I. V. MICHURIN

PRINCIPLES *and* METHODS

I. V. MICHURIN
(1855-1935)

I. V. MICHURIN

PRINCIPLES *and* METHODS

FOREIGN LANGUAGES PUBLISHING HOUSE
Moscow 1952

CONTENTS

AUTHOR'S PREFACE TO THE THIRD EDITION

For dialectics "... nothing is final, absolute, sacred. It reveals the transitory character of everything and in everything; nothing can endure before it except the uninterrupted process of becoming and of passing away, of endless ascendancy from the lower to the higher." (F. Engels)

This principle has always been and remains the basic principle of all my work. It has been emphasized in all of my numerous experiments on the improvement of existing varieties and on the origination of new varieties of fruit and berry plants.

Of particular significance are the changes that have taken place in our country during the years that have elapsed since the Revolution.

The socialist system has brought the working people in our country to confront new historical tasks in full accordance with their vital and intellectual requirements

By the unsurpassed efforts of the working class guided by the Bolshevik Party, Russia, hitherto

a backward, stagnant country, has been successfully converted into an industrial state, which is being built on the basis of a complete technical re-equipment of the entire national economy. The task of developing the productive forces of the Soviet Union is being solved in a new way on the principle of expedient planning which reveals the fabulous economic opportunities, that for the most part still have not been made use of.

Where the private proprietors formerly plundered there now works in full harmony a unanimous and powerful society armed with a much better technical equipment and with scientific knowledge.

Relations between the town and the village have accordingly undergone great changes. The problem of production and consumption has now acquired an entirely new aspect; new economics, new customs and new laws have come into existence. It is natural, therefore, that both industry and agriculture have to meet absolutely new requirements of the working people, so that any lag, any discrepancy or lack of agreement in the work with the general socialist principles of economic management will do great harm and will hinder the construction of the new socialist national economy. The same holds true with respect to our field of work, that is, to the work

of producing new varieties of fruit and small-fruit plants, which is an integral part and one of the most important branches of socialist agriculture.

Only when the problem of producing new fruit and berry plants will be tackled by the experimental stations scattered all over the U.S.S.R.—stations that are affiliated with the Scientific Research Institute of Fruit Growing named after me; only when these stations will carry their work of producing and testing new varieties of plants directly to the point of production of each district and will manage to attract the attention of sovkhoz and kolkhoz workers to this task, only then will the requirements of agrotechny and selection be more fully taken into account and selection will to a greater extent be able to meet the demands of agrotechny. Only on such terms can selection become a mighty weapon in the fight against the drought, in the struggle for high and steady yields from cultures grown in socialist fields and orchards.

To be brief, the fruit grower in his work must always serve the interests constituting the essence of our economic and social system; he must be fully aware of the methods he employs and of the ultimate purpose of his work.

The urgent tasks of the present day set before the workers of socialist agriculture are absolutely

definite. The Seventeenth Congress of the Communist Party of the U.S.S.R. outlined the course of development of agriculture, expressed by Stalin in the following words:

"... every region will have to develop its own agricultural base, so as to have its own supply of vegetables, potatoes, butter and milk..."

That means that the urgent task set before fruit growers is the extension of the fruit-growing area to the north and east.

Publishing this third revised edition comprising two volumes of my works, I want to draw the attention of fruit growers to the necessity of making as much use of my experience as possible in their work, giving it a proper direction to meet the requirements of today.

As regards the production of new varieties of fruit and small-fruit plants, the breeders are confronted with the following tasks:

1) The determination of the regional distribution of varieties and a thorough study of the varieties that I produced as regards their behaviour in the different regions of the central and northern zones of the U.S.S.R. varying however little in soil and climatic conditions; propagation of these varieties should be based on the results of this study and should be carried out on a scale that would meet the requirements of the developing socialist horticulture.

2) The correct choice of stocks which are of decisive importance as a base for the fruit trees. Making use of the results of my experiments where they have proved to be perfectly reliable or where they may offer a foothold, no matter how small, for the further ascent to more perfect methods.

3) The production of new local varieties of fruit and small-fruit plants for every region, carried out in the very region for which the new variety is planned, directly in the orchards of its state farms and collective farms. In his work the breeder must strive to solve the most urgent problems set before fruit growing by present-day requirements, i.e., he must produce such varieties as would in the first place contribute to solving the problem of nutrition of the working people; such varieties as would be suitable for the purposes of industry and export trade and afford the possibility of mechanizing fruit-crop harvesting.

4) With the purpose in mind to wrest from Nature more and more new valuable plants for introduction into culture, all measures should be taken for the tireless quest of wild plants worthy of cultivation. In these searches use should be made of the experience accumulated by investigators and at the same time this experience should be increased by exploring the mountains,

the forests, the steppes and the marshes of the vast remote regions of our country, particularly those of the Caucasus and of the Far East—the regions that still conceal a great many valuable species that are as yet unexploited.

It is true, that this is a thorny track fraught with many a disappointment for young Soviet fruit growers. All the more, every new discovery will serve as the greatest reward and will win the greatest esteem in the country of working people. Fruit growers will never get off the track if they always follow my firm rule: "We cannot wait for favours from Nature; we must wrest them from her."

The present edition, as I have already mentioned, is in fact the third revised and reduced in price edition comprising the first two volumes of my work *Results of Half a Century of Work in Producing New Varieties of Fruit and Small-Fruit Plants,* that have already been published. It includes only about one-half of the total of my actual achievements in the origination of new improved varieties of fruit and small-fruit plants for the regions of the central zone of the European part of the R.S.F.S.R. The principles and methods of my work are described in this edition, besides it gives the description of the most valuable new fruit-plant varieties that I have originated. These are the new varieties of apple, pear, quince, moun-

tain ash, sour cherry, sweet cherry, plum, apricot, almond, raspberry and actinidia. The description of the remaining new varieties of apple, pear, plum, cherry, apricot, quince, grape, walnut, rose and various species of berry shrubs, as well as the description of many experiments and methods of work has to be deferred untill the subsequent volumes are published in the next edition.

CHAPTER I

THE ASSORTMENT OF FRUIT VARIETIES GROWN IN THE ORCHARDS OF THE U.S.S.R. AND THE MEASURES FOR ITS IMPROVEMENT

The government of tsarist Russia did not care a bit about satisfying the requirements of the working people in respect to fruit and was not much interested in the development of our home horticulture. For centuries practically no measures whatever were taken for its improvement, especially in the central and northern zones of European Russia.

Only occasionally did the individual horticulturists try to do something in this respect on their own initiative, but unfortunately, in pursuing their goal they followed the wrong track. They tried to replenish their assortment of fruit-plant varieties exclusively by introducing into their orchards specimens of already fully-formed best foreign varieties; but since their constitution had been formed in warmer lands, under much better climatic conditions, these properties upon being

transferred into our country with its relatively rigorous continental climate, could not grow and develop normally. Despite the application of various measures of the notorious acclimatization, the foreign newcomers suffered, grew sickly and finally perished with very rare exceptions. In the meantime the weakened sickly organisms of those fruit trees afforded a favourable basis for the development of hosts of various pests and thus infested all our orchards with their hardy local varieties, which had never experienced such an invasion of foes. Those rare specimens of foreign varieties that survived in our unfavourable climate degenerated to such an extent that the fruit of many of them became inferior even to our old local varieties in their appearance, taste and yielding capacity. All this in combination with other unfavourable factors gradually contributed to that disastrous decline of our horticulture that we witnessed before the World War. The consequences of that war altogether killed it.

Now we are confronted by a rather difficult but honourable task of great national importance: in the process of the socialist reconstruction of our fruit-growing economy we must restore and raise in the nearest future the yielding capacity of our existing orchards and, therefore, their marketability. We must also create a new socialist horticulture based on the advanced technique,

feasible mechanization and strict planning, using for this purpose the well-tried socialist methods of labour—socialist emulation and shock work. The objects of such horticulture is to supply in sufficient quantity cheap fruit of high quality for the working people, raw material for industry and also fruit for export. It is, first and foremost, from this standpoint that the suitability of our old varieties of fruit plants in the assortments of the northern, central and southern zones of former European Russia, the Ural region, East and West Siberia, the Caucasus and Central Asia should be viewed. Any varieties that proved to be of low productivity when cultivated in orchards should be ruthlessly eliminated from further cultivation. That, according to my opinion, unfortunately, would be the destiny of most varieties that are at present cultivated in our orchards. After such a thorough purge it will be obvious to all how poor the lists of our really highly productive varieties actually are, and the urgency of replenishing them by the selection of new varieties of improved quality will become quite obvious.

Without repeating the error of the old horticulturists, who hoped in vain to acclimatize foreign varieties in our country, hybridization and other methods must be used to produce from seeds our own improved and hardy varieties for each locality.

After thirteen years (beginning with 1875) of thorough theoretical and practical study of plant life, and, in particular, of the state and requirements of horticulture in Central European Russia, after having toured and inspected all the outstanding orchards and horticultural institutions of those days as well as on the basis of my personal examination of the qualities and properties of fruit-plant varieties suitable for cultivation in central and northern parts of former European Russia, I came to the conclusion in 1888 that the level of our horticulture was very low. At that time our assortments besides being poor, were contaminated with various semicultivated, sometimes even absolutely wild forms of forest trees. The only varieties tolerably good in respect to productivity that were figuring in the first place everywhere at that time were: among apples—Antonovka, Borovinka, Skrizhapel, Anis, Grushovka and the like; among pears—Bessemyanka, Tonkovetka, Limonka; among cherries—Vladimirskaya and its seedlings; among plums—the seedlings of blackthorn and different varieties of damson. Only rarely here and there in the orchards some varieties of foreign origin (variants of Reinette, Calville and Pippin) would be found scattered in small quantities.

Among pears there were absolutely no winter varieties. As for sweet cherries, apricots, peaches

and grapes, these fruit plants could be found only in hothouses, and nobody ever dreamed of cultivating these species in the open. With such assortments of varieties no results worth mentioning were to be expected from the orchards.

In the meantime the import of various fruit into the northern regions from the South and from abroad cost the state many million rubles.

A survey of the state of affairs made evident the urgent necessity of radically improving the existing assortments of our orchards. This compelled me to found in 1888 a nursery of fruit plants with the only object of originating new, improved and more productive fruit-plant varieties.

At first I tried to achieve this result by the selection of seedlings grown from the seeds of the best varieties—both our native and foreign. But finally the results convinced me that the new varieties thus obtained had been insufficiently improved. It became evident that the choice seedlings of the best local varieties were but slightly better in quality than the old varieties, while the seedlings grown from the seeds of the foreign varieties in most cases proved to lack hardiness and were destroyed by frost. I had to resort to hybridization, i.e., to make crosses between the most productive and best flavoured but

delicate foreign varieties and our hardy local fruiters. Such crosses rendered it possible for the hybrid seedlings to combine the characters inherited from both parents, the beauty and the fine flavour of the foreign varieties and the hardiness of our local cold-resistant forms to the climate of our region.

CHAPTER 2

FALLIBILITY OF THE VIEW THAT SOUTHERN PLANTS CAN BE ACCLIMATIZED BY SIMPLY TRANSPLANTING THEM

I think it will be of benefit to future students of my experiments if I also make mention here, at least in brief outline, of my errors in method and the mistaken conception which I at first had of certain phenomena in the life of plants. In most cases these errors were rooted in the fact that, owing to my then inexperience, I trusted too much to the opinions of the horticultural authorities of those days, and did not test their truth for myself.

Such errors caused me a vast amount of uselessly wasted time, labour and means. Whole decades of unproductive effort were spent unprofitably in the execution of certain details. And it has to be said that even today, after the lapse of more than forty years, survivals of these mistaken notions still make themselves strongly felt at times in the work of some horticulturists, and do undoubted harm. Thus, there is the long-standing

belief that grafting onto the crown can hasten the onset of the fruiting period in a young hybrid, or that grafting a tender variety onto a cold-resistant stock can lend it hardiness—this was preached in his time by the well-known Moscow horticulturist Grell. There is also the claim of the botanists of those days that interspecific, and all the more so, intergeneric hybrids are impossible, that if they do sometimes appear, they are bound, one and all, to be sterile, and so on.

Some have claimed that in the central areas of the European part of the U.S.S.R., it is useless even to contemplate the cultivation of winter pears, grapes, sweet cherries, apricots, peaches and walnuts. All this has proved to be mistaken in one or another degree, and has only been borne out in exceptional cases.

For example, the grafting of a young hybrid onto the crown of an adult tree hastens fruiting in the hybrid only if the latter has itself already entered a period close to fruit bearing. Furthermore, by its vegetative influence, due to the work of the whole crown's leaf system, the adult stock will alter the properties of this young hybrid, in the majority of cases for the worse.

Only as a rare exception, by a chance happy choice of a stock suited to the properties of the hybrid grafted onto it, is the result a success, that is, an improvement in the external and in-

ternal properties of the hybrid is obtained. Such a new variety, however, will not have the exact characters which it inherited from the crossed parent plants; its properties will be a combination of these with the properties of the stock, that is to say, a vegetative hybrid will result.

Accordingly, if it is necessary to make such a grafting, circumspection is required in choosing the variety of adult tree that is to serve as the stock.

As the best stock for such purposes, I would name, of the apple trees, the Skrizhapel and its variations, or, better still, young trees grown from its seedlings; and of the pears, the Malikovka, the Tonkovetka and their seedlings.

Well-tried new hybrid varieties, which have already been bearing fruit for several years, and also all long-standing varieties of apples and pears, both native and foreign, do indeed begin to bear fruit much sooner when grafted onto the crowns of adult trees; and, moreover, if the influence of the stock affects their properties at all, it does so only in a barely perceptible degree which is of no practical importance.

Of course, there may be exceptions here too. Thus, a cutting of the 600-gram Antonovka, grafted onto the crown of an adult specimen of the small Siberian crab, produced fruits of a cylindrical shape totally alien to the Antonovka.

Again, a cutting of the Malikovka pear, grafted onto the crown of an adult of the new Bergamotte Novik hybrid, yielded fruits twice the usual size, etc.

Next let me deal with the mistaken view that foreign varieties of fruit which lack resistance to our frosts can be acclimatized by supplying them with cold-resistant stocks.

That this belief of Grell and his disciples—Romer and others—is a delusion, is altogether obvious.

Varieties propagated in this manner perished from the cold with the greatest regularity. But here too exceptions occur, although very infrequently.

Occasional specimens which strike by accident upon stocks with an exceptional individual power of influencing the scion, in respect of imbuing it with their own hardiness, do become hardy. Such young trees grow to maturity and sometimes bear fruit for several years.

But this cannot be described as acclimatization, if only because, when it is attempted to propagate such plants by cuttings, the latter usually prove to lack hardiness and are killed by frost in the first few winters.

As to the very few foreign southern varieties which have proved fairly resistant to our frosts, this can be explained by their having already

possessed, in their native countries, a capacity for resisting temperature drops below the usual range of warmth and cold fluctuation in those countries.

When transplanted to our parts, such varieties endure our climate with comparative ease. But what has acclimatization to do with it?

This is commonly termed the naturalization of plants in a new environment.

CHAPTER 3

METHODS OF PRODUCING NEW VARIETIES AND THE SIGNIFICANCE OF A SPECIAL REGIME FOR TRAINING HYBRIDS

The breeding of new and improved varieties of fruit trees and small-fruit shrubs grown from seeds is effected by one of three methods iterated below.

The first consists in a simple selection of seedlings grown from the seeds of the best local varieties which happen to possess good fruit qualities and can stand the climatic conditions of the given district. All the assortments of the orchards of former Northern and Central Russia and of almost all the neighbouring Western countries have been built up by such "chance varieties." In the peasant Anton's kitchen garden, for example, an apple tree grew up from a stray seed. The apples were large and their taste was good; thus, from that time on people began to breed this variety and called it Antonovka. In the Volga Region another variety was found that likewise grew up from a seed fortuitously sown; this new apple had

prettily coloured fruits and its flavour faintly reminded one of anise, so it was named the Anis; the same is true of the various Borovinkas, Grushovkas and such pears as the Tonkovetka and Poddulka. In Western countries varieties were collected much in the same way: for example, in Belgium, from a seed of a cultivated variety that had been accidentally dropped in the forest by bird or man, a tree grew up that bore fruit of excellent flavour and size; hence this new variety was called Forest Beauty [Fondante de bois], etc.

Many persons, as for example, Van Mons and parson Hardenpont in Belgium, Tourasse in France, Ross and Veitch in England, and, finally, in Russia on my initiative and advice, Kuzmin, Kopylov, Spirin; and on their own initiative in Siberia Neznayev, Komissarov, Prof. Kashchenko, Bedro, Nikiforov, Krutovsky and others began deliberately to sow seeds of their best varieties and then select saplings with better fruit that may have accidentally grown from them.

Thus gradually in the course of a few hundred years all the orchard assortments of fruit trees were formed.

But work with this method, based as it is on chance findings of trees of good quality, may be carried on only in districts with the favourable climatic conditions of warm Western countries

or in California where the well-known originator, Luther Burbank, has been working lately. Under a warm climate, and particularly if mass planting is practised, such chance findings of better varieties as well as much valuable material may be obtained without any particular effort on the part of man. But in our country, particularly in the northern and central belts of the U.S.S.R., under our severe climatic conditions and comparatively short vegetation period such a method will not get one far ahead.

From the planting of seeds of our local varieties we can only obtain fruit of the same quality with but very few casual improvements. In general, very slowly, in the course of several centuries by breeding many generations of plants much improvement may be achieved in our country as well; this is evident from the history of the development of horticulture everywhere. But the contemporary rapid pace with which the various phases of man's life evolve makes it impossible to wait so long for improvements.

Most of the seedlings raised from the seeds of the best foreign varieties, with very rare exceptions, will prove to be non-resistant to our frosts, and as a result we shall not be able to improve very much the varieties of our fruiters.

Let us now turn to the second method of solving the problem which gives much better possi-

bilities of augmenting the quality of new varieties of fruiters. This method is based on the introduction of so-called hybridization, i.e., crossing. Since each plant organism usually contains male and female reproductive organs by means of which it produces its offspring, it is possible to improve our hardy local varieties by crossing them with foreign ones that had been raised in a warmer climate and which yield fruit of better quality as compared with our own, but are unable to resist our frosts. From such crossings fruit are obtained the seeds of which are sown and seedlings raised; from these seedlings we select the specimens which, as far as it can be judged from their external characters, had inherited from their parents the improved fruit flavours inherent in the foreign varieties, and the resistance to frost characteristic of our varieties. By such a method qualitatively improved new varieties are obtained that are able to stand the conditions of our region.

However, although the second method gives the greatest percentage of improved new varieties, it nevertheless does not provide for all the ways of man's purposefully alterating the structure of hybrid seedlings.

It is likewise necessary to take into consideration all changes in the structure of hybrid seedlings, which I shall deal with later on.

