4-1-1929

Experiments in Plant Heredity

N.E. Hansen

Bulletin 237 April, 1929

Experiments In Plant Heredity

Horticulture Department
Agricultural Experiment Station
of the
South Dakota State College of
Agriculture and Mechanic Arts
Brookings

Experiments in Plant Heredity

N. E. HANSEN

The fruit-breeding experiments at this station since 1895 have yielded the many new hardy fruits described in Bulletin No. 224. Some of them have become popular and are now widely grown in many western states and north into Canada. These thirty-three years of work in producing several hundred thousand fruit seedlings have enabled the writer to make some deductions which have been presented in addresses prepared for International Science meetings and published in the reports of these associations. It appears best at this time to publish three of the papers in order to make them available to a larger audience.

In recent years the land in this department was all planted to fruit seedlings and there was no more land available. Since there was no money available for the purchase of land, the only way was to secure the use of state land and of land furnished free by local people interested in the development of horticulture.

In past years as soon as one generation of fruit seedlings was fruited, the selections for propagation were made and the remainder dug up and burned. This gave room for the next generation.

In recent years it became necessary to establish orchards elsewhere. It was a much better test of hardiness than to plant them all at one place, since there is a wide diversity in climate in so large a state as South Dakota. This wide diversity is evident in the recommended Fruit List of the South Dakota State Horticultural Society, in which the State is divided into six fruit districts.

State Orchards and Their Field of Work

Watertown—Area 50 acres. Contains many thousand seedling pears, apples, plums, sandcherries, grapes and small fruits. The specialty is the Harbin pear seedlings grown from seed obtained in 1924 by the writer from fresh fruit in the mountains along the Siberian railway some fifty miles east of Harbin, North China, the northwest limit of this species, **Pyrus Ussuriensis**. If enough land is made available, this will be the largest pear orchard in the world and will make possible the improvement of this hardy pear by selection and hybridization, and provide hardly pear stocks resistant to fire blight.

Eureka—Area 26 acres. Orchard fruits especially plum, apple and pear for the open prairies in the northwestern part of the State.

Pierre—A test of new hardy ornamental shrubs in cooperation with the new city park. Sometimes a surplus results after completing the selection work with hardy roses and other ornamentals. These have also been furnished to the city parks of Sioux Falls, Watertown and Aberdeen.

Philip—Area 5 acres. The development of the native sandcherry **(Prunus Besseyi)** by selection. The development of new alfalfas bred by the writer from hardy varieties obtained in several tours as Agricultural Explorer in Russia and Siberia, especially the Hansen Whiteseed alfalfa with white seed and white flowers.

State Rose Garden at Sioux Falls—Area 16 acres. There is a small orchard of many of the new hybrid fruits described in South Dakota Bulletin No. 224. But the main work is with roses.

The American Rose Society has over 5000 members in the United States and in foreign countries. In the annual report for 1928, the interesting record is made that South Dakota has the honor of establishing the first State Rose Garden.

This rose garden, together with the land at Brookings, makes a total of over 20 acres devoted to the originating of roses that will be hardy without winter protection.

Many thousand seedlings are grown every year. Much attention also is given to the production of hardy rose stocks for budding and grafting the new hybrids produced in these experiments. This is necessary because the prohibiting in the near future of all rose stock importations has been announced by the United States Department of Agriculture.

Some Sterile and Fertile Plant Hybrids

Address before the International Conference on Flower and Fruit Sterility, New York City, August 12-14, 1926.

N. E. HANSEN

During the past 31 years, devoted to the improvement of fruits, the writer has originated many hybrids. A brief mention will suffice at this time. Some species yield fertile hybrids with certain species, and sterile hybrids with other species. The reason for this is not yet clear. But homozygous material in general gives better results than heterozygous material as in complex hybrids, where apparently the chromosome structure becomes too complex or inharmonious.

Prunus Besseyi x P. triflora. Highly fertile. Bears on one-year old shoots from the bud in nursery. Example: Opata, Sapa. These are widely grown in our prairie Northwest. The South Dakota Sand Cherry is dominant in hardiness and in habit of bearing; the Japanese plum transmits quality and large size of fruit.

Prunus Besseyi x P. Simonii. Not hardy. Fruits sparingly. Tokeya, the only one named, was discarded.

Prunus Besseyi x P. Americana. The named varieties, Sansoto and Cheresoto, are highly fertile. The quality not up to Opata and Sapa. This is to be expected as neither parent possesses high quality.

Prunus Besseyi P. Pissardi (P. cerasifera purpurea). Fruits of no value and sparingly produced. But as ornamental shrubs with red leaves the varieties Cistena and Stanapa are popular in western gardens.

Prunus Besseyi x P. Armeniaca. Very shy bearer. Not of thrifty growth, rather slender.

Prunus Besseyi x P. avium. Growth very dwarf and plants soon perished.

Prunus Besseyi x P. Persica. Kamdesa, my hybrid of the Sand Cherry of South Dakota with the peach, is of special interest. It has shown fruit only once in its history. The flowers instead of one pistil, have two to six pistils. The pollen is sterile. In this connection should be recalled the sterile peach x plum hybrids that have appeared in various places.

Prunus Besseyi, F2 hybrids. All highly fertile, when as in my

Tom Thumb and Oka, the pedigree is evidently three-fourths Sand Cherry and one-fourth Japanese plum **(P. triflora).**

One of my hybrids, combining four species, **P. Besseyi, P. Simonii, P. americana** and **P. triflora,** is nearly sterile. Selfing with plums I find very difficult.

Prunus americana x P. Simonii. My varieties Hanska and Kaga give choice fruit and are productive in mixed orchards. Inkpa, the sister variety, is not productive. All have the excellent quality and fragrant firm-fleshed fruit of the **P. Simonii** of China.

Prunus Simonii x P. americana. Tokata is larger in fruit and considered one of the very best in flavor. Needs good pollination to produce fruit. It is evident that **P. Simonii** gives high quality. Most hybrids must have good pollination in mixed orchards.

Prunus triflora x P. americana. The hybrids are all highly fertile. The fruit of my Waneta is two inches in diameter. The tree is very strong and vigorous in growth. Also the two sister varieties, Kahinta and Tawena.

Prunus americana x P. triflora. The many choice hybrids produced by others as well as myself are fertile and early in bearing and show clearly that these two species are mutually fertile.

Prunus Americana x P. domestica. These two species combine either way with difficulty. They are not valuable and are generally sterile so far as noted in my experiments.

Prunus nigra P. triflora. The native plum of Manitoba, Prunus nigra, combines well with the Japanese plum and its hybrids. Examples, my Cree, Pembina and Ojibwa.

Prunus nana x P. Persica. The Siberian almond always gives sterile hybrids with the peach but they are desirable ornamentals.

Pyrus baccata x P. Malus. Thousands of hybrids have appeared since the Siberian crab-apple was brought to America. **Pyrus Malus** is considered by C. Koch to be a composite of six species, hence great variety is found in all the **P. Malus** hybrids. These hybrids are usually productive. When sterility is evident they are soon discarded. The best are of economic importance as a fruit for preserving. When too large they are not of importance, as they are too large for a crab-apple and too small for an apple. Some of the best crabs, like my Dolgo, are direct importations from Russia. The pedigree is not known. My Alexis crab which is very similar in every respect to Dolgo, was grown from seed of **Pyrus baccata** received from the Botanical Garden at Leningrad.

Pyrus Malus x P. baccata. My best so far is Maga crab, a hybrid of McIntosh apple with the Virginia crab (a hybrid crab). My Olga crab (Duchess of Oldenburg apple **x P. baccata cerasifera)** is highly fertile.

