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Yield Components among Sour Cherry Seedlings

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Abstract. **Yield components were measured from 115 sour cherry *(Prunus cerasus* L.) hybrid seedlings from 13 full-sib families to investigate the potential of breeding for increased yield. Those families with the highest number of fruit and reproductive buds had the highest yields. In general, increased fruit size was not able to compensate for low fruit count. Fruit set and flower count per bud were inversely related, suggesting compensation between these two components. Yield components from six selections chosen for differing fruiting habits were measured for an additional 2 years. In year 1, those selections with a majority of their fruit on l-year-old wood had higher yield efficiencies (yield per branch cross-sectional area) than those with fruit on spurs; however, but year 3, the higher-yielding selections were those that fruited primarily on spurs. The data are discussed relative to selecting for yield in a sour cherry breeding program.**

Sour cherry cultivars differ dramatically for tree size and fruiting structure. Tree size ranges from that comparable to sweet cheny (≈ 5 m) to dwarfs that reach a mature height of 1 m. Most sour cherry cultivars fruit on both l-year-old wood and spurs; however, certain cultivars fruit exclusively on one or the other (Iezzoni et al., 1990).

To compare yield efficiencies (yield per cross-sectional area) between sour cherry cultivars with diverse growth and fruiting habits, we have previously used yield components as a tool with the ultimate goal of selecting for increased productivity (Chang et al., 1987). Engledow and Wadhan (1923) suggested that selection for increased yield could be facilitated by dividing yield into its component parts and selecting for the component parts rather than yield itself. Individual yield components would likely be controlled by fewer genes and have higher individual heritabilities than yield itself (Leng, 1962).

Yield per limb in sour cherry can be defined as the product of the primary yield components: fruit size and fruit number (Chang et al., 1987). The secondary yield components that contribute to fruit count are: 1) fruit set, 2) the number of flowers per bud, 3) the number of flower buds per node, and 4) the number of flowering nodes. A lateral flower bud and a flowering spur are each scored as one flowering node. However, a lateral flower bud in cherry has one flower bud per node, while a spur has more than one flower bud per node. Therefore, if the total number of flower buds per node equals one, the flowers are produced from lateral buds on l-year-old wood. If the total number of flower buds per node is greater than one, some of the flowers are produced on spurs.

Breeding for yield in general, and yield components in particular, is especially problematic in a fruit tree breeding program. First, the relative importance of the yield components may change over years as the seedlings mature. Second, the fruiting structure of an unpruned seedling may bear little resemblance to that of a pruned tree in a commercial orchard.

This study was undertaken to investigate the potential of breeding for increased yields in sour cherry. The objectives were to 1) determine the variation for individual yield components in a sour cherry breeding population and 2) evaluate yields over 3 years from unpruned seedlings selected for differing yield components.

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Materials and Methods

Pollen was collected in Spring 1983 from the following locations in eastern Europe: Fruit Research Institute, Cacak, Yugoslavia; Fruit Growing Research Institute, Plovdiv, Bulgaria; Research Institute of Pomology, Pitesti, Romania; and the Enterprise for Extension in Fruit Growing and Ornamental, Budapest, Hungary. The pollen was brought back to Michigan and used in crosses with the sour cherry cultivars English Morello and Rheinische Schattenmorelle, generating nine and four full-sib families, respectively (see Table 1). All trees were planted in a completely randomized design with 1.5 m between plants within the rows at the Clarksville Horticultural Experiment Station, Clarksville, Mich. The trees, which were never pruned, were 4 years old when evaluated in 1988.

In 1988, a single branch with a diameter of 20 to 25 mm at the base of the branch was randomly selected on each of 115 hybrid seedlings and an own-rooted 'Meteor' tree. When the flowers were in open cluster, the number of flowering nodes, flower buds per node, and flowers per bud were recorded from each branch. At harvest, the number of fruit per branch was counted, and a mean fruit weight was calculated from the fruit undamaged by birds. Yield per branch was computed by multiplying mean fruit weight by fruit number.

Yield components from the 13 full-sib families were analyzed by principal component (PC) analysis to examine the relationships among the yield components (Iezzoni and Pritts, 1991). The PRINCOMP procedure of the SAS Statistical Package was used (SAS Institute, Cary, N.C.). Family means were used to create a correlation matrix from which standardized PC scores were extracted. A scatter plot of the first two PCs was created with SAS/Graph. To determine which of the PCs accounted for the greatest amount of variation for each trait, the eigenvectors of the two PCs were compared for each trait. The trait being considered was ascribed to the PC having the largest absolute value. The progressive increase or decrease of the family means for each trait along a given PC was followed to assign a trend to the PC for the trait being considered.

