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PHENOTYPIC AND CYTOLOGY STUDIES
OF NATURALLY OCCURRING MUTATIONS OF THE
'MONTMORENCY' CHERRY

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PHENOTYPIC AND CYTOLOGY STUDIES OF NATURALLY OCCURRING MUTATIONS OF THE 'MONTMORENCY' CHERRY

BY

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ABSTRACT

PHENOTYPIC AND CYTOLOGY STUDIES OF NATURALLY OCCURRING MUTATIONS OF THE 'MONTMORENCY' CHERRY

BY

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Eleven suspected somatic mutations, 7 whole trees and 4 individual limbs, of 'Montmorency' cherry (_Prunus cerasus_ L.) were compared to standard 'Montmorency' for possible phenotypic and ploidy differences. The phenotypic traits investigated included height, trunk diameter and circumference, leaf area, crotch angle, yield, fruit weight and removal force, pollen germination, living flowers/100 buds and fruits/100 good flowers in July. Six of the mutants were different for some plant characters. Fruit quality characters such as pH, soluble solids, titratable acidity and color were also determined for some mutants with no differences being found.

Histological analyses revealed that ploidy increases did not occur, leading to the conclusion that the phenotypic differences observed were not due to an increase in chromosome number but rather to simple genetic change(s).

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INTRODUCTION

Prior to 1910 horticulturalists thought that once asexually propagated cultivars were established somatic variation in plant and floral character(s) did not occur (59). As chromosomal genetics emerged in the 1920's-30's views on clonal stability and variation began to change. As a result of experimental observations such change in understanding has occurred so that today somatic variation plays an important role in introducing new cultivars.

Although much somatic variation observed is minute, occasionally distinct variants occur. This sudden appearance of somatic variation from the parental type was called "bud sport" by Darwin (23) and later "bud mutation" by DeVries (34). In 1907 Winkler (68) introduced the term "chimera" in an attempt to describe somatic variation. In Greek mythology a chimera was a creature composed of 3 genetically different animals. Winkler's plant chimeras were characterized by having 2 or more genotypically different cell types distributed in a sectorial, mosaic, or mantle-like arrangement (20).

Somatic variation in higher plants can be due to several gene or genome abnormalities. Genetic changes possibly leading to variation include loss or addition of chromosomes, deletions, duplications, inversions or translocations (35,50). One of the most frequent causes is an increase in ploidy (22,30,37). Ploidy variants generally exhibit distinctive characteristics such as increased fruit and twig size and more spreading growth habit (22).

Somatic variants have played an important role in the genetic improvement of deciduous tree fruits. They have been reported in fruit crops for over 350 years (36). However, most early reports suggested they rarely appeared. Because of studies begun at the Michigan Agricultural Experiment Station (40) and other research reported in the literature, it was concluded by Drain (36) that somatic variants of deciduous fruit species occurred quite frequently.

The majority of the variants that occurred are aberrant and generally possess little commercial value (9,36). Therefore, care must be taken to thoroughly evaluate the horticultural merit of somatic variants prior to commercial introduction.

Apple variants have historically received the majority of selection attention within deciduous fruits so that many present apple cultivars originated as bud variants (12). Variants have also been found in other deciduous fruit crops, including the tart cherry, *Prunus cerasus* L. *P. cerasus* L. cv. 'Montmorency' is one of the oldest tart cherry cultivars, having been cultivated in Europe long before its commercial introduction to the United States. Currently it accounts for over 90% of U.S. tart cherry production.

'Montmorency' exhibits considerable somatic variation in both tree and fruit character(s) (43). Studies on these variants began at the Michigan Agricultural Experiment Station in 1922 (40), mainly to determine their commercial potential. This research has continued to the present time (1,14,15,26).

In 1967, many 'Montmorency' orchards were visited by Dr. R. F. Carlson (14) to identify variant trees of potential superior quality in fruit, vigor and yield. Through the cooperation of County Extension agents and growers, 11 suspected variants were selected and propagated for further testing. Four more trees were identified in 1968 by Dr. Carlson and added to the collection which has been designated the MC series, MC-1 through MC-15. Lately, other variants observed by growers have been brought to the attention of the Michigan State Agricultural Experiment Station, including both whole trees and single limb(s) or sector(s) variants.

Although the phenotype of many 'Montmorency' variants is quite striking in some cases, no quantitative data has been obtained to determine if the variants are different than 'Montmorency', nor have the causes for observed phenotypic differences been investigated. The objectives of this study were twofold: 1) to verify that selected 'Montmorency' variants differ from the parental cultivar in quantitative characters and 2) to determine cytologically the ploidy level of the 3 histogenic layers of the variants.

LITERATURE REVIEW

The earliest record of a bud variant is probably 'Bizzaria Orange' in a Florentine garden in 1644 (51). The next is described in a letter to Linnaeus from Peter Collinson in 1741 (18) where he described a russet apple on a green fruited tree and a tree which produced both peaches and nectarines.

In 1816, Knight (48) addressed the Horticultural Society of London refuting the belief that new forms arose only from genetically differing seedlings (61). He believed "that many varieties of fruit which are supposed to be totally distinct have been propagated from branches of the same original tree and that few if any varieties of fruit can, with strict propriety, be called permanent, when propagated by buds or grafts." To support this hypothesis he reported a 'Yellow Magnum Bonum' plum having a branch with fruit similar to 'Red Magnum Bonums' and a 'May Duke' cherry with a limb variant of late-ripening, oblong fruit of inferior quality (61). He pointed out "the necessity of selecting their (nurserymen) grafts and buds from such trees only, as are found to afford each variety of fruit in its greatest state of excellence, or from such as may happen to present any valuable peculiarities of character." He recognized variant selection as a means of cultivar improvement, a view not prominent until over 100 years later.

Lists of variants began to appear over the next 120 years as discovery increased. The first list in 1865 included 35 variants in both fruit and vegetables (16). Darwin (24) in 1868 listed 46 variations in tree fruits and Cramer (19) in 1907 cited 56 instances in fruits and stated that all banana and pineapple varieties had their origins as somatic variants. Powell (53) in 1898 and Beach (6) in 1905 recorded more variants. In spite of evidence that new forms could and did originate as variants, the belief that asexually propagated cultivars were entirely stable and that only seedlings gave rise to new forms was still predominant among early horticulturalists (39).

Early references to bud variants are limited to a report of occurrence and description, with the particular variant remaining a curiosity. In 1922, Stark Brothers Nursery attracted attention to bud variants by paying $5,000 for a color sport of the 'Delicious' apple (3). The variant was named 'Starking' and had occurred as a single limb on an otherwise normal tree and bore apples that consistently developed a deep, almost solid red color 2 or 3 weeks ahead of the other fruits.

Increased interest in variants was documented by an increase in the number of recorded apple variants. Prior to 1911 only 8 variants in 5 cultivars were reported (10). In 1912 Hedrick and Wellington (45) reported that 4 cultivars out of 698 were of variant origin. In 1921 the list included 12 variants in 6 cultivars. By 1930 Breggar (9) reported 125 variants in 20 cultivars; in 1931 Shamel and Pomeroy (60) reported 173 in 26 cultivars. In 1932 Shamel et al. (62) reported 331 variants, and finally by May 25, 1936 (61) 391 variants in apple were recorded. The 1936 list also included 93 pear, 146 peach, 26 plum, 120 cherry, 87 grape, 1,664 citrus and 124 variants in other fruits. The Register of New Fruit and Nut Varieties: 2nd Edition (12) shows the strong current role variants play in the release of modern cultivars.

Fruit color variants are the most conspicuous. However, other morphological and physiological characters are certainly subject to somatic mutation. Many review articles describing morphological variants have appeared (9,10,20,54,58,61). Theoretically, variations can be found for all plant characters (35); therefore, disease resistance, self fertility, better storage quality, more efficient photosynthesis and other qualities not visually observed are possible. Physiological variants are often overlooked because they are not phenotypically obvious and suitable methods for their rapid detection have not yet been developed (35).