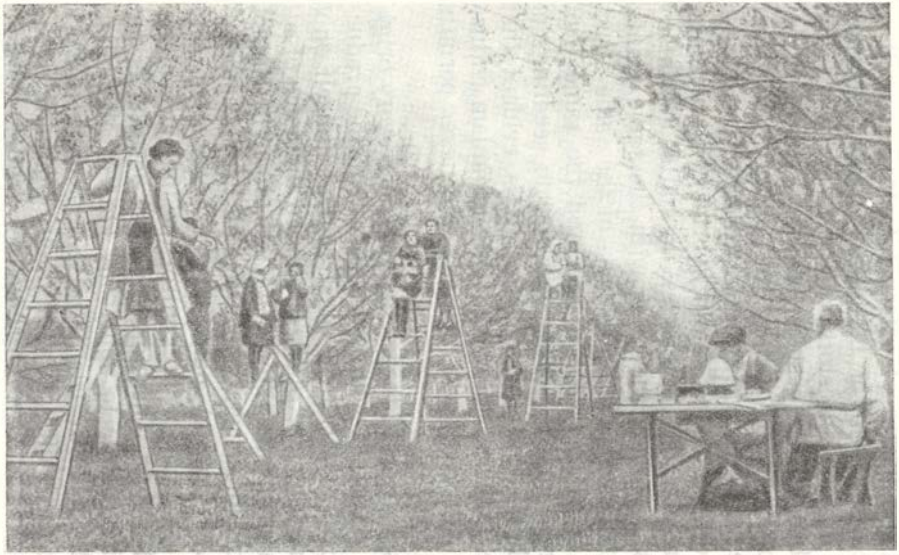

Fig. 1. Pollinating apple blossoms in the orchard of the Plant-Breeding and Genetics Station in Michurinsk

The influence of external factors as well as the combination of hereditary factors obtained from distant ancestors will here become manifest. Besides, the results obtained from the crossing of the same pair or progenitors will never be repeated twice; in other words, if we cross a pair of plants and obtain hybrids with a combination of certain properties, no matter how many times we repeat the cross with the same plants, we shall never obtain hybrids of the same structure. Even the seeds in one and the same fruit obtained from the cross give rise to seedlings of completely different varieties. It is evident that in creating new forms of living organism Nature gives rise to infinite diversity and never permits repetition.

As a result of these circumstances every originator (a person who is occupied with the production of new varieties) must content himself only with making use of the combined influence of all the internal and external factors, since he cannot possibly know what properties all the ancestors of a given pair of parent plants possessed, and since he is unable to control the influence of external factors. Therefore, in these cases it is not only impossible to apply any kind of Mendelian calculations, but it is likewise impossible to work on the basis of strict preliminary planning in the production of two varieties of fruiters closely

resembling each other. And if my conclusions are erroneous on this point, I beg to show me the firm basic principles which could lead me out of the labyrinth of misunderstanding. Only please don't offer the usual unconfirmed hypotheses; I myself can offer a whole set of them, but they are absolutely of no aid in practice.

Furthermore, in the work of producing new varieties of fruiters the third method should be regarded as the most important one; it consists in repeated crossing of the hybrids to the best cultivated varieties (including foreign ones).

When applying this method we may follow the lines of giving the proper training to the seedling during its development. Namely, in most cases we may enhance the development of useful characters and weaken or altogether suppress the development of harmful ones, basing judgment on the external manifestations of both. When carrying out such work we are partly guided by scientific data, but in most cases there are none to go by, so that we are obliged to base it on experience gained by many years of labour.

Many persons, having erroneously interpreted the term "segregation of the parent types" expect good results from the planting of hybrid seeds in the second generation, hoping by this means to secure a repetition of the foreign variety structure but of a more resistant type.

But, in the first place, in the course of my practice of many years after numerous experiments on planting hybrid seeds of perennial fruiters I have, in general, never met with an exact repetition of the structure and form of the parent plants. Evidently Nature does not permit the repetition of form; always plants are obtained with new combinations of properties and characters. There cannot be complete segregation of parental types simply because the form of each hybrid, as I have already repeatedly stated, is built up by a mixture of inherited characters, only a small part of which comes from its direct parents, whereas the rest come from their kin. Secondly, the structure of each hybrid in the course of its development from the time of its germination up to its first years of bearing in most cases is greatly altered under the influence of external factors, which also eliminates the possibility of repetition. Besides all this, the properties of the seedlings of the second generation grown from seeds that were obtained from self-pollination of the hybrid (without repeated crossing to the best varieties) always deteriorate or are completely lost due to the repeated deleterious influence of our climatic conditions.[1]

[1] As factual proof of this phenomenon in my nursery there is a whole series of trees belonging to the second generation.

Quite the opposite results are obtained if the hybrid is repeatedly crossed to the best foreign varieties; here in most cases a considerable general improvement is observed both from the introduction of a new variety into the cross possessing new and desirable qualities and from the greater susceptibility of a young hybrid, particularly one that has been standing on its own roots.

Of course, all these rules cannot be applied to the hybrids of local fruiters belonging to pure species or to hybrids of local grain cultures, or to annual vegetables; these may, after all, manifest improvement in the second generation. There can be no great difference between the properties of the ancestors and those of the hybrid obtained from the crossing of local pure species of fruit trees. As for annual field and vegetable plants, in most cases the continued action of external factors during postembryonic development is absent. Thus, in hybrids between pure species of rye, wheat, oats, peas, millet, etc., I consider the "phenomenon of segregation of the parent types" to be quite possible. The Mendelian laws are applicable here in many details.

I shall cite one of the many hundred examples. In 1900 I fertilized the flowers of the apple *Malus Niedzwetzkyana*—a pure species—with the pollen of Antonovka. The former is remarkable for its marked red colouring of both leaves and fruit.

As a result, one fruit set and ripened, from it I obtained fourteen seeds, and in due course the following types of seedlings: six with red leaves and seven with green leaves, and one had one side of its shoots and leaves coloured red and the other green. Both the red and the green seedlings developed with the usual vigour, whereas the striped one (evidently due to the difference in the structure of its cells on both sides) at first grew very sparingly—was about half the size of the rest, but gradually the red colouring expanded, and when it finally encircled the circumference of the trunk, the growth of the sapling increased and the tree reached the height of the others. Finally, in 1914/15 all the trees bore fruit; it so happened that the seven red trees produced fruit of about the same size, but twice as large as those of the mother plant, all of the winter type and of approximately the same flavour. The seven green forms produced fruit that greatly varied in size, shape, colouring (for the most part pale and designed) and flavour—from very sweet to extremely sour, a property not met with either in the paternal plant—Antonovka, or in the mother—the Niedzwetzkyana apple. Such a diversity of types was evidently the result of the manifestation of the recessive characters of Antonovka's distant kin. Furthermore, from the self-pollination of the seven red hybrids due to the

dominance of the Niedzwetzkyana pure-species type trees were obtained the fruit of which had an extremely red flesh. On the other hand, if the flowers of the red hybrids were pollinated by any green hybrid or by any other cultivated variety, the trees produced from the cross yielded fruit that were coloured only from the outside, whereas the flesh remained white and was of a miserable flavour.

When the pollen of the first red hybrids was used to fertilize the different cultivated varieties the resulting hybrids yielded fruit of completely red colour but only of the rind; their flavour was excellent and always of the winter type. The latter property was the result of the shorter period of vegetation in our parts as compared with the longer period necessary for the Niedzwetzkyana apple. The seedlings of the first seven green hybrids when self-pollinated, yielded in the second generation only typical wildings; the same occurred when they were crossed with cultivated varieties. Here it is evident that the recessive characters of Antonovka's wild ancestors proved to be dominant. Now just how is one to apply Mendel's laws in such a case?

In the cited instance if we consider the increased size and better flavour of the fruit from the first-generation red hybrids as the result of the influence of the Antonovka characters, then where

does the diversity of types obtained from the green hybrids come from? Particularly, since they failed to manifest a single character of their parent plants. Furthermore, why does the pollen of the red hybrids when used to fertilize other old cultivated varieties, despite its dominance, produce fruit of good quality, whereas the pollen of the first seven green hybrids produces only wildings? Even if segregation does take place, in this case, at any rate, half of the characters belong to Antonovka's very distant past and not to the direct and immediate parents of the hybrids.

One point is clear, namely, that the characters of the Niedzwetzkyana apple, being those of a pure species, in all cases prove to be strongly dominant and suppress and leave in a recessive state most of the characters of other varieties. The cited case likewise demonstrates one of the reasons for dwarfed growth, proving it to be due to the correlative influence of the incongruity of structure and growth of the cells in the different halves of the plant; externally no other characters were manifest except the red colour of the bark.

A second example: in 1903 I fertilized the flowers of *Pyrus salicifolia Pall.* with the pollen of the Bessemyanka pear; the former produces small, very hard and inedible fruits of a grey

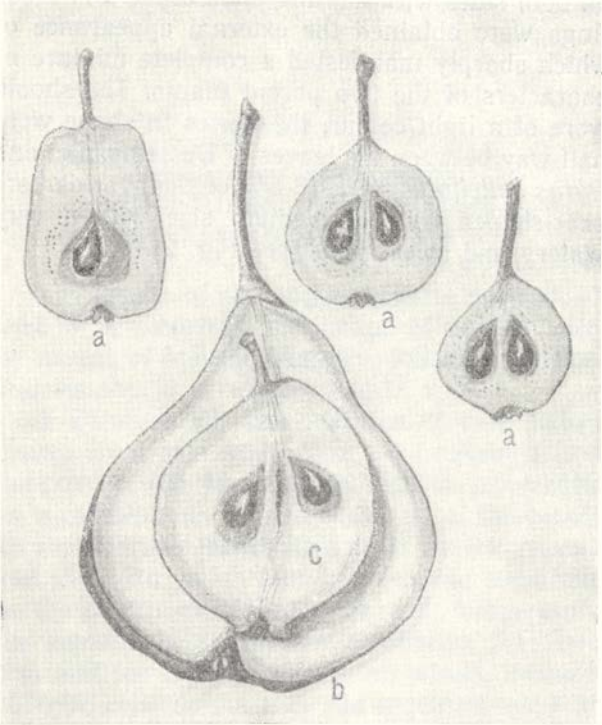

Fig. 2. Hybrid of *Pyrus salicifolia Pall.* with Bessemyanka; a—fruit of the *Pyrus salicifolia*; b—fruit of the Bessemyanka; c—fruit of the hybrid

colour and with long and narrow leaves covered on both sides with a white pubescence. Six seedlings were obtained the external appearance of which sharply manifested a complete mixture of characters of the two parent plants. The shoots were of a light colour, the leaves in shape were half-way between the leaves of Bessemyanka and *Pyrus salicifolia*. In 1918 one of the hybrids bore pear-shaped fruit of medium size with a very watery and sweet pulp [see Fig. 2].

CHAPTER 4

CONDITIONS FOR SUCCESS IN OBTAINING NEW VARIETIES BY MEANS OF HYBRIDIZATION

The results of my long experience have shown that for a successful production of new varieties by means of hybridization the following circumstances should be always had in view.

1. First of all, the qualities of each hybrid grown from fruit seeds that were obtained from the cross of two parent forms will be represented by a combination only of that part of the hereditary properties transmitted to it by its parents and their kin which found favourable conditions in the environment (air and soil temperature, the amount of atmospheric electricity, the direction and the force of the ruling winds, intensity of light, soil composition and moisture, etc.) for their development from the earliest stages of the hybrid's growth. Therefore, the organism of each hybrid seedling is a sum-total, and its items are the characters of the parent plants and their kin plus the influence of external factors. All these

conditions are ceaselessy and constantly changing, so that not only unlike hybrid forms arise at different periods from the crossing of one and the same parent plants, but even separate seeds from one and the same fruit produce hybrids that completely differ from one another in properties. In general, a repetition of the same form is never met with in hybrids of perennial fruit plants; this is more or less possible only in seedlings of pure species.

On the ground of my recent observations I have come to the conclusion that it is impossible, with rare exceptions, to obtain completely constant varieties of cultivated fruit plants by natural sexual propagation (by means of seeds) because it is impossible to have plantations of only one selected variety that would be protected from cross-pollination. In such cases the simplest method of propagation is the rooting of layers only. This will be dealt with later on.

2. The more distant are the parent plants used in the cross with respect to place of origin and environment the more easily adaptable will their hybrid seedlings be to the external conditions of the new locality. I explain this by the fact that in such cases the properties inherited by the hybrid from its maternal and paternal parent and from their nearest kin, not finding the usual conditions to which they had been ac-

customed in their place of origin, will not be so dominant as to manifest themselves one-sidedly in the development of the hybrid organism, which is of enormous significance in practice. For a clearer understanding of this phenomenon I shall cite an example from my investigations. When crossing foreign varieties of winter pears with our Tonkovetkas, Limonkas and other hardy varieties hybrids are obtained with better taste qualities, but all of them are early-maturing forms and have small-sized fruit due to the dominance of the characters of our local varieties for the development of which the climatic and other conditions of our regions are appropriate and usual. On the contrary, when I crossed the foreign winter pears with the wild Ussurian pear [*Pyrus ussuriensis Max.*], which I had raised from seeds obtained from Northern Manchuria, one half of the hybrids had large fruits of excellent flavour that ripened in winter storage; all the top part of the plants were perfectly resistant to our frosts. The second half of the hybrid trees manifested properties of the foreign variety, were non-resistant to frost, and what is more interesting, the quality of their summer-ripening fruit, both in flavour and in the insignificant size, was very low—a property of the Ussurian pears.

3. All fruit plants that are not grafted but have their own roots when crossed give a greater

number of cultivated varieties with good qualities as compared to those that are grafted to wild stock. This clearly shows that the plant's root system plays a very active part in the formation of the seed. That is why my first crossings of apple I began with young seedlings of *Malus prunifolia Borkh.* in their first blossoming, and after that, when the hybrid trees were raised and new varieties could be distinguished, the subsequent crossings were effected with the saplings of the new varieties grown from seeds and standing on their own roots.

4. The age and health of the parent plants chosen for the crossing are of very great significance in practice. Young hybrid plants in their first bearings, or older plants that have been bearing for many years but which were weakened by a dry or unusually cold spring during the given vegetation period, possess a weaker individual capacity for hereditarily transmitting their properties, and, conversely, plants belonging to pure species and, particularly, wild forms in their prime, possess the greatest capacity of handing down their properties to the hybrids. Thus, for example, from the cross of the Crimean Kandil Sinap with the Siberian crab apple [*Malus baccata Borkh.*] hybrids were obtained with fruits the size of our ordinary orchard Kitaika [*Malus prunifolia Borkh.*], whereas the cross between

Kandil Sinap with the seedlings of our orchard Kitaika in its first blossoming produced fruits of an excellent taste. In this case the maternal parent was the young seedling of the Kitaika, not the pure type of course, but a hybrid; this became evident later from the larger size of its fruit as compared with the ordinary size of the Kitaika. That is why its resistance properties were not transmitted with due intensity, and as a result the shoot ends of the seedlings obtained from this cross suffered from the frost. To eliminate this shortcoming the hybrids had to be placed once again under the influence of their female parent—*Malus prunifolia Borkh.*—by grafting cuttings of the seedling into the crown of the maternal tree, which soon gave the required degree of resistance to the new variety. This circumstance should be taken into consideration when choosing the parent plants.

It has been likewise remarked that flowers chosen for fertilization on the maternal plant, if placed nearer to the main vertical branches of the trunk, give better hybrids with larger-sized fruit but such that tend to deviate considerably in structure in the direction of the maternal plant, and, conversely, flowers on the horizontal branches, placed nearer to the periphery of the crown generally give hybrids with fruit of smaller size and such that deviate in the direction of

the male parent. The shady side of the maternal plant yields hybrids of poorer quality as compared to the sunny side. This is particularly clearly expressed by the depth of the outer colouring of the fruit and by the amount of sugar in the pulp.

5. Under the climatic conditions of our localities, when raising new varieties from seeds obtained from the crossing of delicate foreign varieties with our local hardy species or when simply sowing the seeds of fruit plants from warmer countries (as compared to the region where the seedlings are grown), the seedlings should in no case be given too rich a soil; particularly, fertilizers that increase the growth of the seedling should be avoided, otherwise the properties handed down by the varieties of the warmer climate will be too dominant in the development of the hybrid. As a result, delicate seedlings are obtained with a friable structure of the wood which fails to mature sufficiently and to finish its growth on time before the fall and, consequently, practically all such forms perish. These are the reasons in most cases for the failures to raise new varieties from seeds which so many amateur horticulturists in our districts have attempted; this is particularly true of Siberia where the soil is extremely rich and virginal.

I myself have committed the same error at the beginning of my career by trying to produce

luxuriantly growing hybrid seedlings. Within a few years I lost hundreds of them due to freezing, until at last I resorted to especially prepared lean sandy loam for the beds where the sowing and the pricking out were effected. Of course, when selecting one-year-old seedlings raised on rich soil a greater number of better trees was obtained, but all of them proved to be totally unfit for our districts due to lack of resistance. Those that had been reared in severe conditions on the lean soil, proved to be completely resistant to frost, although the number possessing excellent varietal properties was smaller. The necessity for such training of hybrids became so clearly evident in practice, that I was obliged to sell in 1900 the plot of black earth which I had used for a nursery and to look for another plot of lean sandy loam for it. Otherwise I would have never succeeded in producing new varieties of fruiters and in introducing new types of plants into culture in our parts.

Here it is necessary to turn our attention to the very essence of the problem of raising new plant varieties: its aim, you know, is to obtain fruits of better flavours and not trees with the most luxuriant growth; I repeat, an orchard must yield fruit for food and not wood for fuel.

I begin to apply manures only at the stage when the young hybrid plant normally begins to form reproductive organs, i.e., the fruit buds.

At this stage manuring becomes essential both for the increase in the number of fruit buds that are more fully formed and for the development of larger fruit. When the plant has reached the stage of maturity, fertilizers cannot do harm because the seedling has already acquired comparative stability to changes in all parts of its body with the exception both of the seeds, which are being formed in the fruit for the first time, and of the pericarp. It is the development of the latter two that is enhanced by the manuring. But even here mineral fertilizers should be usually preferred to organic ones so as to avoid infecting the plant with rot and parasitic fungi which, according to my repeatedly checked observations, often happens to trees of winter varieties of apples and pears. In all stone-fruit cultures organic manures lead to gummosis; this is particularly manifest in sour and sweet cherries, where surplus mineral fertilizers such as lime are harmful because they enhance the development of the stones to the detriment of the quality of the fruit.

Organic manures may be applied to shrub small-fruit cultures such as the gooseberry, raspberry, currant, etc., during all stages of their development.

In general, it should be known that the luxuriant growth of a plant in most cases does not

accelerate the onset of fruiting; this has been well known to horticulturists for a long time. If a fruit tree grows intensively, "lays no eggs" as the horticulturists say, it fails to bear. The separate vegetative shoots in the tree's crown remain barren for a long time. As to contrary opinions such as the work of Tourasse in southwestern France in the eighties of the last century, early fruiting in pear seedlings was a mere coincidence and not the result of accelerated growth due to increased nutrition, as he asserted. I, too, witnessed such cases of premature fruiting in two-year-old hybrid pears, apples, cherries, walnuts and chestnuts, but in most cases the subsequent growth of such plants either proved to be abnormal or their fruit buds would be damaged by the frost or would simply develop into shoots. Thus, for example, in two-year-old peach seedlings a premature development of fruit buds was a sure sign of a particular lack of resistance to frost. In other words, this phenomenon should be regarded as pathological, which is proved by the fact that such plants are short-lived; I have not been able to preserve a single specimen. Only at the age of five-six years was the onset of fruiting normal in some of the specimens.

6. The artificial induction of excessive fruit size in specimens obtained from the cross is likewise to be avoided, since the seeds from such

abnormally large fruits or, better to say, pericarps are in most cases underdeveloped, meagre and as a rule give rise to forms with small-sized fruit. For example, the seedlings grown from the seeds of an extremely large pear (almost 600 grams) Beurré d'Hardenpont taken from a trained tree gave fruit of excellent flavour but weighing no more than ten grams, whereas seedlings grown from seeds of a 300-gram fruit from the same tree yielded fruits weighing 150 grams. The same is observed in other plant species and varieties.

