Fruit Cultivar and Germplasm Evaluation

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The period from 1880 to 1900 has been called the "Era of Variety Testing," for considerable effort was devoted to comparison of varieties of fruits. Much of this work has been criticized for lack of vision, and the results would not be accepted in many modern scientific journals. Was this concentration on variety testing justified? In this paper I will address this question, emphasizing the reasons for such concentration, as well as the fruit testing programs at two U.S. experiment stations. The term "variety" will be used in place of "cultivar," given its general use during most of the period covered.

FRUIT VARIETIES IN AMERICA

Early American settlers were little concerned with varieties of fruits and vegetables; survival depended upon producing fruits, vegetables, and grains, without regard to variety selection. Thus the fame of Johnny Appleseed—Jonathan Chapman—in distributing seeds to pioneers in western Pennsylvania and the Midwest. In Europe, however, those with time and money to spare had begun to collect varieties well before the founding of Jamestown in 1607. Richard Harris, Henry VIII's fruiterer, is credited with making the first large collection of fruit varieties at Trynham, Kent, in 1533; this was to become "the chief mother of all other orchards" in England (Morgan and Richards, 1993). Others soon followed in England, Germany, France, and other European countries (Table 1). An estimated 120 varieties of apple were under cultivation in Europe in the early 1600s (Morgan and Richards, 1993).

Varietal collections in America

Almost 200 years were to pass before similar projects were undertaken in America. One of the first American collections was that of Robert Prince, who established a commercial nursery at Flushing, L.I., in 1730; he listed 42 varieties of pear in his catalogue in 1771 (Hedrick, 1921). Bernard M'Mahon in his *American Gardener's Calendar* (1806) listed 59 varieties of apple. Soon others were collecting and/or compiling lists of varieties, including William Coxe (1817) and J.J. Thomas (1903) (Table 1). Robert Manning (1838) established a pomological garden in Salem, Mass., in 1823 to compare foreign and native fruits "as were hardy enough to endure the inclemency of a northern winter." "...it was intended to select for permanent cultivation, those varieties ...fitted to the climate of New England, and of high merit in themselves." He imported many varieties from Europe, and supplied scions of American selections to European collectors; in his book he describes 51 apple, 81 pear, 15 peach, 20 plum, and 14 cherry varieties, in addition to varieties of several woody ornamentals. At the time of his death in 1842, Manning had accumulated some 2000 cultivars, more than half of which were pears (Hedrick, 1921). Many American selections were introduced into Europe because of his work, resulting in a plethora of new varieties under test there.

Each year new varieties were named as American farmers found promising seedlings. Andrew Jackson Downing described 88 apple varieties in the first edition of his book, published in 1845. Charles Downing, who succeeded his brother (Downing, 1845) as compiler after the latter's untimely death, listed 1856, 1099 of which were American, in the 1872 edition (Bailey, 1893). Bailey (1893) recorded 878 varieties of apple that were available for sale by American nurseries in 1892; of the 13 most often listed, only 'Northern Spy' is of any commercial importance today.

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Grower organizations

This profusion of varieties, most of which originated from chance seedlings, created confusion among growers as to which varieties they should plant. As if this were not enough, many varieties were known by several names. Leroy (1867, cited by Hedrick, 1921), for example, reported that 900 varieties were known by a total of 3000 names. As a result, many fruit grower organizations sprang up in an attempt to exchange information on varietal characteristics. At least eight state horticultural societies had been established by 1850, and another 10 by 1875 (Fisher and Upshall, 1976). A major purpose of such groups was evaluation of varieties. The purposes of the conventions in Buffalo and New York City in 1848 that eventually resulted in the formation of the American Pomological Society (APS) were focused on comparison of varieties, including their merits, demerits, and nomenclature, and disseminating information on such varieties (Tukey, 1976). Marshall Wilder, who served as president of APS from 1852 to 1886, preached the gospel of "raising new and improved varieties from seed as the best method of increasing and preserving our supply of choice fruits." (Wilder, 1857). This should be combined with hybridization. "Plant the most mature and perfect seeds of the most hardy, vigorous, and valuable varieties; and, as a shorter process, insuring most certain and happy results, cross or hybridize your best fruits." (Wilder, 1867). "The great loss sustained in the importation and trials of trees from foreign shores, and even from different quarters of our own country, which are not adapted to our own location, suggests ... that new varieties must be produced from seed, and to the manor born, to remedy this evil." (Wilder, 1875). An example of the emphasis on varieties was the display of more than 6000 plates of fruits, mainly apples, by state and local horticultural societies and commercial nurseries at the 14th session of the APS in Boston in 1873. The APS established a committee on variety evaluation that had authority to add or subtract varieties from the organization's recommended list. Be-

Table 1. Early fruit variety collections/compilations in Europe and America.

