PARENT SELECTION IN STRAWBERRY

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Summary

In order to evaluate the potential of parent selection in strawberry, different selection experiments were performed with 20 progenies based on crosses between the maternal parents 'Elsanta' and 'Valeta' on ten paternal clones, which all have a reasonable horticultural value. It was shown that there was good agreement between selection based on progeny testing with 40 plants per half-sib family and selection based on progeny testing with 1,000 plants per half-sib family (Pearson $r=0.87$; Spearman $r=0.54$). The choice for parent selection should depend on the type of crosses that are to be made. If it concerns crosses between clones differing considerably and rapid improvement can be expected, then the best way would be to choose parents based on their phenotypic value. If, however, the horticultural level is already high, progeny testing can provide the breeder with information on the breeding value and indicate the best possible cross combinations.

The coefficients of correlation between data from parents and from half-sib families were low ($r<0.3$) when they concerned anther quality, growth of the plant, flowering capacity, firmness and shape of fruits, and somewhat higher ($r= 0.3 - 0.7$) when they concerned length of inflorescence, setting of primary fruits, mildew resistance of leaves, toughness, fruit size and setting of the fruits, position of the achenes and attractiveness of the fruits.

1. Introduction

In strawberry breeding, traditionally the best cultivars are crossed and from their progenies, the best genotypes are selected. Many successful cultivars have originated from crosses between two good cultivars. However, there are exceptions, e.g. 'Elsanta'. It has been used by many breeders in their breeding programmes, but so far with limited results. Both 'Gorella' and 'Redgauntlet', on the other hand, have proven to be excellent

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parents.

Plant breeders are often faced with the problem of choosing the best parents out of a large number of selections. This is, for instance, the case when a programme is started with the goal to incorporate in new cultivars disease resistance present in sources with poor horticultural value. Parents can be chosen based upon their phenotype, or based on the results of progeny testing. When the character of interest has a high heritability, the parents can be selected on the basis of their phenotypic value (Barritt, 1979; Shaw, 1990). However, when the heritability is low progeny testing is favoured, even though it is time and labour consuming.

This paper compares three different methods of parent selection: (1) selection on the basis of phenotypic value, (2) selection on the basis of limited size progeny testing and (3) selection on the basis of large size progenies as is often done in a regular breeding programme.

2. Materials and methods

2.1. Plant material

Ten clones that had evolved from a programme focused on the improvement of the level of resistance to *Phytophthora fragariae* were used in this study. These clones exhibited a high level of resistance, but their performance concerning fruit characters was not yet sufficient to compete with the standard cultivar Elsanta. They were therefore crossed with 'Elsanta' and 'Valeta', both as maternal parent. Their parentage is given in Table 1.

2.2. Experimental design

Progenies of the 20 crosses were grown in two separate field experiments. Experiment 1 was designed to apply negative and positive mass selection on the progenies, as is done in a regular breeding programme. From each cross 500 seedlings were planted. The field was composed of 20 plots, with one plot for each family (not randomized), containing 500 plants. Thus, the total experiment consisted of 10,000 plants. Experiment 2 concerned the progeny testing. The 20 progenies and their parents were evaluated on a much smaller scale. This experiment involved two locations: Elst (experiment 2A) and Wageningen (experiment 2B). At both locations 20 plants per progeny and 20 plants per parent were planted. They were planted in a randomized block design with four replications per location. Each replication consisted of 32 entries (20 progenies and 12 parents) grown in single-row plots of five plants. A row of strawberry seedlings was planted around the total experiment to avoid border effects. Per location 640 plants were evaluated.

The seedlings in the experiments were planted in Wageningen on July 6 and July 8, 1993 and in Elst on July 13. The runners representing the parents were planted on August 17, 1993. The planting distance was 50 x 100 cm.

2.3. Evaluation and selection

Negative mass selection for the plant traits (Table 3) was applied in 1994 with regard to the plants of Experiment 1 until about 75% of the plants had been discarded. Subsequently, positive mass selection for mainly fruit traits (Table 3) was applied and finally 119 plants were selected (Table 4). The selection was based on visual assessment and no additional data were recorded.

For Experiment 2 the plant characters, that were recorded in 1994 were: anther quality, length of inflorescence, general performance of the plants at the end of spring, flowering capacity, setting of the primary fruits and mildew resistance of the leaves. These were scored only once during the production season. The fruit was judged at each harvest date, with respect to firmness of the flesh, toughness of the skin, size, shape, position of the achenes, and attractiveness. There were in total 5 harvests. All characters were scored on a scale from 1 to 5, with 1 representing a low acceptance and 5 representing a high acceptance. A weighted mean, based on the yield per harvest, was calculated for each fruit character. An analysis of variance with Student's t-test was applied for all observed plant and fruit characters. Pearson's correlation analysis was performed for all data of parents and their half-sib families.

