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I. V. MICHURIN

SOME PROBLEMS OF METHOD

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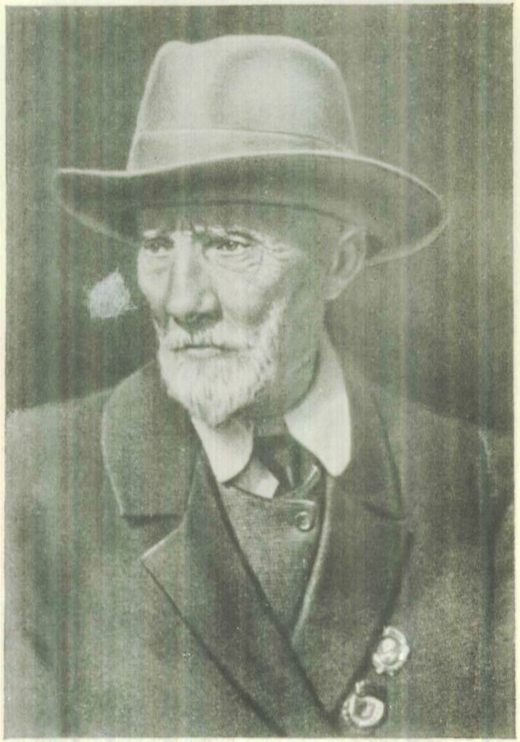

I. V. MICHURIN
(1855-1935)

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SOME PROBLEMS OF METHOD

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IN WHAT RESPECTS DO MY METHODS OF WORK DIFFER FROM THE METHODS EMPLOYED BY OTHER SPECIALISTS

Before proceeding to discuss the difference between my methods of work and those used by other specialists, it is necessary to know where and who in the U.S.S.R. besides myself has been occupied with the selection of fruit trees and shrubs and has produced any new varieties of these plants. With the exception of the scant works of Kopylov, Spirin, Bedro and Professor Kashchenko, each of whom has produced three or four new varieties of plants of third-grade quality, I do not know of a single horticulturist working to produce new varieties on a scale worth mentioning. Therefore, I cannot explain the difference between my methods and those of other workers in the same field, so far as the breeding of apple trees and pear trees, cherries, plums, apricots, etc., is concerned. As to the methods employed by foreign horticulturists, their having been elaborated in the conditions of climate and soil entirely different from those of the U.S.S.R., makes them inapplicable in our country in most cases.

Furthermore, as the readers probably know, neither in any of the West-European countries, nor in America, are there any such institutions at the present time, working exclusively on the production of new orchard varieties of fruit trees and small-fruit shrubs. Perhaps some of the readers will not agree with my statements. I am not going to dispute such opinions for the reason—if for no other—that many agriculturists in their approach make no distinction between annual herbaceous plants and perennial fruit trees. Actually there is an immense difference between these plants in the length of time during which they are subjected to the action of environmental factors that affect the constitution of the newly developing plant organism of every new variety. Very great indeed, I repeat, is the difference between the complete life cycle of, say, Mendel's pea and that of any variety of apple, the development of which may continue until the age of twenty or thirty years. During this time the entire structure of the hybrid is often changed beyond recognition

under the prolonged influence of diverse environmental factors, with some of its properties vanishing so completely that no trace of them is left, others developing, and with still others becoming manifest. Besides, sport variations displaying properties of some of the grandparents of the parental plants likewise occasionally occur.

Many people are inclined to consider that the difference between my methods of rearing the plants and the general rules of horticulture lies in the fact, that, when laying out a nursery, I never use deep turnings of the soil, never give the young hybrid plants any fertilizers, plant these hybrids very densely, etc. My first answer to these criticisms will be that it is one thing to run an orchard with already existing varieties of plants—here there can be no denial of the necessity to keep up a high level of culture in rearing the plants—and quite a different thing to produce and to rear new fruit-plant varieties, and these two things should never be confused. I have come to the Spartan regimen of rearing the plants after having thoroughly studied the life of fruit trees and small-fruit shrubs belonging both to the wild species growing in our forests and to the cultivated varieties bred in our orchards. The difference in longevity between the first and the second is very significant. Forest plants live in general four times as long as cultivated ones and, what is most interesting, the better the treatment the plants are given, the shorter becomes their life span. At the first superficial glance the main cause of this phenomenon appears to be the more rapid exhaustion of the plant organism as the result of its fruit bearing being intensified by culture. But is that quite so? Don't we see in our forests wild-growing apple trees and pear trees yielding abundant crop every year and living more than two hundred years, while in our orchards they barely reach the age of fifty? For example, apricots and peaches grown in orchards rarely live over fifteen to twenty years, whereas in the forests of Manchuria and the Caucasus the same species attain the age of seventy and eighty. Even plantations of black currant and blackberry in our orchards get exhausted and have to be renewed and transplanted to a fresh site every eight or ten years, while in the forests black currant lives and yields abundant crops of large berries for almost a hundred years, remaining in the same place all the time. On viewing this phenomenon from the purely materialistic standpoint, it becomes evident that the cause of the shorter life span peculiar to all these coddled "bourgeois" of the plant world grown in our

orchards is the loss of the capacity for "self-activity" in cultivated plant organisms. This is the result of the constant interference of man—lasting for hundreds and thousands of years—who provided these plants with ready conditions of comfort thus hoping to secure intensified fruit bearing. It is for this very reason that the majority of cultivated plants, having lost their property of self-activity, can no longer do without the care of man.