My Hopa red-flowered crab **(P. Malus Niedzwetzkyana x baccata)** is highly fertile. The fruit is small, but the tree is very ornamental when in bloom.

The longer I work with **Pyrus baccata** the more I am convinced that pure selection work should be done with this species. Apparently the best form is the most northern type so far available. The Nertchinsk seedlings from the Amur River region of eastern Siberia are wonderfully productive trees. Since my best South Dakota sand cher-

ries this year are one inch in diameter, the product of selection through several plant generations, I believe that the pure Siberian crab, **Pyrus baccata**, can be developed to full apple size by selection only, without the hybridization with the cultivated apple, **Pyrus Malus**, which some times gives sterility or lack of winter hardiness.

Native American Apple. The wild west American apples **Pyrus Soulardi** and **P. ioensis** combine well with the cultivated apple, **P. Malus.** (Note my Kola, Zapta, Tipi and Shoko). But the work is not finished as the wild crab acerbity is yet too much in evidence. My Anoka apple is very popular as it is of good quality and bears in one or two years after transplanting one year budded trees on one-year-old wood. It is from seed of the hybrid wild crab Mercer topgrafted on Duchess of Oldenburg. The tree is a remarkable annual bearer and remains semi-dwarf from its heavy bearing.

The Future Program for the Apple. If it is true that six species are in the ancestry of the cultivated apple, it would be an extremely difficult piece of work to reduce the apple to the homozygous condition, which is so desirable for F1 combinations. Homozygosity is the ideal of the apple breeder, but it appears very difficult to secure this judging from the experiments so far in several states. Many valuable varieties have been obtained by the use of entirely heterozygous material, but it would be well to go further and determine the results of using purely homozygous material.

Hybrid Alfalfas. Alfalfa is an old Arabic word meaning the best fodder. More and more alfalfa is becoming the great essential to successful farming over a large area of the United States. In Asia and southern Europe wherever the common blue-flowered alfalfa, **Medicago sativa**, and the yellow-flowered alfalfa, **Medicago falcata**, grow near together the hybridization takes place freely. Botanists call these hybrid forms **M. media** and the farmer calls them "Sand Lucerns." These hybrids are very numerous and consist of all sorts of mixtures in varying proportions of the yellow and blue alfalfa. As a class they are very productive and more desirable than either parent in vigor and productiveness.

Since **Medicaga falcata** is very widely distributed in Europe and Asia, ranging in Asia from India north to above the Arctic Circle in northeastern Siberia, the plant varies greatly in its ability to resist cold, hence it follows that hardiness of this hybrid alfalfa must depend largely on the region from which it comes. Coming from the mild region of southern Europe it could not be expected to be as hardy as if it came drier and more severe climates. Hence while nature has indicated in the Sand Lucernes a method of increasing the vigor of alfalfa by hybridization, we do not know, that any one combination is the best one that it is possible to make.

The strongest and best of these hybrid alfalfas is the one I brought from Russia in 1906 and named the Cossack. The small spoonful of seed which I brought over in 1906 has been developed in the hands of many farmers so that the 1916 crop in the western part of South Dakota was fully one thousand bushels and since then the acreage has steadily increased.

These hybrid alfalfas as a class are superior to either parents in vigor and productiveness. I have originated many varieties by alter-

nate machine transplanting of one-year-old plants of two varieties as first noted in South Dakota Bulletin, 159, April, 1915. But pressure of other work has prevented their further development and propagation. South Dakota No. 1 and South Dakota No. 2 are the only two of this series of hybrids that have been distributed. The chief trouble is that the variable variegation in the color of the flowers makes it impossible to identify them. So their sale is entirely a matter of good faith. This need of a definite trademark led me to work for a white-flowered alfalfa.

This has been done in my white-flowered alfalfa and later in this present year, 1926, in my Hansen white-seed alfalfa, which has both white flowers and white seeds. It is the only alfalfa ever introduced that has a distinguishing characteristic so that it does not need certification or affidavits as to genuineness.

Conclusion.

For further light in this matter it will be necessary to make all possible combinations of species. We will then know better what species are mutually congenial. To cross heterozygous with heterozygous parents is like aiming in the dark. But as Nature produces them in vast numbers, some good results are bound to be obtained. I favor using homozygous material as much as possible as greater hybrid vigor is obtained.

Shall We Tame the Native Fruits or Rely Upon Importations?

Address Before the International Congress of Plant Sciences.
(Fourth International Botanical Congress.)
Cornell University, Ithaca, New York, August 16-23, 1926.

N. E. HANSEN

The history of the world's horticulture indicates that Nature's distribution of plants was not complete, also that the Ice Age destroyed or retarded the migration of plants through natural causes. Hence, the true answer to this question is that we must improve the native species whenever possible, and when there are no native species that meet the need, importations must be made. To rely wholly upon the development of native species would sadly reduce our present fruit lists. Our American pomology is based largely upon importations. It is, no doubt, true that our native species would have received much greater attention if importations had been impossible. Hundreds of millions of dollars have been lost in America by planting fruits from milder climates of the world. The accumulated evidence goes to show that a species of plant cannot be acclimated to any extent to a greater degree of cold. By selection we may shake the sieve thoroughly, but there is left in the sieve only what was there in the first place. This variation in hardiness points to a slow process of acclimation by nature. De Candolle writes in "The Origin of Cultivated Plants:" "The northern limits of wild species * * * have not changed within historic times although the seeds are carried frequently and continually to the north of each limit. Periods of more than four or five thousand years, or changements of form and duration, are needed apparently to produce

a modification in a plant which will allow it to support a greater degree of cold." We should take full advantage of this great work done for us by nature in acclimating plants, and cultivate our local form of the native species instead of the form adapted in the course of thousands of years to a mild, moist climate.

In our discussion of hardiness we should leave out annual plants. Annual plants such as corn have been carried many hundreds of miles north of their original limits. By selection for short season the corn plant has been reduced in stature from 20 feet to 3 feet and in a season from 7 months to 3 months. Furthermore, over winter it is not a plant but a seed. The real truth of this matter is that we should obtain hardiness from plants that are hardy in the first place. For South Dakota I have found the best results come from the native species of the prairie Northwest or from similar climates of Eurasia, especially Siberia, East Russia, Mongolia and North China. A study of isothermal lines running around the world and the study of maximum and minimum temperatures, and annual rainfall, all will help to form a judgement as to where hardiness against winter cold and summer heat may be expected in the plants from any region. Ecological consideration must also be considered. Dry climates favored xerophytic plants. Large size and high quality of fruit are usually obtained best from plants that have been under cultivation for a long time. In fruits it seems that Nature provides for bright color, edible quality and large size mainly as a means of attracting animals that will eat the fruit and thus distribute the seeds. Man must step in to increase these qualities up to the market standard. The larger and better the fruit, the greater the value for the market. While we may obtain perfect hardiness from the native fruits, the element of time and convenience must come in, so we have relied largely upon importations. In doing this we have sadly neglected a number of choice fruits. It appears we have improved the native fruits only when it became a necessity because imported fruits failed. The American grape and American raspberry are good examples. With the new light in heredity we now know that choice quality in fruits may be regarded as a gene which can be combined with winter hardiness, also a gene, in the same plant, although the two genes come from far distant lands. This international view of fruit-breeding is the best view. Present market conditions demand the very best. To bring to market an inferior product when a better and choicer product could be grown just as well is to invite financial failure for the fruit grower. Another point to be noted is that of late years the demand for long distant transportation has brought out varieties with hard flesh and capacity for distant shipping, at the expense often of tenderness and high quality. But to carry this to excess only invites failure. If the purchaser finds that a certain fruit deteriorates in quality, he does not know just what has happened but he gives sufficient answer by turning his attention to other fruits. If we make apples taste more like potatoes the purchaser may buy other fruits the next time.

