

Yield Components in 'Montmorency' and 'Meteor' Sour Cherry

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Abstract. Two sour cherry (*Prunus cerasus* L.) cultivars 'Montmorency' and 'Meteor' were evaluated over two seasons to determine the relative importance of different components of yield. A path coefficient analysis was performed to determine the direct and indirect effects of primary, secondary, and tertiary components on limb yield. Fruit number, fruit weight, the number of lateral buds and spurs, and fruit set were found to be the most important components affecting limb yield in both cultivars. However, the fruiting habits of the two cultivars were significantly different. 'Montmorency' produced 68% of its fruit on lateral buds on 1-year-old wood, while 'Meteor' had 70% of its fruit on 2-year-old spurs. When the data were standardized by dividing by limb cross-sectional area, 'Meteor' had a higher flower bud density (number of flowers/cm²) and yield efficiency (grams of fruits/cm²) than 'Montmorency'. Although 'Meteor' had higher limb yields than 'Montmorency', the 'Montmorency' trees sampled had about four times more limbs than 'Meteor', and, therefore, higher tree yields.

Selection for individual yield components has been proposed to be more efficient than selecting for yield itself (4, 5, 8). Leng (10) found the heritability of yield components to be much higher than the heritability of yield alone. This concept enables the plant breeder to separate yield into the product of its parts and then choose parents selected for their independent yield component superiorities.

There is limited information in sour cherry concerning the genetic control of yield components. Roberts (13) reported that the higher yield of 'Montmorency' compared to 'Richmond' was the result of higher fruit set on 'Montmorency' spurs vs 'Richmond' spurs. However, numerous cultural and environmental factors have been reported that affect sour cherry flower number and fruit set. They include pruning and fertilization (7, 9), light reception (9), pollen source (12), and competition among flowers (2, 3).

For this yield component study, two cultivars of sour cherry ('Montmorency' and 'Meteor') were evaluated. 'Montmorency' was chosen because it represents ≈97% of the sour cherry acreage in the United States (1), and 'Meteor' was chosen because preliminary observations indicate that it has a different fruiting habit than 'Montmorency'. The objectives of this study were to: a) determine the relative importance of different yield components for 'Montmorency' and 'Meteor', b) measure the effects of the individual components on yield, and c) describe the morphological basis of these differences.

Materials and Methods

In 1983 and 1984, data were taken from three representative trees each of 'Montmorency' and 'Meteor' at two locations—Clarksville Horticultural Experiment Station, Clarksville, Mich., and Hilltop Orchards and Nurseries, Hartford, Mich. The trees at Clarksville and Hartford were 7 and 8 years old in 1983, respectively. The two cultivars were grafted on *P. mahaleb* seedling rootstocks and trained to a modified central leader.

One random 3- or 4-year-old representative limb from each

tree was measured for limb diameter, and the following were counted in both 1983 and 1984: flowers, flower clusters, lateral flower buds, spurs, and flowering branches. Three limbs within a tree also were selected, and the number of leaves along the main branch of each limb were counted. Five random leaves from each limb were measured for leaf area using a LI-3000 leaf area meter (square centimeters). Fruit at maturity were counted and weighed for each limb and kept separate within the limb by age of wood. Tree yields were taken at both locations in 1984.

Path analysis (11, 14) was used to calculate the relationships between yield components using the causative relationships diagrammed in Fig. 1. The path coefficient analysis partitions the correlation into the direct and indirect effects. The path coefficients are calculated as standard partial regression coefficients and are a measure of the relationship between two yield components when the influence of related yield components is removed. The direct effect is the influence of one component on another without considering the interaction between components. The indirect effect is the difference between the correlation and direct effect. The significance of the path coefficient was analyzed with an F test.

