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# Stability of Yield in Highbush Blueberry Cultivars

JAMES H. SIEFKER AND JAMES F. HANCOCK


## Abstract

Seventeen blueberry cultivars were harvested for 13 years at a single site in Michigan. Yield stability was estimated using a linear regression of cultivar yield on the mean of all cultivars for each year. In general, high yielding cultivars were more stable than lower yielding ones. Cultivars with a history of successful performance in Michigan had better than average yield and stability.


## Introduction

Stability of yield is particularly important in fruit crops. A year of low production and high prices can result in reduced demand in subsequent years as consumers and processors turn to more available and therefore cheaper alternatives. Exceptionally high production may excede consumer demand and processing capacity.

Methods of quantifying stability have been developed by several authors. Finlay and Wilkinson (3) used the regression coefficient of cultivar mean on environmental mean as a measure of stability to take into account the dynamic response of genotypes to different environments. Eberhart and Russell (2) established criteria for a desirable cultivar as: 1) high yield, 2) regression coefficient near 1.0 and 3) Low deviation from regression. The regression coefficient represents that portion of the variability in yield that can be ascribed to a common environmental influence, while the deviation from regression represents that portion that is due to other sources.

In perennial crops, factors come into play which are not important in annuals. The performance in a particular year is affected by environmental conditions not only in the current year but also previous years. The regression coefficient of cultivar mean on environmental mean will be increased for a cultivar with a higher than average rate of growth or recovery from injury. In addition, vigorous genotypes may reach their maximum yield early and then have a yield plateau while the yields of other genotypes are still increasing. This will increase deviation from regression.

The regression method has been employed in several perennial species including cocksfoot (1), bromegrass (11), and strawberries (12, 4 and 5), but in none of these cases was data collected for more than two years. In this study, we examined the relationship between yield and stability in a number of highbush blueberry cultivars over 12 years to determine which were the most consistent producers.

## Materials and Methods

Seventeen cultivars were planted at Grand Junction, Michigan in 1966 in a completely randomized design, with 4, 4 bush replicates of each cultivar. Bush spacing was 1.2 meters within rows and 3 meters between rows. Bushes were maintained according to standard cultural practices (8). The significant environmental conditions in Michigan for the years of the study are listed in Table 1.

Department of Horticulture, Michigan State University, East Lansing, MI 48824

**Table 1. Total Michigan blueberry production and significant environmental conditions from 1969 to 1981. (Source-Michigan Agricultural Reporting Service, Lansing, Michigan).**

| Year | $10^6$ Kg | Environmental Characteristics |
|---|---|---|
| 1969 | 18 | Dry during and after harvest |
| 1970 | 12 | Moderate winter injury |
| 1971 | 18 | |
| 1972 | 8 | Freeze in early June |
| 1973 | 18 | |
| 1974 | 15 | Dry August and September, Considerable mummy berry |
| 1975 | 13 | Early spring, Hail on July 13 |
| 1976 | 14 | Early spring, Frost in May |
| 1977 | 5 | Severe winter injury |
| 1978 | 10 | |
| 1979 | 16 | Cool spring, Wet August |
| 1980 | 18 | |
| 1981 | 16 | Spring freeze |

Fruit yield was recorded for each plot starting in 1969 and continuing through 1981. Fruit was generally harvested by hand held shaker in two pickings. On rare occasions fruit was hand picked. Berries harvested by shaking were sorted to remove green fruit, damaged fruit, and debris. The weight of the remaining "marketable" fruit was used to represent yield.

The regression of plot means for each genotype on yearly means was performed using the method described by Sokal and Rohlf (10) for more than 1 value of Y per value of X. Because the regression coefficient is biased by the magnitude of yield (9), the regression coefficient for each cultivar was adjusted by dividing it by the ratio of the cultivar mean yield to the mean yield of all the cultivars. The deviation from regression, $d_{Y \cdot X}$, for each cultivar was also adjusted by dividing it by the mean for that cultivar.