Breeding Better Apples.

De Candolle considers the apple* to have existed in Europe, both wild and cultivated, from prehistoric times. The lack of communica-

*Origin of Cultivated Plants, De Candolle, p. 236.

tion with Asia before the Aryan invasion makes it probable that the tree was indigenous in Europe as in Anatolia, the south of the Caucasus, and Northern Russia, and that its cultivation began early everywhere.

According to A. C. Koch § it is the descendant of six different species, native of the temperate parts of Europe and Asia. This process of amalgamation has taken place during the past 4,000 years. Koch found the pollen of all cultivated apples non-uniform, due to this mixed ancestry, while that of primitive species was uniform. Fixity of type, as indicated by uniformity of pollen, shows a homozygous condition.

To cross cultivated apples with each other is breeding mongrels to mongrels, because the cultivated apple is in heterozygous condition. It must be admitted that Nature with the aid of insects has been doing this work with success for thousands of years. Most of the standard varieties now in cultivation are the result of this haphazard work. Meanwhile, it is very evident that we have neglected the indigenous apples, although they have many good points. Much work has been done in amalgamating the Siberian crabapple with the cultivated apple. I have been working especially with hybrids of the indigenous American apples, for many years and have obtained some interesting results. I am preparing a bulletin covering this work. It is time that our indigenous apples and the apples of Siberia received more attention than they have in the past.

Breeding Pears Immune to Blight.

Since the pear is not native to North America, all of our pears are imported. The cultivated pear, **Pyrus communis**, is indigenous to temperate Europe and western Asia. The pear is not native of North America. The limiting factor to successful pear culture in the Northwest is fire blight (**Bacillus amylovorus**), and winter-killing. Fire blight is native of the northwestern United States, and Pyrus communis has not had occasion in its early history to build up any resistance to fire blight. For this we must look to the pears of northern Asia, especially Pyrus Sinensis and allied species, such as Pyrus calleryana from southern China and Pyrus Ussuriensis from northern China and eastern Siberia.

In 1924, on my sixth tour to foreign lands in search of new seeds and plants, I went from Seattle to Japan and through Japan to Korea, southern Manchuria via Mukden, and north to Harbin on the Siberian railway where I made my headquarters. From Harbin I went east and west on the Chinese Eastern railway which forms a part of the Siberian line for nearly a thousand miles. I found the western limit of the pear a few miles east of Harbin. I went from village to village in the mountains and got the Chinese to bring in the pears as they ripened. The main work was in the region about 50 miles east of Harbin. The Chinese cut down other timber in the mountains but leave the pear trees as they furnish an annual supply of food. From many thousand pounds of pears I picked the best for special selection work. Sixty-eight pounds of seed was obtained from the fresh fruit.

§ Pflanzen-Mischlinge. Wilhelm Olbers Focke, Berlin, 1881, p. 144.

I hope that these pears will be carried through several generations as was done by Van Mons in Belgium, but utilizing the latest improvement in theory and technique.

I have several hybrids coming on between these hardy Oriental pears and pears of choice quality of Europe. I think it is quite possible to obtain varieties with the choice quality of the best pears of western Europe, and the hardiness and blight-resistance of tree of north Manchuria and east Siberian wild pears.

Improvement of the Plums.

"The Battle of the Plums," * mentioned by Dr. Bailey in 1895, is still being waged. The European plum proves of no value for the prairie Northwest owing to lack of hardiness. Progress has been made with seedlings of the native plum (**Prunus Americana**), and also the native plum of Manitoba, **Prunus nigra**. Fully ten thousand seedlings of Prunus Americana have been grown at this Station in the endeavor to improve the fruit in size and quality. But I found it very difficult to get any one to plant these native plums after my new hybrids with Japanese plums came on. My Waneta bears fruit two inches in diameter, weighs two ounces and is of choice quality. The trees in the nursery are extremely vigorous, showing the hybrid vigor. This saves a year's time in nursery propagation. So far no successful hybrids have been made of native plums and European plums.

Improvement of the Cherry.

The sweet cherries of Europe so extensively raised in our eastern states and on the Pacific Coast are not hardy in the prairie Northwest. The sour cherries of Europe are much hardier but not sufficiently hardy to recommend for general planting in South Dakota. The Early Richmond and allied varieties are grown to a small extent in the extreme southern part of the state.

At this writing the chief limiting factor in hardy cherries at the North are the tender Mahaleb and Mazzard stocks used in commercial propagation. Chief among the objections to the northern Pincherry (**Prunus Pennsylvanica**) as a commercial cherry stock are the numerous root-sprouts. This suckering habit makes it difficult to control. The Moscow probably will not be hardy as far north as the Sand Cherry hybrids. But even if none of the true cherries prove sufficiently hardy at the North, some very good quality substitutes can be found among the numerous Sand Cherry hybrids already originated.

Sand Cherries.

The native Sand Cherry (**Prunus Besseyi**) of western South Dakota, is a low bush, bearing black fruit. It is one of the most important native fruits. Many thousand seedlings were fruited by the writer through several plant generations with the result that the best seedlings bear fruit one inch in diameter and of good quality. The stature of the plant, however, has not been materially changed. But I have produced many successful hybrids of Sand Cherries with Japanese plums. Two of the best are Opata and Sapa which are extensively propagated and are very popular over a wide area, from Oklahoma north into Canada. They bear well on one year shoots in the nursery. When transplanted they bear abundantly the year after planting.

*The Survival of the Unlike, C. H. Bailey, page 418, 1895.

It appears to me that the future cherries of the prairie Northwest will not be cherries at all, although they will look and taste like cherries. They will be derived from some amalgamation of the Sand Cherries of South Dakota and the best plums of Japan.

Choke Cherries.

Prunus Virginiana and the allied species are extremely productive. I have been working with them for many years in endeavoring to improve the fruit in size and quality. It is very difficult to get the "choke" out of the fruit. However, some success has been attained in locating trees growing wild that have very little of this acerbity. This work is greatly accelerated by my discovery that the choke cherry makes a strong nursery tree budded on the May Day tree of Eastern Siberia, **Prunus padus commutata.**

Some yellow-fruited choke cherries have also been located. Prairie settlers find good use for the fruit in its present form, for jellies, especially when mixed with apple juice.

It appears then that while the tame cherries of Europe will not acclimate to our western prairies, yet we can develop very acceptable substitutes for them from the native species.

Developing Hardy Grapes.

The grape of history, **Vitis vinifera**, according to De Candolle, grows wild in the temperate regions of western Asia, southern Europe and northern Africa, and has been under cultivation for many thousand years. In Egypt, the records of grape cultivation go back some six thousand years. In 1897 and 1909 while traveling through Transcaucasia, I learned that this species is abundant in a wild state and is considered truly indigenous.

It cost America many thousand dollars to learn that this species was not a good foundation for grape culture in the eastern part of the United States. It was not until amalgamation took place with native species of eastern America that success became possible. The grape culture of California is founded upon Vitis vinifera.

The Concord grape first fruited in 1849, and was grown from seed of the wild Fox grape, Vitis Labrusca, by E. W. Bull of Concord, Massachusetts, near the famous bridge still standing from the American Revolution.

The vine is marked by a permanent tablet. It seems eminently fitting that this Mother vine is so honored when we reflect that 75 per cent of all the grapes raised in eastern America come from this famous Concord vine and its pure breds and cross-breds. But the Concord grape and its offspring, great as they are, will not help South Dakota and the prairie Northwest since even with careful winter protection they are not sufficiently hardy.