In 1988, one branch was evaluated as described above for one own-rooted 'Meteor' tree and the seedlings 120(36), II 5(9), I 22(19), I 20(60), and II 5(30). These seedlings were chosen based on differing yield components in 1988.

In 1990, the evaluations were repeated; however, within each tree, eight 20- to 25-mm limbs were evaluated to provide within-tree samples for an analysis of variance.

Abbreviations: PC, principal component.

Results and Discussion

In 1988, yield differences varied about 4 fold among the 'English Morello' and 'Rheinishe Schattenmorelle' full-sib families (Table 1). Yield components also differed dramatically among the sour cherry families. Fruit count and the number of flowering nodes tended to be higher in the higher-yielding families. For all the families, maximum mean fruit set was just 32%; however, there may be genetic variance to increase fruit set. The mean number of buds per node ranged from 1.1 to 1.8. Values close to one indicate that a majority of fruit is on l-year-old wood, while values greater than one indicate that at least a portion of the fruit is on spurs. In the 1988 data, the highest-yielding families had a majority of their fruit on l-year-old wood.

The first two PCs of the 1988 seedling yield component data accounted for 37% and 27% of the variance among family means (Table 2). From plus to minus on PC1, the family means generally decreased for fruit count and the number of flowering nodes and increased for fruit weight (Fig. 1, Table 2). The highest-yielding families, with the exception of 'English Morello' × M71, tended to be at the positive end of PC1. This result indicated that high fruit count is the most important component contributing to increased yields and, with the exception of the 'English Morello' × M71 family, fruit weight was not able to compensate for low fruit count. In a previous study with sour cherry, fruit count was a more important primary yield component than fruit weight (Chang et al., 1987), Since the other four yield components are secondary yield components contributing to fruit count, it would be expected that their contribution to yield would be less than that of fruit count.

From plus to minus along PC2 the percent fruit set tended to increase while the number of flowers per bud decreased. Most of the higher-yielding selections had intermediate values, suggesting a balance between these two characters. This inverse relationship is similar to compensation that may occur between yield components (Adams, 1967).

-Pollen parents that transmitted various growth habits when crossed with 'English Morello' and 'Rheinische Schattenmorelle' were identified. For. example, within the 'English Morello' families, crosses with M71 and 'Karessova' gave progenies that fruited primarily on spurs, while crosses with 'Sumadinka' and 'Meteor' gave progenies that fruited to a large extent on 1-year-old wood. Although 'Meteor' produces ≈ 70% of its fruit on spurs (Chang et al., 1987), its hybrid progeny more closely resembled the fruiting habit of 'English Morello'.

The most productive genotypes changed as the trees matured. Relative yield per branch of I 20(60) in 1988 was almost twice that of 'Meteor' and the other selections (Fig. 2); the following year, the yields of the six selections were similar. In 1990, 'Meteor' and I 20(36) had significantly higher yields per limb than the other four selections (Table 3). The higher 1990 yields for 'Meteor' and 120(36) can be attributed to higher fruit counts, number of flowers per bud, and number of buds per node (Table 3). The differences in flower buds per node indicate that 'Meteor' and I 20(36) produce most of their fruit on spurs, while the other selections fruit primarily on l-year-old wood. Because sour cherry flowers are simple (i.e., without an accompanying vegetative bud), l-year-old fruiting wood will be barren the next year. Although those trees that fruited on l-year-old wood were initially more productive, the accumulation of barren wood that had fruited the previous year resulted in relative reductions in yield compared to the spur-type trees.

Although the objective of this article was not to determine which fruiting habit would be the most productive in a commercial orchard, it is possible to speculate based on production records of trees with different growth habits. In eastern Europe, types that fruit on l-year-old wood are most common. For example, the low-vigor Yugoslavian sour cherry 'Sumadinka' fruits exclusively on l-year-old wood. When grafted on mazzard and planted at 3 x 5 m, 'Sumadinka' yields 30,000 $kg \cdot ha^{-1}$ (Nikolic and Stancevic, 1987). 'Montmorency', the only commercially important sour cherry cultivar grown in the United States, has ≈ 30% of its fruit on spurs and yields ≈22,000 $kg \cdot ha^{-1}$ when planted at 4.6 × 3.1 m (J. Flore, personal communication).