Results and Discussion

Sour cherry buds are simple, producing either floral or vegetative growth. Therefore the number of flower buds on 1-year-old-wood reduces the number of nodes that become spurs or lateral branches the following season. In 1983, an average of 152 lateral buds flowered on the sampled limbs of 'Montmorency' (Table 1). In 1984, the mean number of flowering spurs on those limbs was only 27. In contrast, the mean number of flowering lateral buds on the sampled limbs of 'Meteor' was 26 in 1983, and the mean number of flowering spurs in the following year was 168. The numbers of flowering lateral buds and spurs on 'Montmorency' have been reported to be influenced by vigor (7, 9, 13). If tree vigor is moderate to low (shoot growth <25 cm), the majority of the lateral buds are floral buds. As vigor increases (shoot growth >45 cm), more buds on the shoot remain vegetative and produce spurs at the basal portion of the shoot (9). Although very few flowers are produced on vigorous shoots, an increased bearing surface is formed for the next year. Fruiting spurs develop on these 1-year-old branches. For the two years (1983 and 1984), the average terminal shoot growth for 'Montmorency' and 'Meteor' was 38 cm and 47 cm,

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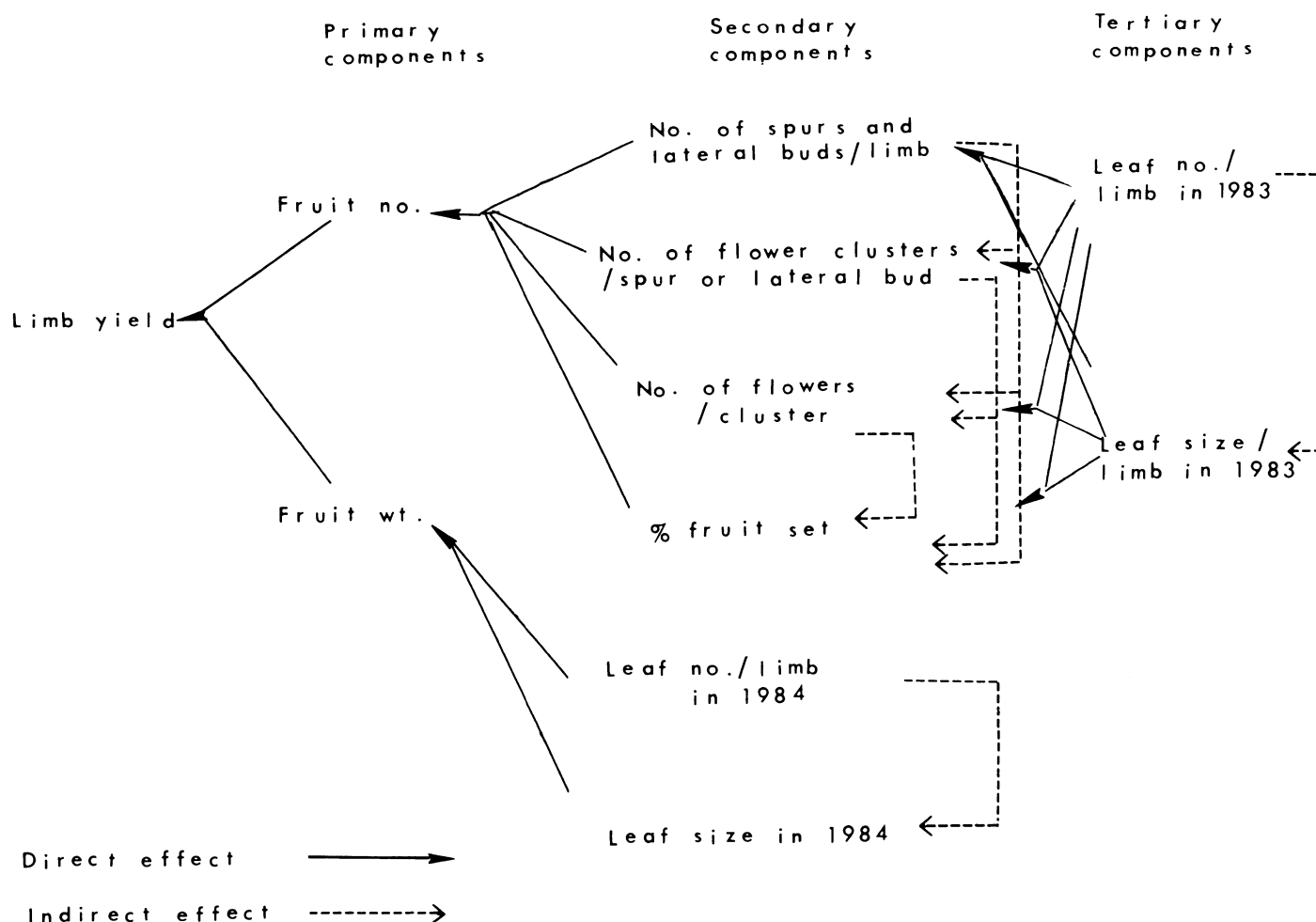