7. When crossing the best foreign varieties with new and improved hybrid varieties of recent origin, the latter, although lacking sufficient power of hereditary transmission due to their juvenility, nevertheless give good results as maternal plants, if only because their nearest kin possessed fewer negative qualities.

8. When choosing frost-hardy plants for crossing with delicate foreign plants it is insufficient to take into account only the severe conditions of their place of origin. It is likewise essential to consider both the soil conditions and the length of the period of vegetation. Otherwise it may so happen that plants, able to resist a 45° R. frost in their native country, freeze in our districts at —25°; this happened to the Nerchinsk apricot (*Prunus sibirica L.*) that grows on the mountain slopes in the environs of the town Nerchinsk in

Siberia. In Michurinsk seedlings of this apricot always perish during their first winter. In this case the freezing is explained by the fact that this apricot is accustomed to the short summer of its native land and to the dryness of the mountain slopes. In our parts (if it is not planted on a steep hillside), in the middle of the summer its growth is finished and towards autumn a second flowing of sap begins, and, being unable to "gather it in" again, the plant freezes. Conversely, I have come across facts that are hard to explain, for example, the following: In 1888, from the cross of the Winkler White Cherry with the Vladimirskaya Rozovaya cherry I obtained a new hybrid variety—a large-fruited pink sour cherry, which I named Krasa Severa; this excellent variety was an interspecific hybrid between *Prunus Cerasus* and *Prunus avium L.* and during its first years in our regions the ends of its shoots suffered from frost; when transferred to Siberia in Omsk it sustained the Siberian frosts and fruited abundantly, whereas the ordinary European varieties of *Prunus Cerasus* and even the half-wild Vladimirskaya Rozovaya sour cherry freeze completely in those parts.

9. It is impossible to know beforehand with certainty what the result of the crossing of two parent plants will be, if only for the reason that not only do crossings of all cultivated varieties

of fruit plants of hybrid origin manifest completely unexpected atavisms (the appearance of properties characteristic of their remote ancestors), but also because the same is true of crossings between pure species. Thus, for example, a pure species of Siberian currant (*Ribes diacantha Pall.*) growing for several years in my orchard, gave seedlings of its own typical structure, but in 1924, after having been self-pollinated, produced seedlings which were all very much like the species *Ribes pubescens*, that is, like the pubescent Siberian currant, although there was never a single specimen of it in the nursery. In general, it has been noticed that seedlings acquire through heredity not only the characters of their direct and immediate parents, but a mixture of the characters of their kin along the paternal and maternal lines.

It follows from what has been said above that all preliminary exact calculations and plans in hybridization are a waste of time, the more so because the influence of external factors plays a considerable part in the habit of the hybrid seedlings, and it is impossible to know beforehand their potency and composition. Besides, it is beyond man's power to eliminate completely such as may be undesirable.

10. As to the influence of external factors I must say that at present it is impossible to

compute with exactitude their diversity and number in all its magnitude; it is likewise difficult to make an evaluation of their action upon the structure of the plant organism. For the time being we may confine ourselves to the following:

a) In general, the influence of the sum-total of external factors on the structure of the hybrid organism is so great, that in most cases it overrules the action of the characteristics and properties hereditarily transmitted by the parent plants. In particular this influence manifests itself in the mother plant at the time when seeds of the future hybrid organism are being formed, and in the resulting hybrid during its earliest stages of development favouring some and serving as insuperable impediment for the manifestation of other hereditary characters. And almost always the degree of success in crossing plants solely depends upon such influence.

b) When the springs are warm, temperately moist and mild the number of crossings with good end results is highest. Under such weather conditions the characteristics and properties of the best foreign varieties that had been formed under the favourable factors of a warm climate are more fully handed down to the hybrids in our region.

And, conversely, the years when the springs and summers are cold, rainy and stormy are

unfavourable for the transmission and development of the best properties of the foreign varieties, with the result that the lower qualities of our varieties, characteristic for our comparatively severe climatic conditions, will in most cases be dominant in hybrids produced during such periods.[1]

c) Heavy clouds and frequent precipitations, the prevalence of cold north and dry east winds, late morning frosts greatly hinder successful hybridization.

d) The excess watertightness of cold, heavy soils, the proximity of subsoil water likewise exert a harmful influence

e) Localities that are not proof against strong air currents and are open to wind are no good for the growing of hybrid seedlings.

Here are the principal facts which I in the course of my sixty years of experience have been able to note as essential for a better approach to the problem of raising from seeds new and improved varieties of fruit plants for our region.

Of course, it would be too bold on my part,

---

[1] But, on the other hand, hybrid varieties raised from seeds and developing during their first years under conditions of comparative cold give a much greater percentage of resistant individuals, than when the springs are warm and the summers hot. Comparatively dry vegetation periods likewise sponsor resistance, and vice versa.

putting it mildly, were I to claim that such a way of tackling the problem is a completely scientific one, as one learned Siberian horticulturist has declared about his own work. But, on the other hand, to say that all my new varieties have been produced without any scientific basis whatsoever, "illegitimately" so to speak, as most theoreticians and complete ignoramuses in practice are apt to declare, would be altogether ridiculous, if only because contemporary science has been unable to give the needed instruction upon which such work could be based. No combined efforts will be of any use until a firm basis will be found in future investigations.

All the investigations of contemporary science in our sphere have as yet resulted mostly in unfounded hypotheses which are of no use in working the problem. The trouble is that when a breeder fertilizes a flower of a chosen variety of fruit plant with the pollen of another variety he obtains from the seeds of one and the same fruit seedlings of different types, which manifest not only the characters of their direct and immediate parents, but also the characters and properties of both near and distant kin of the parent plants which are in most cases altogether unknown to the breeder; to this must be added the changes that arise under the influence of external factors as well as the diverse sport bud deviations.

The question arises, in what way under such conditions can the laws of Mendel or the hypothesis of the role of the chromosomes help in the matter?

I by no means deny the merits of the Mendelian law On the contrary, I merely insist on the need to introduce amendments and addenda into it, for it is evident to everybody that his calculations are not applicable to cultivated varieties of fruiters, for when crossing separate varieties of them, the structure of the hybrids is not due to the hereditary transmission of the characters of the direct and immediate progenitors, but in most cases of those belonging to the ancestors of the parent plants, unknown to the originator. In addition, it is due to the influence of external factors, which not infrequently introduce the utmost perturbation into the organisms of the hybrids not only at the initial stage of seed formation after the cross, but also cause the manifestation of sport deviations within the several years during which the hybrids grow to full maturity. It should be added that the greater part of these influences of both internal and external factors are beyond the control of man.

It would be quite a different matter if we were to cross not the cultivated varieties of perennial fruiters whose ancestors are unknown to us, but pure species of wild fruit plants such as *Malus*

baccata Borkh. or *Malus Niedzwetzkyana,* or varieties whose characters do not fluctuate, such as the long-standing varieties of annual grain cultures: rye, wheat, millet, buckwheat, peas, flowering herbaceous plants. Of course, in these cases it is worth while taking into account Mendel's laws and even the chromosome numbers. But not only is it impossible to refer to this category all cultivated varieties of indisputably hybrid origin, but even many wild forms of plants that are considered belonging to pure species such as our forest apple *Malus sylvestris Mill.*, the orchard *Pyrus prunifolia W.*, the wild pears *Pyrus communis L.* and even the Ussurian wild pear *Pyrus ussuriensis Max.*, cannot come under this head. All these plants manifest a marked diversity of qualities and properties. It is very difficult to find two plants belonging to the same wild species that would be exactly alike in appearance, flavour and size of fruit—so great are the fluctuations within these species. The seedlings obtained from the seeds of these species, likewise in most cases differ in structure, which at present makes impossible any preliminary calculations of the results of crosses with such plants.

It therefore follows that we are incapable of choosing parent varieties for crossing on any scientific basis whatsoever; we must be satisfied

with an approximate calculation of the fitness of a given variety based on the judgment of the individual properties which it outwardly manifests. At the present moment man can only approximately choose the parent pairs, select the best hybrid seedlings and then properly train them. This is all that we can do at present with the aid of our practical knowledge and methods; as to assistance from science we can expect it only some time in the future.

CHAPTER 5

DISTANT (INTERSPECIFIC AND INTERGENERIC) CROSSINGS. THE METHOD OF VEGETATIVE APPROXIMATION

The erroneous assertion made by botanists of the past that the crossing of plants belonging to different species and genera cannot be applied and that hybrids thus obtained are always barren for many years deprived me of the possibility of introducing hybridization on a larger scale.

Only after having accidentally come across interspecific and intergeneric hybrids of cultivated plants among my F_2 hybrid seedlings did I turn to artificial crossings of plants belonging to different species and genera. Although the success of this work was slow in coming as compared to the usual crossing of plant variations belonging to one species, nevertheless the results obtained were of considerable value.

Furthermore, in the course of the work the following points became evident, namely, that:

1) interspecific crossings can be effected with greater facility when the female parent is a young hybrid in its first blossoming and not a pure species type;

2) a method which I called "preliminary vegetative approximation" is of great assistance in such crossings; it consists in the following: a few cuttings[1] are taken from one-year-old hybrid seedlings and are whipgrafted on to the branches of the crown of a mature tree belonging to a different species or genus, as for example: a pear on an apple, a mountain ash on a pear, a quince on a pear, an almond, apricot, or peach on a plum, etc. Only a few of the grafted cuttings, particularly in stone cultures, join with the stock.[2] During the following five-six years such cuttings

[1] That is, cuttings of hybrids obtained from the crossing of two varieties belonging to one species; the hybrids must be of recent origin, and such as had not yet fruited; the cuttings from our old varieties of fruit trees should not be used.

[2] Not all cuttings are able to take root. For example, some of the varieties of pear have no attraction for quince, and the reverse; or certain hybrids of almond and cherry fail to join well with plums and vice versa. But in our nursery there are cases of good coalescence even between plants belonging to different families; for example, my closest assistant P. N. Yakovlev has been able to induce coalescence between a lemon and a hybrid seedling of the pear Michurin Beurré Zimnaya.

Fig. 3. Grafting mountain ash onto quince for vegetative approximation

continue to develop under the constant influence of the work effected by the entire leaf system of the stock and gradually begin to change partially in structure up to the time of blossoming; this facilitates the subsequent crossing.

It has further been ascertained that the sterility of interspecific hybrids is not constant in all cases. On the contrary, there are many hybrids which may not give seeds capable of germinating during their first fruit bearings, but in the years following, by gradually improving their structure, it is possible to obtain completely germinable seeds.

I shall cite an example of an interspecific hybrid between the yellow lily (*Lilium Szovitsianum Hort.*) and the red (*Lilium Thunbergianum Roezl. & Schult.*). The hybrid which I named the Fialkovaya Lilia (Orchid Lily) because of its beautiful purple flowers and its orchidlike scent during the first two years of blossoming failed to produce seed balls; on the third and fourth years seed balls appeared, but with empty seeds which of course failed to germinate. Only in the seventh year did the plants begin to produce seeds that would partly germinate. The same was observed when planting the seeds of a black hybrid mountain ash, obtained from the cross of *Sorbus melanocarpa* ♂ × *Sorbus aucuparia L.* ♀. For seven-eight years from about a thou-

sand seeds of this hybrid only one or two seedlings would arise; but in 1924 mass germination was suddenly obtained. Among the seed-

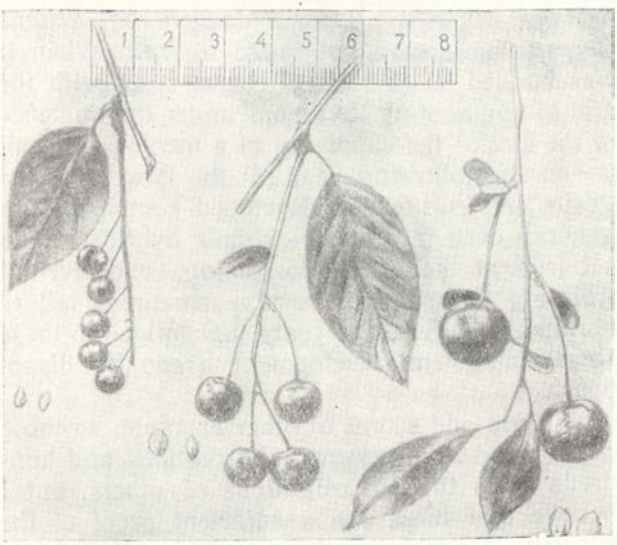

Fig. 4. Interspecific cross of *Prunus Padus Maackii* (left) × *Prunus Cerasus* (right). Hybrid in centre

lings quite a number considerably varied in structure.

Furthermore, the same may be said of the vegetative hybrid between an apple and a pear;

as a result an excellent new variety of apple was obtained which I named Reinette Bergamotte.

Then again, in some cases the sterility of certain hybrids was eliminated. Thus, the hybrid between *Prunus Padus Maackii* × *Prunus Cerasus* blossomed but failed to fruit. When it was budded on to a sweet cherry stock with the aim of augmenting its vigour under the influence of the stock—the supplying of a mentor as I call it—on the following year all the flowers of the grafts set fruit which developed completely. In general, even most of the simple hybrids fail to set fruit at their first blossoming, and even if fruit are formed their seeds sometimes fail to germinate; only in the years that follow do these shortcomings in development gradually disappear.

I could add scores of other examples to those cited above from my own observations and hundreds from the investigations of others, but I believe that these are a sufficient proof of the veracity of my conclusions on the matter. As to citing examples from and referring to the works of other authoritative investigators I consider it rather risky, since the main point of their achievements may be misrepresented.

Besides, it is generally not my custom to sprinkle my works with references to the investigations of others, if only because many of the

postulations of authoritative persons are not very sound.

In general, I am opposed to all forms of pedantry and consider the propping up of my investigations by references to the works of others a form of needless cowardice in the face of criticism.

CHAPTER 6

THE NATURE OF BLENDING OF PARENTAL HEREDITARY CHARACTERS IN HYBRID SEEDLINGS OF FRUITERS

When investigating the application of Mendel's law to the hybridization of cultivated varieties of fruit plants, I recommend that, as a beginning, the investigation be confined to observing the hereditary transmission of one of the two characters, just as Mendel himself did in his work on peas. I find it particularly useful to indicate a few of the best and in every way exemplary experiments in hybridization.

In these experiments a proper choice of the pair of parental plants, i. e., of both the male and the female parent, opens a wide opportunity for carrying out simple and precise observations from the very beginning. Quite suitable for this purpose are such characters, as the colour and the shape of hybrid seeds, the intensity of the colour of cotyledons, also—the colour of leaves, shoots, and flowers and, finally, the shape, structure and colour of the fruit. Occurrence of some of the above-described mutually correlated

changes in structure due to a distinct manifestation of some characters, that had hitherto been in a recessive state, may occasionally be observed in the course of these studies.

Here there is great scope for applying the whole Mendelian calculus to the entire complex of characters of each hybrid.

Furthermore, it can be ascertained in the course of these experiments that if the pair of parent plants belongs to different species, then, despite the generally accepted view, most of the interspecific hybrids thus obtained gradually become quite capable of producing germinable seeds during the few years subsequent to the onset of, if not in the very first years of, their fruiting.

Most fruit-plant species have races or varieties characterized by some parts of the plants being more or less red in colour.

On crossing such a variety to a plant with leaves, shoots and buds of the usual simple green colour and with white flowers, throughout the entire period of development beginning from the cotyledon stage the degree of blending of parental characters will be clearly indicated by the intensity of colour of every part of the hybrid seedling derived from such a cross.

On the basis of my own work, I would recommend to use for these exemplary hybridizations the following pairs: of the apples, *Malus Nied-*

zwetzkyana is good as the male component, and as the female component the following cultivated varieties might be indicated: Anis and its variants, Korichnoye, Kandil Sinap, Chelebi, Chelebi-Kitaika and, especially, Bellefleur-Kitaika and Skrizhapel and its variants. Among pears the best male parent would be Krasnoplodnaya Burakovka; the female parents that may be used in crosses with that male parent are: Tonkovetka, Limonka, Malikovka, Russkaya Moldavka, Bergamotte Zelyony, Pobeda. Among plums I recommend as the male parent *Prunus Pissardii Koehne*, a variety with red leaves; as the female parent: Ochakovskaya, Nikolskaya Belaya, Chernosliv Kozlovsky, Green Reine Claude and the hardy Japanese plum Botan. Among peaches the male parent recommended is *Persica foliis atropurpurea Zab.*, a variety with red leaves. Any of the common cultivated varieties might be taken as the female parent. Among nuts the red-leafed *Corylus avellana atropurpureis K.* and the common hazelnut may be used.

As for sour cherries, no red-leafed varieties of this species or of any closely-related species are as yet available in our country, so that, instead, for a sharper contrast in the structure of shoots and the shape of the leaf blade various races of sweet cherries have to be used as the male parent in crosses with the different varieties of sour cherries.

If the plants to be used as parents are not available and the crossings cannot be made, seeds should be obtained from red-leafed plant varieties that originated from natural cross-pollinations in their native localities. The experiments should then be confined only to planting the seeds and to making observations on the development of the seedlings from the very first days of germination.

It should be pointed out that when choosing the maternal parent preference should be given in general to those varieties from which seedlings are obtained that in their constitution deviate towards cultivated forms, i.e., even if they are not perfectly constant—which is actually never observed in seedlings of cultivated varieties—such should be chosen that at least do not give rise to specimens of rough and wild habit. It is with this in mind that I iterated the above-mentioned varieties as the more suitable for the role of progenitors.

The urgent necessity for such practical model experiments is quite obvious nowadays from the use that they bring, particularly in educating and training new young specialists for socialist horticulture, familiar with the practical methods of producing new and improved varieties of fruit and small-fruit plants.

CHAPTER 7

DETAILS OF CROSSING AND SUBSEQUENT CARE OF HYBRIDS

I now proceed to set forth in full the details of the work according to the second and the third methods (see Chapter 3).

And so, in order to produce new, better quality varieties of fruit plants, we must cross our hardy old varieties of fruit plants with the best foreign ones. For this it is of course necessary to obtain beforehand plants of these varieties, and, where wintering sheds specially built for planting these varieties with a view to protecting them from the winter frosts are not available, each plant has to be put in a separate wooden box, which should be forty centimetres high and as much across at the top and thirty centimetres at the base. Three round holes, two centimetres in diameter each, should be made in the bottom for draining superfluous water. Over the bottom of the box it is first necessary to spread a drainage layer two centimetres thick made up of brick

rubble and covered with coarse sand. Only then the box should be filled with earth consisting of one part of completely decayed manure two or three years old, two parts of not very fine sand and three parts of black soil. Into this mixture the sapling is planted after the ends of its roots have been pinched with a sharp knife and all of them have been dipped in a thick solution of clay.

The box with the sapling in it is placed at first somewhere in the shade, near the wall of some structure or near a fence, and should be well watered with river or rain water. The box must not be moved about or shifted to another place soon after the watering; otherwise the shaking may cause the still moist earth to settle markedly and become compressed, and this is sure to have a very harmful effect on the plant. Saplings should be obtained preferably grafted on low-growing stocks: apples on Paradise or Doucin stocks, pears on quince, plums and apricots on blackthorn, cherries on Mahaleb.

It is much better, however, if all the plants, both those which are to serve as female and those which are to serve as male producers, are not grafts but own-rooted—obtained by layering. For the easier rooting of layers of cultivated varieties of our fruit plants I have now elaborated a special method quite accessible to all, a descrip-

tion of which is given below. That it is of much greater benefit in hybridization to use plants having their own roots rather than grafted plants is a fact which has become obvious to me as the result of observations and numerous experiments. One glance at rows of hybrids from progenitors having their own roots and hybrids from those grafted on stock (from wild varieties) standing next to each other, will convince anybody once and for all that the structure of the former is far superior to that of the latter.