Already at the very beginning of my work in horticulture I observed that the hybrid seedlings grown on better soil—such as was fertilized and turned over—were by far the inferior in their resistance to all kinds of adverse climatic conditions when compared with the seedlings of the same hybrids grown on unfertilized sites with sandy soil; true, among the former a greater number deviated in structure towards the cultivated form. During the first decade of my work I still had doubts about the necessity of altering the regimen in rearing hybrid seedlings in the sense of affording them a better opportunity to develop the capacity for self-activity. I, naturally, supposed that any severe treatment in rearing these seedlings despite the culture properties inherited from the parent plants, would result in the appearance of wildings only, and in their incapability of producing the large-sized fruit of cultivated varieties. But fortunately it so happened that a few hybrid seedlings reared under relatively severe conditions gave large fruit of the finest quality on the sixth year after their germination, whereas all the coddled specimens raised in the best conditions were all destroyed by frost. I was therefore compelled to transfer my entire nursery to another site with a more meagre soil, and I did it without any hesitation. It was a venturesome matter to transfer the entire nursery, but later on it proved to have been justified and gave good results. Now this is where the difference lies between my methods and those of other horticulturists. Further, at the beginning of my work I used to cross the best foreign varieties of fruiters with our hardy local ones, but later such hybridization turned out to be a serious mistake, and it became evident that some different principle of choosing parents must be adopted.

The reason for that was, that when our hardy local cultivated varieties were pollinated with the pollen of the best foreign varieties, hybrids were obtained in the vast majority of which characters peculiar to our varieties proved to be dominant; subsequently these qualities developed, while the properties of the foreign varieties failed to manifest themselves and remained in a latent state. This was due to the fact that the hybrid seedlings were grown under the conditions of soil and climate habitual to our varieties. Thus, for example, although the fruit of hybrid pears had a fine taste, they were, however, small and ripened in summer. Both these features are peculiar to our Russian varieties of pears. In order to avoid the undesirable results of such unsuccessfuel combinations of mates, I began using as the hardy components for the crosses forms from very distant localities (in this particular case from the Far Eastern Territory of the U.S.S.R. and from Manchuria). By fertilizing these hardy forms with the pollen of the best foreign varieties, I succeeded in attaining an equal participation of both parents in the hereditary transmission of their properties to the hybrids, since they were now to the same extent deprived of the habitual environmental conditions of their native localities. Still another important advantage of such hybrids deserves being especially mentioned. They are all distinguished by their outstanding capacity for adaptation to environmental conditions of a new locality. So I rear hybrid seedlings without deep turnings of the soil, and without any fertilizers until the first appearance of fruit-buds. Only then do I give them some liquid fertilizer and cover the soil right under the young plant with a layer of fresh manure to obtain better-formed and larger-sized fruit. The layer of manure also affords some protection against over-drying of the soil. I plant the seedlings rather densely. After the first three-four years of bearing, when the new variety has already fully attained stability, some cuttings are taken from the mother-tree for the propagation of the new varieties by grafting on stock. If some defects in the hybrid's qualities are revealed after the onset of bearing, at times, although by no means in every case, some of these defects can be either partially or entirely removed by the expedient choice of various kinds of stocks or even partly by grafting as mentors cuttings taken from some other varieties. As for the origin of new species of plants, they appear rather rarely as a result of intergeneric, sometimes also of interspecific, hybridization. Similar phenomena arise by mutations, as well.

Some of the excursionists visiting our institution—their number reaches five thousand every year—at times ask me such questions: "Why is it necessary to produce new and improved varieties, when we have plenty of our old varieties?" I have to repeat to such naive persons what I have written time and again as far back as forty years ago in many of my articles: in nature the

forms of life are not frozen and fixed; life is incessantly moving and continuously changing, and all living creatures that for some reason have come to a standstill in their development are inevitably doomed to extinction. Much of what seemed of old to be the best in its perfect adjustment to conditions of life that prevailed in the past, nowadays proves to be unfit and must be replaced. The same holds true with respect to our old varieties of fruit plants, most of which in the old days, when labour used to be gratuitous or cheap, were more or less suitable for commercial cultivation; in our days they are not only unworthy of being cultivated, but are a pernicious litter contaminating our orchards. Moreover, many of our old varieties have already lost their fine qualities or, as they say, "degenerated" and must give place to young new varieties.

I shall conclude this article by saying that the work of qualitatively improving fruit-plant varieties is of colossal importance for the future life of all mankind. That is why this activity must be unceasingly promoted and the necessity of working in this field must be impressed by all means into the minds of the entire population of the Soviet Union.

CHOOSING COMBINATIONS OF PARENTAL PAIRS OF PLANTS

The following conditions should be observed when combinations of parental pairs of components are chosen for crossing fruit trees:

1. For the role of maternal plant preference should be given to own-rooted specimens, not to ones grafted on to stocks of wild varieties.

