yields were higher than yields of other cultivars when not irrigated and also responded more to irrigation. Yield increases of 57, 50, 30 and 19% over the 4 year period were found for 'Tifblue,' 'Southland,' 'Garden Blue,' and 'Delite,' respectively. Fruit from irrigated plants tended to have lower soluble solids than controls in 1981 and 1982 (Table 5).

Thus, rabbiteye blueberries can be very productive in the Tennessee Valley, though cold weather may periodically damage plants and reduce yield. Irrigation was very beneficial, resulting in over 40% more yield. 'Tifblue' was best adapted of the cultivars tested.

Literature Cited

1. Andersen, P. C., D. W. Buchanan and L. G. Albrigo. 1979. Water relations and yield of three rabbiteye blueberry cultivars with and without irrigation. J. Amer. Hort. Soc. 104: 731-736.
2. Clark, J. R., J. N. Moore, and E. C. Baker. 1986. Cold damage to the flower buds of rabbiteye blueberry cultivars. Arkansas Farm Research 35(6):3.
3. Davies, F. S., A. H. Teramura, and D. W. Buchanan. 1979. Yield, stomatal resistance, xylem pressure potential, and feeder root density in three rabbiteye blueberry cultivars. HortScience 14:725-726.
4. Kenworthy, A. L. 1972. Trickle irrigation . . . the concepts and guidelines for use. Michigan State Agr. Exp. Sta. Research Report 165.
5. Moore, J. N. 1976. Adaptation and production of blueberries in Arkansas. Ar. Agr. Exp. Sta. Bul. 804.
6. Mullins, C. A. 1977. Performance of three rabbiteye blueberry varieties. Tenn. Farm & home Sci. 101:30.
7. Spiers, J. M. 1981. Fruit development in rabbiteye blueberry cultivars. HortScience 16:175-176.
8. Spiers, J. M. 1981. Harvest intervals of six rabbiteye blueberry varieties. Miss. Agr. and For. Exp. Sta. Research Rpt. 5:(14).
9. Spiers, J. M. 1983. irrigation and peatmoss for the establishment of rabbiteye blueberries. HortScience 18:936-937.

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Evaluation of Advanced Strawberry Selections in Quebec[1]

SHAHROKH KHANIZADEH,[2] MICHEL LAREAU,[3] AND DEBORAH BUSZARD[4]

Abstract

Promising strawberry selections have been evaluated from 1983 to 1990. Out of more than 5000 seedlings from crosses made in 1983 and 1984 seven were selected. Final evaluation of these seven advanced selections at three locations resulted in the naming of SJ84187-3 and SJ83184-3 as 'Chambly' and 'Oka' respectively. The other five selections will be kept and used as parents for future crosses.

Additional index words. yield, fruit size, Sensory evaluation, breeding, *Fragaria x ananassa* Duch.

Introduction

The objectives of the Quebec strawberry breeding program are the development of high yielding cultivars suitable for mechanical harvesting (concentrating ripening, reflexed calyx, raised neck, firmness) and processing (colour, low juice loss and structural integrity after thawing, flavour), adapted to local growing conditions and environmental stresses such as

[1]Agriculture Canada, St-Jean-sur-Richelieu, Contribution No. 335/91.06.01R
[2]Research Scientist, formula developer, Agriculture Canada, Research Station, 430 Boul. Gouin, St-Jean-sur-Richelieu, Quebec, Canada J3B 3E6
[3]Agriculture Canada, Research Station, 430 Boul. Gouin, St-Jean-sur-Richelieu, Quebec, Canada J3B 3E6.
[4]Department of Plant Science Macdonald College of McGill University, Ste-Anne-de-Bellevue, Quebec, Canada H9X 1C0.

low winter temperatures and with resistance to leaf diseases and herbicides. On the basis of the breeding objectives, selections were either retained for commercial trials or used as parents. Out of more than 5000 seedlings from crosses made in 1983 and 1984 seven were reselected after four years of evaluation in advanced trials (Fig. 1). Final evaluations of these seven advanced selections were made at three locations: Deschambault, Quebec in 1987 and 1988; Bouctouche, New Brunswick in 1989 and L'Acadie from 1987 to 1990. Seven commercial cultivars adapted to Quebec were used for comparison in these regional trials.