For many years past I have worked on this problem and have grown a lot of seedlings of the wild grape of the Dakotas, but this was very slow work as this wild grape is not equal to the wild Fox grape of Massachusette in size in its original condition. So I began crossing the wild grape of the Dakotas with some of the choice tame grapes. This was done in the fruit-breeding greenhouse of South Dakota State College. The work was a success. In 1895 I introduced 32 of these hybrids. All are hardy at Brookings without winter protection of any kind.

In recent years, I have endeavored to trace this native grape, Vitis riparia or Vitis vulpina, to its northern and northwestern limit in Manitoba. These are now receiving attention. Hybridization is evidently the quickest way.

I have produced several thousand seedlings of wild grapes, but find them to be very fixed as to size of fruit. This line of effort should not be neglected, although it may take several generations to complete the task. By that time we will know whether hybridization of foreign species or development of the pure wild grapes by seedling selection, is the better way.

Breeding of Hardy Raspberries.

The red raspberry of Europe did not prove sufficiently hardy for general cultivation in our eastern states and still less so in the northwest prairie sections. The cultivated raspberries from the east are mainly of native origin, but show the influence of the west European type. However, these raspberries are not hardy for the prairie northwest. Many years ago I began the work of growing thousands of seedlings of the red raspberry of South Dakota, North Dakota, Minnesota, Manitoba and Saskatchewan. The work is still going on. By hybridizing with the standard cultivated varieties of raspberry a number of promising seedlings have appeared. The Sunbeam was the best in the first seven thousand seedlings, and the Ohta the best in the next six thousand. Both have become prominent over a large area. The object of this work is to develop red raspberries that will be hardy without winter protection. In 1923 six varieties more were offered with the same idea in mind. Therefore, they are not intended to compete with the larger fruited varieties that need to be protected by laying down the canes and covering with earth over winter. It may be that our future ideal hardy red raspberry will be derived exclusively from the pure native wild raspberry of the Northwest, but my experience with many thousands of seedlings indicates that this will be a slow process. Meanwhile, these hybrid varieties will be useful.

To obtain a hardy blackberry or dewberry, appears to be a much more difficult problem and the work is just in the beginning stage. The trouble is to find a hardy species to serve as a starting point.

Breeding Large, Hardy Gooseberries.

The largest gooseberries in the world are those grown in western Europe. A few years ago I succeeded in crossing these giant gooseberries with the wild Sioux Valley gooseberry (Ribes gracile), from Lake Oakwood and Gary, South Dakota. This work was done in the fruit-breeding greenhouse at South Dakota State College. The European gooseberries did not live long even with special care, but long enough to make the cross. In the spring of 1924 the Sunset Gooseberry was offered for the first time as the result of this work. In 1925 ten more varieties of these hybrid seedlings were distributed. These eleven varieties indicate that large size of fruit, hardiness and productiveness of plant can be secured much more quickly by hybridization than by selection only. The pure native gooseberry has been carried through eight generations. I find that we can obtain large size of fruit, but they all have the fault of ripening through a long season while in the hybrids the fruit ripens more at the same time which is necessary from a commercial standpoint.

Developing the Wild Black Currant.

The wild black currant (**Ribes floridum**) is abundant throughout the state. I have grown many thousand seedlings of this species through several plant generations, as found at Lake Oakwood and Gary, South Dakota, beginning in the fall of 1895. But in 1923 there was a decided break and a number of plants appeared with fruit of remarkable size and so productive that they appear worthy of propagation and introduction, although the ideal berry in quality has not yet arrived. The wild black currant is a good ornamental shrub with large yellowish white flowers in drooping racemes and smooth black fruit. One advantage of the wild black currant as a low shrub is that they endure more partial shade than many other shrubs. In European gardens this American species is considered worthy of a place in the ornamental shrub collection and it should receive equal consideration here at home. The foliage turns to a handsome brown red color in the fall.

The common black currant, (**Ribes nigrum**), of northern Europe and Asia has not generally proven productive on the prairie uplands of the west. Perhaps better results can be obtained from these indigenous black currants, but the white pine blister rust may stop all future work with either species, at least in sections where the five-leaved pines are grown.

In Conclusion.

The foregoing will cover the main lines of my work in improving and importing fruits since 1895 at the South Dakota Experiment Station, and as an Agricultural Explorer for the United States Department of Agriculture. I am working with many other plants such as alfalfa and roses but this will suffice to give the main idea:

1. That we should improve the native species whenever possible.
2. That we should import other species if improvement is to be expected from them.

The Relative Value of Homozygous and Heterozygous Parents In the Breeding of the Apple, Plum, Cherry, Grape, and Other Fruits.

Address for the Fifth International Congress of Genetics, Berlin, Germany, August 11-18, 1927.

N. E. HANSEN

During the past thirty-five years in the endeavor to originate new fruits of value for cultivation in the northwest prairie section of the United States, it has been my plan to find some key or principle that would be useful for future work. This period comprises the years 1891—1895 at Iowa State College, Ames, and the period 1895-1927 at South Dakota State College, Brookings. To blaze a path through the jungle of plant heredity would make it easier to plan future experiments. In this work special attention has been given to native species in the endeavour to improve them as far as possible. Imported species have been used as needed. In the course of six tours as Agricultural Explorer to northern Eurasia, must material has been collected and used in these experiments. It was my good fortune to

hear Bateson give the first lectures in America on Mendel's Law at the First Congress of Genetics in New York City in 1902; in 1904 to hear De Vries' address on mutation at the World's Fair at St. Louis; in 1906 to hear the later developments at the International Congress of Genetics in London, which I attended as a delegate from the United States Department of Agriculture; and in 1926 to hear the progress in genetic research at the International Conference on Fruit and Flower Sterility in New York City, and the International Congress of Plant Sciences at Cornell University. The present congress shows the world-wide interest in this important subject. My own work with hundreds of thousands of fruit seedlings at Brookings indicates that uniting homozygous species is better than uniting heterozygous species. Due to the many years necessary for definite results with long-lived trees such as the orchard fruits, this must be considered as a provisional hypothesis. Much more work must be done for the full demonstration and proof.

Experiments with Apples.

The cultivated apple, **Pyrus Malus,** is highly heterozygous. According to A. C. Koch § it is the descendant of six different species, native of the temperate parts of Europe and Asia. This process of amalgamation has taken place during the past four thousand years. Koch found the pollen of all cultivated apples non-uniform, due to this mixed ancestry, while that of primitive species was uniform. Fixity of type, as indicated by uniformity of pollen, shows a homozygous condition. The species **Pyrus Malus** is highly variable as is seen by the many thousands of named varieties grown in Europe and America. Hundreds of thousands of other seedlings remain unnamed. In recent years a large number of named varieties of the apple have been crossed and some good varieties have been obtained, but it must be admitted that it has been impossible so far to formulate definite rules from this work. Some excellent seedlings have been obtained from poor parents, and poor seedlings from good parents.. In other words, to cross cultivated apples with each other is simply the breeding of mongrels to mongrels and hence is purely a game of chance. It must be admitted that Nature has been doing this with the aid of insects in cross-pollination, for thousands of years, and that most of the best varieties now in cultivation are the result of this haphazard work. We now know from much experimental work in many states in crossing good cultivated apples with each other, that **Pyrus Malus** is highly heterozygous in genetic composition. It is highly desirable to reduce **Pyrus Malus** varieties to a homozygous condition. It would enable us to make new combinations and obtain greater heterosis or first generation hybrid vigor. The past few years, following Shull of Princeton, the breeders of corn **(Zea Mays)** have achieved definite and valuable results by reducing corn to a homozygous condition by selfing or inbreeding for several generations, then following this up by F1 hybrids of homozygous parents. Ever since this distinguished success in applying Mendelian principles, it has been the goal of apple breeders to reduce Pyrus Malus from the present heterozygous to a homozygous condition, so as to secure the superior heterosis that may be expected

§Pflanzen-Mischlinge, Wilhelm Olbers Focke, Berlin, 1881, p. 144.

from uniting homozygous parents. But apple-breeders are experiencing great difficulty in selfing apples. Many varieties are completely self-sterile. Sib crosses are now being made as the next best thing to do. But if six species are involved in the ancestry of **Pyrus Malus**, it will take a long time to reduce this species to a homozygous condition. If it should require ten generations of the apple to do this, before the desired heterosis with homozygous parents can be obtained, the work will in most cases remain undone, as it exceeds the working years of most experimenters. However, the work should be continued as the fixed policy for a long-time experiment by experiment stations that are interested in the improvement of the apple. We do know that the union of heterozygous parents has brought with it many undesirable qualities, such as sterility, susceptibility to fungus and insect troubles, and weakness of growth or constitution. Heterosis with homozygous parents is the goal apple-breeders must reach as soon as possible. If homozygosity could be attained with **Pyrus Malus**, we might find that was good enough. In that case the apple could be propagated cheaper as the species would come true to seed. This would obviate the present nursery troubles in using inferior frost-tender stocks.