Source/collector	Year	Location	No. entries
Early collections in Europe			
Richard Harris	1533	Trynham, Kent	?
Charles Estienne	1540	France	16
Valerius Cordus	1542	Hessen and Saxony, Germany	31[z]
Jean Bauhin	1598	Montbeliard, France	60[z]
Olivier de Serre	1608, 1628	Pradel, France	83
Le Lecteur	1628	Orleans, France	254[y]
John Parkinson	1629		60[z]
Collections in America			
Bernard M'Mahon	1806	Philadelphia ?	59[z]
William Coxe	1817	Burlington, N.J.	280
Robert Manning	1838	Salem, Mass.	180
Prince Nurseries	1845	Flushing, L.I., N.Y.	350
Indiana Agr. Expt. Sta.	1894	W. Lafayette, Ind.	130
Mich. Expt. Sta.	1895	S. Haven, Mich.	420+
Mich. Agr. College	1895	E. Lansing, Mich.	750
NYS Agr. Expt. Sta.	1896	Geneva, N.Y.	3020[x]
Compilers in America			
Andrew J. Downing	1845		88
Charles Downing	1872		1856
J.J. Thomas	1903		954[w]
S.A. Beach	1905		698[z]
U.P. Hedrick	1921		2900[y]
Ont. Dept. Agr.	1906		419

[z]All apple.
[y]Pears only.
[x]May include seedlings (983) under test.
[w]Apples and pears.

tween 1858 and 1867, the list of approved varieties of all species grew from 300 to 561 of a total of 1186 evaluated.

VARIETY TESTING BY EXPERIMENT STATIONS

The activity of this and similar organizations brought pressure on state experiment stations to begin varietal testing. Beach (1905) noted that during the period when the New York Experiment Station was being established at Geneva, "there was an insistent popular demand that the testing of varieties of fruits and vegetables be made a prominent line of work here."

Before discussing a topic, one should define it. What is "variety testing"? And is it "research"? L.H. Bailey (1908) provided his views on the subject in his 1907 ASHS presidential address: "...Variety testing is ordinarily not research; in fact, it is a question whether it is ordinarily even good experimenting: but the variation of varieties, their relationship to soil and climate, the correlation of their behavior under different conditions and in different places, ought to be research of the best kind." In the same presentation he gave his views on what research is *not*: "...It is not observation, it is not testing; it is not demonstration; ...it is not description..." At first glance, these statements seem to be contradictory, but the gist of the message is that varietal testing can be research if the approach is broader than mere description and includes an analysis of the reasons why varieties differ.

Criticisms

Criticism of varietal testing was evident as early as 1897, when W.H. Jordan (1897a), director of the Geneva Experiment Station, wrote in his annual report for 1896, "Probably no American station is so largely engaged in a study of varieties, chiefly of fruits, as is this one, and consequently its officers are specially interested in the adverse criticisms which occasionally appear concerning what is known as variety testing." The two major criticisms were (a) the "low grade of work" that needed little training, and (b) the limited value of the tests outside the local area. Jordan then raised the question, "Should the collection be maintained and still further developed, or shall it be reduced in variety and extent to the dimensions ... necessary for certain lines of investigation,..." He concluded that it should be maintained because of (a) its value to both fruitgrowers and nurserymen, who were producing "an immense annual output of nursery stock," in Western New York, (b) the fact that the collection served as a "living museum" providing "a magnificent opportunity" for botanical study, as well as for breeding; and (c) the potential use of the wide range of germplasm in the collection for studies of pest control.

Some 20 years later, U.P. Hedrick (1916), chairman of the Pomology Dept. at Geneva, commented on fruit growers' complaints about some of the varieties described in publications from the Geneva Station, but indicated that this was to be expected. To the rhetorical question, "What purpose then do the tests of fruits on the Station ground serve?," he listed seven reasons: (1) to distinguish between varieties by growing them side by side; (2) determine relative times of bloom, leafing, ripening, and plant maturity; (3) determine precocity/tardiness in bearing; (4) establish susceptibility to insect and fungus pests; (5) find purposes for which they are best adapted; (6) provide descriptions for use in identification; and (7) determine adaptability to soil/climatic conditions at the Station. Hedrick deemed all seven to be of permanent value to the fruit grower; nevertheless, the grower "must find out for himself whether a variety is adapted to his farm."