Fig. 1. Causal system of path-coefficient analysis in this study.

Table 1. Mean values and coefficients of variation (cv) for yield components from limbs of 'Montmorency' and 'Meteor' in 1983 and 1984.

		Yield components													
Cultivar	Year	No. of flowering lateral buds/limb		No. of flowering spurs/limb		No. flower clusters/limb		No. flowers/limb		No. fruit/limb		No. flowering branches/limb		Limb yield (g)	
		$\bar{x}$	CV	$\bar{x}$	CV	$\bar{x}$	CV	$\bar{x}$	CV	$\bar{x}$	CV	$\bar{x}$	CV	$\bar{x}$	CV
Montmorency	1983	152 a ^z	79	31 a	41	213 a	57	573 a	82	226 a	57	31 ab	65	854 a	22
	1984	135 a	33	27 a	80	214 a	40	523 a	20	242 a	30	51 a	26	910 a	25
Meteor	1983	26 b	60	70 a	45	194 a	51	528 a	64	163 a	89	17 b	51	759 a	91
	1984	152 a	143	168 b	51	789 b	69	2131 b	68	486 b	36	53 a	91	2248 b	59

²Mean separation in rows by Duncan's multiple range test, 5% level.

respectively. Therefore, 'Montmorency' tree vigor would be classified as moderate.

In 1984, 'Meteor' had a significantly larger number of flowering spurs, flower clusters, flowers, and fruits per limb, and a greater limb yield than 'Montmorency' (Table 1). However, in 1983, there were no differences between the cultivars for these traits. The cultivar $\times$ year interaction was highly significant, and 'Meteor' exhibited large differences between the two years. In general, 'Meteor' also had greater variation within years than 'Montmorency', as indicated by the larger coefficients of variation.

When several of the yield components were standardized by

dividing by the limb cross-sectional areas, there were significant differences between 'Montmorency' and 'Meteor' (Table 2). 'Meteor' had a higher flower bud density than 'Montmorency'; however, the difference in crop density (fruit number/cm²) was not significant. This lack of difference in fruit load resulted because 'Montmorency' had a higher fruit set (46%) than 'Meteor' (28%). However, there was a significant difference in crop density between the Clarksville and Hartford orchards, presumably resulting from differences in fruit set in 1983 and 1984. Even though 'Montmorency' and 'Meteor' had similar crop densities, 'Meteor' had a higher yield efficiency than 'Montmorency' because of differences in fruit weight. Average individual

Table 2. Mean values ($\bar{x}$) and coefficients of variation (CV) for limb cross-sectional area (cm²), number of flower buds/limb, and number of flower buds, fruit, and yield/cross-sectional area (g·cm⁻²) for 'Montmorency' and 'Meteor' in 1983 and 1984.

Cultivar	Trait									
	Limb cross-sectional area (cm ²)		No. flower buds/limb		No. flower buds/cross-sectional area (cm ²)		No. fruit/cross-sectional area (cm ²)		Yield (g)/cross-sectional area (cm ²)	
	$\bar{x}$	CV	$\bar{x}$	CV	$\bar{x}$	CV	$\bar{x}$	CV	$\bar{x}$	CV
Montmorency	6.7	11	212.2 a ^z	38	32.9 a	14	37.5	16	134.0 a	19
Meteor	7.5	10	493.9 b	16	60.0 b	8	46.0	13	211.0 b	12

^zMean separation in columns by LSD, 5% level.