Variants may affect a single character or several characters (22,36). Drain (36) noted that in some instances there was a high association between some variants such that when one mutant character was observed another was instinctively sought. Certain variations have been repeatedly mentioned throughout the literature and some seem to be recorded more frequently than others, i.e., barren spurs in cherry and tetraploidy in apples (22,30,37,41,47).

Somatic variants occur on plants of all ages (61,67) as limbs or whole trees and can lead to cultivar improvement through selection for more desirable horticultural characters or degradation through propagation of inferior strains (63). Number of variants occurring in a cultivar is generally directly proportional to the number of planted trees (10,36).

Many early reported variants originated from callus tissue at graft unions and were hybrid in character between stock and scion giving rise to the "Graft Hybrid" theory (20). This theory implied that variants resulted from fusion of somatic nuclei similar to fusion of gametes. Rejection of this theory came as a result of investigating such plants as Cytisus adami, a supposed graft hybrid between Cytisus pupureus and Laburnum vulgare. Both C. pupureus and L. vulgare have 48 somatic chromosomes and a true graft hybrid should contain 96 (2x48), C. adami cells contained 48, refuting the hypothesis.

In 1868 Hanstein (44) distinguished 3 histogenic regions in apices, an outermost layer (dermatogen), one or more underlying layers (periblem) and a central core (plerome). This concept led Baur (5) to conclude that variegation in Pelargoniums resulted from a white layer over a green core, an arrangement he called a periclinal chimera. He then hypothesized that graft hybrids could be explained in this manner with outer tissue originating from one parent and the inner, from another.

The present concept of variants in decidious fruits uses Schmidts (58) tunica-corpus theory which delineates 2 regions of growth, the tunica, or outer region, of the meristem which divides anticlinally while the inner region, or corpus divides in all directions. Through work by Satina et al. (55,56,57) and Dermen (27, 28,29) it has been established that most angiosperms possess 3 histogenic layers in the apical dome, the 2 outer layers corresponding to the tunica and the inner the corpus. For simplicity, the layers have been labeled L-I for the outer layer, L-II for the next and L-III for the inner tissue.

Since Winkler introduced the term chimera, 5 types have been described:

1. Mixochimera (57) - dissimilar cells mixed without visible order.

2. Sectorial Chimera (57) - a well defined sector that differs from the rest of the plant.

3. Periclinal Chimera (57) - one component encircles another.

4. Mericlinal Chimera (46) - an incomplete periclinal chimera.

5. Cytochimera (31,51) - a chimera arising as a result of a change in chromosome level.

Most variants can be explained as chimeras of one type or another, with the majority being periclinal chimeras (11), which are also the most stable.

Chimeras may be due to different causes:

1. Spontaneously (17,66) - Those that arise as a result of natural processes. These can affect the entire genome or single chromosomes (35). Genome mutations affect the ploidy, raising it from the normal 2n, 3n, or 4n state to 4n, 6n, or 8n, respectively. This type gives rise to giant variants common in the literature (22,37,52). Chromosome mutations consist of loss or addition of chromosomes, or chromosome breakage followed by deletion, duplication, inversion or translocation (35,50).

2. Induction (66) - Those mutations that are a result of the application of mutagenic agents. It is assumed that most induced variants resemble spontaneous variants (38) and are due to the same genetic changes.

3. Sorting-out from variegated seedlings (66) - Variegation, a type of chimera not dealt with in the research of this paper, is the result of chlorophyll deficiency in one or more layers. Occasionally an entire white or green shoot will arise from a variegated plant as a result of bud

primordia consisting of all white or all green cells.

4. Grafting (66) - This type results from production of a shoot in the graft callus between stock and scion. The structural makeup is such that one parent surrounds the other giving an intermediate phenotype. Grafting has resulted in few well documented cases among woody plants (4,7,32,51,64).

Studies of induced periclinal-cytochimeras have made it possible to determine the exact origin of tissues and tissue systems. Through induction of polyploidy in a particular layer, that layer can be observed throughout the development of the plant, observing which tissue it forms. As a result scientists have found that L-I, L-II and L-III remain separate and give rise to distinct tissues (31,33, 51,57).

L-I remains single celled throughout its existence, mainly forming epidermal tissue of mature plants. In stone fruits, L-I gives rise to suture tissue from skin to pit (31) accounting for suture ripening and color variants. In most cases adventitious shoots originate from this layer (11).

L-II makes up the majority of leaf tissue and plays a small role in other tissue systems. One of the important tissues derived from L-II is the reproductive cells (54). The cytological status of L-II is important if chimeras are used as breeding material, because the desired traits may not occur in L-II and, therefore, will not be transmitted during breeding. However, through layer manipulation, traits of L-I or L-III can be moved to the L-II position.

L-III makes up the majority of plant tissue and is responsible for growth in volume and length. L-III usually gives rise to the inner part of cortical tissues, conductive tissues and pith. It is usually involved in production of giant fruit variants and accompanying changes in twig size and growth habit. Adventitious roots (37) and in some cases adventitious shoots (31) originate from this layer.

Since most angiosperms possess 3 layers in the meristem it is possible for mutations to be present in any combination of the layers. Because the histogenic layers remain distinct, a mutation in an initial cell may be expressed in the subsequently derived tissue(s). Therefore, whole tree limbs or sectors thereof may contain mutant tissue. Even though mutant tissue is present it may not be phenotypically expressed. In some instances L-II or L-III may contain a mutation for epidermal character(s) that may never be expressed since L-I is normal (51). Another case may occur when L-I has mutated to a polyploid while L-II and L-III remain normal. Since L-I constitutes so little tissue, few or no polyploid characters will be observed.

Breggar (10) reported that occurrences of variants have in some cases been associated with unusual environmental conditions inducing adventitious shoot growth. Magness and Dermen (49) and Dermen (31) reported expression of an internal polyploid as a result of forced adventitious buds. Dayton (25) attributed the high incidence of mutations in 'Delicious' apple to the fact that it readily forms adventitious shoots.

The stability of variants is critically important to their commercial use. Proof of "trueness" following propagation is found in the stability of large numbers of plantings devoted to cultivars of variant origin, but questions of their stability and reversion still exist.

Some fruit skin color variants of apples have been observed to revert quite readily. In 1959, Brown et al. (13) found that striped cultivars of 'Delicious' were more prone to reversion than those of uniform or solid color. Darrow (21) reported that thornless blackberries revert to the thorny condition due to forcing of inner thorny tissue. Although these instances of reversion are due to layer replacement it is also possible for genetic reversion to occur (31).

Layers can replace each other through periclinal divisions or damage to initial cells. Normal displacement usually takes place in an inward direction. Rarely will an inner layer replace an outer one. However, if an outer layer is damaged, an inner one may replace it and assume the former's role, a process termed perforation (8). With inward displacement a chimera type 2-2-4 (diploid-diploid-tetraploid) may become 2-2-2 and one of type 2-4-2 may change to 2-2-4. When L-II replaces L-III, L-III can be lost from the apical meristem and take no further part in apical growth. Because L-I consistently divides anticlinally it is rare to find a 2-4-4 changing to 2-2-4 or 2-2-2. However, if a 2-4-4 chimera is induced to produce adventitious buds the resulting shoot would in most cases be totally diploid. Dermen (31) found that no type of chimeral situation he studied was strictly permanent. The most stable arrangement occurred when L-I differed from the other layers. Einset (37) also found this situation to be very stable in polyploid apples. Stability is greatest in this arrangement because the plane of cell division becomes increasingly random in cells further away from the surface of the apical dome (31). Therefore, in L-III cell divisions are random, while division in L-II is predominantly anticlinal, and in

L-I it is virtually always anticlinal. Because of layer replacement, the layer which holds the favorable mutation should be isolated to obtain a plant of pure mutant tissue, thus eliminating reversion through layer replacement.

PLANT MATERIALS

Eleven suspected variants identified in 'Montmorency' orchards and thought to have originated as somatic mutations were used in this study. Seven were whole trees and 4 were individual tree limbs. Standard 'Montmorency' was used as a control and where the variant was a limb, the normal portion of the tree was also used as a control for the cytological study.