Subsequent critics, including former presidents of ASHS, have labeled variety testing unscientific. L.C. Corbett (1915) suggested that, "...fully one-fourth of the horticultural publications which have emanated from the state experiment stations, bear evidence of this type of work...yet every one of us has been guilty of contributing to this hodgepodge and still the game goes merrily along." In this and in both previous (1905) and subsequent (1917) papers Corbett stressed the need for more uniformity in evaluation and presented a set of "note blanks" for such use. He also stressed the differences between testing of vegetatively vs. seed-propagated varieties, the latter requiring greater care in establishing pure strains to avoid the problems of "mixed lots." T.C. Johnson (1918) also called for more systematic work to allow better comparison across locations. J.H. Gourley (1924), president in 1923, said of the APS that it was, "...unfortunate ...that so much time was spent...in varietal discussion." Although Gourley praised the APS for clearing up nomenclature and in discarding worthless varieties "by the hundred," "...this era [1880–1890]...is typified by extensive and repeated testing of all sorts of horticultural plants, ...and little else was attempted by many workers." "...we do not find any scientific advance during this era worthy of the name...".

Evaluation by ASHS

A report on "Lines of work in which [ASHS] members are engaged" (Close, 1917) revealed that of 46 locations responding, 32 were conducting variety trials and 28 had breeding programs. Several papers dealing with variety testing, including that of Corbett cited above, were presented at this meeting. This series of papers served as the basis for formation of a committee on variety testing, chaired by Prof. Gourley, then of New Hampshire. The following year Gourley (1917) reported "a difference of opinion as to the value and advisability of the variety orchard in station and college work." "It is well known that such work is not looked upon favorably by the Office of Experiment Stations, and hence any considerable fund for the work must come from the state or other sources." Gourley noted that "...it is a passion or at least a real pleasure to most pomologists to work with and study varieties, so much so that we have often been accused of showing a weakness in this direction and even that some have done little else." Among the justifications, however, was that "...we have doubtless all had the experience of winning the confidence of orchardists more by knowing varieties than by any information we could give them."

The committee conducted a survey to determine the status of variety testing (Gourley, 1917). A questionnaire was sent to each experiment station and agricultural college in the United States and to Canadian members. Responses (43 in all) indicated that 34 stations/colleges each had 100 or more varieties and/or seedlings of all species combined, and nine had from 500 to 4000; of these varieties, 64% were apples. Half of the respondents indicated that maintenance of a large collection of tree fruit varieties was an institutional policy, but responses from three states (Wisconsin, Indiana, and West Virginia) revealed that state horticultural societies or commercial orchardists had taken responsibility for variety collections. Expressed opinions varied widely. S.A. Beach's comments are of particular interest with regard to criticisms of scientists' knowledge of practical matters today. He observed that a large percentage of professional workers in pomology were under 25–30 years of age, and that "Very many of them have not had opportunity to get a personal acquaintance with the pomological varieties with which they are concerned and in which their constituency are interested." Thus maintenance of variety collections was important not only for variety testing, but also for educating staff members. Prof. W.J. Green of Ohio suggested that an instructor must know varieties and "would be lame without such an orchard." C.I. Lewis reported that the orchards at Oregon State College were divided into experimental and teaching orchards, with three to four commercial varieties in the former, and "about 300 varieties to be used in systematic pomology" in the latter. Thus variety collections served extension and teaching, as well as research functions.

A second report (Gourley, 1918) listed orchards containing notable collections of varieties of fruits and nuts maintained by colleges, experiment stations, private growers, or commercial nurseries. Apple varieties were again the most abundant. Collections with more than 100 varieties or unnamed seedlings of apple were reported by 14 states, two Canadian provinces, nine private growers, and one nursery (Stark Brothers). Benjamin Buckman, an Illinois grower, reported having 1400 apple varieties—probably seedlings. Several respondents had more than 100 varieties/seedlings of grape, pear, plum, cherry, or peach. Oregon, for example, had 700 named varieties of pear. Although not included in Gourley's list, the Vineland Station in Ontario had 164 apple varieties under test in 1917 (Close, 1918).

VARIETY TESTING PROGRAMS

Reviewing the entire history of variety testing would require volumes. Therefore, I have chosen two programs—the New York

Station at Geneva and the Michigan Station at South Haven—and will trace the development of variety testing from the origins of the respective stations until the beginning of "scientific" breeding programs.