Materials and Methods

Climate and locations. L'Acadie, located south east of Montreal, Quebec, 45° latitude and 46m elevation) has a clay loam soil with moderate drainage and a continental climate with little snow cover during the winter. Deschambault, located east of Quebec city, Quebec, (47° latitude and 30m elevation) has a loam soil and a continental climate with good snow protection during the winter. Bouctouche, located on the east coast of New Brunswick (46° latitude and 30m elevation) has a sandy loam soil and a modified maritime climate with good snow protection during the winter.

Experimental Design and Plant Materials. A completely randomized design was used in each trial with four replicates of each genotype.

Plants were set 60 cm apart in single row 5 m long plots on 10 cm raised beds, spaced 120 cm apart and watered immediately with 250 mL of a fertilizer solution (10-52-10). Flowers were removed twice and all runners kept and spaced within the 50 cm wide row. In November of each year the plantation was mulched with 6-7 cm of straw for winter protection.

Data Collection. Harvesting was done between mid June and late July in all years. At harvest a 2 m section of each plot was used for collection of yield and fruit size data as well as calculation of percent juice lost after thawing of frozen fruit. Fruit and plant characteristics (neck size, calyx and achene position, fruit and flesh colour, flavour, firmness, ease of decapping, plant vigour and leaf diseases) were ranked using a 1 to 5 scale.

Data analysis. Data collected from the three locations during the 1988-1990 harvests (1987, 1988 and 1989 plantings) were combined. Percentage and rank data were tested prior to analysis to established whether or nor the General Linear Models (GLM) could be used. An arcsine square root percent transformation was applied to all data except for total yield and average fruit size prior to analysis of variance. Data were analyzed on an IBM/AT 386 compatible using PC-SAS (2). The General Linear Model procedure (GLM) of PC-SAS was used to analyze genotypes and multiple comparison was made on least square means using a split split plot in time and location.

Three formulae were developed for genotype evaluation: an index of earliness (IE) as an indicator of both relative fruiting period and yield; an index of concentration (IC) as an indicator of concentrated ripening; and an index of deviation from known cultivars (ID) which allows grouping of genotypes based on all characteristics.

Index of earliness is calculated according to equation 1.

$$IE = \sum_{i=1}^{n} \left(\frac{Y_i}{D_i}\right)/n \qquad \text{Eq. [1]}$$

where i = 1,2,...,n is the number of harvests; Y_i is the yield at *ith* harvest and D_i, is the number of days from the start of harvesting to *ith* harvest e.g., $D_1 = 1$ for 1st harvest on June 24, $D_2 = 6$ for 2nd harvest on June 29, etc.). Late genotypes will have smaller IE than early ones.

Index of concentration is calculated according to equation 2.

$$IC = \frac{\sqrt{\sum_{i=1}^{n} (Y_i - \bar{Y})^2/n}}{n} \quad \text{Eq. [2]}$$

i = 1,2,...,n is the number of harvests; Y = percent of total yield picked at the *ith* harvest and $\bar{Y}$= average of percent yield for n harvests. Genotypes with shorter harvest periods (suitable for mechanical harvesting) will have larger IC values than those with longer requiring several harvest periods.

Breeders may be interested in knowing how a new genotype deviates or compares to commercial cultivars. Comparison based on individual characteristics do not help to identify similar genotypes or their overall deviation from the other genotypes. Also, it is sometimes helpfull in selection evaluation to have single index values to compare selections with known cultivars for important traits. Eq. 3 was used to calculate an index of deviation (ID) or similarity relative to other genotypes in the same trial. ID considers all the characteristics entered for the genotypes.

$$ID_{i'} = \sum_{j=1}^{t} \left[\sum_{\substack{i=1 \\ i \neq i'}}^{c} (R_{i'j} - R_{ij})^2 \right] \quad \text{Eq. [3]}$$

where i' = specific genotype selected from c total genotypes; i = other genotype in the same trial; j = the specific trait of t total traits for i'*th* and *ith* genotype and R = score values given to each i'*th* and *ith* trait.