Table 3. Mean values of primary yield components associated with spurs and lateral buds for 'Montmorency' and 'Meteor' in 1983 and 1984.

Cultivar		No. lateral buds or spurs	No. flower clusters	No. flowers/cluster	Percentage of fruit set (no. fruit/100 flowers)	Individual fruit wt (g)	Yield (g)
Montmorency	Lateral bud	144 a ^z	1.0 a	2.6 a	41 ab	3.8 b	609 b
	Spur	29 b	2.4 b	2.4 a	52 a	3.3 b	272 b
Meteor	Lateral bud	89 a	1.0 c	2.5 a	28 ab	4.7 a	376 b
	Spur	120 a	2.9 a	2.6 a	27 b	4.6 a	1127 a

^zMean separation in columns by Duncan's multiple range test, 5% level.

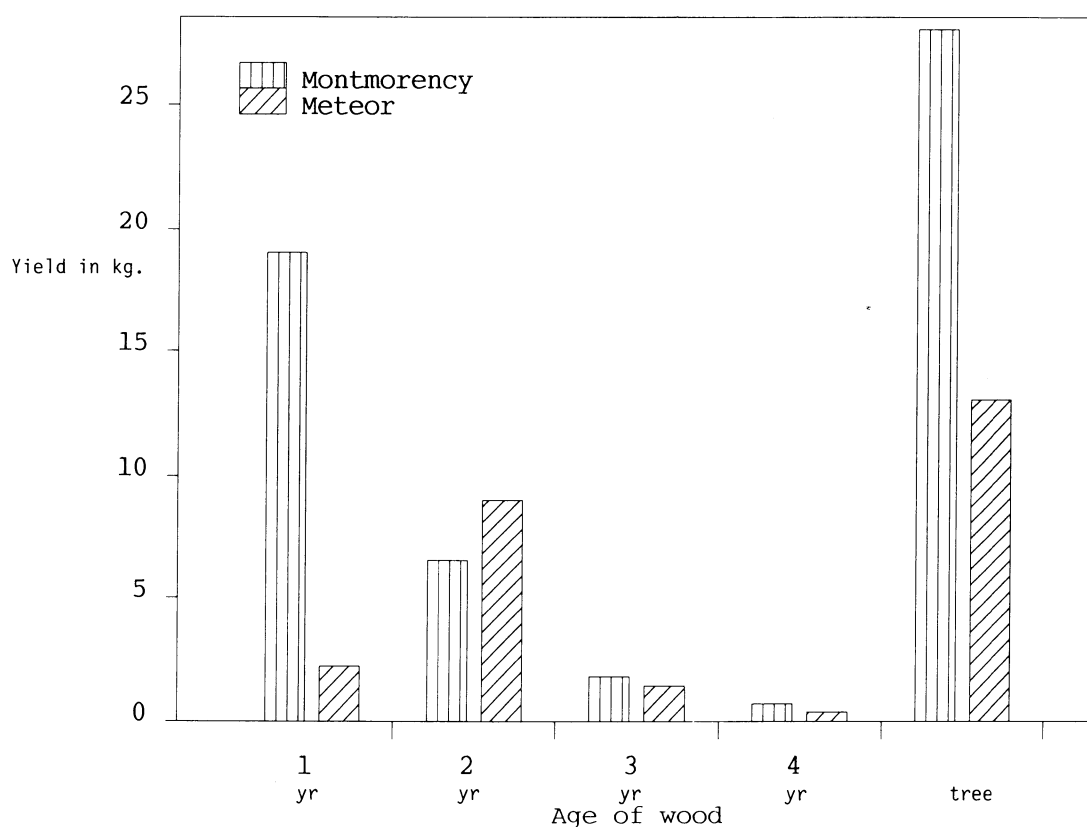


Fig. 2. Yield for 8- and 9-year-old trees of 'Montmorency' and 'Meteor' in 1984 partitioned by the age of the wood. yield is expressed as kilograms per tree.

fruit weight for 'Meteor' was $\approx$ 4.8 g, compared to 3.6 g for 'Montmorency'.