Homozygosity is the ideal of the apple-breeder. For many years I have been working along this line with various primitive species which are much more nearly in a homozygous condition. One of my favorites is the wild American crabapple. I am combining it with other species. It gives us drouth-resistance, hardiness of the blossom, earlier bearing, long keeping, and the fruit keeps one year.

A good apple-like fruit made up of quite different species than those that entered into the make-up of the cultivated apple, is quite possible.

Indigenous American Apples.

The indigenous apples of America form an interesting group of species that have been neglected because the cultivated apples, **Pyrus Malus**, with better and larger fruit, came from Europe more than three centuries ago. However, a few trees with large fruits have been found among wild American apples. During many years the writer has made a study of these large-fruited sports found in the woods of our western states, especially Iowa, Illinois, Missouri, Wisconsin and Minnesota. An extensive series of hybridizing experiments have been carried on using this native material as a foundation. A large number of these F1 hybrids have been produced.

In the endeavour to originate an apple that will keep all winter in a common cellar, I have for some time been building up a series of complex or derivative hybrids of the apple, combining several varieties and species, especially the cultivated apple, Siberian crabs, and our native wild crabs (**Pyrus Malus, baccata, prunifolia, Soulardi, and Ioensis**). In the present state of development many of these seedlings have value as ornamentals only, or as a foundation for something better. In other words, it will take a series of crosses before the desired apples of commercial value are obtained. A hardy, productive apple, with fruit of good size and quality that will keep until late spring, is the desired goal.

The indigenous American crabapple of western states, **Pyrus Ioensis**, is a strongly marked homozygous species. There is only one species

over the greater part of its range and there is little variation, except rarely in size of fruit. Some of the desirable characters of **Pyrus Ioensis** are:

1. Early bearing.
2. Annual bearing.
3. Early ripening of wood.
4. Late keeping capacity of fruit.
5. Resistance to fire blight.
6. Winter hardiness.
7. Late blooming, thus escaping many frosts.
8. Dwarfish nature, much smaller than that of **Pyrus Malus**, the common apple.
9. Beautiful fragrant pink blossoms.

Some of the undesirable characters of **Pyrus Ioensis** are:

10. Acidity and acerbity of fruit.
11. Oiliness of the fruit. This oil is fragrant and perhaps could be utilized in moderation.
12. Small size of fruit.
13. Thorniness of tree; the numerous thorns are objectionable.

Some larger-fruited trees have been found from time to time, some of which have been named and propagated. These are considered as hybrids of **Pyrus Malus** and **Pyrus Ioensis** and are classified as **Pyrus Soulardi.** However, the exact genetic composition of **Pyrus Soulardi** must be left to future cytological investigation. It may prove that they are only large-fruited forms of **Pyrus Ioensis** or perhaps allied species. Some of these named varieties of this indigenous wild apple are: Mercer, Missouri, Hamilton, Andrew, Entz, Forest King, Giant, Eden, Wild Red, Oskaloosa. Many more have been collected and are held at present under number. The danger at present is that some even better varieties will be lost in the clearing up of the native timber. The search for large-fruited forms of the indigenous crabapple should be continued. My experiments so far indicate that there are great possibilities in developing valuable apples from this indigenous species.

Experiments with the Apple.

While waiting for the coming of homozygous seedlings, **Pyrus Malus**, it has been my endeavor for many years to work with homozygous species of **Pyrus** using fixed primitive species, also by combining primitive species with various varieties of **Pyrus Malus.** In the following list, the usual rule is followed of naming the pistillate parent first. The resulting seedlings may be classified as follows:

1. Heterozygous x Heterozygous	**Malus x Malus.**
2. Homozygous x Heterozygous	**Ioensis x Malus.**
	Baccata x Malus.
3. Heterozygous x Homozygous	**Malus x Ioensis.**
	Malus x Baccata.
4. Homozygous x Homozygous	**Baccata x Ioensis.**
	Ioensis x Baccata.

Heterozygous x Heterozygous Apples.

The result of the work with 10,000 apple seedlings is outlined in my Plant Introductions, 1895—1927 (South Dakota Bulletin No. 224, May 1927). Many varieties of standard cultivated apples were crossed with each other. Seedlings were grown from prize specimens of apples exhibited at State Fairs, at meetings of Horticultural Societies, and gathered from many orchards. There was no law or principle that could be deduced from the work so nearly all were discarded. The following seedlings were named: Adno, Caramel, Chance, Elta, Goldo, Oxbo, Sasha, Sereda. I decided this was too much of a game of chance and that the thousands of seedlings already in existence in Europe and America would suffice to show what could be done in this line. In addition to my own experience I can note that thousands of seedling apples have been examined at various Horticultural exhibitions and in the orchards of fruit growers and private orchards in many states. The ideal apple is still to be found.

The evidence from many hand-made crosses accumulates that some varieties of apples can transmit their good quality much better than other varieties, but it is slow and uncertain work.

Homozygous x Heterozygous Apples.

Kola is a hybrid of the wild native crabapple, **Pyrus Ioensis x Malus**, from Elk River, Minnesota, with pollen of Duchess of Oldenburg apple. The fruit is flat, green, 2½ inches in diameter, weight 3 ounces. The skin is oily as in the wild crab. The fruit cooks up into acceptable sauce of fair quality. The trees appear immune to fire blight and winter-killing, and are heavy early annual bearers. The Zapta, Tipi, Shoko, are also varieties of similar pedigree, all noted for their early bearing. Kola is the Sioux Indian word for "friend".

Tipi Wild Crabapple. Also a hybrid of the wild crab of Elk River, Minnesota, with pollen of the Duchess of Oldenburg apple and much the same in tree and fruit as Kola. Tipi is the Teton Indian for "tent".

Shoko Wild Crabapple. A hybrid of the wild crab of Elk River, Minnesota, with pollen of Alexander apple, one of the largest Russian apples. Fruit nearly two inches in diameter, green, acid, but cooking into an acceptable sauce. The size of the fruit will probably increase, as the original tree is much crowded in nursery rows. Shoko is the Sioux Indian for "seven".

Zapta Wild Crabapple. A hybrid of the wild native crab apple from Elk River, Minnesota, with pollen of the Bismarck apple, a large variety from New Zealand resembling the Alexander. Fruit two and one-eighth inches in diameter, green acid and acerb, but cooks up well into sauce. Zapta is the Sioux word for "five".

Red Tip Crabapple. Female parent, a wild crab from Elk River, Minnesota. Male parent, **Pyrus Malus Niedzwetzkyana**, a small red-fleshed apple from Turkestan in the high mountains between Turkestan and China. The pedigree does not indicate any promise as a table fruit but the red-tipped young leaves make it an interesting tree from the ornamental standpoint. The fruit is small.