Detailed of the above formulae with comprehensive examples are available upon request from the author (SK) on 5.5- or 3.25-inch micro flexible disk.

Results and Discussion

Total yield and average fruit size. Total yield and fruit size were averaged over four harvest-years (1987-1990) and three locations (split split plot in time and location). All figures given in the tables are based on sound fruits; those for mean fruit size are based on records for all pickings throughout the season.

SJ83OR-2 and SJ84187-3 significantly outyielded SJ8416-1, SJ83145-1, 'Sparkle,' SJ8357-1, 'Bounty,' 'Redcoat' and 'Midway' but not 'Glooscap,' 'Kent,' SJ83184-3, SJ84325-1 and 'Honeoye' (Table 1). 'Redcoat' and 'Midway' yielded the least and 'Sparkle,' SJ8357-1, and 'Redcoat' produced the smallest fruit compared to other genotypes (Table 1).

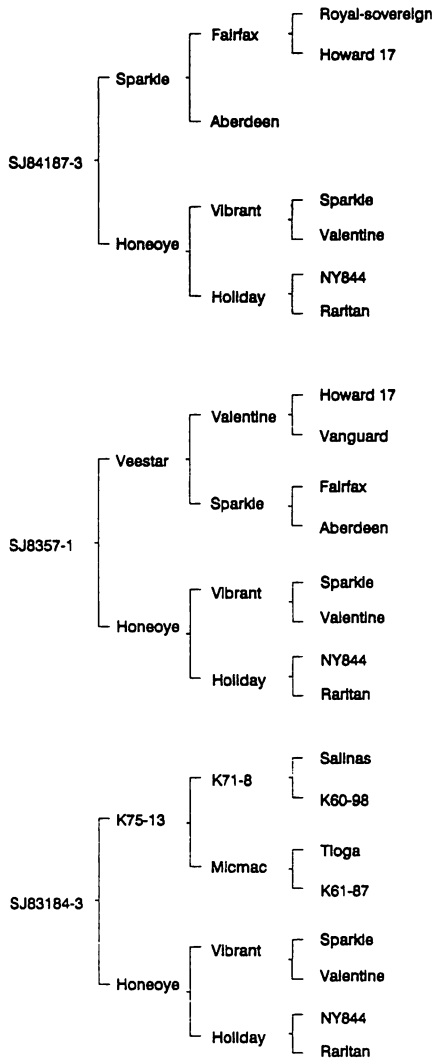

Figure 1. Pedigree of the advanced St-Jean selections.

Table 1. Mean yield, fruit size, percent harvested fruit at 3 dates, indices of earliness and concentration of 14 strawberry genotypes.[z]

Genotype	Yield (g $2M^{-1}$)[y]	Fruit weight (g)[y]	Cumulative percent yield 1st harvest	3rd harvest	5th harvest	Index of earliness[w]	Index of concentration[w]
SJ83OR-2	5683 a[x]	9.0 ab	1.4	57.5	98.9	11.1	1.9
SJ84187-3	5658 a	8.8 ab	9.1	68.8	98.7	19.0	1.8
Glooscap	5545 ab	7,6 ab	5.8	60.9	96.9	16.2	1.7
Kent	5451 ab	8.9 ab	7.6	57.4	97.0	15.8	1.4
SJ83184-3	4966 abc	9.8 a	10.9	66.1	98.3	15.0	1.6
SJ84325-1	4395 abcd	9.9 a	3.8	58.4	96.6	13.3	1.7
Honeoye	4201 abcd	8.0ab	8.8	62.1	96.7	16.9	1.6
SJ8416-1	3950 bcd	8.9 ab	11.2	63.3	95.4	17.7	1.3
SJ83145-1	3727 cd	8.5 ab	6.3	45.2	96.9	10.4	1.5
Sparkle	3517 cd	6.5 b	3.3	42.0	96.8	12.0	1.7
SJ8357-1	3397 cd	6.5 b	15.7	66.3	99.3	14.0	1.5
Bounty	3275 cd	8.3 ab	8.1	19.6	88.3	11.0	2.1
Redcoat	3034 d	6.2 b	17.3	70.2	97.6	16.3	1.5
Midway	2943 d	7.7 ab	22.3	70.5	97.4	13.8	1.5

[z]Average of four replicates for four years (1987-1990) and three locations.
[y]Fruit weight = total yield divided by total number of sound fruit for 7 harvests.
[x]Means followed by the same letter within columns are not significantly different based on Duncan's new multiple range test at 5% level.
[w]Index of earliness and index of concentration were calculated according to Eq. 1 and Eq. 2 respectively (see text).