The average limb yields for 'Montmorency' and 'Meteor' in 1984 were 882 g and 1504 g, respectively. However, the 'Montmorency' trees sampled had about four times as many 4-year-

old-limbs as 'Meteor' (33.3 compared to 8.5) and, therefore, a considerably higher tree yield.

The average tree yields for 'Montmorency' and 'Meteor' in 1984 were 28 and 13 kg, respectively (Fig. 2). The fruiting habit of the two cultivars also differed significantly. 'Mont-

Table 4. Path coefficients showing direct and indirect effects of fruit number and fruit weight on limb yields of 'Montmorency' and 'Meteor' sour cherry. Yield is divided into the yield from lateral buds and spurs.

Type of effect	Montmorency		Meteor	
	Lateral buds	Spurs	Lateral buds	Spurs
Fruit no. (x)				
Direct effect (P_{zx})	1.04**	1.02**	1.00**	0.99**
Indirect effect via fruit wt	-0.04	-0.02	0.00	0.00
Fruit wt (y)				
Direct effect (P_{zy})	0.13**	0.08**	0.03**	0.02

**Indicates significance at the 1% level.

Table 5. Path coefficients showing direct and indirect effects of secondary yield components on fruit number of 'Montmorency' and 'Meteor' sour cherry in 1983 and 1984. Yield is divided into that from lateral buds and spurs.

Type of effect	Montmorency		Meteor	
	Lateral buds	Spurs	Lateral buds	Spurs
No. of spurs and lateral buds per limb (a)				
Direct effect (P_{xa})	0.81**	0.92**	1.00**	0.78**
Indirect effect via:				
No. flower clusters per spur or lateral bud	0.00	-0.13	-0.01	-0.19
No. flowers per cluster	0.18	-0.03	0.00	-0.02
Percentage of fruit set	0.02	-0.11	-0.01	-0.15
No. of flower clusters per spur or lateral bud (b)				
Direct effect (P_{xb})	0.03	0.37**	0.03	0.34**
Indirect effect via:				
No. of flowers per cluster	-0.03	-0.10	0.00	0.04
Percentage of fruit set	-0.05	-0.16	-0.08	-0.04
No. of flowers per cluster (c)				
Direct effect (P_{xc})	0.21*	0.35**	0.00	-0.17
Indirect effect via:				
Percentage of fruit set	-0.05	0.01	0.05	0.44
Percentage of fruit set (d)				
Direct effect (P_{xd})	0.21*	0.71**	0.16**	0.63**

***. *Indicates significance at the 1% and 5% levels, respectively.

morency' had 19 kg (or 68%) of its fruit on 1-year-old wood, while 'Meteor' had only 2.1 kg (or 16%) of its fruit on 1-year-old wood. Seventy percent of 'Meteor's' yield was on 2-year-old spurs.

Lateral bud and spur reproduction was considered separately because there was a highly significant interaction between cultivar and reproductive location. Although the cultivar $\times$ year interaction was significant, the age of wood for reproductive type $\times$ year interaction was not significant for all parameters. 'Meteor' had significantly more spurs, flower clusters per spur, and spur yield than 'Montmorency' (Table 3). However, 'Meteor' spurs had significantly lower fruit set (27%) than 'Montmorency' spurs (52%). Individual fruit weight for 'Meteor' was $\approx$ 4.8 g, compared to 3.6 g for 'Montmorency'. The fruit set on 'Montmorency' spurs was higher than the 30% fruit set reported by Diaz (3) on 'Montmorency' limbs. It is most likely

that differences between years contribute to the differences in fruit set.

Limb yield of the two sour cherry cultivars was designated as the product of fruit number and fruit weight (Fig. 1). Fruit number had a larger direct effect on yield than fruit weight for both cultivars (Table 4), although fruit weight also had a significant positive effect on 'Montmorency' yield. The indirect effect of fruit number via fruit weight on yield was small and insignificant.