Phenotypic descriptions of the variant plant materials were obtained by visual evaluation and a few preliminary tests. Most descriptions are compiled from notes taken by Dr. R. L. Andersen, Dr. R. F. Carlson and the author's. The plants varied widely in their phenotypic characters:

AE-408 - A 40 plus year old tree variant discovered in 1972. Heavy annual fruit crop and extensive spur system were the prime reasons for its selection. Bloom and maturity dates are normal as for 'Montmorency' but with smaller fruit size, possibly due to heavy annual production. Tree habit is more spreading than normal 'Montmorency.'

AE-414 - A single limb variant observed in 1972 that occurred on a large secondary scaffold of an approximately 30 year old tree. Its fruiting spurs are longer lived (many 15 years old), more numerous than its progenitor and with fewer lateral branches. It consistently bears a heavier crop than the parent and neighboring trees. Serious leaf drop due to Sour Cherry Yellows Virus occurs on all neighboring trees but has never been observed on either the variant or its normal sectors. Bloom date is normal, with later maturity and larger fruit size than 'Montmorency.'

AE-415 - A 25 plus year old whole tree variant selected in 1972 because of its consistently heavy fruit yield. All other characters appear normal.

HN-418 - A single limb variant observed in 1973 that occurred on a small secondary scaffold of a 25 plus year old tree. It was selected because of its extensive spur formation, few lateral branches and heavier consistent yield per unit length of fruiting wood.

RM-409 - A single limb variant of a 30 year old tree. The variant was identified in 1973 because of its fair fruit crop while other trees had light crops due to frost damage. Subsequent observations reveal that it blooms over an extended period of time and exhibits a more spurry character. Fruit size is average for 'Montmorency.'

The previous variant selections are under observation and testing by a private nursery as well as by Michigan State University. The following 5 variants are from the MC cherry series collected by

Dr. R. F. Carlson and are currently under testing, observation and supervision of Michigan State University.

MC-5 - A whole tree variant 8 to 10 years old when selected in 1967. It was selected for increased fruit production and better spur system. It is a vigorous tree with fruit characteristics, bloom and harvest dates similar to or slightly later than 'Montmorency.'

MC-9 - A 12 to 15 year old whole tree variant selected in 1967 for its high yield, better spur system and high vigor. Fruit characteristics, bloom and maturity dates appear similar to 'Montmorency.'

MC-13 - A whole tree variant selected in 1968 for its blooming and ripening characters. It blooms unevenly for 5 to 7 days and also ripens over an extended period of time. Fruit is not as globose as 'Montmorency,' having a bumpy shape. Tree age at the time of selection was unknown. Tree propagules have fair vigor and a somewhat spreading growth habit.

MC-14 - A whole tree variant selected in 1969 for its extremely heavy spur system. Even though the tree is well spurred, few buds are floral buds and what fruit is present has long forked pedicels and bitter taste. Structurally it is predominantly semibarren spurs but there are areas of normal growth that have normal tasting fruit, suggesting a mixochimera arrangement. Blossoms can be found in spur sections in midsummer. Age at time of selection was unknown.

MC-15 - A whole tree variant 6 years old when selected in 1968. It was chosen for its morello-type fruit. It is vigorous, large leaved and self-sterile. These characteristics along with early blooming and ripening indicate that it may be a hybrid between *Prunus avium* and *P. cerasus* termed "duke." The occurrence of the original may therefore be due to the planting of the incorrect species.

All 10 previous variants were selected in Michigan, many in the Traverse City area. The following variant is the only one in the study not found in Michigan, but was included because it is one of the few spur type cherries in commercial production.

'Idaspur' - A limb variant found in an Idaho 'Montmorency' orchard. It was selected for its extensive spur formation with all other characters appearing normal for 'Montmorency.' Year of selection and tree age at selection was unknown.

SECTION I

QUANTITATIVE EVALUATION OF SUSPECTED SOMATIC MUTATIONS

QUANTITATIVE STUDY OF

MC-5, MC-9, MC-13, MC-14, MC-15 AND 'IDASPUR'

INTRODUCTION

Trees of the MC series have been increased by vegetative propagation and planted in commercial sites at several Michigan locations. However, they have not been extensively evaluated. Because of its attractiveness as a tart morello-type cherry, MC-15 has received the most attention. Other variants such as MC-13 and MC-14 need little evaluation as to their differences since they are readily observed in the field (Plant Materials section). The members of the series that merit extensive evaluation are those which were selected for consistently heavy yields such as MC-5 and MC-9.

Significant yearly increases in yield of any MC clone over 'Montmorency' has yet to be determined. If yield increases were found it could be due to a number of physiological factors related to tree and fruit growth and development. In 1979, Dr. F. G. Dennis Jr., Department of Horticulture, Michigan State University began a study of the entire MC series to provide quantitative data on yield components. Yield studies of certain MC clones have been conducted by Dr. R. L. Andersen since 1975. Measurements from some of their studies are included in this thesis.

The purpose of this section of research was to determine if MC-5, -9, -13, -14, -15 and 'Idaspur' differ from standard 'Montmorency.'

MATERIALS AND METHODS

All data, except fruit yield for MC-5 and -9 at Runge Farms, was collected in 1979 at the Horticultural Research Center (HRC), East Lansing, Michigan from 8 year old trees. Yield data from Runge Farms, Lake Leelanau, Michigan has been collected since 1975. Components of yield presented here from Dr. Dennis' data were collected by him from other MC plantings, however, only data from the HRC is presented herein since extensive winter and/or spring frost damage occurred at the other sites during the course of this research.

Data taken on the MC variants at the HRC included: fruit yield, trunk circumference, average weight/fruit, number of live flowers/100 buds, number of fruits/100 flowers in July, pollen germination, leaf area and fruit removal force. An analysis of variance for a completely randomized design (65) was performed for all factors and mean separation done by Duncan Multiple Range Test (65).

Four trees of MC-5, -9, -13, -14, -15 and 'Montmorency' were used for collecting yield component data. One northerly and one southerly oriented branch on the 4 trees were used to obtain fruit weight, living flowers/100 buds and fruits/100 flowers in July. For fruit weight, 10 cherries from each limb were weighed (20 fruit/tree) and average weight/fruit obtained. Living flowers/100 buds was obtained by counting the number of live flowers/100 buds at full bloom from terminal of each limb. The mean number for the 2 branches was calculated. Fruit/100 flowers in July was obtained in the same manner. Yield was obtained by picking the fruit from the entire tree and weighing it. Trunk circumference was measured 20 cm above the soil line.

Five trees of each clone (except 3 for 'Idaspur') were used for determining leaf area. Leaf area was obtained from the 3rd, 5th, and 7th leaf of southerly branches, 5 feet from the soil line and measuring them with a Li-Cor Portable Area Meter.

Fruit removal force (FRF) was obtained from 3 trees of MC-5, -9, 'Idaspur' and 'Montmorency.' FRF was measured at 4 different times during fruit maturation. Fruit from these trees was also used to determine certain fruit quality characteristics which are presented in Appendix B.

Pollen germination was obtained by randomly removing flowers from 3 trees of each variant prior to full bloom. Anthers were collected and small amounts placed in a 13 x 100 mm culture tube. A 15% sucrose solution (10 ml) containing 10 ppm boric acid was added, the tube shaken, and the solution pipetted onto 1% agar blocks containing 15% sucrose and 10 ppm boric acid. The blocks were incubated under natural light at 25^{o}C for 18 hours, and percent germination recorded.

Yield data from Runge Farms was obtained for 15 trees of each variant and 'Montmorency' in pounds/tree in 1975. In 1976 and 1977, data was obtained in pounds/row for 15 trees. In 1979, 12 trees were visually rated and a number 1-10 assigned, with 10 being a full crop. Data taken in 1976 and 1977 was not amenable to statistical analysis.

RESULTS AND DISCUSSION

MC-15 differed from 'Montmorency' in all characters except pollen germination (Table 1 and 2). MC-14 also varied from 'Montmorency,' especially in yield components (Table 1). These findings were not unexpected since these 2 variants have obvious morphological differences, one having sweet cherry-like characteristics (more vigorous growth evident in larger trunk diameter and leaf area) and the other barren spurs.

