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Color and Russet Variation Among Selections of 'Bosc' Pear

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Abstract

Surface color and russet coverage were measured on fruit of 'Bosc' pear and four high-russet selections of 'Bosc': 'Golden Russet Bosc', 'Bronze Beauty', 'Mt. Adams Bosc', and 'Wenatchi Gold'. In four years of study varying in the amount of rainfall during the post-bloom period of russet vulnerability, russet coverage varied substantially in 'Bosc', while all high-russet selections developed full russet in all years. Fruit color, as indicated by hue values, was not significantly different among the high-russet selections, although all were different than 'Bosc'. The 'Bosc' value for color saturation (chroma), was greater than that for 'Bronze Beauty' and 'Wenatchi Gold'. 'Bosc' color was lighter than the high-russet selections over the four years. In a year of relatively high rainfall during the post-bloom period, fruit cracking developed in some of the high-russet selections. The highest incidence of cracking was observed in 'Mt. Adams Bosc', 'Bronze Beauty', and 'Wenatchi Gold', with small amounts in standard 'Bosc' and 'Golden Russet'.

The 'Beurré Bosc' ('Bosc') pear (*Pyrus communis* L.) is believed to have originated from a seedling in Belgium or France early in the 19th century (10, 14), and is widely cultivated in the Pacific Northwest region of the United States (18). 'Bosc' is called 'Kaiser Alexander' or simply 'Kaiser' in Italy and some other countries (2). While known as a russet variety, the extent of russet development on the fruit varies considerably with climatic and cultural conditions (9, 14). In the generally dry inland valleys of the Pacific Northwest where many orchards of 'Bosc' pear are located, the extent of russet coverage on the fruit varies from year to year and can be a significant factor in successful marketing.

Several selections of 'Bosc' have been made from bud mutations that present more consistent and complete russet coverage of the fruit ("high-russet selections"). Of these, the most widely grown in the United States is 'Golden Russet Bosc' (13), described as a complete russet, which develops relatively early in the growing season (1, 20). 'Bronze Beauty' (21) is also described as a complete russet, and cited as "rougher to the touch" than the smoother 'Golden Russet'. Both were found as sports on trees of 'Bosc' pear in northern Oregon. Other non-patented selections have also been named, including 'Wenatchi Gold', 'Noble Russet', and 'Mt. Adams Bosc', found as sports on trees of 'Bosc' in the state of Washington. To the best of the authors' knowledge, all selections are grown to varying extents in commercial pear orchards in the Pacific Northwest. The objective of this study was to compare the fruit color and extent of russet development in 'Bosc' pear and four high-russet selections over four growing seasons in the Rogue River Valley near Medford, Oregon.

Materials and Methods

Trees of standard 'Bosc' pear and four high-russet selections were planted at the Southern Oregon Research and Extension Center near Medford in 1991. High-russet selections were 'Golden Russet Bosc', 'Bronze Beauty', 'Mt. Adams Bosc' and 'Wenatchi Gold'. The selection 'Noble Russet' was not available at the time of organizing this study. Three replicate trees of each cultivar were randomly arrayed in a single row. All trees were grafted on 'Old Home x Farmingdale #97' rootstock (3). Trees were managed with conventional cultural and pest control practices (16).

In 2004-2007, 10 fruit were harvested at commercial maturity from each replicate of

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each cultivar and stored at 0 °C for 4-6 weeks until color and russet were evaluated. Color was measured on each fruit with a Minolta CR-200b portable tristimulus colorimeter (Konica Minolta Sensing Americas, Ramsey, NJ), using the Commission Internationale de l'Eclairage L*, a*, b* color space coordinates (12, 17) where L* indicates relative lightness (higher values) or darkness (lower values), a* indicates value from green to red, and b* indicates value from blue to yellow. Hue was calculated as $\tan^{-1}$ b*/a*, and chroma (color saturation) was calculated as $(a^2 + b^2)^{½}$ (17). Color was measured in a random location along the widest portion of each fruit.

The extent of russet coverage was estimated on each fruit according the Horsfall-Barrat system (11), in which the extent of russet was assigned to one of 12 categories between 0 and 100 %, with a greater number of categories at the extremes of this range than between 25-75 %. The percentage of fruit with ≥ 75 % of the surface covered (high russet) and ≥ 94 % of the surface covered (full russet) were then calculated from the distribution of fruit among the Horsfall-Barrat categories.

All color and russet data were subjected to analysis of variance with the aid of Statistix software version 8 (Analytical Software, Tallahassee, FL), using a randomized complete block design, with blocking by year. Means were separated using Tukey's HSD test at the 5 % level.

Results and Discussion

Fruit color, as indicated by hue value, was not significantly different among the high-russet selections over the four-year period, although all were different than standard 'Bosc' (Table 1). Standard 'Bosc' had a significantly greater value for color saturation (chroma) than 'Bronze Beauty' and 'Wenatchi Gold'. Standard 'Bosc' had the highest L* value (was lighter in color) every year and was significantly higher than the high-russet selections over the four years (Table 1). These color difference may reflect the contribution to color quality imparted by the russet, and/or qualities of the ground color of the fruit surface.

All high-russet 'Bosc' strains developed full russet (≥ 94 % of surface covered) in all years of study. Russet on fruit of standard 'Bosc' varied from year to year; the percentage of fruit with high russet ranged from 22.0 – 96.7 % and fruit with full russet ranged from 0 – 80 % (Table 2), with mean values of 63.2 % and 22.4 %, respectively (Table 1). The year with the lowest russet coverage was 2006, which corresponded to the year with least rainfall during the post-bloom period (Table 3).

Table 1. Colorimetric characteristics of selections of 'Bosc' pear grown in Medford, Oregon, and percentage of fruit with ≥ 75 % or ≥ 94 % of the surface covered in russet at harvest, 2004-2007[z].