The index of earliness (IE) shows that two SJ selections (SJ 84187-3 and SJ8416-1) cropped earlier than 'Honeoye,' 'Redcoat,' 'Glooscap' and 'Kent.' SJ83145-1 was the latest genotypes preceded by 'Bounty,' SJ83OR-2 and 'Sparkle' (Table 1). 'Bounty' and SJ3OR-2 had the most concentrated ripening based on the IC whereas 'Kent' and SJ8416-1 had the least (Table 1). These 2 indices are very important in selecting genotypes suitable for mechanical harvesting since they permit better harvest scheduling.

Using the index of deviation, six distinct categories were generated of which 3 appeared to contain only one genotype (Figure 2). The 6 were: 1) 'Kent'; 2) 'Redcoat,' SJ83OR-2 and SJ83184-3; 3) SJ8416-1, SJ84325-1, 'Glooscap,' 'Honeoye' and 'Midway'; 4) 'Sparkle,' SJ8357-1 and 'Bounty'; 5) SJ83145-1; 6) SJ84187-3. Representatives of each of these categories were completely different from those of the other categories in terms of plant and fruit characteristics (Figure 2, Table 2). This ID will be useful in determining phenotypic deviation of genotypes in the same trial.

Fruit characteristics. A raised neck and reflexed calyx are important characteristics for mechanical decapping of strawberries since they minimize cutting waste (1). SJ84187-3 was the only genotype with a raised neck and reflexed calyx. 'Sparkle' and SJ84325-1 were characterized by the absence of a raised neck and with a calyx cov-

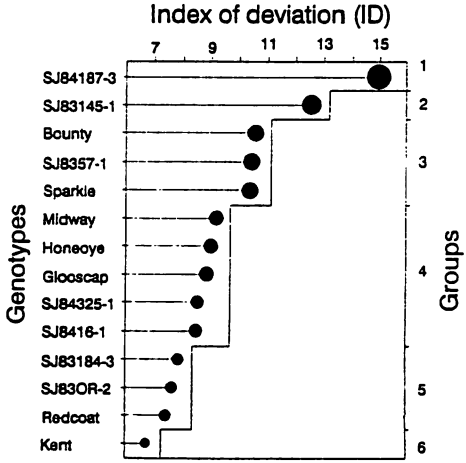

Figure 2. Classification of strawberry genotypes based on an index of deviation (ID). Circle sizes are relative to the ID value.

Table 2. Comparison of fruit and plant characteristics of traditional cultivars with St-Jean selections.[z]

Genotype	Neck size	Calyx	Achenes	Colour		Flavour	Fruit firmness	Ease of decapping	Plant vigour	Leaf diseases
				External	Flesh					
Bounty	50 c[y]	65 b	50 a	57 a	50 abc	57 a	39 bc	76 b	76 a	50 ab
SJ84187-3	80 a	89 a	50 a	63 a	63 a	63 a	57 a	90 a	50 c	63 a
Glooscap	63 ab	72 a	43 abc	58 a	55 ab	60 a	50 ab	92 a	63 b	63 a
Honeoye	50 c	39 c	39 abc	50 b	50 abc	50 b	50 ab	63 b	63 b	63 b
Kent	61 ab	58 b	41 abc	46 b	46 bc	55 ab	53 a	68 b	60 b	58 ab
Midway	59 b	59 b	38 abc	46 b	46 bc	46 ab	39 bc	76 b	50 c	63 a
Redcoat	60 b	51 c	47 ab	50 b	47 bc	50 ab	47 abc	76 b	76 a	63 a
SJ83145-1	50 b	45 c	50 a	50 b	39 c	57 a	57 a	76 b	51 c	50 ab
SJ83184-3	50 c	50 c	26 c	54 ab	47 bc	51 ab	42 bc	81 b	68 b	59 ab
SJ8357-1	48 cd	55 b	34 abc	61 a	53 abc	57 a	34 c	83 b	59 b	46 b
SJ83OR-2	57 b	57 b	32 abc	57 a	53 abc	55 ab	46 abc	90 a	76 a	63 a
SJ8416-1	50 c	50 c	38 abc	57 a	57 ab	55 ab	50 ab	90 a	50 c	50 ab
SJ84325-1	47 cd	47 c	29 bc	51 ab	48 bc	50 c	51 a	63 b	72 b	59 ab
Sparkle	43 d	55 b	41 abc	50 b	39 c	63 a	39 bc	81 b	81 a	63 a