MC-15, although capable of producing a crop by cross-pollination, did not since an adequate pollinator was not present; therefore, yield, fruits/100 flowers in July and weight of fruit were not obtained. MC-14, although largely barren, did bear some fruit so that data on yield and fruits/100 flowers in July were obtained and were significantly lower than 'Montmorency' (Table 1).

MC-13, another variant with obvious phenotypic traits, proved to differ from 'Montmorency' only in fruit weight and leaf area. Since M-13's distinguishing character is its uneveness in ripening, average fruit size was expected to be smaller. Why leaf area differs is unknown. The earliest fruits of MC-13 appear ripe at the same time as 'Montmorency,' but many small, immature fruit were also present which, when added to the sample, would lower the average fruit weight.

MC-5 and -9 had smaller leaf areas but greater fruit weight and pollen germination (Table 1 and 2). MC-5 had a larger trunk circumference. Although neither selection had greater fruit yield than 'Montmorency' at the HRC in 1979, both selections, especially MC-5, had consistently higher yields than 'Montmorency' at Runge Farms (Table 3). In 1975, both selections had higher yields than 'Montmorency' probably because 'Montmorency' when planted (1969) were noted as being smaller than MC trees. However, in 1976 and 1977, MC-5 appeared to maintain its yield advantage, while MC-9 was equal to 'Montmorency.' Both MC-5 and -9 had significantly larger fruit at the HRC, as well as better pollen germination, both possibly contributing to increased yield.

Fruit removal force for the 4 sampling dates was not different from 'Montmorency' except for MC-5 on 7/18 (Table 3). All data on 7/18 are not readily interpreted since they did not follow the expected decreasing trend. Why FRF increased so much for MC-5, 'Idaspur' and 'Montmorency' is unknown.

A significant difference was found for pollen germination and leaf area, but not for FRF on 'Idaspur' grown at the HRC. Pollen germination was twice that of 'Montmorency,' a possibly important characteristic if it remains consistent.

TABLE 1.--Yield Components of Variant 'Montmorency' Clones Grown at the Horticultural Research Center. (Dr. F. G. Dennis Jr., unpublished data).

Clone	Trunk Circumference (inches)	Yield (lbs)	Living Flowers/ 100 buds	Fruits 100/ live flowers July	Weight/ Fruit (gms)
MC-5	18.5bc	62.5f	227.6b	35.3bc	5.2de
MC-9	15.2abc	44.0cdef	191.4ab	40.9bc	5.3e
MC-13	15.9abc	31.5bcd	244.5b	37.0bc	3.4b
MC-14	15.9ac	1.8a	233.0b	10.3a	4.4c
MC-15	21.4d	0a	153.8a	-	-
Mont.	14.3a	50.8def	231.6b	54.2c	4.3c

Identical letters in the same column indicate no significant difference at the .05 level using Duncan's Multiple Range Test.

TABLE 2.--Pollen Germination, Leaf Area and Fruit Removal Force for 'Montmorency' Variants Grown at the Horticultural Research Center

Clone	Pollen Germination %	Leaf Area (sq cm)	Fruit Removal Force (g)			
			7/11	7/13	7/18	7/23
MC-5	34.7bc	155.9c	375a	236a	487a	254a
MC-9	36.9b	150.5d	407a	302a	314b	264a
MC-13	25.5d	141.4e	-	-	-	-
MC-14	26.8cd*	156.1c	-	-	-	-
MC-15	23.0d	239.6a	-	-	-	-
Mont.	26.2d	164.2a	393a	203a	381b	276a
Idaspur	55.5a	147.4d	397a	249a	460ab	270a

*from normal sector.

Identical letters in the same column indicate no significant difference at the .05 level using Duncan's Multiple Range Test.

TABLE 3.--Yield in Pounds of Fruit Per Tree of MC-5, -9 and 'Montmorency' at Runge Farms for 1975-1979

Clone	1975	1976	1977	1979*
MC-5	18.1a	20.4	79.3	4.4a
MC-9	14.6b	15.4	67.8	3.5b
Mont.	9.9c	14.6	69.5	3.0b

*Visual rating on a 1-10 scale, 10 being best.

Identical letters in the same column indicate no significant difference at the .05 level using Duncan's Multiple Range Test.

QUANTITATIVE STUDY OF

AE-408, RM-409, AE-414, AE-415 AND HN-418

INTRODUCTION

The more recent variants identified in the Northwest Michigan fruit growing area are maintained by a private nursery; thus they have not been extensively evaluated. However, they are of greatest interest due to their morphological differences and possibilities of improved horticultural characters. In some cases, the variants are so obvious that photographic documented observations provide sufficient evidence of their differences. However, a study of selected quantitative traits was initiated to determine if AE-408, RM-409, AE-414, AE-415 and HN-418 differ from 'Montmorency.'

MATERIALS AND METHODS

Ten nursery trees of each of the variants and 'Montmorency' were measured for leaf area, crotch angle, height and trunk diameter. All trees were clones and grown under similar nursery conditions. All variants were chip budded using Mahaleb seedlings as the rootstock. Soil type of the nursery was a uniform sandy loam.

Leaf area was obtained by measuring the 3rd, 5th and 7th leaf from the terminal end of the central leader. Leaf area was determined on a Li-Cor Portable Area Meter. Analysis of variance was performed for a completely randomized design (65) and mean separation obtained using Duncan's Multiple Range (65).

Verticle crotch angle was obtained for the 1st, 2nd and 3rd lateral branches on the central leader, with the uppermost branch being the first. Angles were obtained with the use of a protractor. Analysis of variance for a completely randomized design with missing data (65) was performed and mean separation obtained by Duncan's Multiple Range (65).

RESULTS AND DISCUSSION

All suspected variants, except AE-415 were different at the .05 level (Table 4). The only parameter in which AE-415 differed was height. AE-415's apparent similarity to 'Montmorency' was not surprising since it was selected for consistent and apparent heavier annual yields and not general tree structure.

Since a commercial nursery setting using the nursery's propagated trees was used, proper replication was not possible, but soil type in the field is uniform and all trees are grown by identical cultural practices, allowing the conclusion that AE-408, RM-409, AE-414 and HN-418 differ from 'Montmorency' in several young tree characteristics. Thus, supporting the visual observations which led to their selection. Height, trunk diameter and leaf area differences revealed by statistical analysis of the nursery trees were also readily visible in the nursery.

Since the variants have not been treated for virus removal, whereas the 'Montmorency' controls are virus-free, these data need to be repeated using virus-free plant material or infected controls. It may be that the measurements merely indicate that virus free trees are more vigorous in the nursery than infected ones. Due to the gross morphological differences of the variants this is highly unlikely except possibly for AE-415.

Degree of lateral branching appeared to differ among the variants. RM-409 appeared to branch more than the other variants. This may be a function of height since in the taller variants, crotch angles of 3 laterals could be measured, but in AE-414, the shortest variant, only 5 of the 10 trees had 3 or more lateral breaks.

Analysis of variance for leaf area showed differences existed not only between the leaves of the variants and 'Montmorency,' but also between the 3rd, 5th and 7th leaf. The between leaf difference could be due to 3 possible causes: 1) the leaves may not have been fully expanded, 2) trees trained with a strong central leader will reveal such leaf size differences or 3) leaf areas are truly different. The most likely reason is that the leaves were not fully expanded. This is likely because the trees are grown very vigorously and even though data was collected after terminal growth ceased, leaf expansion was not completed.

MC-9 was evaluated in this section because it was also propagated in the same field. It also proved to differ significantly from 'Montmorency' in all parameters.

Since these selections are still under evaluation, observation of the variants needs to be continued for spur development (compactness), fruit production, photosynthetic activity, fresh and processed fruit quality and winter hardiness. If they prove desirable they may bring about the same change(s) in cherries as spur-types did for apples. The natural dwarfing tendency of spur mutants could prove valuable since commercially acceptable dwarf rootstocks for cherries have not been developed.

TABLE 4.--Height, Diamter, Crotch Angle and Leaf Area of Nursery Trees of AE-408, -414, -415, HN-418 and MC-9.