This fully proves that the root system is most closely involved in the building up of the seed.

When it is impossible to obtain ready plants of the best foreign varieties for crossbreeding, or if it is not desired to waste several extra years for their layers to grow, all that can be done is to order from southern fruit farms the pollen of such varieties, and the orders should be placed in good time, towards the end of the winter. If it is sent by mail before the local varieties begin to flower, it is necessary to bear in mind that, when preserved in a dry state, the pollen in any event retains its fertilizing capacity for a month. It should be noted here once again that for greater success it will be of much advantage to replace even our hardy varieties of fruit plants with varieties from colder northern localities: the two

parent plants will thereby be placed in new environmental conditions, conditions to which neither of them is accustomed, and this will prevent the dominance in the hybrids of the characters of our local varieties by virtue of the fact that the conditions in our localities, which are their native habitat, are more favourable and habitual to them. This circumstance is of considerable importance for the flavour of the hybrid fruits, their size and the prolongation of the period of ripening in winter storage.

Let us now examine the process of crossing in all its details. After choosing, on the basis of the conditions for better mating already explained, pairs of parent plants for crossing and after ascertaining which flowers on the maternal plants are best suited on account of their location, it is necessary to open the buds which are ready for blossoming the next day and, using tweezers or scissors, carefully castrate them, removing all stamens with the pollen sacs. Then, in order to prevent undesirable pollen from other plants being carried over by the wind or by insects, all such castrated flowers are to be covered with little bags of white gauze or some other white transparent stuff.

One or two days before the castration, pollen sacs of the male parent plant are collected from the flowers already beginning to blossom, in a

small glass jar, which is then covered with gauze and put away in a dry place. The work of cross-fertilization begins on the day following the castration of the flowers of the maternal plant, the best time being the morning hours (from eight to twelve). The jar with the collected pollen should be slightly shaken and the pollen which has settled on the walls of the jar should be gathered simply with the end of a finger or, best of all, with the end of a thin plate cut from soft cork or rubber, and applied to the stigma of the pistils of the maternal plant. The flower thus pollinated is then again carefully covered with a little gauze bag. Such pollination should be repeated in the course of the next three days. In dealing with interspecific crossings definitely known to be difficult, I have often achieved success by adding a very small amount of pollen from the maternal parent to the pollen of the male parent. This, in my opinion, has helped better to stimulate the stigmas of the pistils, particularly if the stigma is of a somewhat compound structure, and not simple, as in the case of stone-fruit plants. When the mentioned method is employed there forms on the stigmas a substance peculiar to each species of plant, which helps the pollen grain to germinate. Further, in the 'nineties I made use of the influence of discharges of statical electricity upon the pollen, but the cause

of success could hardly be attributed to the action of the electricity alone, which in these experiments was inseparably connected with the inevitable ozonization of the pollen.

The pollen was also subjected to the action of weak inductive currents of electricity. Lastly, it was placed for a brief period of time in the interpolar space of powerful magnets. I shall not set forth here the results of such experiments or what deductions are to be drawn from them, in view of the fact that they have not been completed.

Such experiments, if they are to be conclusive, require all one's time—a condition which I could not meet. Here I have made brief mention of them only to point out to my followers the possibility of applying them in hybridization.

But to go on. The fertilized flowers, covered with gauze, and supplied with a cardboard tag bearing the number and name of the variety of the male parent, are left in this state until the fruit is fully matured, to prevent them from being injured by any insects. On the maternal plant it is necessary to remove superfluous flowers and as far as possible to prevent the shading of the fertilized flowers. Besides, care should be taken to ensure the general well-being of the maternal plant by the usual methods, excluding only such

measures as may prove unsuited for the aims pursued because they hinder the development of the desired qualities of the new variety, as stated above. After the mature fruit has been plucked it should be left lying for at least a week in the case of early varieties (summer-ripening) and for several months in the case of fruits which remain fresh in the winter. After this, in the case of drupe cultures the stones are immediately planted in beds; in the case of pomes which mature in the summer, however, the seed, after being dried for two or three days, are stored in sand until they can be planted in the autumn directly in beds. In the case of varieties which mature and remain fresh in the winter, the seed are collected only when the fruits begin to spoil, but not later than in April, and are immediately sown in boxes prepared beforehand. When the seed are sown in boxes the varieties are separated from one another by glass partitions, and zinc tags bearing the name of the variety are placed in each compartment.

The box is then protected from mice by a wire netting fastened to its edges, and is covered with a layer of snow five centimetres thick. The melting of the snow at room temperature serves as the first watering.

After this, the box with the planted seeds is carried into the garden and buried in the snow

dug down to the soil, where it remains until the spring.

Hybrid seedlings, if there were delicate foreign varieties among their progenitors, should in our localities be reared on meagre sandy soil easily permeable to water, so as to prevent the development of luxuriant growth with a crumbly structure of the woody tissue and a too protracted vegetative period of growth, as mentioned above. And yet it is necessary by timely pinching off of shoots at the end of each summer to check further growth of individuals that are late in terminating their growth. When pricking out the young growth after the formation of the third leaf, above the cotyledons, when transplanting the one-year-old plants, and, lastly, during the final planting out at the age of three years, the plants are provided different areas: 400 sq. cm. for each individual at the time of pricking out; 2,500 sq. cm. for each one-year-old; and, approximately, from 2 to 4 sq. m. for each three-year-old, where they remain until they begin to bear fruit. All species of drupes (apricots, peaches, cherries and plums), when being pricked out, are planted with larger intervals between them than in the case of pomes, because they suffer greatly when transplanted before they have borne their first fruit and, gradually deviating in structure towards that of wild species, they lose most of their good qualities.

They may, when absolutely necessary, be transplanted—and that with great caution—in the spring, and only at a later age. But in the case of particularly valuable hybrids of drupe cultures it is best not to transplant them at all, but wait until they have borne fruit for two years and only then propagate the best strains by engrafting on suitable stocks.

In order to graft a new variety of sour or sweet cherry for the first time, it is better in all respects to start by getting a supply of seedlings of white sweet cherry, even if of a wild variety.

I insist on white because if a sour cherry hybrid with fruit of a white colouring is obtained, such a hybrid, grafted on the stock of white sweet cherry seedlings, will not change the colouring of its fruits.

I have found the influence of the stock most strongly pronounced in the case of the new variety Krasa Severa, whose fruits on the maternal seed tree were a pure white, but when propagated by grafting on the seedlings of the common red sour cherry, the fruits on the grafted trees were of a pink colouring. Here it should also be noted that new hybrid varieties of drupes in general and cherries in particular, when first budded, yield a very small percentage of buddings that have joined, and only when grafted in the second year with cuttings from individuals

that joined in the previous year, the budding is more successful. In the subsequent years the percentage of buddings that join gradually reaches the normal.

The same is observed also in pomes, only in a less pronounced form.

We find an analogous phenomenon in the propagation of fruit plants by layers and cuttings.

Here too the first cuttings and layers of the new variety take root with incomparably greater difficulty than cuttings obtained from a specimen already layered or grafted; those obtained from the latter, rooted, specimens develop roots much more easily and quickly.

Even among currant hybrids we find varieties whose first cuttings require a hotbed for rooting, whereas the subsequent cuttings take root even when planted in the autumn directly in the ground.

We see from all this that only gradually does each plant become accustomed to the various operations performed on it by man.

I further repeat that, since recent experiments have fully corroborated that the completeness of hereditary transmission of the best characters of foreign varieties to hybrids largely depends on the influence of external factors, it is necessary under our climatic conditions as far as possible

to eliminate or at least partially to mitigate the influence of harmful and to promote the action of useful external factors. Since it is known, for example, that strong winds have a very harmful effect upon hybrids when they are young—in the first three or four years of their life—because they hinder the work of the leaf system—the seedling beds should be placed, as far as possible, where they are most protected from the winds, overdrying should be avoided, the soil hoed in proper time, and the weeds removed.

The best and fullest possible development of the structure of each plant organism depends entirely on the work of the leaf system. The larger the number of leaves and the more complete their development, the better does the building up of the other parts of the plant proceed. It is therefore necessary to take good care to protect the entire leaf system from various pests by administering timely sprayings with specially compounded chemical solutions (fungicides) against scab, rust and other diseases caused by parasitical fungi.

I recommend as the best compound for such sprayings: 100 grams of blue vitriol ($CuSO_4$), 100 grams of quicklime (CAO) and 10 grams of treacle to a vedro of water. Against gooseberry mildew (*Sphaerotheca*) I recommend a solution

of 60 grams of liver of sulphur, which is a mixture of potassium polysulphide and thiosulphate (there is no definite formula), or from 30 to 60 grams of soda (Na_2Co_3) to one vedro of water.

Spraying with insecticides should be applied against insect pests which attack the leaves. To destroy various aphids, scale insects, etc., I regard as most convenient the washing of the leaves with a broth of 150 grams of quassia in one-fourth of a vedro of water, to which there should be added, after cooling, 100 grams of green soap, 10 grams of treacle and another three-fourths of a vedro of water. The spraying should be administered towards the end of the day.

In general, it is necessary to exercise great caution in applying solutions for spraying young, one-year-old hybrids. Weaker solutions should then be employed.

Otherwise, wrongly compounded solutions may often injure the plants, which in this case is of particularly great importance. For example, tobacco dust or a broth of tobacco are sometimes used to protect plants against aphids; but under no circumstances should young, one-year-old seedlings of plants, especially of drupes, be subjected to this treatment.

One-year-old cherries perish completely as the result of such treatment.

If these conditions are observed the characters of the best foreign varieties have a chance to develop more fully in the hybrids. Otherwise, even when they are transmitted to the hybrids, they will, in the absence of conditions favourable to their development, remain in a latent (recessive) state.

CHAPTER 8

CARE OF HYBRID SEEDLINGS: SOME SPECIAL METHODS

1. Hybrid seedlings must be prevented from developing a large number of small twigs by pinching off the side branchings in order to direct the flow of sap to the growth shoots. It is particularly necessary to perform this operation on drupe cultures, which in the early stages of their development are very prone to deviate towards a wild form with small branchings in the aerial parts, with the result that their fruits are of small size.

2. The first application of manure to seedlings should be made, as pointed out above, only when the plant begins to form its fruiting organs. The provision of extra nourishment should be continued in the course of the first three to five years of its fruit bearing, because during this period the young hybrid seedling establishes the form and quality of its fruit, after which, in the succeeding years, the entire structure of its organism remains unchanged.

3. Even the neighbourhood of other varieties of the same species of plants during this period exercises, through their fertilizing pollen, a very great influence upon the form and quality of the fruit of the new variety, altering them in their own direction. If this influence continues for several years in succession, the alteration is fixed and becomes stable in the new variety.

This phenomenon is strikingly in evidence also among old varieties of fruit plants—for example, in the apple trees Bessemyanka, Antonovka and even our traditional Grushovka, and, of my varieties, in the Paradox. Here lie most of the causes owing to which the fruits of one and the same variety, but from different orchards in the same locality, are of different merit and even priced differently in the market. The influence of cross-pollination with neighbouring trees of other varieties, coupled with the action of a whole complex of local climatic and soil conditions, sometimes changes the qualities of the fruit of even our old, long familiar varieties of fruit plants to such an extent that fruit growers erroneously give new names to such strains, which results in a great deal of confusion. It is reckoned, for example, that as many as twenty-six strains of Antonovka apples are to be found in our orchards, although actually there exist hardly five strains, which have been produced by the planting of An-

tonovka seeds in various localities. Among the others we find either strains which have nothing in common with the Antonovka, for example, the Antonovka-Kamenichka, placed in the market by the Janichen nursery, and the Antonovka Zolotoy Monakh put in the market by Kleinmichel's nursery, or strains representing the ordinary Antonovka only temporarily modified by the influence of special environment conditions. In the orchards in the environs of the town of Belyov, for example, there is an ordinary Antonovka whose fruit retain their freshness until the spring, although as a rule the Antonovka becomes mealy and begins to spoil already in January. Another example: in the reproduction department of our breeding and genetics experiment station, in the old orchard, we have an Antonovka with fruit of a particularly dark-green colouring, which is apparently due to the action of the pollen of a number of neighbouring Arabka trees.

Nevertheless, the qualitative vegetative deviations are lost after transplantation to localities with other conditions, and the fruits become those of the ordinary Antonovka, as an old variety with stable properties.

In young hybrid varieties, on the other hand, and in the first years of their fruit bearing, such alterations may become fixed and remain forever in the new strain. All this must be borne in mind

when training young hybrid seedlings. It is necessary, as far as possible, to eliminate undesirable or, in general, harmful influences of the environment and promote the influence of useful factors in the first three years after the saplings of the new varieties begin to bear fruit and until they attain complete stability in their structure.

CHAPTER 9

THE MENTOR METHOD AND THE VALUE OF GROWTH PROMOTERS

It not infrequently happens that hybrid seedlings, particularly if produced by crossing flowers from trees grafted on wild stocks or on stocks of a different species from themselves (apple on Paradise, pear on quince, etc.), have poor root systems incapable of sufficiently nourishing the aerial parts of the plant. This makes itself apparent in shoots too thin and leaf blades too small for the general form of the plant. In such cases, by way of replacing the inadequate root system, I use as "mentor" a well-grown two-year-old stock—the seedling of some cultivated variety with suitable properties; into it I bud the best eyes of the hybrid seedling, or else graft a cutting from the seedling onto its bark. Among apples I find Skrizhapel seedlings the stock best suited to the role of mentor; among pears, seedlings of Tonkovetka; among plums, seedlings of Ochakovskaya; and among cherries, seedlings of the wild white sweet cherry. Although as the result of such

a graft the young hybrid seedling does change under the influence of the stock, this change is preferable to that which might occur if it were left on its own inadequate roots.

If a hybrid seedling is insufficiently hardy, it must be subjected anew to the influence of that of its parents which acted in the cross as transmitter of frost resistance. To accomplish this, cuttings of the seedling are grafted temporarily, for some two or three years, onto the crown of this parent, which serves in such cases as the necessary mentor for inducing greater hardiness. This is what was done in the case of the new Kandil-Kitaika variety of apple.

If the fruiting of a hybrid seedling is abnormally delayed, it often helps to graft onto its crown, by way of an inducing mentor, fruit-bud-bearing cuttings of some abundantly-yielding variety. Among apples one may take as such a mentor Slavyanka, Tayozhnoye, Anis, etc.; among pears, Tsarskaya, Bergamotte, etc. Such grafts remain on the tree only temporarily, for some two years, after which they are cut out. Such artificial forcing of fruit bearing succeeds only in the case of older hybrids, of over ten years of age, not in the case of young seedlings.

Here I must warn many people against the mistaken fashion of grafting hybrid seedlings onto the crowns of adult fruit trees in hopes of has-

tening the onset of fruiting in the new seed-grown variety. First of all, as I have said, this works only if you graft old varieties that have long borne fruit, and not young, not yet bearing hybrid seedlings; the onset of fruiting in the latter, far from being hastened, is delayed by it. Moreover, as the result of such a graft the new seedling variety in most cases loses a large proportion of its best qualities and sometimes actually shows a strong tendency to run wild. That may be clearly perceived the year after the grafting if a shoot from the graft is compared with shoots of the own-rooted seedling. This degeneration is occasioned, first of all, by the grafting process itself, by the young seedling undergoing an unaccustomed operation, with subsequent formation of a union between the cutting and the stock; all this is fraught with suffering, as it were, because essential vital functions of the plant are interrupted. Secondly, it is due to the potent influence of the stock, as an old variety possessing a great individual power of modifying the young organism of the seedling. This latter circumstance produces considerable complications in the hybrid's constitution, since included among its properties now are properties of the stock as well, so that the result is already a vegetative hybrid.

From what has been said, it would appear that all the methods usually employed to reduce the

excessive length of time between germination and fruiting of hybrid seedlings fail to achieve their purpose. But this is a state of affairs that can hardly be accepted. Man's life-span is so short that, after growing to adult age and spending two or three decades more on a thorough study of the laws of plant life, he is barely able, in the second half of his lifetime, to rear two or at most three generations of seedlings to fruiting age along the lines he desires. And that is certainly not enough for control experiments which would clear up many problems and riddles in the breeding of new fruit varieties. Searching for a way to overcome this difficulty, I discovered in 1924 the following amazing results of treating sprouts of the Posrednik almond with a 0.02% (by weight) aqueous solution of potassium permanganate ($KMnO_4$), as a vigorous growth promoter for the seeds of certain species. The results surpassed all expectations. Here I must mention first of all that, in our soil, seedlings of this almond variety usually grow during the first year to a height of 50 cm., during the next five years they attain a stature of 180 cm.,and only in the sixth year do they bear their first fruits. When treated as I said, however, four such seedlings grew in the first year to a height of 180 cm. and formed flower buds, while in the second year they flowered and bore fruit.

This astounding leap in development was effected by the chemical catalyzing agency of the manganese, which not only enormously hastened the growth of the almond plant, but made itself felt in the second year as well, affecting the stones of the ripened fruits: the stones opened while the fruits were still on the branches, and the seeds sprouted. A diminution was also to be observed in the size of the fruits and the leaf blades, probably in consequence of excessively rapid growth and insufficient absorption of nourishment from the soil.

And although treatment with this manganese solution produced no effect on seedlings of pomes (apple, pear, quince, mountain ash, etc.), yet this fact I have described gives full grounds for hoping that at no distant date we shall find suitable chemicals for hastening the growth of other fruit plants too.

I have also succeeded by the mentor method in partially obviating various undesirable qualities of the fruit during the early fruiting years of a new variety. Here is an example. By crossing the first-rate American winter variety Yellow Bellefleur with our orchard Kitaika, I got a new variety with large fruit-size and splendid flavour, which I called Bellefleur-Kitaika. Its first fruits ripened in the latter part of August and kept only until mid-September. Such early ripening was, of

course, highly undesirable and needed to be remedied. To do this, I used as a mentor the renewed influence of the maternal variety. Some cuttings of the American Bellefleur were grafted in the crown of a tree of the new hybrid type. And beginning with the very next fruiting, the time of ripening receded gradually to a later date, until finally the fruits kept in winter storage until January.

Mentor action in transmitting colouring pigment has been revealed in a case I have cited before—the case of propagating by grafts the new cherry variety called Krasa Severa, which got its pigmentation from being grafted onto seedlings of the red cherry. But it is not every hybrid variety that is receptive to such transmission of colouring pigment. As an example of that we have a case when two green-leafed apple hybrids were grafted onto the same red-leafed Niedzwetzkyana stock: the fruits of one took on the colouring, but those of the other showed no trace of it. The mentor method described above had a beneficial influence in many different ways in the case of a hybrid of the bird cherry and sour cherry.

A refining influence was exerted by the mentor in the grafting of a hybrid seedling of the Beurré Easter pear. This was a ten-year-old tree which, while satisfactory in all other respects, had large

numbers of long prickles and was very slow in growing. When slips from this hybrid were whip-grafted into the crown of a five-year-old grafted sapling of the Michurin Beurré Zimnaya, half of the vigorous limbs put forth by these slips were entirely without prickles, while the other half did have them, if only a few. It has thus become possible to propagate the new variety from the better, prickleless shoots only.

