other cultivars for pH and titratable acidity but not for soluble solids. In addition, there were differences among the years for soluble solids and titratable acidity, and there were no cultivar × year interactions for any of these traits (Table 4). While 'Baby Blues' had high soluble solids, they were not significantly different from the other cultivars. We are not sure why the fruit in 2010 were sweeter than the other years, but presumably the growing and ripening conditions were more ideal for sugar accumulation, there was a greater leaf to fruit ratio, or, more likely, the fruit had a lower moisture content thereby concentrating the sugars. While the fruit pH varied among cultivars, they were all below the level (pH 3.5) where anthocyanins are stable in a processed product. The fruit of 'Baby Blues' had a titratable acidity that was comparable to all of the other cultivars except 'Aurora' that had a much higher titratable acidity level. The variability from year to year cannot be attributed to anything simple; however, the range from 7.61 to 9.28 $g \cdot L^{-1}$ as citric acid for all cultivars in all years is not that dramatic. In the 2004 evaluation, where fruit from 'Rubel' plants established in 2000 were harvested as were fruit from 'Baby Blues' plants established in 2002, the chemistry traits for these cultivars were fairly comparable with soluble solids, pH, and titratable acidity of 17.0 °Brix, 3.27, and 8.25 $g \cdot L^{-1}$ as citric acid for 'Baby Blues' and 18.1 °Brix, 3.30, and 9.15 $g \cdot L^{-1}$ as citric acid for 'Rubel'.

The cultivars were evaluated for anthocyanin content and profile and contained similar anthocyanins. However, the proportions of the various anthocyanins varied (Table 5). 'Rubel' had the greatest amounts of anthocyanin followed by 'Baby Blues', 'Draper', and 'Bluecrop'. Since 'Baby Blues' has small fruit and therefore one might assume more anthocyanin-containing skin per unit fresh weight, it was not surprising that it had higher levels than the larger fruited 'Draper' and 'Bluecrop', but it was surprising that 'Baby Blues', with fairly similar fruit weight to 'Rubel', had much lower anthocyanin levels. All of the cultivars predominantly contained malvidin-based anthocyanins (51% to 92%). Compared with 'Rubel', 'Baby Blues' proportionally had lower delphinidin (15% vs. 21%) and cyaniding (5% vs. 14%), higher malvidin (64% vs. 51%) and petunidin (14% vs. 11%), and similar peonidin (3% vs. 2%) based anthocyanin levels. 'Baby Blues' anthocyanins in proportion of total are most similar to 'Draper'.

'Baby Blues' sets fruit when manually self-pollinated, but fruit set was less than when manually pollinated with a bulk pollen sample from multiple genotypes. Typically, fruit set with self-pollen was approximately two-thirds of that for pollination with bulk pollen and seed number per fruit, but not fruit size, were less (data not shown).

The harvest season for 'Baby Blues' tends to be ≈3 d later than 'Bluecrop' and ≈7–10 d earlier than 'Liberty' and 20–26 d earlier than 'Aurora' (Table 3). In the 2000 planted replicated trial, 'Rubel' and 'Bluecrop' were nearly identical in their 5%, 50%, and 95% harvest dates (8, 13, and 30 July, respectively) over the 5 years of study (data not shown). In a direct comparison, we would expect 'Rubel' to ripen its crop ≈3 d ahead of 'Baby Blues'. The length of the harvest seasons for 'Bluecrop', 'Baby Blues', and 'Liberty' were identical, while 'Draper' and 'Aurora' had a longer season (Table 3).

'Baby Blues' was significantly more vigorous than 'Draper' and 'Aurora' and was similar to 'Liberty' and 'Bluecrop' (Table 2; Fig. 5). While there were significant differences among years, the general trend was for plants to be scored as more vigorous at the end of the trial when they were older. A significant cultivar × year interaction was largely due to 'Aurora' having poor vigor in its first year, with steadily increasing vigor in subsequent years, whereas vigor did not vary much from year to year in the other cultivars (data not shown). 'Aurora' getting a low vigor score in the first year was likely a result of its growth habit not being well known when we began this evaluation; 'Aurora' is a squat bush in its establishment years until, with maturity and pruning, it grows out of this habit.

Table 4. Fruit chemistry characteristics for five blueberry cultivars grown at Oregon State University's North Willamette Research and Extension Center (Aurora, OR) and harvested in 2010–12.

| Cultivar | Soluble solids (°Brix) | pH | Titratable acidity ($g \cdot L^{-1}$ as citric acid) |
|---|---|---|---|
| Aurora | 15.76 a[z] | 2.91 c | 11.96 a |
| Baby Blues | 16.39 a | 3.47 ab | 7.56 b |
| Bluecrop | 13.49 a | 3.37 ab | 7.54 b |
| Draper | 14.08 a | 3.48 a | 6.50 b |
| Liberty | 13.95 a | 3.24 b | 7.91 b |

[z]Mean separation within columns by least significant difference, $P \leq 0.05$.