	Hue	Chroma	L*	High russet (% ≥ 75 %)	Full russet (% ≥ 94 %)
Standard	80.9 a[y]	35.5 a	55.2 a	63.2 b	22.4 b
Golden Russet	74.9 b	31.2 ab	47.6 b	100.0 a	100.0 a
Bronze Beauty	73.8 b	30.1 b	48.2 b	100.0 a	100.0 a
Wenatchi Gold	71.2 b	29.6 b	46.5 b	100.0 a	100.0 a
Mt. Adams	74.6 b	32.6 ab	48.9 b	100.0 a	100.0 a

[z] Color was measured with a Minolta CR-200b portable tristimulus colorimeter, where L* indicates relative lightness (higher values) or darkness (lower values), a* indicates value from green to red, and b* indicates value from blue to yellow. Hue was calculated as $\tan^{-1}$ b*/a*, and chroma (color saturation) was calculated as $(a^{*2} + b^{*2})^{½}$.

[y] Values within columns followed by the same letter are not significantly different according to Tukey's HSD test ($P \geq 0.05$).

Table 2. Variability in annual incidence of standard 'Bosc' pear fruit with ≥ 75 % or ≥ 94 % of the surface covered in russet at harvest, 2004-2007.

Year	High russet (% > 75 %)	Full russet (% > 94 %)
2004	55.0 ab [z]	0.0 b
2005	96.7 a	80.0 a
2006	22.0 b	0.0 b
2007	76.7 a	3.3 b

[z] Values within columns followed by the same letter are not significantly different according to Tukey's HSD test ($P > 0.05$).

Table 3. Rainfall recorded at the Southern Oregon Research and Extension Center near Medford, Oregon, during periods following full bloom (full bloom = day 1).

		Rainfall (mm)				
		Days after full bloom				
Year	Full bloom date	1-7	8-14	15-21	22-28	Total
2003	11 April	22.4	34.0	5.8	12.7	74.9
2004	29 March	10.2	0.0	10.9	7.1	28.2
2005	29 March	14.0	7.1	9.9	7.6	38.6
2006	21 April	0.3	0.0	0.0	0.0	0.3
2007	6 April	6.6	24.1	12.7	6.4	49.8

Russet results when periderm tissue replaces the epidermis and cuticle in response to frost, pest or chemical injury, or to environmental conditions such as moisture and temperature (6). Pome fruit cultivars vary in their inherent propensity to russet in response to russetting agents or conditions, which may involve the thickness or structure of the cuticle and its ability to protect underlying cells from potential russetting agents (15). Regardless of the degree of russet susceptibility, the most vulnerable period appears to be during the period of intensive cell division within approximately 30 days of full bloom (4, 9). During this rapid fruit growth, the cuticle is relatively thin, and cracks may develop (5).

Increased fruit russet is associated with wetter conditions during the period of vulnerability. Epidermal cells may be injured by excessive uptake of water that contacts the cells via cuticular cracks, causing them to rupture and stimulating the surrounding cells to produce periderm (6). High-russet selections of 'Bosc' pear may have altered cuticular structure that facilitates epidermal contact with water, but this remains to be established experimentally. On the other extreme, a 'Russet-free Bosc' selection (PI 541509) exists in the pear collection of the National Clonal Germplasm Repository (19).

In 2003, prior to the beginning of the color study, visible fruit cracking was noted in late

Table 4. Incidence of fruit cracking in selections of 'Bosc' pear evaluated on 27 May 2003[z].

Cultivar	Percentage of fruit with visible cracks
Standard	1.2 c[y]
Golden Russet	0.8 c
Bronze Beauty	46.0 ab
Wenatchi Gold	27.2 b
Mt. Adams	49.3 a

[z] Full bloom date: 11 April 2003.

[y] Values followed by the same letter are not significantly different according to Tukey's HSD test ($P > 0.05$).

spring, especially in the high-russet cultivars. The percentage of fruit with visible cracking was evaluated in late May. The cracking persisted through the growing season, although cracks were often partially healed by harvest, leaving a sunken scar that would likely be unacceptable in commercial packing. The highest incidence of cracking was observed in 'Mt. Adams Bosc', 'Bronze Beauty', and 'Wenatchi Gold', with small amounts in standard 'Bosc' and 'Golden Russet' (Table 4). The cracking took place in a relatively wet year (Table 3); there was no cracking observed in any of the subsequent years of study. Some growers who applied copper-containing products to standard 'Bosc' for fire blight control near petal-fall in 2003 reported observing similar cracking in commercial crops.

'Bronze Beauty', 'Golden Russet', and 'Wenatchi Gold' all developed full russet during two years in the relatively moist growing conditions of northwestern Washington, where standard 'Bosc' also developed full russet (7, 8). Our results indicate that those three high-russet selections of 'Bosc' and the 'Mt. Adams' selection can develop complete russet under a variety of environmental conditions during the post-bloom period of russet vulnerability, including years in which russet development was severely limited in standard 'Bosc'. However, our color measurements do not indicate consistent fundamental color differences among the high-russet selections, as grown in southern Oregon.

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The Wilder Medal is presented to individuals or organizations that have rendered outstanding service to horticulture in the area of pomology. Special consideration is given to work relating to the origination and introduction of meritorious fruit cultivars. Individuals associated with either commercial concerns or professional organizations will be considered if their introductions are truly superior and have been widely planted. Significant contributions to the science and practice of pomology other than through fruit breeding will also be considered. Such contributions may relate to any important area of fruit production such as rootstock development and evaluation, anatomical and morphological studies, or noteworthy publications in any of the above subjects. Information about the award, past recipients, etc. can be found on the APS web site at http://americanpomological.org/wilder1.html.

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