F2 Hybrids of Pyrus Ioensis.

In the foregoing list, the wild crab is dominant in the extra early and heavy annual bearing. Many more hybrids along this line have been produced but not named. The lesson from this work with the native wild crab is that the wild crab is homozygous and introduces early bearing and strong resistance to fire blight (**Bacillus amylovorus**). The trees have the strength to produce fruit buds and a heavy crop of fruit every year. Other desirable characteristics are late blooming and early ripening of the wood, and long winter keeping of the fruit. It now remains to make many back crosses with the apple to introduce better quality in these hybrids. One of the outstanding varieties of this series that has appeared so far is the Izo Crabapple.

Breeding International Apples.

The term "International" might be applied to some of my hybrid apples now beginning to bear fruit, because they combine the apples of three continents: **Pyrus Ioensis** of North America, **Pyrus Malus** of Europe, and **Pyrus baccata** of Asia. It remains to be seen whether these will suffer from a too complex chromosome structure. The trees bear abundant fruit. Only two of this series of apples are mentioned at this time, the Izo and No. 7132.

Izo Crabapple. Male parent, Yellow Transparent apple; female parent, Fluke No. 10, which is a seedling of Mercer Wild Crab with some standard apple. This makes this pedigree one-half Russian apple, one-fourth West European apple, and one-fourth wild crab from Mercer County, Illinois. Izo is the Sioux Indian word for "peninsula". Fruit regular, oblate, yellow with bronze cheek, russet dots and firm subacid flesh. The compact entire carpels of the core show influence of the wild crab. The flesh is a clear acid. The Izo appears promising as a crab that will keep all winter and makes good pleasant flavored sauce. Diameters of fruit 1⅞ x 2½ inches.

No. 7132. Pedigree: Fluke No. 26 apple x **Pyrus baccata** pollen. This makes the pedigree about one-fourth West European apple, one-fourth wild crab from Mercer County, Illinois, and one-half Siberian crab. This is just beginning to bear; fruit, 2⅛" x 2½" in diameter; clear light yellow; flesh white, finegrained; sweet, of excellent quality. Season not determined, probably October. The fruit will probably be larger on grafted trees. The sweet flavor in this apple must come from the West European apple.

S. 5129—E. 694.

Pedigree: Native wild crab from Nevis, northern Minnesota, x Wolf River apple pollen. Nevis, Minnesota, is probably the extreme northwestern limit of this native crab, **Pyrus Ioensis.** The first fruits are appearing this season so the winter keeping capacity is not determined but they apparently follow the native wild crab in this respect. Fruit 2⅛ inches in diameter; round, truncated, somewhat cylindrical; partially covered with mixed and striped bright red. Tube cylindrical; stamens marginal; flesh white, acid, but a great improvement over **Pyrus Ioensis.**

S. 5109—E. 700.

Pedigree: Nevis, Minnesota, wild crab x Northern Spy apple pollen. Fruit 1⅝" x 1⅞" in diameter. This is the first year of fruiting, hence, the winter keeping capacity has not yet been tested, but the fruit looks

like a late winter keeper. Surface yellowish green with much mixed and striped bright red. Tube cylindrical; stamens marginal; flesh white, acid.

S. 5145—E. 699.

Pedigree: Nevis, Minnesota, wild crab x Northwestern Greening apple pollen. Fruit green, cylindrical, 1⅞" x 2" in diameter. This is the first year of fruiting. The fruit looks like a late winter apple; flesh white; juicy, sharp acid; tube cylindrical; stamens marginal.

S. 4961—E. 696.

Pedigree: Giant wild crab from Sherrard, Illinois x pollen of one of our hybrids, Elk River, Minnesota wild crab x Alexander apple pollen. This makes the pedigree about three-fourths wild crab and one-fourth cultivated apple. Fruit oblate; yellow with blush; tube cylindrical; stamens marginal; flesh juicy, subacid, sweet. This is the first year of fruiting so the winter-keeping capacity has not been determined. It is probably midwinter. The sweet flavor must date back to some ancestor of the Alexander apple. The Alexander apple is the old Emperor Alexander, one of the largest of apples. It belongs to the Aport group of Russian apples.

The Anoka Apple.

The Anoka apple is a seedling of Mercer County (Fluke) wild crab topgrafter on Duchess of Oldenburg. The Mercer County is classified as **Pyrus Soulardi**, a natural hybrid of **Pyrus Ioensis** and **Pyrus Malus**. This would make the Anoka about three-fourths **Malus** and one-fourth **Ioensis**. Here a decided change is made as this variety bears on one year old wood and begins to bear the second year after planting a one year old tree. The new character that has been introduced is the habit of extremely early bearing. This variety is becoming very popular. The quality is better than that of Oldenburg. It is the most outstanding variety in over ten thousand seedlings. Its wonderful habit of early bearing is evidently derived from the **Ioensis**, while the quality is that of a good **Malus**.

5560 No. 1. Pedigree: Mercer x Tallman Sweet. Fruit, 2⅛ inches in diameter; round, truncated; slightly angular; skin thin, yellow, thickly covered with thin striped red with whitish scarfskin. Dots distinct russet. Cavity wide, obtuse, with trace of russet. Stem medium; basin shallow, slightly wrinkled; flesh white, subacid with sweet fragrance; spicy with faint trace of wild crab. Cooks up very easily into excellent sauce. Season, winter. The remarkable point about this variety is the rich fragrance of the fruit which is evidently derived from the wild crab as a dominant character. This seedling of the Mercer, together with other seedlings of similar pedigree, indicate that the strong homozygous character of the native crab, **Pyrus Ioensis**, is effective even when it consists of only 25% of the ancestry.

Heterozygous x Homozygous Apples.

Chinook apple The first of a series of hybrids of **Pyrus Malus** with the wild American crab, **Pyrus Ioensis**, in which the wild crab is the pollen parent. In this case the seed parent is the Baldwin apple and the pollen parent is the wild crab of Elk River, about forty miles north of Minneapolis, Minnesota. The first fruits of the Chinook apple are only two inches in diameter but this will probably increase somewhat

on older trees. Fruits oblate, of a fine dark red, subacid, season probably all winter. Later fruits of the Chinook apple are 2" x 2½" in diameter.

Bismer apple. Pedigree: Bismarck apple crossed with Mercer wild crab. The name is made up from these two names. It is the second of a series of hybrids of the standard apples with the wild crab in which the wild crab is the pollen parent. Roundish oblate, two and one-quarter inches in diameter; yellow striped and mixed with brown-red; flesh, yellow, pleasant; good subacid; sweet. An early bearer; season, probably winter. Fruits of the 1927 crop are larger up to 2⅛ x 2⅞ inches.

Homozygous x Homozygous Apples.

Since the indigenous apple of east Siberia, Pyrus baccata, and the Pyrus Ioensis of North America are both deficient in size and quality of fruit, it would not seem promising to combine these two species. They are both strongly homozygous except in size of fruit. Both species are very productive. I have now many hybrids coming on of these two species. The trees are very productive. The fruit is such as would be expected from such a combination. Some of them show winter hardiness and long keeping of **Pyrus Ioensis** with the bright color and crisp flesh of **Pyrus baccata.** Some of them are worth considering as a crab-apple that will keep all winter and far into the spring. The next work is to cross these hybrids back to the parent species and to self them for a better combination of the unit characters of the parent species. Some of them show the tendency to fire blight of **Pyrus baccata,** although they are all winter hardy. The main thing is to retain the winter-keeping capacity and blight-resistance of **Pyrus Ioensis** with the bright color and crisp juicy flesh of **Pyrus baccata.** Judging from the climate of their native habitat, **Pyrus baccata** will contribute greater hardiness than **Pyrus Ioensis.**

Pyrus baccata Hybrids.