Clone	Height (cm)	Diameter (cm)	Crotch Angle	Leaf Area (sq cm)
Mont.	145.8a	2.54a	51.2a	216.1c
AE-415	129.2b	2.40ab	48.7ab	212.2cd
RM-409	110.9c	2.15bc	45.3bc	206.4dc
HN-418	108.0c	1.81d	44.3c	200.8e
AE-408	93.8d	2.02cd	44.8c	259.9a
MC-9	91.0d	1.42e	45.3bc	-
AE-414	67.2c	1.49e	38.1d	248.8b

Identical letters in the same column indicate no significant difference at the .05 level using Duncan's Multiple Range Test.

SECTION II

CYTOLOGICAL INVESTIGATIONS OF SELECTED 'MONTMORENCY' VARIANTS

CYTOLOGICAL INVESTIGATION OF SELECTED SOMATIC VARIANTS

INTRODUCTION

Since the 3 histogenic layers present in most angiosperms are known progenitors of different tissues, various methods have been employed to determine the ploidy level in these layers (22,50). The most direct method involves slicing a meristem transversely or longitudinally and determining the cell size of the independent layers (31). If a layer has an increased chromosome complement its cells will generally increase in size proportional to the ploidy level (31,53).

Chromosome counts using root tip squashes is applicable if only L-I, L-II or L-III root tip tissue is obtained. The production of roots from L-II and L-III is feasible. L-III roots can be obtained by forcing adventitious roots (31,37), while pure L-II root tips can be obtained from seedlings since their progenitors are gametes which arise in L-II (54). Root tips from L-I would only be possible through tissue culture, rooting of adventitious propagules and seedlings obtained from fruit born on them. Because of the time needed to obtain root tips of L-I, stomatal size was used to reflect ploidy of L-I (57) while root tip squashes and chromosome counts were used in studying L-II and L-III.

MATERIALS AND METHODS

To determine ploidy of L-I, 10 stomates from 5 leaves of each variant and 'Montmorency' were measured by light microscopy and the aid of an occular micrometer. Measurements were made from impressions obtained by applying clear finger nail polish tinted with a few drops of red nail polish. Fixed tissue was tested but the contrast was not sufficient for accurate measurements. Impressions gave the desired contrast while seemingly maintaining accuracy of stomatal size. The impressions also made sample measurements, handling and storage easier.

Mature, fully expanded leaves from current season's terminal growth were selected 5-7 feet from ground level. Samples were taken at fruit maturity to insure sampling plants at a uniform stage of development. Samples were obtained from original variants or from clonally propagated MC and 'Idaspur' trees at the HRC.

Average stomatal size in length and width was obtained for each leaf. An analysis of variance for a completely randomized design was performed and an F statistic calculated (65).

Ploidy of L-II was determined on self-pollinated derived seedlings of all the variants except 'Idaspur,' MC-15, spur sections of MC-14 and HN-418. Open-pollinated seeds were used in studying these variants. Open-pollinated 'Montmorency' and self-pollinated normal sections of limb variants were included as controls. Selfing was done in 1978 by collecting anthers, drying them overnight, removing pollen and placing it on pistils of flowers emasculated the previous day.

Fruit was harvested at full maturity, flesh removed, seeds dipped in a mild fungicide solution (¼ teaspoon Captan/liter water) and stratified at 5°C until germination. Any pits which did not crack naturally after 7 months were mechanically broken and seeds placed in Petri dishes on moist filter paper in a 17°C cooler until radicle emergency was observed.

After growth began, the seeds were placed in pots in the greenhouse. Root tips were removed as needed, fixed and stored in 3:1 absolute ethanol:acetic acid. They were removed from the alcohol-acetic acid, placed in 1N HCl at 60°C for 35 minutes, rinsed with water and returned to the alcohol-acetic acid and removed as needed to make squashes. Tip sections 1 mm long were used for observation with 1% acetocarmine as the stain.

Observations were made with a Zeiss Photomicroscope II at 787x magnification. Suitable smears were photographed with a Linhof 4x5 view camera. The resulting picture was at 1980x. Chromosomes were indicated on the print as they were counted through the microscope.

For determining ploidy of L-III all variants, normal appearing sections of limb variants and 'Montmorency' were used. Adventitious roots were obtained from hardwood stem cuttings of the longest, 1 year old growth that could be found on the trees. Handling, preparation and observation of L-III root tips was the same as for L-II with chromosome counts also being obtained.

RESULTS AND DISCUSSION

No ploidy differences were observed in any of the 3 layers. Differences in stomatal size were not found between 'Montmorency' and the variants (Table 1 and 2). The normal number of 32 chromosomes was found in L-II of all variants and in L-III of those variants which produced adventitious roots.

L-I does not give rise to sufficient tissue to account for the morphological differences observed; L-II and/or L-III must also be involved. This does not mean that the variants could not have originated in L-I, it is highly possible they may have since L-I can give rise to adventitious shoots, in which case all 3 layers would possess the mutation and it would be expressed.

Since L-II gives rise to reproductive tissue, changes in this layer may be reflected in fruiting potential and characters, both qualities evident in the variants (Plant Materials section). However, those variants with spur-type growth, as well as changed fruit characters (RM-409 and MC-14) may not be due solely to a change in L-II. L-III makes up a majority of the woody tissue and therefore probably influences spur development. So variants with changed spur and fruit characters have whatever genetic change responsible, probably in both L-II and L-III, but those with just fruit character changes (MC-13, MC-5, MC-9 and AE-415) may be due to genetic mutations only in the L-II.

Open pollinated seed was used for some variants for different reasons. Open pollinated 'Montmorency' and 'Idaspur' seed from isolated tree plantings is most likely equivalent to self-pollinated seed. MC-15 is known to be largely self-sterile (2) making cross-pollinations necessary. Self-pollinations of HN-418 and spur sections of MC-14 were made, but the seeds were nonviable, so that open-pollinated fruit was used.

Ploidy level of L-III could only be determined for MC-5, -14 (normal section), -15, AE-408, -415, HN-418 and RM-409. Rooting techniques for cherries have given variable results depending heavily on tissue vigor. Growth of sufficient vigor did not occur on some of the variants and therefore roots were not obtained.

Even though adventitious roots were not obtained for 5 of the variants (MC-9, -13, -14, AE-414 and 'Idaspur'), it is unlikely they contain complete genome changes, with morphological differences due to other genetic change(s). None of the variants have characteristics typical of polyploid trees. Tree structure, although different than 'Montmorency' in some variants is definitely not spreading, fruit is not abnormally large and twigs are not abnormally thick. The branches of the spur mutants look much more compact, but are no thicker than 'Montmorency.'

The genetic change responsible for heavier spur production is probably present in L-III but may also be present in the other layers. L-III contributes more to tree structure and therefore spur formation than do other layers. The mutation may have originated in L-I or L-II, but it was necessary for these layers to move to the L-III position before the trait could be expressed.

Sampling time proved important in obtaining appropriate mitotic stages. Samples taken from 12:00 A.M. to 1:00 P.M. had sufficient mitotic activity for counting of chromosomes, but roots removed between 9:00 and 10:00 A.M. or 2:00 and 3:00 P.M. had a majority of their nuclei in interphase.

The HCl high temperature treatment of the root tips facilitated cellular spreading by loosening cell walls. The treatment also dissolved starch grains which could interfere with chromosome counts.

By storing root tips in alcohol-acetic acid they retained their natural color whereas browning occurred, giving chromosomes a darker background than desired if 70% alcohol was used.

Two mitotic stages, metaphase and anaphase (Figure 1 and 2), were found to be best for counting. Figure 1, although the chromosomes appear in a prophase arrangement, their shortness indicate a polar view of metaphase.

TABLE 1.--Analysis of Variance for Stomatal Length of AE-408, -414, -415, HN-418, RM-409 and 'Montmorency.'

Source	D.F.	S.S.	M.S.	F
Total	79	7.22		
Clone	15	0.00	0.00	0
Error	64	7.22	0.11	

Tabular F = 1.82 @ .05
Standard deviation = 0.0017
Variance = 2.6×10^{-6}

TABLE 2.--Analysis of Variance for Stomatal Width of AE-408, -414, -415, HN-418, RM-409 and 'Montmorency.'