In our study, the family 'English Morello' × 'Sumadinka' had the highest yields in the seedling analysis, and one of the offspring from this family, I 20(60), had the highest yields of the six selections in 1988 (Fig. 1). Like its pollen parent 'Sumadinka', I 20(60) fruits exclusively on l-year-old wood and exhibits extremely high yields. If the l-year-old fruiting wood on 120(60) were removed in the fall, as is done with 'Sumadinka' in Yugoslavia, it would be conceivable that high per-hectare yields could be maintained with a smaller tree form and a higher

Table 1. Mean values for yield component characters measured on 115 seedlings from 13 sour cherry families in 1988.

Family	No. seedlings/ family	Yield/ branch (g)	No. fruit	Fruit wt (g)	Fruit set (%)	No. flowers/ bud	No. buds/ node	No. flowering nodes
English Morello x								
Sumadinka	12	504	130	3.9	29	2.7	1.1	160
North Star	14	430	132	3.2	17	2.7	1.3	234
Oblacinska	8	392	109	3.6	23	2.6	1.2	156
M71	5	323	77	4.2	10	3.2	1.7	120
English Morello	5	296	88	3.3	21	2.6	1.2	171
Meteor	14	248	73	3.4	18	2.6	1.1	122
Hungarian Meteor	13	289	78	3.7	16	2.6	1.2	102
Karessova	6	170	46	3.7	32	2.4	1.8	65
Galaxy	5	122	37	3.3	6	2.9	1.4	157
Rheinische Schattenmorelle x								
Erdi Botermo	10	269	74	3.7	23	2.6	1.1	119
Crisana 1/8	12	198	50	3.9	16	2.8	1.2	121
Mocanesti 16	6	144	48	3.0	23	2.9	1.2	61
M112	5	65	14	4.5	12	2.6	1.3	56

Table 2. Eigenvectors of the first two PC axes from PC analysis of yield components from 13 sour cherry families.

Character	Eigenvector[z] PC1	PC2
Fruit count	0.58	0.13
Fruit weight	– 0.40	– 0.08
Fruit set	0.29	–0.62
Flowers/bud	–0.18	0.64
Buds/node	– 0.37	0.06
No. of flowering nodes	0.50	0.42

[z]Eigenvectors for PC1 and PC2 represent 37% and 27% of the variation, respectively.

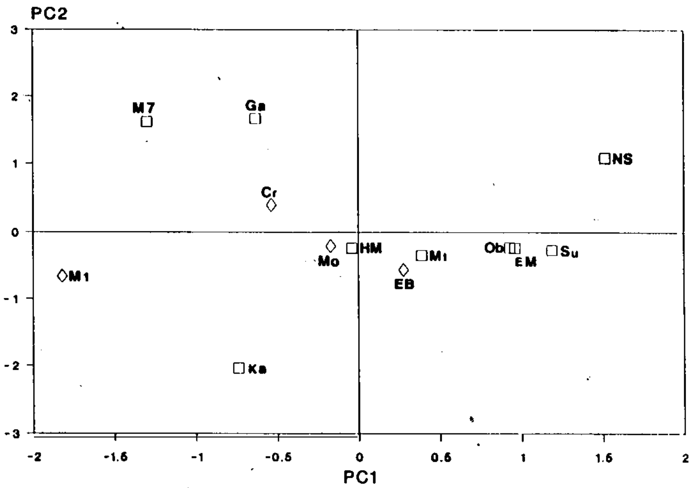

Fig. 1. Positions of PC scores of family means for the 'English Morello' (squares) and 'Rheinische Schattenmorelle' (diamonds) families. Abbreviations: Cr, 'Crisana 1/8'; EB, 'Erdi Botermo'; EM, 'English Morello'; Ga, 'Galaxy'; HM, 'Hungarian Meteor'; Ka, 'Karessova'; Mo, 'Mocanesti 16'; Mt, 'Meteor'; Ml, Ml 12; M7, M71; NS, 'North Star'; Ob, 'Oblacinska'; Su, 'Sumadinka'.

tree density. Since seedlings that fruit on l-year-old wood accumulate barren wood when unpruned, it would be important for the breeder, if interested in these selections, to remove that year's fruiting wood in the fall. Therefore, subsequent yield evaluations would more likely resemble the potential possible in a commercial orchard.

Because the sour cherry industry in the United States is based on mechanical harvesting with trunk shakers, large spur-type trees that require minimal pruning and are planted at low tree densities are considered by the industry as the most desirable. In a previous study where 'Montmorency' and 'Meteor' were compared, the spur-type 'Meteor' tree had a significantly higher limb yield efficiency (yield per limb cross-sectional area) than 'Montmorency', which fruits primarily on l-year-old wood (Chang et al., 1987). Our data also suggests that spur-type trees can have high yield efficiencies; however, once again, it is important to evaluate the total tree canopy of pruned trees planted at commercial spacing. For example, the 'Montmorency' trees sampled by Chang et al. (1987) had about four times as many 4-year-old limbs as did 'Meteor' and, therefore, considerably higher yields per tree.