Of course, it is not all its characters that a mentor imparts; in most cases it is only individual ones among them. For example, on one occasion, when the Posrednik almond was grafted on a particular variety of plum, we got luxuriantly-developing shoots, but the union of these almond shoots with the plum was so precarious that at the end of the summer each shoot separated easily from the stock. When, the same summer, we took eyes from these vigorous almond shoots and budded them into the plum, the shoots resulting from this the following year were not of particularly luxuriant growth; but, on the other hand, the union was complete. Here we see the plum stock exerting its influence through first-year buddings on second-year grafts.

And, lastly, a profoundly interesting and highly valuable experiment has been carried out in our nursery by my immediate assistant, P. N. Yakovlev. In this experiment, lemons have

been grafted as mentors onto a pear, one on June 5 and the other on October 25, 1926. Here we have an opportunity to observe the influence exercised on each other by two plants belonging not only to totally different species and genera, but even to two different tribes—in the one case, one-year-old seedlings of the lemon, an evergreen subtropical plant (*Citrus Limonium Risso*) from Central Asia, in the other, a one-year-old hybrid seedling of the Michurin Beurré Zimnaya pear. It was probably only because they were so young and were taken out of their accustomed environmental conditions that the two could lend themselves to such symbiosis. The lemon, being an evergreen plant, naturally did not shed its leaves with the coming of winter; nay more, at quite an early stage it correlatively, through its influence upon the root system of the stock, prevented the pear too from halting in its growth and losing its leaves, although next to it, in the same room, similar hybrid pear seedlings potted out at the same time discarded their foliage at the usual season.

I need hardly say that we have no intention of growing lemons grafted on pears; we only want by this experiment to see and study the vegetative influence exercised on each other's constitution by two plants essentially so far apart.

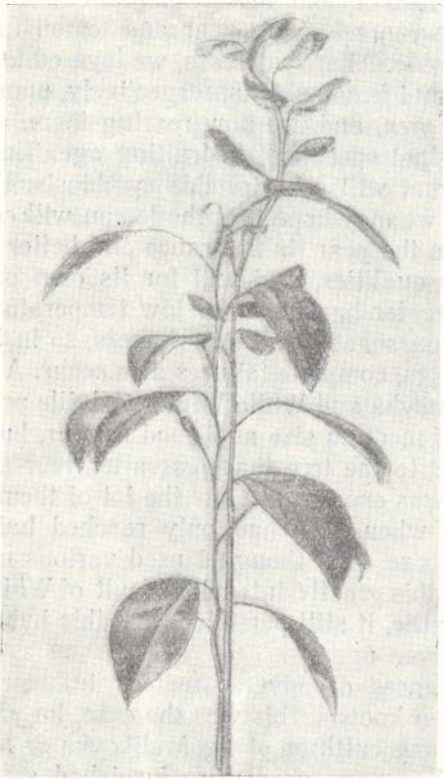

Fig. 5. A six-month-old lemon graft on pear (the larger leaves are the lemon)

For further and more comprehensive observation, we are leaving pear and lemon to grow side by side. After two years, we layered the ends of pear and lemon shoots, respectively, upon roots of their own, and are now rearing them, as also the original specimen, to fruiting age. Time will show what will come of this symbiosis. For the present we may hope that the lemon will communicate to the pear its fragrance and better winter keeping qualities, and will for its own part acquire greater hardiness for low temperatures.

Of course, as in all experiments, so in the use of mentors, complete failures also occur. A hybrid of Antonovka and White Winter Calville produced fruits of medium size and good flavour, but so ill attached to the tree that year after year a slight breeze was enough to blow the lot of them to the ground when they had only reached half their normal size. And though I used various mentors to cure this greatly intensified fault of White Winter Calville, it still persisted, and this hybrid had to be given up.

Instances of adverse mentor influence have also been known. This was the case, for example, when some cuttings of the Malikovka or Moldavskaya Krasnaya pear were furnished as mentor to an adult of the new Bergamotte Novik pear, in order to increase the latter's yield. Here the results of mentor action were of a somewhat unex-

pected kind. While the Novik yield did increase greatly, the fruit-size diminished by half and ripening was delayed by half a month. As for the mentor itself—the limbs of the Moldavskaya Krasnaya scions—in the first fruiting years they bore fruits twice the usual size, but afterwards this feature gradually disappeared. So in this case the mentor did nothing but harm.

CHAPTER 10

ACTION OF MENTORS AND THE CONCEPT OF "XENIA"

First of all let us examine the doubts entertained by some horticulturists as to the possibility of what is known as "mentor" action. These, in effect, naive doubts are the direct outcome of insufficient practical knowledge on the part of many theoreticians. First of all, these people forget about the long and generally recognized influence of the stock upon the scion; secondly—and this is the chief thing in the present instance—they fail even now to realize that in young hybrid plants in the early stage of their development the faculty of changing constitutionally under various environmental influences is so much stronger than in firmly-stabilized old, long-standing species and varieties, that to judge of the change of the former by the latter is absolutely impossible. It would be laughable, you will agree, to compare the extent to which a child's organism reacts to its environment with the reaction of an adult or old organism. A blade of grass bends in the

lightest breeze, while on a grown tree that breeze makes no impression whatever.

And if in propagating old fruit varieties we are compelled to recognize, after all, that the stock does undoubtedly influence the constitution of the scion—a thing now proved by thousands of examples—then, by sheer force of logic and common sense, even without any experimental verification, we have to recognize the ten times greater force of this influence upon young hybrid seedlings whose constitution is only just being formed.

And I in the course of my practical work, observing numbers of these phenomena constantly over a period of many decades, could not help arriving at the conclusion that if a whole root system exerts maximum influence upon a comparatively small scion of an old stable variety, then, conversely, though in lesser degree, a young hybrid seedling must also be influenced by having a cutting of some stable old variety grafted upon it; particularly as here the lesser potency of influence is compensated by the young hybrid's considerably greater susceptibility as compared with old stable varieties. And so it proved in the course of practical experiment, though the latter also showed that the result is by no means always a success; it all depends on the individual constitutional properties of the pair of plant organisms joined together.

Now let us make a general survey of all the factors by virtue of which one species influences another when they are conjoined.

First of all let me note the long and generally known influence of the dwarf Paradise, Doucin and quince stocks, which figure so often in our horticultural work in producing fruit trees trained for form. Here we see that, when grafted upon such stocks, our old, quite stable varieties alter many of their properties: the growth of the shoots is cut short, the fruits become larger and more highly coloured, the flavour of many varieties improves considerably, especially in the case of pears on a quince stock—and some of these changes are caused wholly by the influence of the stock, while others proceed from intensive culture.

Further, I have had occasion to see adult pear trees which had been grafted by accident upon an apple stock; the taste of the fruits changed quite considerably as a result.

Then, a discovery made in my nursery among a party of grafts of a single pear variety. Among these trees, which had already reached fruiting age, I found one whose fruit, while outwardly identical with the grafted variety, had flesh of so firm a texture as to be totally inedible. Suspecting this to be a chance sport variation of the bud grafted on this particular tree, I tested it by grafting a cutting from this tree onto the crown of

another. But the limb that grew from the cutting bore fruit with good flesh, convincing me that my surmise had been mistaken. Clearly, the thing was due to exceptionally strong influence of the stock.

Lastly, when a young tree of a tender southern variety survives as a chance exception in our orchards in the north (such trees are falsely regarded as acclimatized), it does so simply because it had the good fortune to land on a stock with a peculiar capacity for increasing the hardiness of the southern variety. Proof of this is the fact that grafts grown from cuttings from such specimens turn out to lack hardiness.

I should remark here that both in this last example and in all that went before, all changes in the properties of old, long-standing varieties proved to be unstable and conditioned only by the influence of a particular kind of stock. When the varieties in question were transferred by grafting onto ordinary, usual stocks, all these changes vanished without a trace.

The picture is very different as regards the influence of a stock upon a young hybrid that has been grafted onto it. Here the one- or two-year-old hybrid seedling, whose constitution is only just being formed, succumbs in maximum degree to the influence of the stock, and all changes occurring in it are to be observed in subsequent he-

reditary transmission. In the years that follow, as the seedling develops to fruiting age, its receptivity to changes in its properties diminishes gradually, until by the time of complete maturity the hybrid tree attains maximum constitutional stability, equal to that of old, long-standing varieties.

In making a general study of all changes produced in plants by hybridization, one must also mention, of course, the earliest manifestations of such changes in the fruits and pericarps. For some reason, it is the general practice these days to describe outward changes in the fruits from crosses of two varieties as "secondary xenias," treating such changes as due to the influence of the male parent's pollen. Here I perceive much that is wrong. In the first place, such changes may result from the influence either of the immediate or of distant progenitors of the variety that provides the pollen; and secondly, they depend to no little extent on the influence of environmental factors upon the formation of the hybrid embryo in its seed—that is fully proved by the fact that the types of xenia vary in different years, though the combination of crossed forms is the same.

Then, too, supposing one does accept numerical designations for different types of xenia, it would be more fitting to describe a change in the appearance and even in the internal struc-

ture of the pericarp as tertiary, not secondary xenia, considering that the real, essentially important change induced by hereditary transmission occurs not in the pericarp, nor even in the whole of the seed, but only in the structure of the embryonic radicle of the seed, and this is what should be called primary xenia; a change in the structure of the accessory parts of the seed—the future cotyledons—will be secondary xenia, and a change in the pericarp, already tertiary xenia. Now secondary and tertiary xenias, which fluctuate in form and depend to a great extent upon the influence of the environment, are actually of no significance whatever for practical work; and all efforts to study them,

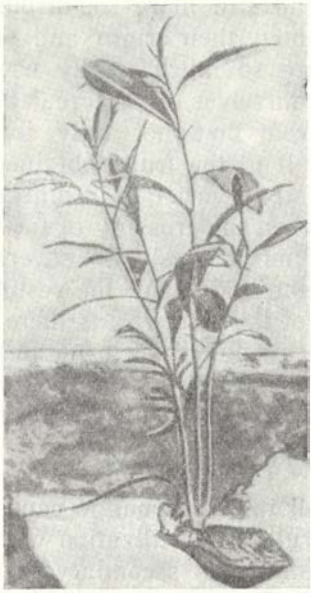

Fig. 6. The result of fertilizing almond with apricot pollen (the fruit obtained had an almond seed with four kernels from which four plants developed)

and still more so, disquisitions and hypotheses about their origin and sketches of their forms, are so much totally useless labour. Judge for yourselves. Every real horticulturist must have seen that not only to different changes result in the fruits obtained by crossing the same pair of varieties in different years, but that even when the crossing of the two varieties is effected simultaneously on several flowers of the same maternal plant, the resultant forms of xenia are not the same. So is there any purpose in making drawings of such infinitely varied phenomena, to describe which is simply laughable, not to say more? Yet many people pore over this futile occupation.

Thus it should be remembered once and for all that the change caused in the appearance of fruits by fertilization with alien pollen (which is known as secondary xenia) varies infinitely in most cases as regards both the shape and the colouring of the fruit, and exhibits no recurring regularity whatever. One year, or very seldom in two years, you get one form, while in succeeding years, crossing of the same pair of varieties produces a totally different form of both fruit and pericarp. It all depends entirely upon the conditions of the environment, that mighty factor operating throughout the universe, under the influence of which all forms of living organisms, with the hu-

man species at their head, have taken shape. And so it is pointless to found any conclusions on such inconstant phenomena. All attempts to reproduce on paper the forms of these infinitely diversified changes in the fruits are, in effect, a useless occupation which cannot be of any practical value at all.

But let us go further. Let us assume that the combination of parent plants for crossing was suitably chosen. We plant the resultant seeds. We get seedlings, and here we encounter an infinite diversity of constitutional form, determined by the hereditarily transmitted characters of the parent plants, and also, once again, by the environmental conditions prevailing at the particular time. Still, the general degree in which each of the seedlings tends towards culture properties can be seen, and it enables one both to choose the best among them by its outward appearance and, if so wished, to employ mentors in order to accentuate the deviation in the desired direction.

That will be expedient if we see that the development of the aerial parts of some of the better seedlings is retarded by an inadequate root system. This is very often the case because of the hereditarily transmitted influence of the parent plants' wild stocks, particularly if these latter have long been propagated solely by layering, as for example quince, Paradise, etc., which in the

role of the parent tree's stock mostly produce, in hereditary transmission, hybrid seedlings with very poor root systems.

Here the seedling must be given as mentor a stock with a well-nourishing, strongly-developed root system—in the case of apples, for example, extra well-developed seedlings of cultivated varieties, particularly Skrizhapel; in the case of pears, seedlings of Tonkovetka; in the case of plums, the cherry plum; in the case of cherries, the sweet cherry; in the case of roses, the Leucantha rose; and so on. The development of the hybrid can nearly always be considerably improved in this way. In general, by such provision of mentors we increase the number of choice hybrids by more than half.

In the same way, the vegetation period of the hybrid can be reduced or increased by supplying as stock a species with a shorter or longer vegetation period.

In addition, by this method we can sometimes change the hybrid's constitution so much as to obtain a totally new type of plant. This is done by inarching the hybrid seedling with another hybrid seedling of a different species or even a different genus.

Usually in such experiments, where different species and even different genera are joined together, we leave the stock its mainshoot with part

of the foliage, so that the substances elaborated by the leaves of the stock may help to work more considerable changes in the scion and also in order to nourish the stock's root system.

It is sometimes possible to induce such changes by supplying a mentor to an adult but not yet stabilized hybrid, which is done by grafting cuttings of the mentor variety onto the main branches in its crown; but, of course, the results will not be as stable as in the case of younger hybrids.

Let me describe in this connection several particularly revealing instances of mentor influence in its various applications.

1. The largest-fruited hybrid cherry variety existing today is Krasa Severa, which I originated in 1884 by crossing Vladimirskaya Rannaya Rozovaya sour cherry with Winkler White Cherry. In its fourth year of growth and first year of fruiting, this hybrid produced very large early-ripening fruits of pure white colour. That same year, this variety was budded onto a whole block of seedlings of the common red cherry. Starting with the third year, the budded seedlings began to bear fruits of the same size, shape and flavour, but pink in colour and somewhat later ripening. Here we see, in the first place, the influence of the stock upon the scion, manifested in the appearance of colouring pigment in the fruits; and, secondly, an instance of the mistakenly early prop-

agation of a young hybrid variety, which had not had time to fix its properties sufficiently, otherwise the stock would not have affected the colouring of the fruit, as it does not do when old sweet cherry varieties with white fruit are budded onto it.

2. In most cases when young hybrid seedlings are grafted onto the crowns of adults of wild species, or even of cultivated types, under the mistaken impression that the influence of the stock and its root system will hasten the fruiting of the new variety, the result is a marked deterioration in the qualities of the hybrid. This can readily be seen by comparing the various features of the hybrid seedling's appearance with the corresponding features of the branch that grows from the graft in the crown of the stock. What is more, this practice will not help at all to hasten the onset of fruiting, as it does when an old variety is grafted on in the same way. Here too, I repeat, it is excessively naive to expect the same results from grafting onto the crown of an adult tree a cutting taken from an old, long-standing variety and a cutting of a young hybrid seedling. In the latter case, the onset of fruiting, far from being hastened, is actually delayed.

3. Even at the time of the first fruiting, a young hybrid variety is often still so susceptible to external influences that its ripening period may

change even from fertilization with alien pollen. When a hybrid seedling of the Malgorzhatka pear produced its first flowers in the spring of 1927, and some of these flowers were fertilized with pollen from Michurin Beurré Zimnaya, the fruits from this cross ripened two weeks later than those which set from selfing. Here the alien pollen acted as a mentor.

4. An adult tree of the Bergamotte Novik hybrid pear set fruit very scantily during its first three fruiting years; this fruit ripened early (at the end of July) and was similar to the Bergamotte in shape. After some cuttings of the Malikovka pear had been grafted as mentor onto the crown of this tree, it fruited abundantly the second year, but two weeks later than before, and the shape of the fruits changed beyond recognition.

In addition, the fruits on the mentor scions themselves were twice the usual Malikovka size.

5. Sometimes mentor influence has proved effective in inducing fruit bearing in already adult trees of hybrid varieties which had long failed to bear; to serve as mentors in these cases, cuttings of old varieties noted for generous yields were grafted onto the crown.

But we get just the opposite results if we act on the misconception that the onset of fruiting in a young hybrid seedling at an early stage of de-

velopment can be hastened by grafting a cutting of it onto the crown of an adult, already bearing tree of some variety.

By doing that, we get exactly the opposite—instead of hastening the onset of fruiting, we delay it, except where this operation is performed not with a young hybrid variety, but with an adult one close to fruiting age. There, one can indeed secure fruits in the second or third year after the graft, just as when one makes the usual graft of any old cultivated variety. But judging by numerous experiments of this sort, this method in most cases impairs the quality of the hybrid. Whereas with old, long-standing varieties, that happens very seldom, and then only if the graft is made onto the crown of an adult of a wild species, when the whole leaf system of the wild specimen brings its influence to bear on the small limb developing from the graft.

6. Lastly, as the most striking instance of mentor influence, let me quote the following: in 1926 (as I have mentioned before) my immediate assistant, P. N. Yakovlev, potted out a one-year-old hybrid seedling of the Michurin Beurré Zimnaya pear and joined a one-year-old lemon seedling onto its stem by inarching. A complete union resulted, and the leaves of the pear seedling gradually changed their colour for a darker one, developed a glabrous surface, increased in thick-

ness of the blades, and did not fall in the autumn in the usual way, but remained unwithered for all of five years. Similarly successful results were obtained when a two-year-old lemon seedling was inarched with a one-year-old seedling of the Severnaya quince. Here the leaf-work of the lemon mentor—an evergreen subtropical plant—fundamentally altered the usual functions of the leaf systems of the young hybrids of respectively pear and quince.

When, however, it was attempted to effect such inarching with grafts of old pear varieties, union between these distant genera failed to take place.

There is a similar difference in the results of experiments in approximating two different species by grafting, as a preliminary to crossing them. These experiments too succeed only with very young hybrid seedlings, in the first year after germination. With old varieties, they are always a complete failure.

In general, most hybrid varieties grafted successfully at an early age on stocks of another species—as, for example, pears on quince, mountain ash, hawthorn, apple, and sometimes on even more distant species—retain the ability to grow freely on such stocks; whereas old varieties in many cases cannot be made to do this—witness the aversion which some pear varieties display

towards quince, etc., as stocks. It is this adaptability of young hybrid plants to external conditions that enables the hybridizer to alter their nature and shape it along the desired lines with the help of a mentor.

The various examples I have cited will, I hope, dispel the doubts and various misconceptions on the part of botanists as to the possibility of using mentors. It should at last be realized that the gap between the fixed properties of old fruit varieties and the weakly developed, only just forming properties of a young hybrid seedling is too wide for the latter to be judged of by the former. There you have the whole secret and cause of misapprehension, especially on the part of people who are only capable of rejecting the arguments of others, and not of producing conclusive evidence to the contrary.

Those are the practical conclusions that provide the answer to the misapprehensions existing in many minds as to the possibility of using mentors to improve the qualities of fruit-tree seedlings.

CHAPTER II

SELECTION OF HYBRID SEEDLINGS

In essence, I divide plant breeding into two sharply different kinds. The first is selection from the mass planting of a certain species or variety of plants of chance deviations expressed in the form of mutations, or such as result from natural crossing with other varieties. I regard this kind of plant breeding as the meanest kind of work an originator can undertake, for only an utter ignoramus can plant haphazardly tens of thousands of plants belonging to one variety and then pick two or three of the best specimens and destroy all the rest. What does man give the seeds of the plants to help them to acclimatize themselves? In all such operations he relies solely on chance, he hopes that among the seedlings there will accidentally appear one out of several thousand specimens that will be relatively more hardy.