Source	D.F.	S.S.	M.S.	F
Total	79	2.350		
Clone	15	0.001	0.000	0
Error	64	2.35	0.037	

Tabular F = 1.82 @ .05
Standard deviation = .0016
Variance = 2.5×10^{-6}

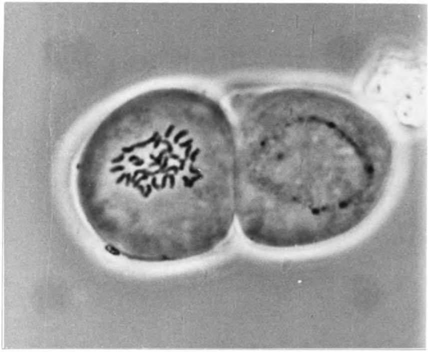

Figure 1. Metaphase of MC-5.

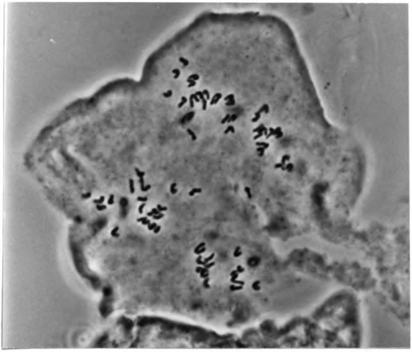

Figure 2. Anaphase of MC-14.

SUMMARY AND CONCLUSIONS

From the data collected in Section I and from visual observations of clonal propagules and/or original limbs, it can be concluded that MC-13, -14, -15, AE-408, -414, HN-418 and RM-409 differ from 'Montmorency' in tree and/or fruit characters and therefore differ genetically from 'Montmorency.' Further cytological and quantitative evaluation of the variants is needed to interpret their origin.

Suggestions of areas of research that deserve further consideration are observations of MC-5, -9, AE-408, -414, -415, HN-418 and RM-409. Since propagated trees of the Northwest Michigan variants have not come into commercial production, their yield potential has yet to be determined. Tree structure of the clones should be observed once they are cleared of virus infection to observe the effect that virus has on them. Nursery row measurements should be repeated using a statistical design.

Morphological differences observed visually and measured in Section I were shown in Section II not to be due to aberrations in chromosome number in the 3 histogenic layers. Throughout the literature, polyploid deciduous fruits have been described as having larger fruit and thicker branches as a result of larger cell size. They have also been described as having a more spreading growth habit. None of the variants studied herein exhibited these traits.

Disagreement among plant anatomists exists as to whether or not angiosperms consistently possess 3 histogenic layers in apical meristems. Peach (*Prunus persica* Batch.) has been shown by Dermen and Stewart (33) to have a 3 layered meristem. However, median longitudinal sections of *P. cerasus* L. apices should be made to determine if it has a 3 layered system as well. Cytochimeras of *P. cerasus* should be obtained to observe which layer gives rise to specific tissues. The histogenic layer that gives rise to certain tissues has been shown in other plants but tart cherry should be evaluated in this respect.

Since the morphological differences of the studied selections are not due to aneuploid or euploid changes in the histogenic layers, they must therefore be due to other genetic change(s). Meiotic chromosomes should be studied to observe possible chromosome pairing abnormalities which would suggest deletions, duplications, translocations or inversions. It is also possible for differences to be due to point mutations. Hybridization of the spur variants should be done to determine if the tree structure is due to a dominant or recessive gene(s).

APPENDIX A

APPENDIX A

FIELD SURVEY FOR 'MONTMORENCY' VARIANTS

INTRODUCTION

'Montmorency' variants have been found in trees of all ages but their frequency and type appear to vary with tree age. Certain variant types appear repeatedly within the literature and in commercial orchards. Correlation between some variant characters has also been observed (36). The purpose of this section was to determine: 1) if frequency of variants is related to tree age, 2) why some variants appear more frequently than others and 3) why certain variant characters seem to be associated.

MATERIALS AND METHODS

In 1976 a search of 2 adjacent orchards each containing 500 trees and operated by the same grower (Woodman Orchards) was conducted to determine whether frequency of limb variants is influenced by tree age. The 2 orchards, one 25 and the other 10 years old, were observed 2 days prior to full bloom (to observe for bloom and growth habit variants) and again prior to harvest (to observe for fruit, foliage, yield and growth habit variants). Suspected variant trees were tagged for further observation.

Several 'Montmorency' orchards throughout the state were surveyed as well as the pomological literature to observe which mutants occur most often in present orchards and which ones observed historically in past orchards still occur. Variant characters that appear to be highly associated were also determined.

RESULTS AND DISCUSSION

Seven limb variants as well as many whole trees of suspected variant types were found in the 2 orchards surveyed. Limb variants included 2 barren spurs, 2 barren with willowy growth, 1 semibarren, continual bloomer, 1 semibarren late bloomer with forked pedicels and 1 semibarren spur. Whole tree mutants included 1 early bloomer, 1 heavy producer, 1 spur and 3 trees of a smaller stature and umbrella shape. None of these variants were found in the 10 year old orchard. All variant types have been reported previously by other researchers, and have been seen by this author in other 'Montmorency' orchards of similar age.

Since all limb variants were in the older orchard it can be concluded that they have a higher frequency of observable limb variants. Since all the limb variants observed were at least 10 years old it is possible that limb variants existed in the young orchard but have not yet developed to a large enough size for easy detection leading to the conclusion that size of mutant sector is an important factor in their discovery. Small limb mutations may have existed in both orchards but a more intensive search would have to be carried out to find them.

One of the main reasons for initiating the orchard survey was because it was noticed by Dr. Andersen that when mutations were found in younger trees they invariably were of the whole tree type, having been propagated from a mutant limb. Although this survey did not support the statement, it does not mean it is incorrect. However, as a result of the survey it was evident that both types of variants, whole trees and limbs, are found in older orchards.

Limb variants may occur with apparently greater frequency in older trees because the number of somatic cell divisions from which new mutations could originate is greater than in younger trees. This does not mean however that mutant expression does not occur in younger orchards. It is possible for expression to have occurred in the first year of growth so that young trees could have a mutant sector of considerable size. Another plausible explanation is that young trees have not been subjected to severe pruning and/or stress which may cause adventitious buds leading to expression of masked mutations. Another plausible explanation is that present-day nurserymen are more careful in selecting genetically uniform propagating material.

The limb variants found in the older orchard were probably of new origin and not the result of masked mutations revealed through adventitious bud break. Evidence supporting this is that the mutations occur only once in their respective trees and no mutant type is observed with greater frequency than another. If the mutants resulted from expression of adventitious buds, the trees are old enough that more than one adventitious bud per tree could have developed to express the character. Also since the trees are from the same commercial nursery, a number of them are probably from the same budwood source, and if the source had a masked mutation that particular mutant type should be found in several trees as a result of adventitious bud breaks.

Three orchards of such nature have been observed by the author in different parts of Michigan. The same mutant type is found recurring throughout the orchards and can be found more than once on some trees. This indicates that the mutation was probably already present when the trees were received from the nursery and the original mutation was unexpressed in the budwood source.

Certain variant types seem to reoccur in existing orchards and throughout the history of 'Montmorency's' commercial production. One particular variant type that appears with great regularity is the spur mutation, ranging from barren to heavy in fruit production. These types of variants were found by Gardner (41,42) and Drain (36) in many 'Montmorency' orchards in several areas of Michigan, a situation also observed by the author. Another variant type having a light crop, willowy growth and late ripening fruit with a large stylar scar (Figure 1) was reported by Gardner in 1949 (42) and observed by this author again in 1979 in different orchards. In the same article Gardner also described a variable ripening variant similar to MC-13.