Our conclusions are based on data from unpruned seedlings without considering the number of branches per seedling. As a result, the following questions still remain. Is a seedling's fruiting habit and yield potential predictive of that of a grafted and pruned tree? What spur : lateral flower bud ratio and branch density would maximize per-hectare yield? These questions must be answered before a plant breeder can confidently select superior seedlings based on yield components.

In summary, there is variability for yield in our sour cherry seedling collection. The most productive seedlings can be iden-

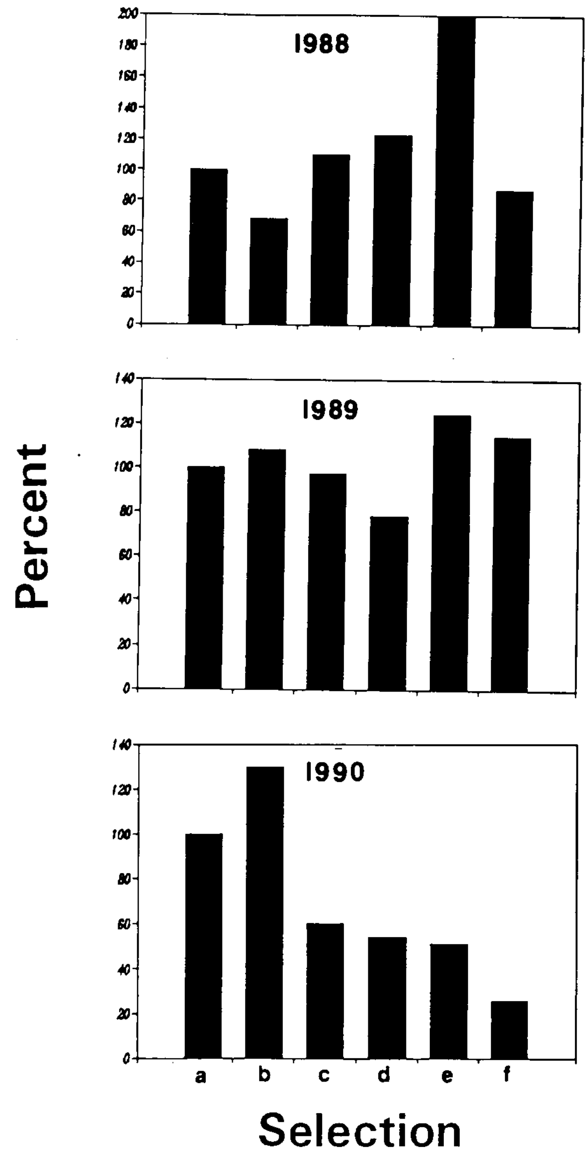

Fig. 2. Branch yield expressed as a percentage of 'Meteor' branch yield for six sour cherry selections in 1988, 1989, and 1990. Branch yield for 'Meteor' was arbitrarily **set** at 100% [a, Meteor; b, 120(36); c, II 5(9); d, I 22(19); e, I 20(60); f, II 5(30)].

Table 3. Yield component data for six sour cherry selections evaluated in 1990.

Selection	Yield/ branch (g)	No. fruit	Fruit wt (g)	Fruit set (%)	No. flowers/ bud	No. buds/ node	No. flowering nodes
Meteor	723 a[z]	180 a	4.2 b	16	2.9 a	3.1 a	118 d
I 20(36)	942 a	185 a	5.0 c	19	2.9 a	1.8 b	206 bc
II 5(9)	435 b	104 bc	4.2 b	26	2.3 b	1.2 c	143 cd
I 22(19)	391 bc	74 c	5.3 c	14	1.9 c	1.2 c	247 b
I 20(60)	370 bc	134 ab	2.8 a	15	2.3 b	1.1 c	370 a
II 5(30)	191 c	67 c	2.7 a	18	1.9 c	1.0 c	242 b

[z]Mean separation within columns by LSD, $P = 0.05$.

tified by the many fruit and flowering nodes they produce. High yields could conceivably be obtained with types that fruit mainly on spurs or l-year-old wood; however, for the latter fruiting habit, yearly removal of the fruiting wood would be necessary. Ultimately, the tree size and fruiting structure desired will depend on the harvesting technique (i.e., trunk shakers, over-the-row harvester, or hand-harvesting) arid the amount of pruning growers are willing to do. Within these limitations, the plant breeder can strive to optimize yields by comparing yield efficiencies among different seedling selections followed by yield evaluations of grafted trees.

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