New York State

E.S. Goff began a fruit variety testing program at Geneva about 1883; this was continued by S.A. Beach when Goff moved to Wisconsin in 1888. To avoid having to buy trees at market prices, a circular was mailed to originators of new fruits and to growers requesting samples for planting. The Station agreed not to allow scions for propagation to be removed from such trees without permission from the originator. By 1900, the Station boasted 700 named varieties of apples, crabapples, and seedlings, as well as many varieties of other fruits. It also began the breeding program for which it is famous; 1000 apple seedlings from controlled crosses fruited in 1888 and 1889, of which 20 were worthy of propagation. Of these, all but five were discarded in 1890. Subsequent breeding work at Geneva has been summarized in several publications (e.g., Hedrick and Wellington, 1912; Way, 1971; Wellington, 1924).

With this collection of fruits as a base, Beach published in 1905 the two-volume *The Apples of New York*, now much sought after for its color plates (actually black-and-white photographs that were tinted in four colors). Of the 698 varieties listed, both parents were known for only one (Hedrick and Wellington, 1912). Work on variety collection and description continued after Beach's departure in 1905 to become head of the horticulture department at Iowa State College. His successor, U.P. Hedrick, although not a fruit breeder himself, continued both the varietal testing and breeding work begun by Beach, as well as publication of monographs on fruit varieties. This led to the appearance (1908–1925) of a series of books describing cultivars of horticultural crops, the most famous of which are volumes on *The Fruits of New York*, including peaches, plums, cherries, pears, grapes, and small fruits. Publication of the books was funded by the State Legislature, and over half of the copies printed went to its members and to the Commissioner of Agriculture. A charge was made only for the books on peaches, pears, and small fruits; copies of these were still in the Station's storerooms in the mid-1960s (Gates, 1966).

Under first Beach, then Hedrick, the fruit accessions increased year by year. In 1896 the Station boasted no fewer than 3020 varieties of all fruits, including apples, pears, plums, grapes, gooseberries, and strawberries (Jordan, 1897b). By 1914 (Hedrick, 1915) the total had been reduced to 2301, with notable reductions in apples, grapes, and gooseberries. These figures did not include plantings at other stations; Cornell reported 1119 seedling apples in 1918 (Close, 1918) and Fredonia about 300 grape cultivars in 1916 (Close, 1917).

In 1919, the Geneva Station encouraged the formation of a cooperative—the New York State Fruit Testing Cooperative Association—to propagate new varieties and sell them at cost to members. This organization served as a means of "on–farm testing" of varieties, with growers reporting their observations at annual meetings. In 1978, the Association had grown to the point that it was propagating 248 varieties of 22 species (Lamb, 1979). A similar association was formed in Ontario at a later date.

Michigan

Other varietal collections were assembled at many colleges and experiment stations near the end of the 19th century, although Geneva seems to have been one of the few at which breeding was also a major objective. In Michigan, much of the impetus came from Theodatus T. Lyon, who started a nursery business near Plymouth, Mich., in 1844, collecting varieties from local orchards. He soon learned that many of these were incorrectly identified, and set out to clarify their nomenclature. This work was "on the side," as he was secretary to the board of superintendents of the poor in Wayne County (includes Detroit), then President of a railroad company, before moving to South Haven, on Lake Michigan. Here he established a nursery and "test orchard" on his property, and eventually became a "walking encyclopedia of the nomenclature of fruits" (Michigan Board of Agriculture, 1895). He served for 40 years as chair of the APS's committee responsible for preparing its [later the U.S. Dept. of Agriculture's (USDA)] fruit catalogue. As president of the Michigan Horticultural Society (name changed to Michigan State Horticultural Society in 1880) for 18 years (1876–1893), he was influential in urging the Agricultural College to conduct trials in fruit testing, insisting that "for the proper development of the unusual capabilities of west Michigan, there should be an experiment station established on the west shore of Michigan..." (Hull, 1983; Taylor, 1901).