This haphazard method of acclimatization is not only totally unscientific, but involves the state in heavy and scarcely productive expenditure of

forces and funds for conducting the work on these lines.

Nature alters the structure of living organisms, adapting them to the conditions of their environment only very slowly, barely perceptibly, in the course of whole millenniums.

By means of artificial cross-pollination (hybridization), however, it is possible to produce in relatively short periods of time considerable changes in the hybrid plants which gradually acquire complete stability if this crossing is repeated for several years.

Consequently, man should proceed only along this more reliable road and resort to selection from simple mass planting only in extreme cases when the possibility of employing hybridization is completely absent. Nevertheless, the majority of our experimental stations base themselves in their work exclusively upon selection from simple mass planting and put this method in the forefront.

Such miserable treasure hunters base themselves solely on the material possibility of mass planting and later are satisfied with isolated, chance finds among these plantings. It is permissible to resort to these methods of selection only as subsidiary work, when there is an extreme lack of experience in raising new varieties.

The originator must strive with the aid of hybridization and individual selection to prepare

beforehand not a hundred thousand, but only some tens of seedlings with approximately the desired structure of organisms and then, by proper training, to improve the largest possible number of them and make them worthy of and useful to man. In all my work I pursue only this aim, and very rarely, in extreme cases, only in between other work, do I permit the seeking for luck. In magazines and various pamphlets certain highly imaginative writers put my work in an extremely false light by placing it on a par with the work of the late Burbank, an advocate of planting many thousands.

Except for error at the beginning of my work, I have not based myself on mass planting and have never been carried away by silly treasure hunting, for I regard such work in horticulture as being, to say the least, of very little value and inevitable only on the introduction in our gardens of entirely new species of plants hitherto unseen in our localities, hybrids of which it is, as yet, impossible to have as, for example, the wild fig tree (*Ficus carica L.*), persimmon (*Diospyrus Lotus L.*), wild lemon (*Citrus trifoliata*), etc.

But for such plantings I was unable in the past to procure seeds in any considerable quantity owing to lack of means; now, however, I receive, through government institutions, some of the seeds of this kind in sufficient quantities for plant-

ing for selection purposes when thousands and not tens of seeds are required.

Here it is necessary to explain how the process of selection itself should be carried out; what to select, and by what characters one must be guided in selecting, will be shown later.

The first selection should be made when the plant is still in the cotyledon state; relatively large cotyledons, their considerable thickness and short and thick stalk under them (*hypocotyl*), and tricotyledonous sprouts are the best signs of cultivation.

The colouring in various shades of the lower and particularly of the upper part of the cotyledon always infallibly indicates the future colouring of the fruit, and in flower plants, roses, for example, the colour of the flowers.

During the second selection, in the last month of the vegetative period of the first year before the seedlings drop their leaves, it is necessary to inspect them several times a day with the sun shining on them on different sides. This is necessary because only by means of such an all-round inspection is it possible more fully to note all the peculiarities of the habit of every seedling. Even a change in the direction of the wind sometimes sharply reveals one or another previously unnoticed character of the seedlings. At the first general glance at the seedlings the best are noted

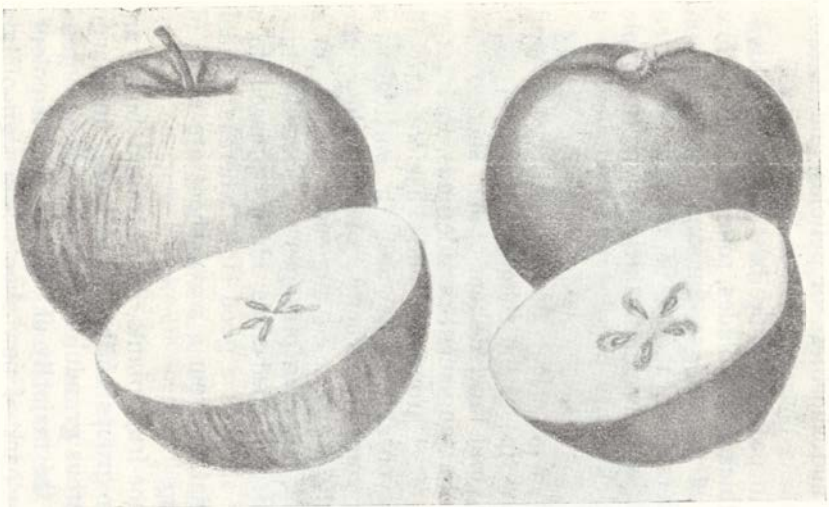

Fig. 7. The influence of alien pollen on the flesh: right—Michurin Bessemyanka pollinated by Oberdieck-Reinette, left—Michurin Bessemyanka pollinated naturally (control)

as regards stouter build, size of leaf blades, thickness and shortness of petioles and thicker shoot tips.

Then, in particular, the best signs of cultivation are: thicker leaf blades, rounded and shallow dentation of their edges, fine and close venation of the undersides of the leaves, dark, flat-coloured and wrinkled top sides, thick down (in apple trees), thick short petioles and well-developed stipules.

Selection after leaf dropping. Large, round buds at the tips of the shoots of the main stem, downy tips and faceted shape of their shoots, close steep-spiral arrangement of side buds, their large size and very prominent bud cushions are all general favourable signs and, in particular, a sign of a compact structure of the pulp of the future fruit; a sparse arrangement of buds in a wide spiral, however, presages a looser structure of pulp. Broadtipped buds, closely pressed to a straighter shoot is a good sign, whereas slender buds, deviating from a wavy shoot are signs of the wilding.

In stone-fruit plants, large round buds, arranged in groups of three and more, and large and numerous grandules on the petioles are good signs. In the majority of cases, a darker colouring of the bark of new shoots is a sign of late winter ripening of the future fruit, whereas a

lighter colouring promises a summer ripening variety.

The absence of small prickles and general low growth are also good signs.

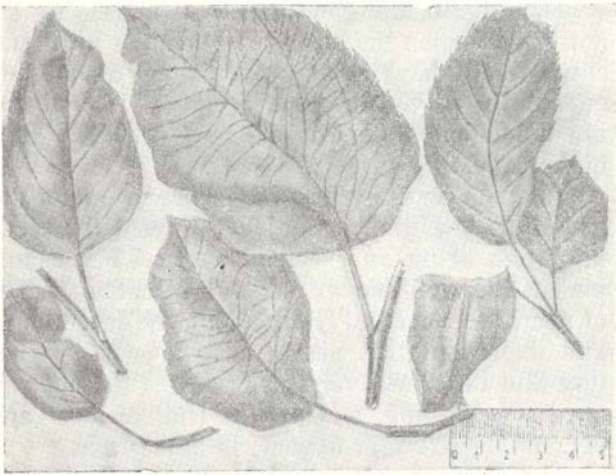

Fig. 8. Leaves of hybrid seedlings of Bellefleur Yuzhny (upper centre—the best of them)

When selecting, it is useful to compare the shape of the shoots and leaves with those of their parents, and to take this or that similarity into consideration when appraising the merits of the seedling. Moreover, it must be borne in mind

that all these signs in one-year hybrid seedlings are in most cases only in a rudimentary, sometimes in a barely perceptible state and gradually develop to their full dimensions only in subsequent years of the seedlings' growth.

Then again, the good merits of a seedling do not depend upon the absence of some of the signs enumerated above at any given time. Sometimes one of the signs develops earlier, while others are noted only later, at the next selection at a higher age.

In some cases even the presence of one of the bad signs does not in the least prevent the seedling from being an excellent variety. For example: in the well-known old and valuable variety of pear, the Beurré d'Hardenpont, the leaf blades and their dentation are of such a coarse structure that they positively give the tree the appearance of a wilding, and yet the fruit of this variety, for its size and flavour, is first grade.

The same may be said about the Olivier de Serres pear which, with all its good qualities, has very small leaves and exceedingly feeble shoots.

The third selection is made according to the same signs in the autumn of the third year of growth, and in the following spring the selected seedlings are transplanted to their permanent locations (each seedling is given an area of two to four square metres) until the fourth and last

selection for bearing, which is made according to the quality of the fruit of the third-fifth year of bearing, and the best of them, those which have fully passed the test for the stability of their characters, hardiness and yield, are propagated by the ordinary method of budding on young, two-year-old stock.

In some years, in the latter part of August, there is a long period of constant high atmospheric pressure (between 760 and 770 mm.). This, according to my observations, greatly affects the organisms of perennial plants and forces some of them to bloom again in the autumn.

In such cases, certain varieties of apple, cherry, mountain ash, bird cherry, and others have a second budding.

In such years a second flow of sap is also observed in hybrid seedlings, and this causes the plants to suffer considerable damage from autumn frost, against which we cannot take any measures; but in selecting we must not reject such damaged hybrids as lacking hardiness.

In conclusion it is necessary to point out once again that the first three selections of hybrid seedlings can be performed only by one who has acquired practical skill in carefully noting the characters of plants. It is quite impossible to give a sufficiently full description of the characters and their various combinations.

The fourth selection, according to quality of fruit, can, of course, be performed by anybody who is in the least acquainted with varieties of fruiters.

Further, in all selections, it is necessary to watch particularly for the manifestation by the hybrid seedlings of any degree of immunity to various diseases in general, and to damage by fungi parasites and insects in particular. Such a quality in certain hybrids must be carefully noted and cherished in general. This is not only of enormous importance in cultivating the given varieties; in the future it will be possible to single out from their progeny a whole series of new varieties that will be staunch in the struggle against plant pests.

And such varieties will be of enormous value for the fruit-growing industry of the U.S.S.R.

CHAPTER 12

SOME SPECIFIC FEATURES OF OWN-ROOTED FRUIT PLANTS

It is wrong to assert, as many do, that in propagating plants from cuttings, the form of variety of the given plant remains unchanged. It is particularly wrong to say that about the propagation of our fruit trees from cuttings. Here it is necessary to bear in mind, first of all, the influence of the replacement of the root system of the cuttings taken from trees grafted on the stock of a wild species by their own roots, which inevitably affects the quality of the variety, although in a good way.

It follows, then, that the variety undergoes partial change. To this it must be added that here we may come across a sport deviation (bud variation) of one of the buds of a cutting (this, in general, happens rather rarely in old, long-existent varieties of plants, but in hybrids, particularly at a young age, up to ten years, sport deviations must be regarded as a common occurrence). Lastly, when raising hybrid seedlings we

also inevitably come across a constant, regular and gradual change in the entire habit (external appearance) of the hybrid, beginning from the first year of its development from the seed to the first five to ten years of bearing. All seeds of hybrid origin, when germinating, produce, as a consequence of atavism (a reversion to ancestral characters), all the parts of the aerial habit of a wild species, which, as the seedling develops, both in the first year of growth and in subsequent years until the plant reaches maturity, differentiates only gradually, undergoes a whole series of changes in form and finally assumes the structure of a cultivated species. Further, if an adult tree of a hybrid that is already beginning to bear is cut to the root neck, its offshoots will again have the appearance of a wilding, and in their subsequent development will go through all the changes that the seedling went through after germination from the seed. And yet, if an adult bearing tree grown from a cutting that was taken from the seedling is also cut to the root neck, the offshoots from the root neck will not have the structure of a wilding, but will at first have the form that the cutting had, and from this form will go through all the other forms until bearing time; however, a considerable deviation for the better is observed owing to the improved structure of a different root system, which is incapa-

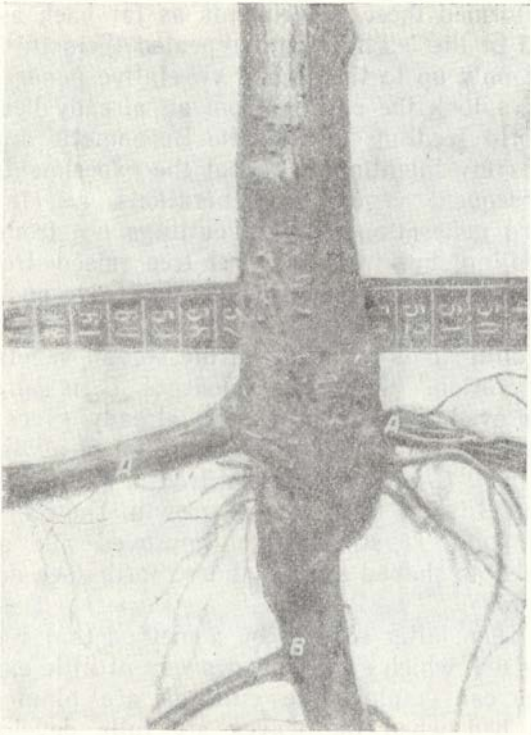

Fig 9. Development of roots by pear (A) grafted on apple stock (B)

ble of giving at first offshoots of a wild type. I performed these experiments as far back as the end of the 'eighties and repeated them in 1915, but only up to the second vegetative generation, i.e., I took the cutting from an already bearing hybrid seedling (a Reinette Bergamotte apple). It is my intention to repeat the experiments on subsequent vegetative generations, i.e., in the third generation to plant cuttings not from the seedling, but from the first tree raised from a cutting, etc. To make this clearer I give an illustration, Fig 10, where *A* is a two-year-old seedling; *B* is a cutting of the second vegetative generation,[1] the root system of *B* is already improved and its root neck already gives offshoots of the structure of *B* and not of a wilding as in *A*; *C* is a plant raised from a cutting taken from *B* in the third year of growth. The root system of *C* is still further improved and gives offshoots shaped like *C*, and so forth (see dotted arrows).

Then, after rooting by a method that I have devised, which even fruit growers of little experience can employ, the cuttings are planted in the bed when the leaves are fully developed. The cutting specimen bears fruit earlier than the

[1] Cuttings are up to 20 cm. in length from a single shoot or one with branches.

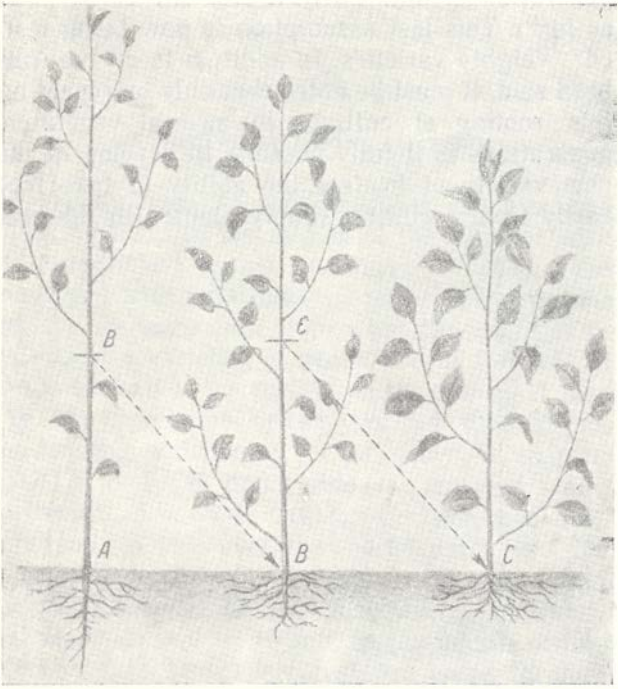

Fig. 10. *A*—two-year-old seedling; *B*—cutting from second vegetative generation; *C*—cutting from third vegetative generation

seedling did. The cutting specimen of the second generation should bear fruit even still earlier, and so forth. This last assumption is now being tested on eighty varieties. In addition to all that has been said, it must be noted that only by repeating this rooting of cuttings in several vegetative generations is it fully possible to develop in the new variety of fruiters the ability to take root easily from a cutting simply planted in the bed.

CHAPTER 13

METHODS OF ROOTING CUTTINGS

My methods of rooting plant cuttings and planting them in the middle of the summer with fully-developed leaves, methods which I have employed with particular success in propagating and at the same time improving the qualities of new hybrid varieties of pears, are as follows. In the latter half of the spring, on the cutting *A* (see Fig. 11) from a one- or two-year-old[1] shoot 20 cm. in length, which may be branched, a strip of bark *B* 5 to 8 mm. wide is removed, and forthwith a rubber tube, *C*, prepared beforehand, is put over the bared part; the tube is 60 mm. long, outside diameter 12 mm., thickness of the walls 2 mm.; consequently, the internal diameter will be 10 mm. In the middle of this piece of tube two apertures[2] are bored through

[1] The younger the hybrid seedling, the easier it is to root; and on the contrary, cuttings from old trees take on with much more difficulty.

[2] The diameter is about 2 mm. less than the outside diameter of the given cutting near the place where the ring of bark is removed.

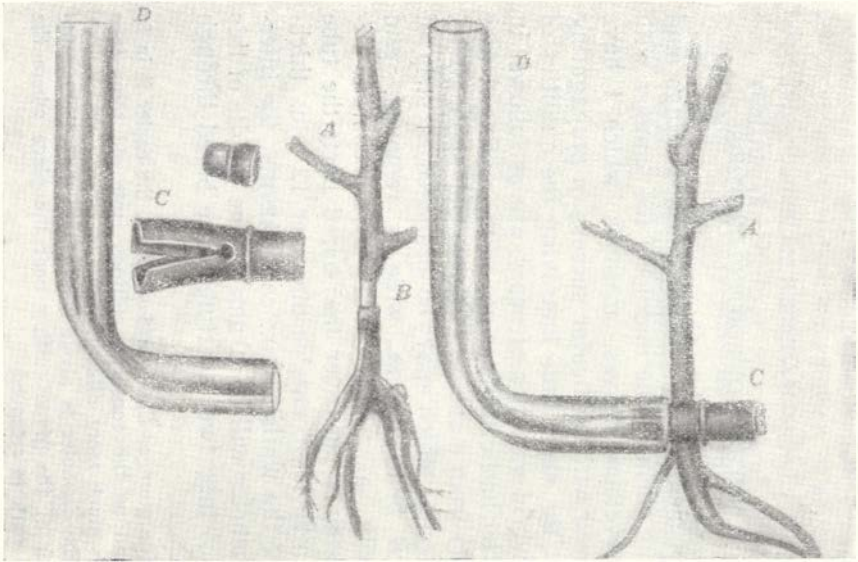

Fig. 11. New apparatus—tube for rooting cuttings

both walls with the aid of a sharp-pointed steel tube worked with a revolving motion; then, half the tube is slit from the tip to each of the apertures in the walls.

The tube prepared in this way is slipped on to the part of the cutting that has been bared of bark *B*. It closely grips the bark of the cutting on the lines above and below the bared ring. Both halves of the remaining parts of the incised rings are inserted in one of the ends of a glass tube *D* bent at right angles and having an internal diameter of 12 mm. If a bent glass tube is not available a straight piece *F* 10 cm. long, of the same diameter (see Fig. 12) may be used.

Moreover, in order that the rubber shall grip the bark of the shoot more tightly, the tube is tied in crisscross fashion with thick cotton thread and smeared with liquid grafting wax; the other, slit end of the rubber tube is stopped up with a cork (see Fig. 13). Then, into the open end of the glass tube, which is fixed in a vertical position, boiled water is poured; as the water in the tube evaporates, it must be replenished; and to prevent putrefaction the water must be changed every week, using cooled boiled water.