## Results and Discussion

An analysis of variance demonstrated statistical significance for the cultivar effect ($F = 40.36$, $df = 16$, $P < 0.01$) and the cultivar by year interaction ($F = 2.74$, $df = 192$, $P < 0.01$). The regression coefficients and deviations from regression for the cultivars in this study are presented in Table 2. Yields ranged from 0.722 kg per bush per year for 'Bluehaven' to 2.844 kg per bush per year for 'Elliot'. Adjusted regression coefficients ranged from 0.606 for 'Blueray' to 1.493 for 'Collins'.

**Table 2. Mean yields, regression coefficients (b) and deviations ($d_{Y \cdot X}$/cultivar mean for 17 highbush blueberry cultivars for total marketable yield for the years 1969 to 1981.**

| Cultivar | Kg/Bush | b | ($d_{Y \cdot X}$/cultivar mean |
|---|---|---|---|
| Bluehaven | 0.722 | 0.759 n.s. | 1.62 ** |
| Darrow | 0.742 | 0.380 * | 1.39 ** |
| Elizabeth | 0.810 | 1.065 n.s. | 1.11 ** |
| Berkeley | 1.233 | 1.382 n.s. | 1.35 ** |
| Earliblue | 1.255 | 1.291 ** | 1.00 n.s. |
| Coville | 1.407 | 1.483 ** | 1.18 ** |
| Collins | 1.622 | 1.493 ** | 0.99 ** |
| Bluejay | 1.736 | 1.330 ** | 0.82 n.s. |
| Bluetta | 1.759 | 1.004 * | 1.34 ** |
| Spartan | 1.894 | 1.084 ** | 0.65 n.s. |
| Rubel | 1.981 | 0.830 ** | 0.57 * |
| Bluecrop | 2.059 | 0.797 ** | 0.59 n.s. |
| Lateblue | 2.138 | 1.076 ** | 0.76 * |
| Blueray | 2.261 | 0.606 * | 0.71 ** |
| Jersey | 2.272 | 0.716 * | 0.76 n.s. |
| Northland | 2.833 | 0.614 * | 0.72 * |
| Elliot | 2.844 | 1.001 ** | 0.55 * |

Stability as indicated by the adjusting regression coefficient, was significantly correlated with yield ($r = 0.506$, $df = 15$, $p < 0.05$). The deviations from regression were also significantly correlated with yield ($r = 0.813$, $df = 15$, $p < 0.01$).

Since all the cultivars have been at least moderately successful in some part of the country, it is doubtful that the low mean yields obtained for some of them are representative of their true yield potential. For example, 'Darrow' and 'Berkeley' yield higher in areas with milder winters than Michigan. Intermittent yield losses due to exceptionally cold

weather would reduce the measured stability and decrease mean yield.

'Bluecrop', 'Jersey', 'Blueray' and 'Northland' had low deviations from regression and regression coefficients below 1.0, indicating higher than average stability. 'Bluecrop' is currently the most widely planted cultivar in Michigan with 'Jersey' and 'Rubel' ranking second and third in acreage. 'Blueray' and 'Northland' are not widely planted because of their low fruit quality, however, they are known to be quite winter hardy (6).

'Bluejay' and 'Spartan' are currently being planted in Michigan because of their high yields and fruit quality. 'Spartan' also has particularly large fruit (7). Our data suggest that 'Bluejay' has poorer than average stability ($b < 1.0$), while 'Spartan' is average. Another early cultivar, 'Bluetta', was comparable to 'Spartan' in mean yield and b value, but had a high deviation from regression and is known to have poor fruit quality.

'Elliot' is now being planted as a late cultivar because of its high yields, and was shown in this study to have moderate stability ($b = 1.001$). Another late fruiting cultivar, 'Lateblue' had moderate yield and stability but was not superior to 'Elliot.'

These analyses indicate that excellent choices were made in the selection of 'Bluecrop,' 'Jersey' and 'Rubel' as major cultivars. 'Elliot' and 'Spartan' are less stable than these cultivars, but are more stable than any other cultivar being considered to extend the fruiting season.

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