Several possible explanations exist for the widespread appearance and recurrence of mutant types. One explanation, that they are masked and unknowingly propagated, was already discussed. This is highly feasible since most adventitious buds originate from epidermal or L-I tissue (11) and as such, would not normally be expressed if only in L-I since it contributes little to plant morphology but when an L-I mutant tree is forced to form adventitious buds the character would be present in all layers of the resulting adventitious shoot. The critical information needed to evaluate the frequency of this masking phenomena is the frequency of L-I adventitious bud formation.

A higher mutation frequency of the genes controlling some characters is another possible explanation in some instances since few orchards with numerous recurrences of a single variant type within them are found.

Through orchard and literature survey, a high association of certain characters was observed. The association most often seen was that growth habit variants (spurry or willowy growth) in most cases affected fruit production characters. The character most commonly associated with growth habit variants is a reduction in yield. Other associated characters of growth habit variants include uneven blossoming and ripening times (RM-409) and longer, forked pedicels (MC-14). Spur variants with normal fruit characters have been found (HN-418 and AE-414) but at a lower frequency than barren spurs. All of these traits and associations were found in the Woodman Orchards study.

Character associations may be due to linkage or plieotropy, so that a single genotypic change can result in more than one phenotypic change. It is also possible for 2 simultaneous mutations of 2 different genes to occur, but the high frequency in which the described associations are found negate the likelihood of this explanation.

Figure 1. Late ripening, large stylar scarred variant similar to variant observed by Gardner in 1949.

APPENDIX B

APPENDIX B

FRUIT QUALITY ANALYSIS OF MC-5, MC-9, HN-418 AND 'IDASPUR'

INTRODUCTION

Fruit quality characteristics are as important to the success of cultivars as are tree structure and yield. For this reason, certain cherry selections are being evaluated by the Department of Food Science and Human Nutrition in conjunction with the Department of Horticulture at Michigan State University. The purpose of the joint study was to determine if selected variants were sufficiently similar or superior to 'Montmorency' to be acceptable for commercial food processing. The data relevant to this research are presented herein.

MATERIALS AND METHODS

In 1978 fruit samples were harvested 3 times from 3 trees of MC-5 and 'Montmorency.' The trees were growing at the HRC and were in their 7th leaf. In 1979 sampling was repeated again using 3 trees at the HRC at 4 harvest dates. The 1979 analyses included MC-5, -9 and 'Idaspur.' The original limb of HN-418 was harvested once in 1978 with analysis performed on its fruit as well.

Six tests were performed on the fruit: size, pH, titratable acidity, soluble solids and exterior color in darkness and redness. For convenience, harvested fruit was pitted and frozen for analyses at a later date. Fruit size was determined as average weight of 10 pitted cherries. Fruit pH was determined using macerated fruit and pH meter. Soluble solids were determined by placing a small amount of strained juice in a refractometer. Titratable acidity was determined by titrating a 10 gram sample of macerated tissue to a pH of 8.0 with 0.1N NaOH and using the formula;

$$T.A. = \frac{\text{ml. NaOH} \times N \times 0.067}{10 \text{ grams}}$$

Both darkness and redness of fruit were determined by using the Hunter color method.

Data was not collected in a manner so that statistical comparisons between selections could be made between harvest dates, but an average over harvest date was obtained and an analyses of variance for a completely randomized design performed (65). Mean separation was obtained using Duncan's Multiple Range Test (65).

RESULTS AND DISCUSSION

All characters measured were not significantly different from 'Montmorency' in both 1978 and 1979 when averaged over the 4 harvest dates (Table 1 and 2).

Since several harvest dates were selected to observe fruit quality changes, trends could be observed during the ripening process. Fruit size changed little for the dates tested except for MC-5 in 1978 (Table 1). Soluble solids (Brix) generally increased over the harvest dates in 1979, but little changes were seen in 1978. A general increase in pH was observed in both years. Titratable acidity was found to decrease with maturation. Hunter color "L," a measure of fruit darkness with 0 being black and 100 white, was found to decrease greatly for both years as the fruit matured. Hunter color "a," or redness, with higher values indicating more was found to be highly variable both seasons.

TABLE 1.--1978 Fruit Quality Characteristics of MC-5, HN-418 and 'Montmorency.'

Clone	Harvest Date	Fruit Removal Force (g)	Unit Size (g)	Brix	Titratable Acidity %	pH	Hunter CDM Values L Darkness	Hunter CDM Values a Redness
MC-5	7/12	341	3.0	14.4	1.29	3.40	21.0	27.2
	7/17*	291	3.2	14.0	1.27	3.35	15.0	24.5
	7/24	250	3.8	13.9	1.11	3.50	16.5	24.4
Mont.	7/12	301	-	13.4	1.40	3.30	16.3	26.9
	7/17	300	-	14.0	1.28	3.40	14.6	25.5
	7/24	261	-	13.9	1.13	3.60	15.6	23.2
HN-418	7/27	-	3.5	14.1	1.13	3.45	13.8	22.7

*Full maturity as predicted from bloom.

TABLE 2.--1979 Fruit Quality Characteristics of MC-5, MC-9, 'Idaspur' and 'Montmorency.'

Clone	Harvest Date	Fruit Removal Force (g)	Unit Size (g)	Brix	Titratable Acidity %	pH	Hunter CDM Values L Darkness	Hunter CDM Values a Redness
MC-5	7/11	375	2.40	11.5	1.60	3.30	22.8	23.4
	7/13	236	2.37	13.2	2.12	3.35	16.5	20.7
	7/18*	487	2.27	12.4	1.39	3.35	20.3	25.6
	7/23	254	2.32	13.2	1.49	3.40	14.4	18.8
MC-9	7/11	407	2.28	11.5	1.72	3.20	22.7	24.9
	7/13	302	2.38	13.2	1.68	3.25	18.0	17.5
	7/18*	314	2.48	12.4	1.53	3.50	19.5	26.4
	7/23	264	1.93	13.5	1.42	3.40	15.8	19.5
'Idaspur'	7/11	397	2.05	12.2	1.90	3.20	24.1	29.5
	7/13	249	2.76	13.2	1.77	3.20	17.0	19.4
	7/18*	460	2.41	13.4	1.51	3.30	18.7	26.8
	7/23	270	2.30	14.8	1.72	3.40	14.8	19.6
'Mont.'	7/11	393	2.10	12.0	1.65	3.30	23.0	27.5
	7/13	203	1.98	12.0	1.57	3.30	16.9	19.1
	7/18*	381	2.00	13.2	1.53	3.35	20.4	28.8
	7/23	276	1.83	14.0	1.63	3.30	14.9	19.1

*Full maturity as predicted from full bloom.

BIBLIOGRAPHY

BIBLIOGRAPHY

1. Andersen, R. L. Unpublished data.

2. ________ and R. F. Carlson. Unpublished data.

3. Anonymous. 1922. Tree limb brings $5,000. N. Y. World, Oct. 29, 1922.

4. Balkema, G.H. 1971. Chimerism and diplontic selection. A. A. Balkema. Rotterdam.

5. Baur, E. 1909. Das wesen und die erblechkerlsverhallnisse der "Varitates albomarginatae hort" von Pelargonium zonale. Z. Indakt. Abslam. Z. Vererbungslehre, I. 330-351.

6. Beach, S.A. 1905. Rept. N. Y. Agr. Exp. Sta. 1903, part 2, 1: 60, 239. 278; 2: 14, 37.

7. Bergann, F. 1958. Variations specifiques dans la greffe siuvant Lucien Daniel et preuves de l'eristence d'induction reciproques ches les Grataegomespili de Bronvaux, p. 186-194. Compete Rendus des Travaux du Colloque International sur la Greffe des tussus vegetaux et animaux. Rennes.

8. ________ and L. Bergann. 1972. Uber Umschichtungen (Translokationen) an der sprossscheiteln periklinaler chimaren. Zuchter, 32: 110-119.

9. Breggar, J. T. 1930. The prevalence and commercial importance of bud mutations in the deciduous fruits. Proc. Amer. Soc. Hort. Sci. 27: 425-429.

10. ________. 1932. Present status of mutation studies in deciduous fruit varieties. Proc. Amer. Soc. Hort. Sci. 29: 144-150.

11. Broertjes, C. and A. M. VanHarten. 1978. Application of mutation breeding methods in the improvement of vegetatively propagated crops. 316pp. Elsevier Scientific Publishing Company.