If this regime is adhered to for a period of five to seven weeks, according to the species and variety of plant, a callus will first appear in the gap of the rubber tube and then roots, and the

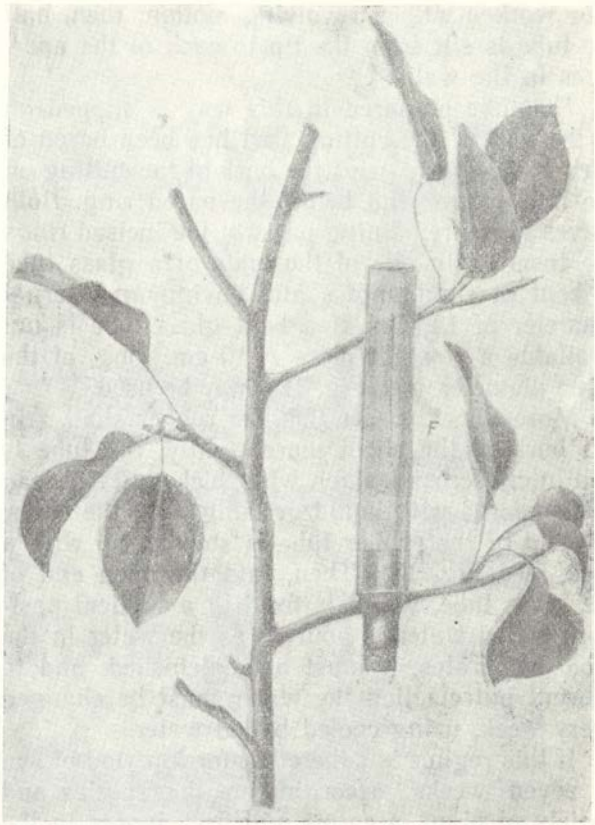

Fig. 12. Straight tube (*F*) for rooting cuttings

shoot above the tube will thicken considerably thanks to the deposits of nutritive substances furnished by the leaf system and retarded in its downward movement by the removal of the strip of bark. This stock of nutritive material will sustain the life of the cutting during the first period after planting in the bed. As a consequence of this, notwithstanding the hot weather in July, the leaves of the cutting do not perish, and this is observed in the majority of pear varieties on which I am at present conducting the work referred to. As regards varieties of apple, with rare exceptions the whole process is limited to the formation of the callus, and cuttings with this callus, on being planted in the bed, lose their leaves and take root in the following summer. The cuttings are made and planted in beds five to seven weeks from the time the tubes were set, at one's own discretion. With cuttings from the second vegetative generation, i.e., when rooting cuttings not from seedlings but specimens previously rooted by cutting, the entire process of development of the roots takes place much more easily and quickly.

Evidently, the plant, in adapting itself to this operation, develops the ability to take root more easily. Some varieties of pears, for example, seedlings from the well-known Olivier de Serres (see Fig. 14), manage to give in one summer two vegetative generations of rooting cuttings (see

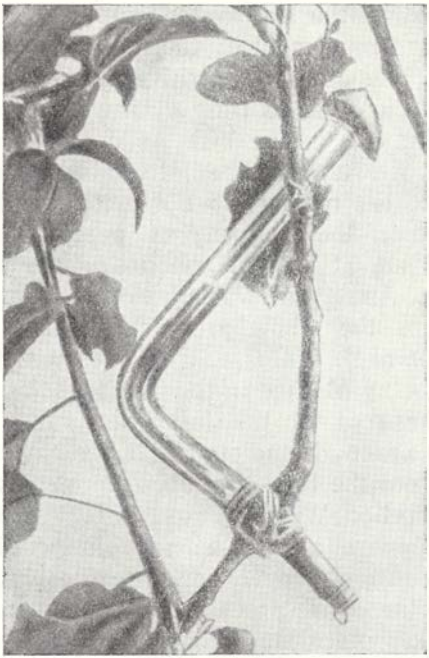

Fig. 13 Formation of roots in tube and thickening of cuttings above tube

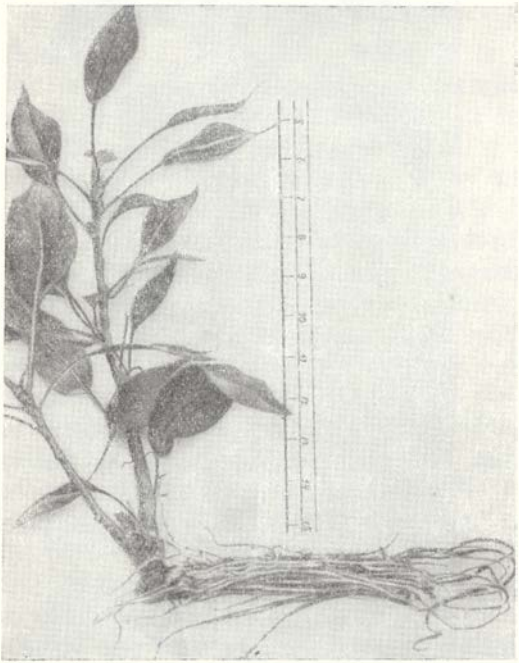

Fig. 14. Cutting of hybrid seedling of Olivier de Serres pears with roots formed in tube

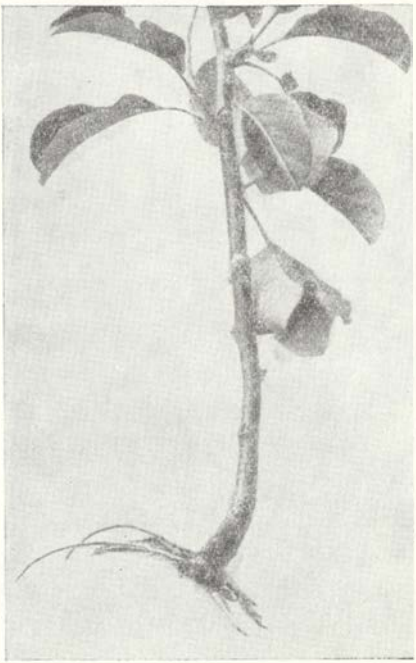

Fig. 15. Detached cutting with roots formed in tube

Fig. 15). In this way, it is easy to root branches taken from the crown of an adult tree with fruit buds and have low fruit trees of the old varieties with their own roots.

This method of rooting, when it is fully worked out methodologically and technically, promises to cause a veritable revolution in the art of fruit growing in the future.

In the present case we will have to wait a much shorter period for the fruit trees to begin to bear than in the case of grafted trees. In conclusion I must say that by way of experiment I cut and planted in the bed several cuttings from a pear with one callus even before the roots developed. True, the leaves of the cuttings suffered somewhat when they were planted in the bed; nevertheless, the cuttings will probably stand the operation well and in the spring will begin to develop roots, and then, perhaps, it will be possible to dispense with the glass tube and water, and it will be only necessary to cover the ringed part of the cutting with the slit part of the rubber tube, which will be fixed tightly to the bark above and below the bare part by tying it with cotton thread and smearing the slit in the tube with liquid grafting wax.

The cutting is made and planted in the bed six to eight weeks after the cuttings tube is fixed to the shoot.

CHAPTER 14

DWARFING STOCKS AND THEIR SIGNIFICANCE

I now have freely growing, without any protection against the winter, a considerable number of southern species and varieties of fruiters—Reinettes, Calvilles, the winter varieties of pears known in the trade by the general name of Duchesse, grapes, apricots, almonds, quinces, cherries, mulberries, walnuts and many new fruit and berry plants hitherto never before cultivated in our parts.

Lately, I have been working to put into cultivation in our orchards peaches, sweet almonds, chestnuts, persimmons, various species of actinidia, and others.

Furthermore, a beginning has been made in raising special dwarfing varieties of stock for trained apples, pears and, in particular, for the cultivation of squat types of apricots and peaches. The extreme need of low growth for the latter is now recognized by all fruit growers in the West and in North America. In our localities, with

their relatively severe continental climate, the production of a dwarf peach with a short vegetative period is absolutely essential.

The point is that with the low-growing types of apricots, and particularly peaches, firstly, the plants always complete their growth (vegetation) earlier than the ordinary tall trees and their wood matures more fully; thus, the vegetative period they need is considerably shorter and their resistance to winter frost is greatly enhanced.

Secondly, it is easier to provide low-growing plants with some kind of artificial protection against the winter, and sometimes a covering of snow alone is sufficient to protect the fruit buds, which suffer from frost more than all the other parts.

It is necessary to obtain low growth, although for an altogether different reason, also in plums, and particularly in sour and sweet cherries; such a type of plant is imperatively called for by the inconveniences noted both in North America and in the U.S.S.R., in picking the fruit from tall trees and protecting them from birds.

As dwarfing stock for apples, I have so far found nothing better than the ordinary Paradise and Doucin. For low-growing pears, however, I have raised to replace the common quince, which is unstable in its resistance to the frost in our parts, a new, quite hardy variety which I have

named the Severnaya quince, produced from the crossing of a wild quince from the Caucasian mountains with a quince from Sarepta in the Volga district. This new variety, which bears every year in my nursery, in addition to complete resistance to frost, possesses the quality of growing in dry locations, a quality which has become fixed and is transmitted by heredity to seedlings already of the third generation that I have. I have also selected pear seedlings of natural dwarf growth. For low-growing types of the tender varieties of plums and apricots, the stock from common seedlings of the low-growing sloe fully answers the purpose, but I think it is far from adequate for cultivating peaches in our parts. Here a much lower growth is needed, and for this reason I select from among the sloe seedlings specimens of exceptionally low growth, and later I will propagate them by the vegetative method—by layering. When selecting I take into consideration the relative stoutness, if one may so express it, of the development of the shoots, i.e., their thickness, which, in my opinion, serves to indicate the ability of the root system of the stock adequately to feed the peach grafted on to it. In the opposite case, i.e., if, when selecting, one comes across a seedling, even of the dwarf species, but with very thin shoots, it is unsuitable for the role of stock. This also happened to the

Siberian fruit grower Nikiforov. He found a dwarf variety of the Siberian crab apple which he named Pigmy. Its root system was so feebly developed that this stock was unable to feed the cultivated variety of apple grafted on it, and all the scions perished from shortage of nutriment. As regards raising stocks for cherries that would really give squat growth to the cultivated varieties grafted on to them, for the time being we must be satisfied with the American sand cherry (*Prunus Besseyi Waugh.*). Although at the present time it is one of the frost-hardiest and in many respects the best stock for cherries, the lowness of the cherry trees grafted on to it is actually inconsiderable. The hybrid I have raised by crossing a sweet cherry with the Ural low-growing pearlike sour cherry, which I have named Gnome, is, however, a splendid, low-growing cultivated variety of cherry, and is really irreproachable as a stock too. It is very short (not more than 50 cm. high when six years old) and has thick shoots (up to 6 mm. at the tips). This stock is quite hardy, although the pace at which it goes through all the phases of its development is extremely slow. Unfortunately, so far I have not succeeded in propagating it by the ordinary methods—by layering, or even by summer budding; evidently, exclusively spring budding with a living bud and subsequent propagation

from cuttings will alone be suitable for this variety.

And in general, to obtain low-growing types of cherries, in addition to selecting stock that answer the given purpose, it is necessary to raise new varieties by requisite selection for yield and hardiness, and exclusively low-growing types.

Only then will their planting bring in a good revenue....

CHAPTER 15

BREEDING NEW FROST-RESISTANT PEACH VARIETIES

In the early period of my activity (back in the eighties of the past century) devoted to the improvement of fruit plants of superior-flavour qualities with a view to making them more hardy in our locality, I could not of course even dream of introducing in our orchard culture fruit plants so exacting in regard to warmth as apricots and peaches. All the more so since among our wild forest types there was not a single representative of these plant species, and, consequently, I could not in this case even think of hybridization, i.e., of crossing delicate cultivated strains with our wild species with the aim of obtaining more frost-resistant seedlings, just as I do with pears, apples, cherries and plums. The almond I obtained by crossing the dwarf almond (*Amygdalus nana L.*) with *Prunus Davidiana Franch.* (David's peach), which I named Posrednik, even though it does cross with cultivated peach varieties, produces for the most part seedlings entirely

identical either with the maternal plant or with the paternal plant, and with hardiness insufficiently enhanced. Besides, all the attempts of horticulturists to introduce peach culture in localities north of the Crimea, even in places much more to the south than our parts, for example, in Kiev or Chernigov, usually ended in complete failure.

But in spite of this I never gave up the idea of finding some means of overcoming all these obstacles. In the end, after further searches I obtained the stones of several hardy varieties of the Manchurian apricot and a semicultivated type of peach from middle Manchuria and, later, of another semicultivated type of peach from North Korea, which thrive in places even severer than our locality (as regards climatic conditions in the winter period, the absence of a snow cover throughout the first half of the winter and the temperature dropping to 33° below zero Centigrade). The only material difference is the longer summer period in their native regions, owing to the fact that their latitude is much lower south than that of our locality. Though, on the other hand, they are partly subject to fog and cloudiness (the number of sunny days there is greatly reduced), which almost equalizes the longer summer period in the home of the Korean peach with our relatively short summer. Nevertheless, in our locality the majority of first-generation seedlings

(owing to the late germination of the stones) have shoots of summer growth insufficiently ripened and, naturally, their tips and sometimes the entire shoots suffer from the winter frosts and freeze down to the snow line. Such individuals, which suffered in the first winter, should be replanted without fail in the spring of the second year, their roots being shortened by one-third. Otherwise they will develop during the summer of the second year very luxuriant shoots replacing the destroyed parts and then they will again freeze in the second winter. The individuals which terminate their growth earlier have to be singled out. The specimens obtained cannot of course as yet represent quite suitable varieties for extensive peach culture on commercial lines in our parts, because the fruits will not have a good enough flavour and will ripen very late. Besides, the saplings of these varieties selected for hardiness will have the defect of early blossoming and, consequently, their flowers will often be destroyed by morning frosts in late spring. But all these defects can be eliminated by one of three methods or by a combination of these methods simultaneously applied.

The first and simplest method consists in planting large numbers of stones from several generations of seedlings selected for relative hardiness and early maturation of fruits in our

locality. The second method, which takes less time, consists in altering the constitution of the peach seedlings at the earliest stage of their development through the influence of the stock (vegetatively), for which purpose the seedling in the first half-year after its germination from the seed should be budded upon a stock of our local feebly-growing blackthorn. The third method is that of hybridization, of crossing the peach with the hardy dwarf almond or its hybrid, Posrednik. Lastly, a more reliable way is to combine the action of the second and the third methods. In this case, by shield budding with still not fully ripened buds from half-year-old peach seedlings upon blackthorn, we introduce considerable alterations into the constitution of the young and still unstable organism through the influence of the stock in the direction of reducing the vegetation period. This is observable even in the fact alone that the buds grafted upon blackthorn stocks complete their formation a full week earlier than the buds of seedlings grown on their own roots. From the very first year all such grafts develop a more squatty growth and complete it much earlier, as a result of which the woody tissue matures much more fully and, naturally, becomes more hardy to the winter frosts. Then, in the spring, the sap from the roots of the stock begins to move much later, with the

result that the beginning of blossoming is retarded, and the fruits are thereby safeguarded from being injured by morning frosts in the spring. All such alterations provide in their sum the opportunity of obtaining quite sturdy and hardy forms close to cultivated peach varieties.[1]

At present the production in our parts of hardy hybrid varieties of peaches by means of hybridization with old varieties which yield large-sized fruits of superior flavour no longer offers any difficulties.

Mention should be made also of a special variety of dwarf blackthorn, two metres in height, suitable for this purpose, which I bred in the course of forty years by planting four generations, by training the seedlings and by strict selection of specimens for low growth and absence of root shoots.

As a result of all this the new variety is easily reconciled to the new plant community. In general, as regards phytocenosis (plant community) it is to be presumed that in the vegetable kingdom, with the exception of epiphytes, cenosis (community) plays an important role only in the beginning of the origin of each species. Later the

---

[1] This approach towards acclimatization of exotic plants is, firstly, quite new and, secondly, fully serves the purpose.

Fig. 16. Dwarf nine-year-old blackthorn

effect of community presents no serious obstacles either for propagation or for the spreading of a species to a different locality; otherwise we would not be witnessing the diffusion of numerous identical species in various parts of the globe.

In this case, apparently, the plant should also more easily acquire the property of changing from a constitution characteristic of short-day plants to a type characteristic of plants adapted to the longer day in our locality, and photoperiodism will not present many difficulties in this respect.

Of the numerous species and genera of stone plants, so far scarcely more than a dozen species have been introduced in our orchard culture; the rest still remain largely in a wild state in various parts of our vast Union.

In this review I shall only mention a small part of the new types I have introduced into culture with varying degrees of success. Yet if many of them had been subjected to the powerful action of hybridization and selection we should most likely have obtained numerous new varieties of good quality as regards productivity and effectiveness for culture in our orchards. Furthermore, in this sphere (introduction to culture of wild species of stone fruits) we come across utterly unexpected phenomena such as the fact that

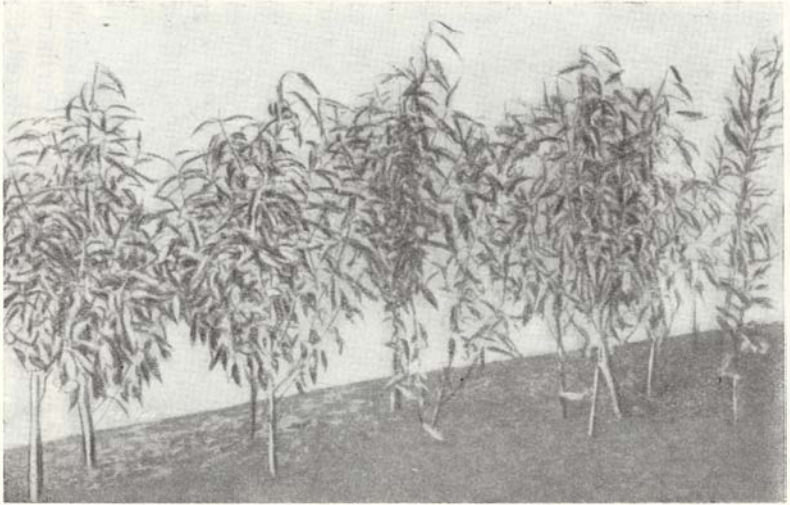

Fig. 17. Korean peach

in the case of the universally-known delicate warmth-loving apricots and peaches which in our country are grown only in the southernmost sections of the Union (Crimea, Kazakhstan, the Caucasus), closely-related species are found in the Far Eastern Territory and in the northern part of Korea. Such plants (see Fig.17) sometimes prove resistant to even intenser frosts than occur in our parts. In their native haunts they endure frosts of 35° below zero Centigrade in snowless winters and produce fruits of a good flavour, only the layer of flesh is much thinner than in the European varieties.

Here is a list of them.

1. A special type of hairy peach grows in middle Manchuria, where it is known by the name of Mao-Tkha-Or. Its fruits have a juicy flesh of a good flavour, but the skin is so thickly covered with down that it must be pared off before the fruit can be used. Its stone has an obtuse end (see Fig. 18) and is not always easily detachable from the flesh. Its hardiness to frost is even greater than that of the Korean peach varieties. The fruits ripen by October 15. In its native haunts in middle Manchuria this species withstands frosts of 35° below zero Centigrade in extremely dry snowless winters with withering north winds. The Americans usually classified it as belonging to the northwest Chinese species,

closely related to the peach and known as *Amygdalus Kansuensis*; however, there is an essential difference between these species as regards the structure of stones, and also as regards the structure of branch growth and of the skin of the fruit.

It is already three years since I introduced this species in large numbers of seedlings into the experiment nursery.