Fruit number was expressed as the product of the following secondary components: the number of spurs or lateral buds, the number of flower clusters per spur or lateral bud, the number of flowers per cluster, and percentage of fruit set (Fig. 1). The number of spurs or lateral buds was the most important secondary yield component influencing fruit number for both cultivars (Table 5). Fruit set also had a significant direct effect on fruit

number, which was more important for spur fruit production. 'Montmorency' spur fruit number was significantly associated with the number of flower clusters per spur and flower number per cluster. For 'Meteor's' accumulated spur fruit number, the number of flowers per cluster also had a positive indirect effect via fruit set, indicating that flower competition within clusters had little effect on fruit set. These results are similar to those of Diaz (3), who concluded that competition between and within flower clusters of 'Montmorency' did not affect fruit set.

There were no significant effects of leaf number and leaf size on that year's fruit weight in either cultivar (data not shown). Possibly this is because leaf number was above the threshold value that would affect fruit development. Flore (6) reported that a minimum of two leaves per fruit were necessary for optimum fruit size and development for 'Montmorency'. However, there was a significant positive effect of 'Montmorency' leaf number in 1983 on the number of spurs and lateral buds in 1984 (data not shown). Presumably, more lateral buds were vegetative in 1983 resulting in more spurs the next year. 'Meteor' also had a similar positive effect; however, it was not significant. Leaf number and size had no other significant effects on the secondary yield components in 1984.

Fruit number, fruit weight, the number of reproductive buds, and fruit set are the most important components influencing limb yields and would therefore be the most efficient characters to select for yield increases. For 'Montmorency', cultural or environmental factors that increase fruit weight may increase yields. Alternatively, for 'Meteor', increasing the fruit set may result in a yield increase. For maximizing the yield per acre, it may be of value to select the spur fruiting habit because of the higher yield efficiency. However, it must be emphasized that the yield efficiency of 'Meteor' was on a per-limb basis. Yield evaluations of sour cherry clones with different fruiting habits must include the number of limbs per tree and trees per hectare, since

this may be one of the most crucial factors influencing the productivity of the orchard canopy.

Literature Cited

1. Anderson, R.L. 1981. Cherry cultivar situation. *Fruit Var. J.* 32:82-92.
2. Bradbury, D. 1929. A comparative study of the developing and aborting fruits of *Prunus cerasus*. *Amer. J. Bot.* 16:525-542.
3. Diaz, D.H. 1979. Development of the inflorescence in 'Montmorency' sour cherry (*Prunus cerasus* L.) and effects of competition between and within flower clusters on fruit set and abscission. PhD Diss., Michigan State Univ., East Lansing.
4. Duarte, R.A. and M.W. Adams. 1972. A path coefficient analysis of some yield component inter-relations in field bean (*Phaseolus vulgaris* L.). *Crop Sci.* 12:579-439.
5. Engledow, F.L. and S.M. Wadham. 1923. Investigation on yield in cereals. Part I. *J. Agr. Sci.* 13:390-439.
6. Flore, J.A. 1985. The effect of carbohydrate supply on sour cherry fruit size and maturity. *HortScience* 20:90.
7. Gardner, V.R. 1936. Factors influencing the yield of 'Montmorency' cherry orchards in Michigan. *Mich. Agr. Expt. Sta. Bul.* 116.
8. Grafius, J.E. 1956. Components of yield in oats: a geometrical interpretation. *Agron. J.* 48:419-443.
9. Kenworthy, A.C. 1974. Sour cherry tree vigor as related to higher yields and better fruit quality. *Farm Sci.* 223:1-4.
10. Leng, E.R. 1963. Component analysis in inheritance studies of grain yield in maize. *Crop Sci.* 3:187-190.
11. Li, C.C. 1956. The concept of path coefficients and its impact on population genetics. *Biometrics* 12:190-210.
12. Roberts, R.H. 1922. Better cherry yields. *Wis. Agr. Expt. Sta. Bul.* 344.
13. Roberts, R.H. 1930. Sour cherry fruiting. *Wis. Agr. Expt. Sta. Bul.* 415.
14. Wright, S. 1921. Correlation and causation. *J. Agron. Res.* 20:557-587.