The selection was done by setting a threshold for each plant and fruit character, the so called independent culling level selection (ICL-selection; Bos and Caligan, 1995). ICL-selection allows the setting of different thresholds for different characters for individual plants. In Experiment 2 the thresholds were arbitrarily set at ≥ 3 for all plant characters and at ≥ 2.5 for all fruit characters. The numbers of plants that were selected per paternal parent i Experiment 1 and 2 were compared through a correlation analysis according to Pearson (on the basis of number of plants that were selected per paternal parent) and according to Spearman (on the basis of ranking orders for the number of plants that were selected per paternal parent).

3. Results and discussion

Table 2 shows the half-sib family means of the paternal parents for the observed plant and fruit characters. No significant differences were found between means of the half-sib families from the maternal parents (data not shown). Therefore these half-sib family means represent data combined across both locations of Experiment 2. Analysis of variance and two-by-two comparisons of half-sib family means using Student's t-tests at the 5% significance level revealed that for each character some half-sib families differed significantly from others. This suggests that there is scope for successful selection between the paternal parents for all the characters that were observed. Table 3 presents the coefficients of correlation between parents and their half-sib families for both the plant and the fruit characters. The correlations were low ($r<0.3$) when they concerned anther quality, growth of the plant, flowering capacity, firmness and shape of fruits, and somewhat higher ($r= 0.3 - 0.7$) when they concerned length of inflorescence, setting of primary fruits, mildew resistance of leaves, toughness, size and setting of the fruits, position of the achenes and attractiveness of the fruits. The low correlation coefficient for growth (0.08), flowering capacity (0.09) and firmness (0.09) is probably the result of the limited variation for these characters (Table 2). When the correlation between parents and their half-sib families is low, it is impossible to assess the breeding value of parents from their phenotypic value. In such cases progeny tests are more useful to estimate the breeding value. Would the paternal parents have been selected on the basis of their phenotypic value? Then the best parent would have been clone 5 directly followed by clones 7, 8 and 2 and the poorest were clones 4, 6 and 9.

Table 4 shows the numbers of plants that were selected per half-sib family of the paternal parents in each of the experiments. A total of 119 plants was selected in Experiment 1 and a total of 78 plants in Experiment 2. Both large scale evaluation (Experiment 1) and progeny testing (Experiment 2A and 2B) led to the selection of paternal parents 3 and 7. Paternal parent 6 produced the poorest half-sib family. The degree of agreement between Experiments 1 and 2 can be described with Spearman's correlation coefficient, or with Pearson's correlation coefficient (Table 5). There is a good correlation between the results of Experiment 1 and 2A and between Experiment 1 and 2A + 2B, both according to Pearson and Spearman. The low correlations between Experiment 1 and 2B are rather disappointing, indicating a location effect which was also found in the analysis of variance (data not shown).

In the case of parent selection based on phenotypic value clone 6 would have been used as parent, while it proved to be a very poor parent in the large scale evaluation as well as in the progeny tests (Table 4). The poor results with clone 6 were mainly due to the high percentage of plants in its offspring being susceptible to June Yellows, a trait that clone 6 inherited from 'Bogota'. However, in clone 6 itself we have never observed June Yellows. On the other hand clone 7 would also have been indicated as a good parent and clone 5 as a poor parent, just like in the progeny tests and large scale evaluation. Clone 3 was, based on its phenotypic value, neither a good nor a poor parent, but was one of the best parents according to experiments 1 and 2A.

4. Conclusions

The choice for parent selection should depend on the type of crosses that are to be made. If it concerns crosses between clones differing considerably and rapid improvement can be expected, then the best way would be to choose parents based on their phenotypic value. This method is faster and cheaper than making test crosses. As it takes at least two years before the results of progeny testing become available, the decision to make test crosses or not, depends largely on the horticultural value of the potential parents and the available time and labour. If that level is rather low, the breeder is likely to make rapid improvement by choosing potential parents on the basis of their phenotypic value and crossing them with high quality cultivars. If, however, the horticultural level is already high, progeny testing can provide the breeder with information on the breeding value and indicate the best possible cross combinations. In the present experiment it is shown that progeny testing proved to be valuable and lead to a different choice of parents than when this choice was based on the phenotypic value of the parents. Furthermore, the results from these experiments demonstrate that 40 plants per half-sib family are sufficient to give a good indication of the breeding value of the potential parents.

5. References

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Table 1. Parentage of the parents.