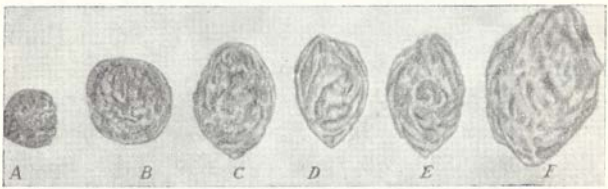

Fig. 18. Stones of peach species:

A—The prickly cherry *Prunus plagiosperma Oliv.*; B—*Prunus Davidiana*; C—*Amygdalus Kansuensis*; D—*Amygdalus Mao-Tkha-Or*; E—Korean *Amygdalus*; F—Peach *Amygdalus*

2. There are several varieties closely related to cultivated strains of apricots, from whose seedlings I have produced here in Michurinsk as many as ten kinds which freely withstand our winter and yield tasty fruits of different shapes. Only late spring frosts sometimes interfere with their early blossoming.

When planting the stones of these peaches and apricots in our parts we may definitely hope (by selection of seedlings and artificial shortening of their usually protracted vegetation period) to obtain new varieties suitable for our section of the country. At present the work with these plants consists only in selection of later-maturing specimens to avoid injury from late-spring morning frosts in our locality. And only when we are through with this work shall we begin to apply to choice individuals various methods of increasing the layer of flesh in the mesocarp by selecting the proper seedlings in the plantings of succeeding generations and also by bringing to bear the influence of stocks of the interspecific hybrid

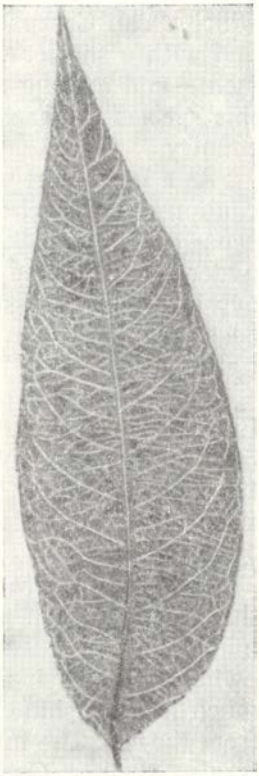

Fig. 19. Leaf of Mao-Tkha-Or

which I call Cerapadus—stocks more nourishing and with a shorter vegetation period of development—and making sure to provide soil to which this species of peach is accustomed in its native country.

As a last resort we may, provided we are very cautious in the choice of male parent (in the sense of avoiding the danger of loss of hardiness under the influence of European varieties), try hybridization, crossing it with southern European and American cultivated large-fruited varieties.

3. A species of peach most closely related to European peach varieties has, as we now learn, been cultivated in North Korea for a long time. Its fruits are much less covered with down than the fruits of the Manchurian hairy peach, Mao-Tkha-Or.

The place where three forty-year-old trees of this North Korean peach have been found[1] is at a distance of fifteen kilometres from the sea, owing to which it is mostly foggy and there is much less sunshine than in places more distant from the sea. The intensity of the heat of the sun is also smaller. Owing to the cold current from

[1] Found during an expedition in 1929 by N. N. Tikhonov, an explorer of the Far East, who lives in the city of Nikolsk-Ussuriisk [now Voroshilov.—*Ed.*].

the Sea of Okhotsk and the prevailing north winds, the climate in its place of origin is much severer—the winter is long and snowless during its first half, the soil freezes to a great depth, the summer is cool, the temperature in winter drops to —33° C.

A specific feature of the structure of the Korean peach is the bright-brown velvety coating sharply distinguished on the trunk and on the lower part of the main branches—a feature which, as we know, is not met with in any other species and varieties of the peach and its kindred. Further, this species possesses a fairly squatty growth (provided the one-year-old seedlings are properly trained by drying and by pruning of roots) and is more hardy than all other species and varieties both of its wild kin and of cultivated peaches.

Only the Mao-Tkha-Or described above can rival the Korean peach in frost resistance.

The fruits of the Korean peach are of an oval shape, 30-40 mm. long, 25-35 mm. in diameter, and weighing 10 gr. The skin of the fruit is of a light-green colouring with a scarlet tint on the side, and it is all covered with down, though considerably thinner than in the Mao-Tkha-Or. The flesh, its layer 8 mm. thick, is juicy, of a good flavour, and freely detachable from the stone. The latter—with little knobs and grooves

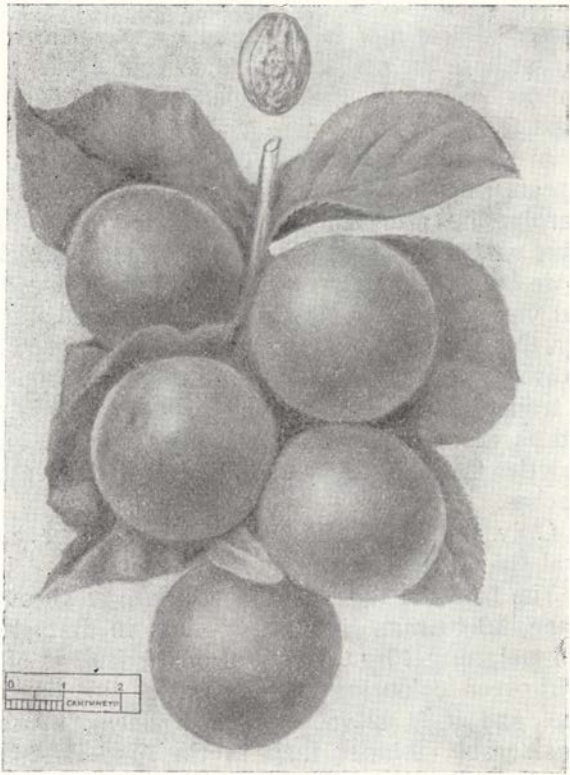

Fig. 20. Black apricot (reduced)

characteristic of all peaches in general—terminates in a sharp thorn.

4. Further, one more eastern species of black apricot is being experimented with—the *Prunus dasycarpa Ehrh.* (See Fig. 20.)

5. Considerable interest attaches to other natives of the Far Eastern Territory—the numerous varieties of the *Prunus triflora Roxbg.*, which I have lately begun to cultivate for the purpose of hybridization with European plums.

6. Another drupe from North China, known there under the name of Ando, may play a big part in the planting of shelter belts. It is the cherry *Prunus tomentosa Thbg.*, a low shrub, not more than 1.5 m. in height, with leaves of a peculiar shape and medium-sized sweet fruits. (See Fig. 21.)

7. Next, the eastern species of what is known as the prickly cherry *Prunus plagiosperma Oliv.*, a rare and singular type with leaves like those of the peach, with flowers of a yellow colouring and long sharp prickles on the twigs, and the stone in the fruit entirely flat, like a button, and marked all over with tiny knobs. Some of its seedlings are fairly hardy. (See Fig. 22.)

8. Seedlings of the dwarf cherry (*Prunus prostrata Labill.*) from the slopes of the Tian-Shan Mountains grow splendidly in my garden. I regard them as very valuable material for breeding

Fig. 21. Ando cherry in bloom

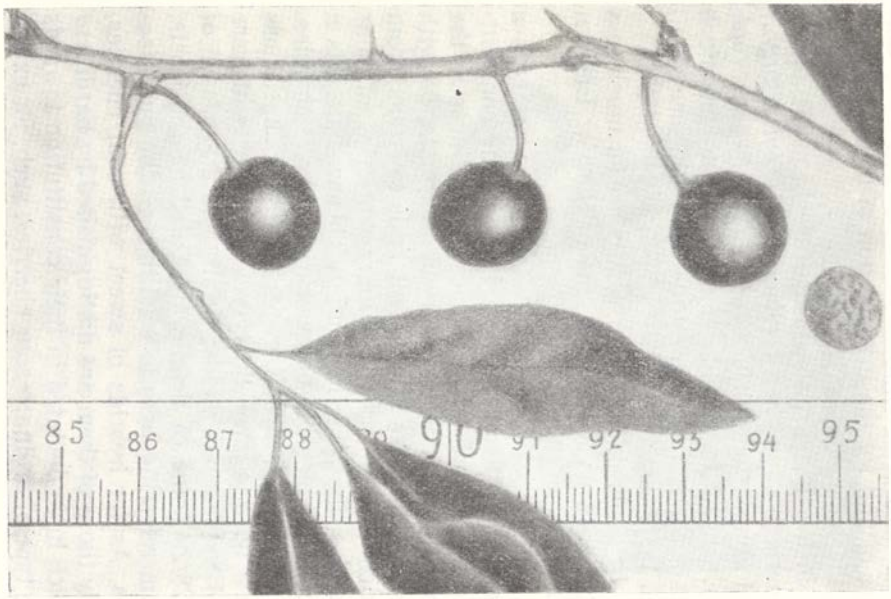

Fig. 22. Fruits of the prickly cherry

cherries of low height as more convenient to take care of and for the introduction of mechanization in the harvesting of the crop.

9. Lastly, various forms (see Fig. 23) of the American sand cherry (*Prunus Besseyi Waugh.*) and a variation of it, *Prunus pumila L.* (*var. typica*). The latter, incidentally, seems to me much less suitable for our region—the fruits are small and tasteless.

In general, American plants are of much less interest to us than the plants of the Far Eastern Territory.

10. The work with sweet cherries presents a somewhat different picture. Here we are confronted not so much with the lack of hardiness in the wood and branches to our winter frosts, as with the sensitiveness of the fruit buds to frosts, from which even our old ordinary varieties of sour cherries, the Morellos, suffer. This weakness is a stumbling block in our work with sweet cherries. For example, seedlings selected for hardiness grew up into large thirty-year-old trees with rare and very small yields; finally, in the winter of 1928/29 some of them were killed by the frosts. I am referring here to seedlings of the pure species. As for hybrids of sweet with sour cherries, only those of them are distinguished by hardiness which have deviated in their constitution towards the type of ordinary sour cherries, such, for exam-

Fig. 23. Fruits of the American cherry
Prunus Besseyi

ple, as Krasa Severa. The hybrids which in their habit strongly deviate towards the sweet-cherry type usually bear an insignificant quantity of fruit, because the winter frosts injure the fruit buds.

11. Some choice seedlings of the rose Virginia chokecherry (*Prunus virginiana L.*) produce very effective-looking clusters of ruby-coloured fruit which attract everyone's attention; their flavour is much better than that of our ordinary bird cherry. The shape of the clusters differs greatly among the numerous varieties, particularly among the hybrids with sour cherries, with which I have succeeded in crossing them in order to make their fruit larger in size.

Their trees are of small stature, from 2 to 3 m. high. They are quite hardy to the winter frosts in our locality. This plant may prove to be good for shelter belts. Besides, this new type of drupe (*Cerapadus*) is a very important component for hybridization and the breeding of new kinds of fruit trees in Voronezh Region, as well as in more northern regions, not excluding Siberia, where, I may mention in passing, even ordinary bird cherries are always in large demand.

12. There exists also a new variety of my breeding—the Kapolina, which is now being experimented on.

Among the other Korean, Manchurian and Japanese types of stone-fruit plants we find such

as bear fruit of enviable quality but some of them possess no hardiness whatever in our region, as, for example, the Kelsey plum and its variety Poksua among the Koreans; others, like the Japanese bitter cherry (*Prunus japonica Thbg.*) or the Japanese apricot (*Prunus mume Sieb.*) and *Prunus serotina Ehrh.*, are hardy in our parts; however, their fruit being of low quality, they are only fit for hybridization experiments, but not for culture in our orchards.

The same must be said of some wild-growing species of American plums and cherries, and also of the new hybrid varieties of fruit and small-fruit species, most of which prove sterile in our parts, and, although they are hardy to our frosts and blossom profusely, they form no fruit at all or in a negligible quantity.

Thus, a large number of seedlings of *Prunus americana Marsh., Prunus hortulana Bailey* and *Prunus nigra Ait.* in my possession have so far remained sterile. Apparently, because they lack pollinating varieties, or, perhaps, because they blossom very early in the spring, at a time when in our locality the insects which help their fertilization have not awakened to activity.

That is why the various enthusiasts who recommend American plants for us would do better to moderate their passion for the introduction of these varieties into our orchards.

In conclusion I consider it necessary to mention once more the special type of dwarf blackthorn (*Prunus spinosa L.*) which I have produced

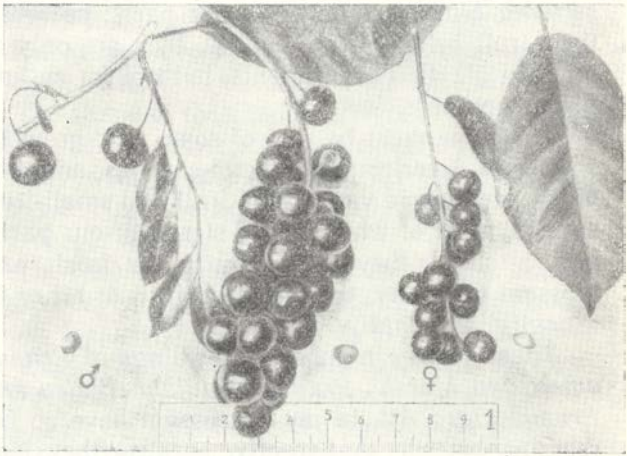

Fig. 24. Interspecific cross between the chokecherry *Prunus virginiana* and Ideal cherry (*Pr. virginiana L.* × *Prunus Chamaecerasus Jacq.* × *Pr. pennsylvanica L.*) Left, Ideal; right, *Prunus virginiana;* centre, the hybrid

in forty years by planting four generations with strict selection for hardiness, dwarfishness and absence of root shoots.

In the regions of Central and Northern Russia there has long been felt the need for this new ideal stock to be used in grafting peaches, apricots and delicate plum varieties for culture in dwarfish shapes. This blackthorn is propagated by the planting of its stones, and it remains constant, without changing its properties.

CHAPTER 16

ABOUT THE TRUE VALUE OF NEW VARIETIES

All originators of new plants, both vegetable and grain, and particularly, fruit and small fruit, should try to avoid causing public sensations by advertising the qualities of new varieties, for this is extremely harmful to our work, if for no other reason than that it arouses illusory and excessive hopes, that are followed by disappointment. On the contrary, in judging the merits of new varieties everything possible should be done to employ a strict standardization, i.e., only the truly useful, first-class varieties which in cultivation yield the best quantitative and qualitative harvests should be released for propagation and distribution; the rest should be rejected. But here is where the difficulty lies, for if, in culling, we base ourselves on the variety's properties in the conditions of the district where the new varieties are being raised, we may reject and destroy many varieties which in other localities or on different soil might prove to be excellent, first-rate ones.

And, vice versa, those that are superior varieties in our parts might be completely worthless in other localities, a point that the originator cannot foresee at all.

Let us take two or three practical examples out of a thousand. I crossed the well-known southern Winkler White Cherry variety with the Vladimirskaya Rannaya Rozovaya and obtained a new hybrid cherry variety excelling in size, flavour and colouring, which I named Krasa Severa. I tested its cultivation on all the different kinds of soils at my disposal, and the result was that the yield from clayey heavy soils was satisfactory, whereas that from sandy soils proved to be a poor one. I wrote about it in that light. Quite suddenly the journal *Progressivnoye Sadovodstvo i Ogorodnichestvo* published an article by the well-known nursery horticulturist, Reshetnikov of Samara,[1] containing the following statement:

"Michurin himself does not know what a treasure he has produced in the Knyazhna (Krasa) Severa variety of cherry. Upon being propagated in our parts it turned out, in the first place, that by comparison with other varieties of cherry this one develops rapidly and begins to bear fruit early, and, secondly, its yield is so high, that everyone comes to the nursery to admire these sap-

[1] Now the city of Kuibyshev.—*Ed.*

lings and marvel at their fecundity." But that is not all. In the city of Omsk, Siberia, this variety splendidly withstands frosts of 35° below zero Centigrade, yields an abundant crop, whereas even the pure variety of Vladimirskaya cherry perishes there from the frost without exception. How could I foresee such a phenomenon? So that even now, when I have the actual facts at hand, I cannot bring myself to write that the sweet cherry hybrid is suitable for cultivation in Siberia.

Here is an example of another kind. I have released for sale a new variety bearing outsize fruit which I named the 600-gram Antonovka, obtained from a sport deviation (bud variation) of the Moghilyovskaya Antonovka Belaya apple; it has a fine, highly attractive appearance, and ripens in late autumn or early winter. Despite inferior storage properties, its fruits are valued for their beauty and flavour much more highly than the ordinary Antonovka both in these parts and in districts farther north. Further, we receive enthusiastic reports about this variety from localities which claim that in their parts its fruits keep fresh until spring. Yet in the town of Voronezh this variety is priced cheaper on the market than the ordinary Antonovka. It appears that the determining factor is what variety the inhabitants of each particular locality are accustomed to use

in their diet, something the originator cannot possibly know.

A third example. Surely, new, excellently flavoured varieties, such as, for example, the Kandil-Kitaika variety, a product of mine, should not be rejected merely because they may lack hardiness in the more northern parts of the Soviet Union. It is impossible to foresee the northernmost boundaries of similar varieties; this requires the data provided by many years of observation in northern localities and under different conditions. Yet another example: the highly productive and valuable variety of pear, Michurin Beurré Zimnaya—another of my products—which ripens in winter storage, yields unprecedentedly large harvests in our region.

In the city of Michurinsk (Ukrainskaya Street No. 120), sixty-four ten-year-old Michurin Beurré Zimnaya trees planted on a half-hectare plot cultivated by citizen Davydova in a most primitive fashion, which is almost tantamount to her not looking after it at all, used to yield good crops both qualitatively and quantitatively, but in the winter of 1929 the greater part of the orchard was killed by frost. A recent report from citizen N. Dianov, living in the Beryozovsky District, Ivanovo Region (600 km. north of the city of Michurinsk) states that in the soil conditions of those parts this variety is a hardy one. The same

variety grows satisfactorily in the Moscow District.

The same must also be said of the immunity of new plant varieties to diseases in general and, in particular, to harm from fungus parasites and to damage by insects. All this depends to a great extent on the soil and climatic conditions of each particular locality. The sterility of individual varieties also depends to a similar degree on such conditions, as is also confirmed by the data of North American horticulture. In a word, our local appraisals of the merits of new varieties, no matter how complete and objective they may be, not only cannot be applied to entire districts, but even within the bounds of a single district must be limited to comparatively small territories with approximately identical climate, landscape and soil.

Where the air and soil are very dry, even in a warm climate, this does not prevent the development of frost resistance in plants, while, on the contrary, a damp atmosphere and humid soil in a warm climate make plants extremely delicate and prevent them developing frost-hardiness.

In some cases the training of hybrids at an elevated temperature, but in extremely dry air, does not hinder them from developing the property of frost resistance, as shown by an example taken from a description of the origin of new spe-

cies of Mongolian apricots and a new seed-raised apple variety called Paradox, that grew in a heated inhabited room where double window frames were retained in the summer. For nine years this seedling was never once taken out into the open air; nevertheless, after being grafted in the garden in the tenth year it excellently withstands all the local frosts and bears large fruits of fine flavour. Hence, we can hope to obtain species which will withstand our climate from plants originating in dry and mountainous regions, though with a warmer climate than ours. In general, it may be presumed that considerable dryness of the air and soil, while hindering the luxuriant growth of plants, may at the same time serve to give a correlative stimulus to the development in the plants of a relative hardiness to frost.

It is only on this basis that I recently procured the seeds of a wild species of fig tree which grows in a very dry mountainous locality, and I am making an attempt to introduce this species of fruiter into cultivation in our locality.

First published in 1929 in
I. V. Michurin, *Results of Half a Century of Work in Producing New Varieties of Fruit and Small-Fruit Plants*

Printed in the Union of Soviet Socialist Republics