In 1888, arrangements were made for Lyon to present a report on the varieties that he had under test. The following year the College leased his property, and the citizens of South Haven donated an adjoining 5-acre site. Thus was established the South Haven Experiment Station, with Lyon as superintendent. Here he planted additional varieties as they became available. From 1890 until his retirement in 1898, Lyon prepared extensive reports on their performance. In 1889, he reported on a total of more than 300 varieties of strawberry, raspberry, blackberry, currant, gooseberry, cherry, grape, peach, pear, plum, quince, apple, mulberry, nuts, and figs. Strawberry cultivars totaled 230 by 1893, although this number stabilized around 150 in later years. Following his retirement in 1890, the space devoted to variety evaluation in annual reports diminished as his successors turned their attention to additional trials with pesticides and cultural practices. Despite this apparent hiatus in publications, the numbers of varieties reported for South Haven in 1918 were apple, 250; pear, 75; plum, 110; and cherry, 72 (Gourley, 1918). A pear breeding program was started in 1915 (S. Johnston, unpublished report), but little came of it. Not until Stanley Johnston began his peach breeding program in the early 1920s was South Haven again to play a significant role in varietal improvement.

THE NATIONAL CLONAL GERMPLASM REPOSITORIES

Maintaining collections of fruit varieties is expensive and requires considerable land area. As a result, funds for variety testing diminished at most experiment stations within the first few decades of the 20th century. Only where breeding was a major concern, such as at Geneva, could maintenance of collections be justified. According to one report (Comis, 1986), all but 1200 of the 8000 apple cultivars known in 1905 had been lost by the mid-1980s.

Not until the 1970s were steps taken to make systematic collections of fruit cultivars in the United States on a national basis. The USDA's Agricultural Research Service (ARS) and the state experiment stations cooperated in establishing national germplasm repositories for preserving cultivated and wild varieties of both seed and clonally propagated species. Currently, there are 10 such repositories specifically for maintaining tree fruit germplasm. Their locations and the fruit species for which they are responsible are listed in Table 2. In 1995, the National Clonal Germplasm Repository (NÇGR) at Geneva listed ≈100 of the 698 varieties of apple described by Beach (1905), and the NCGR at Corvallis had ≈200 of the ≈2500 pear varieties listed by Hedrick in 1921. Other collections undoubtedly contain some of the missing varieties, but many have disappeared. Of the first 12 varieties named by the Geneva Station in 1914, nine had been lost by 1969 (Way, 1971).

Similar projects are under way abroad, supported by national and international organizations, including the International Plant Genetic Resources Institute [IPGRI, formerly the International Board for Plant Genetic Resources (IBPGR)], funded by the Food and Agricultural Organization (FAO) of the United Nations. The IBPGR was established in 1971 as a division of the Consultative Group on Agricultural Research (CGIAR) of the FAO. The organization serves as a catalyst in conservation efforts, providing financial support for meetings, collection trips, and start-up costs of establishing new programs.

THE PRESENT

The burst of activity in variety testing witnessed in the late 19th and early 20th centuries has passed, but fruit growers remain keenly interested in varieties. The current emphasis on dwarfing rootstocks and resultant early production permits rapid changes in apple varieties

Table 2. Locations of National Clonal Germplasm Repositories for fruits and species for which they are responsible.

Site	Species
Brownwood, Tex.	Hickory, chestnut
Corvallis, Ore.	Filbert, hazelnut, strawberry, pear, currant, brambles, blueberry
Davis, Calif.	Kiwifruit, persimmon, pistachio, fig, walnut, mulberry, olive, peach and nectarine, plum, almond, pomegranate, warm-season grape, apricot, cherry
Geneva, N.Y.	Apple, cool-season grape
Hilo, Hawaii	Tropical fruits
Miami, Fla.	Tropical fruits
Mayaguez, P.R.	Tropical fruits
Orlando, Fla.	Citrus
Riverside and Brawley, Calif.	Citrus, date

within relatively few years in response to consumer demand. As evidence, we have the recent rise in production of 'Fuji' and 'Gala' apple. Few experiment stations can afford to maintain large collections of varieties today; the national repositories and international research centers have become today's conservatories, and must be relied upon to serve as the "living museums" and sources of germplasm for both theoretical and applied studies in physiology, genetics, and pest control that W.H. Jordan envisioned in 1897.

Is "variety testing" science? It may or may not be, depending upon one's definition of "science." To quote a successful fruit breeder, Roger Way of the Geneva Experiment Station, "Most of the process of evaluating a variety is subjective...You cannot use science alone to predict which [varieties] will be successful" (pers. comm.)." Variety testing remains essential if growers are to have unbiased information upon which to base their decisions as to which varieties will be most productive and profitable. The "era of variety testing," for all its shortcomings, eliminated hosts of varieties that had limited economic value, and paved the way for the scientific breeding programs of today.

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