Table 5. Anthocyanin concentrations of 'Baby Blues', 'Rubel', 'Draper', and 'Bluecrop' blueberries harvested in 2015 from trials at Oregon State University's North Willamette Research and Extension Center (Aurora, OR).

| | Anthocyanin concentration (mg of cyanidin-3-glucoside/100 g)[z] | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cultivar | dpd-gal | dpd-glu | cyd-gal | dpd-arab | cyd-glu | ptd-gal | cyd-arab | ptd-glu | ped-gal | ptd-arab | mvd-gal | ped-glu | mvd-glu | ped-arab | mvd-arab | Total |
| Baby Blues | 4.2 | 0.1 | 1.3 | 2.1 | 0.1 | 4.5 | 0.8 | nd[y] | 0.9 | 1.9 | 18.5 | nd | 0.8 | 0.2 | 8.9 | 44.3 |
| Rubel | 9.2 | 3.7 | 3.3 | 4.1 | 2.2 | 6.5 | 6.0 | nd | 1.2 | 2.6 | 20.2 | nd | 13.4 | 0.3 | 7.2 | 79.9 |
| Draper | 2.3 | 0.1 | 1.1 | 0.9 | 0.1 | 3.2 | 0.5 | nd | 0.9 | 1.0 | 16.7 | nd | 0.6 | 0.1 | 6.0 | 33.5 |
| Bluecrop | 0.1 | nd | 0.2 | nd | 0.2 | 0.3 | 0.4 | nd | 0.3 | 0.2 | 7.6 | nd | 4.7 | nd | 5.3 | 19.3 |

[z]dpd = delphinidin; cyd = cyanidin; ptd = petunidin; ped = peonidin; mvd = malvidin; gal = galactoside; glu = glucoside; arb = arabinoside. Anthocyanin listed in the order of high-performance liquid chromatography elution.
[y]nd = not detected.

Fig. 2. 'Baby Blues' fruit cluster.

'Baby Blues' under a minimal spray program has not been noted for any disease or pest problems. Plants have been regularly sampled for virus presence particularly BlShV. Since it was first selected in 1999, only two 'Baby Blues' plants have tested positive for BlShV and the first time was 2014. These positive plants were removed before they could be tested a 2nd year to confirm infection. The oldest plants, established in 2001 in a field with many BlShV-positive plants of other genotypes, have yet to test positive for BlShV. While 'Baby Blues' appears to eventually get BlShV, it is tentatively grouped with 'Bluecrop', 'Elliott', 'Jersey', and 'Legacy' as cultivars that are slow to become infected.

'Baby Blues' has not exhibited winter injury in any region of the PNW since it has been planted—western Oregon (USDA Plant Hardiness Zone 8b) in 1997, Abbotsford, B.C., Canada (USDA Plant Hardiness Zone 8a), in 2006, Mount Vernon, WA (USDA Plant Hardiness Zone 8a), in 2001, and in Prosser, WA (USDA Plant Hardiness Zone 7a), in 2013 (USDA Agricultural Research Service, 2012). In southwest Michigan (USDA Plant Hardiness Zone 6a), 'Baby Blues' has survived and produced for 11 years, and while precise records were not kept, it did suffer significant injury in the worst winters and so should be trialed before planting in large commercial plantings there. Its winterhardiness appeared comparable to 'Legacy'. If there is a fully ripe crop on 'Baby Blues', the fruit are susceptible to some fruit splitting with rain or heavy fog. Since this splitting has not led to fruit deterioration and since the fruit of 'Baby Blues' will be mostly frozen, this is not expected to be a serious problem.

'Baby Blues' is introduced as a very high-quality, high-yielding, machine-harvestable, northern highbush blueberry with very small, uniformly shaped and sized, bright blue fruit with an outstanding, aromatic blueberry flavor that is well-suited for processing. 'Baby Blues' should be adapted to most areas where northern highbush blueberries can be grown successfully, but should be trialed in areas with harsh winters before being commercialized.

'Baby Blues' nuclear stock has tested negative by enzyme-linked immunosorbent assay for *Blueberry leaf mottle virus*, *Blueberry scorch virus*, BlShV, *Blueberry shoestring virus*, *Peach rosette mosaic virus*, *Tomato ringspot virus*, *Tobacco ringspot virus* and by RT-PCR assays for *Blueberry mosaic virus*, *Blueberry necrotic ring blotch virus*, *Blueberry red ringspot virus*, *Blueberry fruit drop associated virus*, and blueberry stunt phytoplasma.

An application for a U.S. Plant Patent has been submitted for 'Baby Blues' (U.S. Plant Patent Application Serial No. 14/545,561). When this germplasm contributes to the development of a new cultivar, hybrid, or germplasm, it is requested that appropriate recognition be given to the source. Further information or a list of nurseries propagating 'Baby Blues' is available on written request to Chad Finn (chad.finn@ars.usda.gov); USDA-ARS Horticultural Crops Research Unit; 3420 NW Orchard Avenue, Corvallis, OR 97330. The USDA-ARS and Oregon State University do not sell plants. In addition, genetic material of this release has been deposited in the National Plant Germplasm System as CVAC 2150, where it will be available for research purposes, including development of new cultivars.

Fig. 3. Flat of 'Baby Blues' fruit harvested by hand.

Fig. 4. Three flats of 'Baby Blues' fruit harvested with handheld simulated machine harvest equipment, before sorting or cleaning.

Fig. 5. A 13-year-old plant of 'Baby Blues' in full bloom.

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