Pyrus baccata is a strongly homozygous species. It is a native of Asia from the Himalaya Mountains north into Manchuria, North China and to the Amur River region northeast of Lake Baikal in eastern Siberia. **Pyrus baccata** hybridizes freely with the standard apple. Thousands of **Pyrus baccata** seedlings have originated under cultivation in America. Some good ones like the Dolo crab have come to us from Russia. Other parts of Europe have developed **Pyrus baccata** hybrids. Of most of these the pollen parent in unknown. Some are too small for an apple and too large for a crab so it is difficult to place them on the market. Some of these hybrids are noted for few seeds and uncertain habit of bearing. It would be better if more hybrids could be produced. **Pyrus baccata** is noted for very heavy bearing. No real winter varieties have appeared.

Of the many Siberian crab seedlings produced at this Station, the following have been named: Amur, Beauty, Ivan, Maga, Olga, Nocalyx. One line of work that has been neglected too long is the production of Siberian crab hybrids with **Pyrus baccata** as a pollen parent and **Pyrus Malus** as a seed parent. Two of this type produced here are the Maga and Sapinia, indicating that larger size of fruit may be obtained in this manner. In America the best types of Siberian crab have been found hardy far north into Canada. The most northern type of this species

in cultivation is the one from the Nertchinsk region near the headwaters of the Amur River northeast of Lake Baikal. From this as a foundation stock probably will come the future apples for the most northern regions of Canada. The evidence accumulated shows that hybridization with **Pyrus Malus** introduces insufficient hardiness for the far North.

It may be best to develop **Pyrus baccata** without hybridization by pure selection for size of fruit and resistance to fire blight.

Apples—¾ Malus, ¼ baccata.

Linda Sweet crabapple. A seedling of Malinda apple top-worked on Sweet Russet Crab apple. A large crab apple with skin much russeted. Flesh mild subacid sweet. Apparently a late winter crab. The influence of the Sweet Russet pollen is evident from the sweet flesh and russet skin. Linda is derived from the word Malinda.

Maga Crabapple. A seedling of McIntosh Red apple topgrafted on Virginia crab. Fruit large for a crab, flattened, with bright red stripes. The McIntosh evidently contributed its high flavor as the flesh is of the same type. Season evidently late. This tree looks like a good cross of the McIntosh apple and the Virginia crab, and if it proves hardy under propagation will be something decidedly worth while. The original tree bore a heavy crop in 1919.

Sapinia Crabapple. This is a seedling of Winesap topgrafted on Virginia crab. The name is made up from these two names. One of the forerunners of a new race of hybrid apples, in which the cultivated apple instead of the Siberian crab is the female parent. Fruit thinly washed with dull red, almost two inches in diameter. Evidently a long winter keeper.

Apples—½ Malus, ½ baccata cerasifera.

Olga Crabapple. Pedigree. Female parent, Duchess of Oldenburg apple. Male parent, **Pyrus baccata cerasifera**, which is much like the old Cherry crab. This combines the Russian apple with the Siberian crab. Fruit is regular, oblate, fully one and one-half inches in diameter on the seedling tree. Color, solid bright cherry red all over with blue bloom; dots distinct, white, many large; basin quite shallow, smooth; cavity wide, obtuse with considerable russet. Calyx mostly deciduous. Flesh is yellowish white, crisp, juicy, acid, of good quality. Red core outline in flesh. Very good to eat raw as it mellows. The fruit cooks up very quickly, as easily as Duchess apple itself, and the sauce is of an attractive deep salmon red. Under propagation, the trees may increase slightly in size of fruit. The tree is a vigorous, stocky grower with strong forks and is extremely productive.

Improvement of the Pear.

The cultivated pear of Europe **Pyrus communis** is very subject to fire blight, **Bacillus amylovorus. Pyrus Ussuriensis** from east Siberia and north Manchuria is strongly resistant to fire blight. **Pyrus ovoidea**, originally obtained under the name of **Pyrus Simonii**, a form of **Pyrus sinensis**, shows strong resistance, although not entirely immune. When attacked, strong recovery may be expected. These varieties are described in Bulletin No. 224 of the South Dakota Experiment Station. One of the best of the many hybrids produced is the Ming pear which is **Pyrus ovoidea** x Louise Bonne de Jersey pear. The hardiness and blight-resistance are evidently from the Chinese pear, and the high flavor

of the flesh from the French pear. The evidence so far is that **Pyrus Ussuriensis** and **Pyrus ovoidea** are strongly homozygous species that amalgamate well with **Pyrus communis**. In order to secure hardiness, care must be taken in the selection of the source of the seed. Seed of this species secured from south Manchuria did not prove hardy at this Station, while those from east Siberia proved hardy. It should be remembered that **Pyrus Ussuriensis** is the pear of northern Korea and Manchuria and also the Pacific Coast of Siberia, approximately from Vladivostock to the Amur River. This led to my 1924 tour to north Manchuria where I gathered 66 pounds of seed from fresh fruit picked in the mountains east of Harbin. The western limit was determined to be approximately fifty miles east of Harbin where the temperature falls to about 47 degrees below zero F.

Homozygous Hybrids in Prunus.

My main work in this genus has been with **Prunus americana**, the native plum of the prairie Northwest, and **Prunus besseyi**, the native sandcherry, a dwarf shrub native of South Dakota and other western states which is allied to **Prunus pumila**.

Prunus besseyi. Since 1895 I have fruited some 200,000 seedlings, taking the plant through eight plant generations. But little or no change has been made in the stature of the plant. The fruit has been increased greatly in size, the largest being nearly or quite one inch in diameter and of good quality. This species is evidently strongly homozygous as there is no appreciable change except in the size and quality of the fruit. There are no closely allied species within its range. I have made many hybrids of **Prunus besseyi** with the Japanese plum, **Prunus triflora**. This produced an entirely new type of fruit, bearing freely on one year whips in the nursery. One year trees transplanted bear freely the next year. These hybrids are now very popular from Oklahoma north into Canada. The Opata, with green flesh and Sapa with black-purple flesh, are two of the best. The Japanese plum dominates in flavor, while the sandcherry dominates in its habits of bearing on one-year wood, and its earliness of bearing, also in hardiness.

Prunus americana. Many thousand seedlings have been grown and selection carried through several generations. The species is evidently homozygous in all characters except size and quality of fruit. The seedlings vary in hardiness with the original source of the seed. Wastesa, Yuteca and Teton are three of the best pure native seedlings of **Prunus americana**. This species hybridizes freely with the Japanese plum, **Prunus triflora**. The Waneta plum **Prunus triflora x americana**, bears fruit two inches through and of excellent quality; the tree is of strong growth in the nursery. The Waneta is very popular in many western states. Kahinta and Tawena, the two sister varieties of Waneta, are also very productive and of large size. Many other hybrids have been produced in recent years, showing these two species amalgamate successfully. All these numerous hybrids of the native and Japanese plum indicate that heterosis of these two homozygous species is very successful. The nurserymen save a year's growth in the nursery owing to the rapid growth of the trees, many of the trees being strong enough to market at one year's growth. **Prunus am-**

ericana is dominant in hardiness of tree, and **Prunus triflora** dominant in size and quality of fruit.

In my hybrids of **Prunus americana** and **Prunus Simoni**, the apricot plum of China, the choice quality and high fragrance of the fruit of **Prunus Simoni** is combined with the hardiness of tree of **Prunus americana**. The best of these are Hanska, Kaga and Toka, all **Prunus americana x Prunus Simoni.** The best reciprocal hybrid so far is **Tokata (Prunus Simoni x Prunus americana).**

Prunus nigra, the native plum of Manitoba unites well with **Prunus triflora**, this is shown in my hybrids, Cree, Ojibwa and Pembina. But much work remains to be done with **Prunus nigra.**

The results so far indicate strongly that the best results in the hybridization of Prunus is obtained from the union of strongly homozygous species.