Code	Parentage
Elsanta	{Gorella x Holiday}
Valeta	{Sivetta x Holiday}
Clone 1	{(Redchief x Sivetta) x [Cambridge Favourite x (Sivetta x Holiday)]}
Clone 2	{Korona x Scott}
Clone 3	{Korona x Scott}
Clone 4	{[(Tamella x Redgauntlet) x Md-2700] x Scott}
Clone 5	{[(Tamella x Redgauntlet) x Md-2700] x Yalova 4}
Clone 6	{Bogota x Scott}
Clone 7	{[(Redchief x Sivetta) x Bogota] x Yalova 4}
Clone 8	{[Holiday x (Induka x Sivetta)] x Yalova 4}
Clone 9	{Gelria x Yalova 4}
Clone 10	{[(Sivetta x Holiday) x (Tamella x Induka)] x Yalova 4}

Table 2. Half-sib family means of the paternal parents for plant and fruit characters (combined across both locations).

Plant characters	paternal parent									
	1	2	3	4	5	6	7	8	9	10
Anther quality	4.40 ab	3.88 b	4.26 ab	4.46 a	4.25 ab	4.02 b	4.25 ab	4.06 b	4.06 b	3.88 b
Length of inflorescence	2.77 bc	2.80 b	3.16 ab	2.95 b	3.24 a	2.87 b	2.96 b	2.76 bc	2.73 bc	2.53 c
Growth of plant	3.71 ab	3.63 b	3.85 ab	3.70 ab	3.56 b	3.36 b	3.96 a	3.45 b	3.61 b	3.70 ab
Flowering capacity	3.20 ab	2.95 bc	3.60 a	2.80 bc	2.98 bc	2.55 c	3.41 ab	2.88 bc	3.16 ab	3.10 b
Setting prim. fruits	3.84 ab	3.48 b	3.62 ab	4.04 a	3.62 ab	3.99 ab	3.54 b	3.18 b	3.20 b	3.38 b
Mildew resistance of leaves	3.24 bc	3.50 ab	3.57 ab	2.92 c	3.00 c	3.21 bc	3.91 a	3.77 ab	3.43 b	3.75 ab

Fruit characters	paternal parent									
	1	2	3	4	5	6	7	8	9	10
Firmness of the flesh	3.74 b	4.02 ab	4.02 ab	3.84 ab	3.89 ab	3.74 b	3.86 ab	4.08 a	4.07 a	3.81 ab
Toughness of the skin	3.20 d	3.83 a	3.43 bcd	3.59 abc	3.20 d	3.29 cd	3.28 d	3.63 ab	3.60 abc	3.23 d
Size	3.11 ab	2.72 e	2.89 cde	2.76 de	2.95 abcd	2.78 de	3.15 a	3.05 abc	2.90 bcde	2.92 bcde
Shape	3.16 a	2.91 abcde	2.97 abcde	3.06 abcd	3.07 abc	3.15 ab	2.89 bcde	2.79 e	2.80 de	2.81 cde
Setting of the fruits	4.40 ab	4.21 abcd	4.18 bcde	4.51 a	4.20 abcd	4.37 abc	4.13 bcde	3.88 e	3.92 de	4.07 cde
Position of the achenes	3.48 de	4.15 a	3.71 c	3.70 cd	3.25 f	3.72 dc	3.38 ef	3.80 bc	3.95 ab	3.46 ef
Attractiveness	3.60 a	3.11 cd	3.06 cd	3.11 cd	3.11 cd	2.88 d	3.51 ab	3.13 cd	3.01 cd	3.22 bc

Values in a row followed by a same letter do not differ significantly (P=0.05).

Table 3. Coefficients of correlation (r) between the mean phenotypic value of the paternal parents and their half-sib family means.

Plant characters	r	Fruit characters	r
Anther quality	0.23	Firmness of the flesh	0.09
Length inflorescence	0.63	Toughness of the skin	0.45
Growth of plant	0.08	Size	0.69
Flowering capacity	0.09	Shape	0.26
Setting of primary fruits	0.41	Setting of the fruits	0.31
Mildew resistance of leaves	0.46	Position of the achenes	0.70
		Attractiveness	0.41

Table 4. Number of plants selected in the experiments per paternal parent.

Experiment	paternal parent										
	1	2	3	4	5	6	7	8	9	10	Total
1	10	7	25	6	8	3	29	11	11	9	119
2A	4	2	8	1	3	0	7	1	0	2	28
2B	7	5	4	3	6	1	7	3	9	5	50
2A & 2B	11	7	12	4	9	1	14	4	9	7	78

Table 5. Pearson and Spearman correlation coefficients between the experiments.

Experiment	Type of correlation coefficient	
	Pearson	Spearman
1 versus 2A	0.87	0.54
1 versus 2B	0.33	0.51
1 versus (2A & 2B)	0.80	0.76