[z]Average of four replicates for four years (1987-1990) and three locations; data were transformed using an arcsin square root percentage prior to performing GLM.
[y]Mean separation within column by Duncan's new multiple range test, 5% level.
Table legend: neck size: 0 = short, 100 = long; calyx: 0 = covers the fruit, 100 = reflexed; achenes: 0 = deep in flesh, 100 = elevated; fruit colour: exterior and flesh: 0 = pale, 100 = dark; flavour: 0 = bad, 100 = good; firmness: 0 = soft, 100 = firm; ease of decapping: difficult = 0, easy = 100; vigour: 0 = weak, 100 = vigorous; leaf disease: 0 = entire leaf area affected, 100 = no symptoms.

ering the fruit (Table 2). Among the genotypes tested SJ84187-3, 'Glooscap,' SJ83OR-2 and SJ8416-1 all had easily removed calyces. Indeed, 10-15% of 'Glooscap' calyces were absent after harvest.

'Bounty,' SJ84187-3, 'Glooscap,' SJ-8357-1, SJ83OR-2 and SJ8416-1 ranked highest for fruit and flesh colour. SJ83145-1 and 'Sparkle' had the lightest flesh colour (Table 2). Flavour (sweetness), an important factor in processed strawberries, was ranked highest in SJ84187-3, 'Glooscap,' 'Bounty,' 'Sparkle' and SJ8357-1. These genotypes could therefore be used as parents to improve berry flavour (1). SJ84187-3, 'Kent,' SJ84325-1 ranked highest for fruit firmness whereas 'Bounty,' 'Midway,' SJ8457-1 and 'Sparkle' had the lowest rank. Noteworthy is the fact that 3 of the best flavoured genotypes also had the softest fruit; however, these two characteristics were not correlated (1). The genotypes did not differ significantly for percent juice measured after thawing.

Plant characteristics. 'Sparkle,' SJ83-OR-2, 'Redcoat' and 'Bounty' were the most vigorous genotypes with minor foliage diseases. SJ84187-3, 'Midway,' SJ83145-1 and SJ8416-1 were the least flavourous genotypes. SJ8357-1 was the most susceptible genotype to leaf diseases (Table 2).

Conclusions

Based on the information generated from 4 years data at three locations the following steps were taken: SJ-84187-3 and SJ83184-3 were named 'Chambly' and 'Oka' in 1990 and 1991 respectively. SJ83OR-2 appears to have good potential for introduction but more data is needed before final decision. Even though SJ83145-1, SJ8357-1 and SJ84325-1 are good selections, they do not appear to be superior enough to warrant introduction. These selections will only be used as parents for future crosses along with 'Sparkle,' 'Kent' and 'Glooscap' all of which perform well in Quebec.

Literature Cited

1. Khanizadeh, S., D. Buszard, M. Lareau and R. Pelletier. 1991. Evaluation of strawberry cultivars with different degrees of resistance to red stele. Fruit Varieties Journal 45(1):12-17.
2. Statistical Analysis System. 1988. SAS/STAT, SAS/BASIC guide for personal computers. Version 6.04 (ed.). SAS Institute, Inc. Cary, N.C.