Breeding Hardy Peaches.

So far the experiments in peach-breeding have not been successful. The idea has been to originate peaches that will be hardy in the prairie Northwest. Kamdesa, my hybrid of the peach with the western sandcherry of South Dakota, **Prunus Besseyi**, is sterile, also the hybrids of the peach with the Siberian Almond, **Prunus nana**... They produce an abundance of blossoms which are sterile.

Breeding Hardy Cherries.

The experiments so far have not been successful. My hybrids of the sandcherry with the sweet cherry of Europe made small weak plants but a few inches in height and perished at an early age. I have also tried to hybridize **Prunus Pennsylvanica**, the native pincherry, with the sweet cherry of Europe, **Prunus avium**, but none of the blossoms set fruit. However, I am developing a number of satisfactory substitutes for sweet cherries in the hybrids and derivative hybrids of the native sandcherry, **Prunus Besseyi**, with the Japanese plum, **Prunus triflora.** Two of these are the Oka and Tom Thumb Cherry.

Breeding Hardy Grapes.

The **Vitis vinifera** of Europe is the grape of history and has been cultivated from the earliest times. Its original home is the Caspian or Caucasus region and West India. This is not hardy in the prairie Northwest. In fact, in the United States, this grape is cultivated mainly in California. For many years, I have been working with the native grape of the Dakotas, **Vittis riparia** or **vulpina.** Thousands of seedlings of the pure grape were so strongly homozygous that there was little variation, and the work was too slow. So I began crossing the wild grape of the Dakotas with choice tame grapes. This work was successful and thirty-two varieties were named and introduced in 1924. The best of these are hybrids of the native grapes of North Dakota, South Dakota and Minnesota with the eastern hybrids of **Vitis Labrusca** and **Vitis vinifera.** This makes the pedigree one-half **riparia**, one-fourth **Labrusca** and one-fourth **vinifera.** The evidence so far strongly favors the theory that **Vitis riparia** is strongly dominant in hardiness. **Vitis vinifera** contributes to the size and quality of the fruit, this species having been selected for thousands of years for large size and choice quality of fruit. Too much **Vitis vinifera** in the pedigree carries with it a less degree of hardiness, although this remains to be confirmed by further experiments.

Work in Rubus.

The main work in Rubus has been with **Rubus strigosus**, the native red raspberry of this region. From over 13,000 seedlings produced, eight have been named, crosses of the native red raspberry with eastern varieties, some of which have a trace of European **Rubus idaeus**. Of these eight varieties, the Sunbeam is a hybrid of Shaffer Colossal, a purple-cane hybrid of **Rubus strigosus** and **occidentalis**, with a wild red raspberry (**Rubus strigosus**) from Cavalier County, North Dakota. Hence, the genetic combination of the Sunbeam is three-fourths **strigosus** and one-fourth **occidentalis**. The Moonbeam **Rubus strigosus** from Cavalier, North Dakota, is approximately seven-eights **strigosus** and one-eighth **occidentalis**. Of the other seven varieties the genetic make-up is mostly Rubus strigosus. All varieties of the European **Rubus ideaus** fail here from winterkilling. The endeavor has been to produce varieties resistant to mosaic, and with fruit of good size. Since winter hardiness is the limiting factor in this region, the best results so far as from the native form of **Rubus strigosus**; in other words, heterosis of select varieties of **Rubus strigosus** from the eastern United States, with **Rubus strigosus** from the Dakotas and Manitoba and Saskatchewan. The European **Rubus idaeus**, although not hardy under prairie conditions, may have contributed something of the size and quality. This work in **Rubus** was done before the recent cytological investigations proving the problems of polyploidy in **Rubus**. The future work must be done with these later principles in view. Seedlings of pure **Rubus strigosus** collected in various parts of the prairie Northwest are slow in producing seedlings of requsite market size. Further experiments must decide whether the prevalence of polyploidy in the genus **Rubus** may not make it better to depend chiefly on pure selection with the species **Rubus strigosus** rather than on hybridization with other species. However, the choice varieties found in the purple canes, Rubus **strigosus x occidentalis**, indicate a promising field.

Work with Gooseberries.

Many thousand seedlings of the pure native gooseberry of eastern South Dakota, **Ribes gracile**, have been produced through eight generations. There has been some improvement in the size of fruit but the characteristic of ripening in succession is still dominant. None of these equal in size the eleven varieties which I produced by crossing **Ribes gracile** with **Ribes Grossularia**, the parent of the giant gooseberry of western Europe. These eleven varieties have fruit ripening nearly at the same time and have the heterosis vigor of hardinss and productiveness produced by union of two strong homozygous species. These eleven varieties have been named Sunset, Kawanka. Kopa, Kaduza, Kazonta, Kana, Kataga, Kanega, Keza, Kapoza and Kabu. Perhaps the largest are the Sunset and Kazonta, seven-eighths x three-fourths inch in diameter.

The strong homozygous character of **Ribes gracile** is shown by the uniform character of many thousand seedlings carried through three generations. There is no appreciable advance except in size and quality of the fruit. **Ribes Grossularia** in all hybrids is dominant in a large measure in the size and quality of fruit, probably because it has been selected in Europe for so many centuries for these two essen-

tial characters. These hybrids may prove worthy of trial in Europe, since the native gooseberries are resistant to the American mildew which in recent years has spread to European gooseberries.

Breeding Hardy Strawberries.

In the hope of originating strawberries that would be hardy without winter protection, some ten thousand seedlings have been produced at this Station. Nearly all are hybrids of the native **Fragaria Virginiana** of North Dakota and Manitoba with eastern standard commercial varieties which are derived from **F. Virginiana** and **F. Chiloensis.** The best of these seedlings were one inch in diameter and of excellent quality. When these were crossed back to the standard varieties, the fruit was much larger, in fact fully up to market size, but the plants were not of sufficient hardiness. It is probable that further progress indicates we should go back to the primitive and most hardy types of **Fragaria** and **Chiloensis** rather than to the hybrids of this species. Perhaps this will make possible a stronger heterosis effect.

Summary.

These experiments indicate:

1. Cultivated fruits are generally highly heterozygous. This sometimes results in partial sterility and other undesirable qualities. They should be reduced to a homozygous condition in order to make new recombinations.

2. To hasten the work of amelioration, homozygous species should be used in hybridization. All primitive species should be tested for this purpose because they have not been modified by cultivation. Cultivated fruits are usually homozygous for size and quality of fruit because they have been selected through many centuries for these two essential characters.

The Wild Crabapples in 1928.

Many more hybrids of the indigenous American apple fruited in 1928. These will be described in a later bulletin. The following were named and introduced as indicated.

Redflesh Crabapple.—Introduced 1928. Pedigree: **Pyrus Malus Niedzwetzkyana** x Elk River, Minnesota, wild crab. Red flower; fruit with red flesh and skin.

Wakpala Apple.—Introduced 1928. A choice late winter apple worthy of notice, but probably not for the far North. Pedigree: Mercer crab x Tolman Sweet apple.

Wecota Apple.—Introduced 1929. Pedigree: Nevis, wild crab x Northwestern Greening apple.

Wetonka Apple.—Introduced 1929. Pedigree: Nevis wild crab x Wolf River apple.

The Chinook Apple Keeps 18 Months.

May 14, 1929, fruit of the Chinook apple was examined and found in good condition, and made a good, pleasant flavored sauce. Fruit picked September 3, 1927, and kept in an outdoor cellar.