12. Brooks, R. M. and H. P. Olmo. 1972. Register of new fruit and nut varieties: 2nd ed. University of California Press.

13. Brown, P. S., C. O. Hesse and E. C. Koch. 1959. Reversion of red sports of 'Delicious' apple. Proc. Amer. Soc. Hort. Sci. 74: 40-46.

14. Carlson, R. F. 1968. Special cherry research 1967-1968. III Raw product quality and lower production costs. Clones and rootstocks. Agr. Exp. Sta., Mi. St. Univ. 4-5.

15. ________. 1970. 'Montmorency' cherry selections. Fruit Varieties and horticultural digest. 24; 1: 22-23.

16. Carriere, E. A. 1965. Production et fixation des varieties daus les vegetaux. Paris.

17. Clowes, F. A. L. 1957. Chimeras and meristems. Heredity 11: 141-148.

18. Collinson, P. 1821. A selection of the correspondence of Linnaeus and other naturalists. 1: 7-8 and 70-71.

19. Cramer, P. J. S. 1907. Kritische Uebersicht der bekannten Falle von Knospenvari.

20. ________. 1954. Chimeras. Bibliogr. Genet. 16: 193-381.

21. Darrow, G. M. 1928. Notes of thornless blackberries; their chromosome number and their breeding. Jour. of Her. 19: 139-142.

22. ________. R. A. Gibson, W. F. Toenjes and H. Dermen. 1948. The nature of giant apple sports. Jour. of Her. 39: 45-51.

23. Darwin, C. 1859. The origin of species by means of natural selection.

24. ________. 1868. The variation of animals and plants under domestication. New York.

25. Dayton, D. F. 1969. Genetic heterogenety in the histogenic layers of apple. Jour. Amer. Soc. Hort. Sci. 94(6): 592-595.

26. Dennis, F. G. Jr. Unpublished data.

27. Dermen, H. 1945. The mechanism of colchicine induced cytohistological changes in cranberry. Amer. Jour. of Bot. 32: 387-394.

28. ________. 1947. Periclinal chimeras and histogenesis in cranberry. Amer. Jour. of Bot. 34: 32-43.

29. ________. 1947. Histogenesis of some bud sports and variegation. Proc. Amer. Soc. Hort. Sci. 50: 51-73.

30. Dermen, H. 1948. Chimeral apple sports and their propagation through adventitious buds. Jour. of Her. 39: 235-242.

31. ________. 1960. The nature of plant sports. Amer. Hort. Mag. 39: 123-173.

32. ________. 1969. Graft chimeras 1953-1969. Wiss. Z. Padagogische Hochsch. Potsdam 13: 15-21.

33. ________ and R. N. Stewart. 1973. Ontogenic study of floral organs of peach (Prunus persical) utilizing cytochimeral plants. Amer. Jour. of Bot. 60(3): 283-291.

34. DeVries, H. 1901-1903. Die mutationstheirie. Leipzig. Eng. Trans. 1909-1910 (Chicago).

35. Doorenbos, J. 1977. Spontaneous mutations as a source of clonal variation in deciduous fruits. Acta. Hort. 75: 13-18.

36. Drain, B. D. 1933. Field studies of bud sports in Michigan tree fruits. Mi. St. Col. Tech. Bul. 130.

37. Einset, J. 1952. Spontaneous polyploidy in cultivated apples. Proc. Amer. Soc. Hort. Sci. 59: 291-302.

38. ________ and C. Pratt. 1969. Spontaneous and induced apple sports with misshapen fruit. Proc. Amer. Soc. Hort. Sci. 73: 1-8.

39. Esau, K. 1965. Plant anatomy. 2nd ed. Wiley.

40. Gardner, V. R. 1933. Forward to "Field studies of bud sports in Michigan tree fruits." Mi. St. Col. Tech. Bull. 130.

41. ________. 1935. A study of some unproductive sports of the 'Montmorency' cherry. Jour. Agr. Res. 50(5): 457-477.

42. ________. 1949. Type and variability in bud mutations of the cherry and apple. Mi. Quart. Bull. 32(1): 28-41.

43. ________ and W. Toenjes. 1948. Strain differences in the 'Montmorency' cherry. Mi. Agr. Exp. Sta. Quart. Bull. 31: 83-90.

44. Hanstein, J. 1868. Die scheitelzellgrouppe im vegetationspunkt der phanerogamen. Festschr. Niederrhein. Ges. Natur. u. Heilk: 109-134.

45. Hedrick, U. P. and R. Wellington. 1912. N. Y. (Geneva) Agr. Exp. Sta. Bull. 350.

46. Jergensen, C. A. and M. B. Crane. 1927. Formation and morphology of Solanum chimeras. Jour. of Genet. 18: 247-273.

47. Kinman, C. F. 1930. A study of some unproductive cherry trees in California. Jour. Agr. Res. 41: 327-335.

48. Knight, T. A. 1818. Hort. Soc. Lond. Trans. 11: 160-161.

49. Magness, J. R. and H. Dermen. 1957. An internal polyploid sport of 'Winesap' apple. Proc. Amer. Soc. Hort. Sci. 69: 65-67.

50. Newcomer, E. H. 1943. Studies in the nature of the clonal variety IV. Cytological studies of bud sports of 'McIntosh,' 'Stark' and 'Baldwin' apples. Mi. St. Col. Tech. Bull. 187.

51. Nielson-Jones, W. 1969. Plant chimeras. 2nd ed. London. Methuen.

52. Olmo, H. P. 1935. Bud mutation in the vinifera grape II Sultinina Gigas. Proc. Amer. Soc. Hort. Sci. 33: 437-439.

53. Powell, G. H. 1898. Amer. Gard. 19: 466-467 and 514-514.

54. Sadamori, S. 1965. Utilization of the spontaneous mutations in deciduous fruit trees. Gamma Field Symp. 4: 1-23.

55. Satina, S. and A. F. Blakeslee. 1941. Periclinal chimeras in Datura in relation to development of leaf and flower. Amer. Jour. of Bot. 28: 862-871.

56. ________. 1943. Periclinal chimeras in Datura in relation to the development of the carpel. Amer. Jour. of Bot. 30: 453-462.

57. ________ and A. G. Avery. 1940. Demonstration of the three germ layers in the shoot apex of Datura by means of induced polyploidy in periclinal chimeras. Amer. Jour. of Bot. 27: 895-905.

58. Schmidt, A. 1924. Histologishe studies an phanerogamen vegetationspunkten. Bot. Arch. 8: 345-404.

59. Shamel, A. D. 1921. The improvement of plants through bud selection. Exp. Sta. of the Hawaiin Sugar Planters Association.

60. ________ and C. S. Pomeroy. 1932. Bud variation in apples. Jour. of Her. 23: 173-180 and 213-220.

61. ________. 1936. Bud mutations in horticultural crops. Jour. of Her. 27: 487-496.

62. Shamel, A. D., C. S. Pomeroy and J. T. Breggar. 1933. Better fruit. 28(4): 6, 12 and (5): 3-4.

63. Shamel, A. D., L. B. Scott, G. S. Pomeroy and C. L. Dyer. 1920. Citrus improvement: A study of bud variation in the Eureka lemon. U.S.D.A. Bull. 813. 88pp.

64. Stewart, R. N., F. G. Meyer and H. Dermen. 1972. Camellia + 'Daisy Eagleson,' a graft chimera of _Camellia_ _sasanqua_ and _C._ _japonica_. Amer. Jour. of Bot. 59(5): 515-524.

65. Steele, R. G. D. and J. H. Torrie. 1960. Principles and procedures of statistics. 481pp. McGraw-Hill Book Co. Inc.

66. Tilney-Basset, R. A. E. 1963. The structure of periclinal chimeras. Heredity. 18: 265-289.

67. Weldon, G. P. 1928. Two apricot mutations. Jour. of Her. 19: 15-16.

68. Winkler, H. 1907. Uber Pfrobfastarde und pflanzliche chimeran. Ber. dtsch. bot. Ges., 25, 568-576.