2. Maternal plants should be chosen from among local frost-hardy strains, even if half-cultivated, or they should be taken from geographically distant localities but with similar severe climatic conditions (I must note that the latter combinations yield the best results). Hybrids obtained as the result of such crossings become better and more quickly adapted to the conditions of the external environment of the new locality.[1]

3. As for the choice of the male parent, preference should be given to varieties whose fruit possess the best qualities, mostly brought from warmer lands with better climatic conditions,

[1] The latter combination has, in addition, the advantage that it precludes the dominance in the hybrid of the local strain as the more accustomed to the climatic conditions of its native habitat.

and it is almost immaterial whether an own-rooted or a grafted plant is taken for the role of father.

ON THE REARING OF NEW VARIETIES

It is necessary to rear varieties more resistant both to frost and to the harmful influence of our deeply continental location. This is accomplished by rearing hybrids in the early stage of their lives in dry elevated spots or in places which, while not elevated, have sandy soils permeable to water.

ABUNDANT YIELDS AND EARLY FRUITING AS FUNDAMENTALLY IMPORTANT PROPERTIES OF SUPERIOR VARIETIES

The prime task now confronting every breeder of new varieties of fruit and berry plants is to produce such as, in addition to possessing good flavour, attractive appearance, frost-hardiness, immunity to disease and capacity to resist pests, are early fruiters and abundant bearers. The task is, indeed, a very difficult one, particularly when we consider that fruit growers lack a firm base on which to rely in this matter. Let us examine in detail, and in their order, the principles and observations pertaining to this question.

We shall see, first of all, that seedlings of one group of apple-tree varieties do not begin to bear fruit before seven or eight years, while some of the same group, actually the best,[1] begin still later, only after fifteen to twenty years. All the ingenious contrivances for accelerating the onset of fruiting, far from being of any avail, cause nothing but harm when applied by ignoramuses posing as experts in this field, as they divert young breeders from the right path.

For example, to accelerate the onset of fruiting they graft cuttings of a young seedling onto the crown of an adult tree; they naively point to the work of Burbank as an example of this method, without themselves having tested it, and without taking any account whatever of either California's subtropical climate or of exactly what results were obtained by Burbank from grafting the young seedlings onto the crown.

One feels ashamed of such theoreticians as, for example, the late Zhegalov, and hundreds of

[1] And, on the contrary, the earliest to bear fruit are hybrids that incline toward the wild species, and hence are unfit for cultivation.

other compilers who declare and affirm that Michurin had no grounds whatever for rejecting this method of accelerating the initiation of fruiting. If that were so, Michurin would long ago, in the course of his sixty years of uninterrupted labours, have convinced himself of the utility of applying this method. Even now, however, he asserts that this method will bring the breeder engaged in hybridization nothing but harm. And this is so if only for the fact that the influence exerted by the work of the leaf system of the entire crown and of the entire root system of the stock, on the extremely small part of the young seedling's grafted cutting always changes its structure and, what is more, in a negative direction. But that is not all. Are these ignoramuses aware that the overwhelming majority of hybrid seedlings have, in the first year of their growth, the structure almost of the wild species, and that only in the following years do they gradually change in the direction of the cultivated state, acquiring a completely cultivated form only when they are fully mature. But even in this case the fruits of the first year of fruiting are imperfect both as regards flavour and external qualities, i.e., size and colour; they improve only gradually, during the first few years of fruiting. In proof of this we have a whole series of photographs of the fruits of new varieties taken during their first few bearing years.

These changes in the development of all parts of the hybrid's organism take place only under the influence of the work both of its leaf and of its own root systems. When the cutting of a young hybrid is grafted onto the crown of an adult tree of totally different structure in all its parts, it must inevitably be subject to the influence, and particularly strong influence at that, of the adult stock tree which possesses quantitatively superior leaf and root systems. And the cutting of the young hybrid, transferred and grafted while its organism is only in the initial process of formation, is naturally bound to change, and inevitably does change, its structure as a result of the influence of the stock. Thus, in the first place, the development of the hybrid's structure towards the cultivated type stops at the point it reached when the cutting was taken from the young hybrid seedling,[1] and, in the second place, its structure will change further as a result of the strong influence exerted by the work of the entire leaf and root system of the adult stock, i.e., a vegetative hybrid will be obtained whose parents were three

[1] As is confirmed by Prof. Hans Molisch in his *Pflanzenphysiologie*, p. 264.

varieties. As a result, fruits are obtained of incomparably worse quality than those borne by the seedling itself.

Not to believe these indisputable arguments and, what is more, to refute facts without personally verifying them in practice is an act almost bordering on sabotage. Let opponents who have not themselves produced a single new variety show a practical example confirming their assertion, or, if they have none of their own, let them examine in our nursery several adult trees grafted with cuttings of young hybrid seedlings, and then they will see the result of such labours.

I have obtained a somewhat better result in my work on accelerating the initiation of bearing in hybrid seedlings by bud grafting them on dwarf stocks; this was particularly evident in grafting pears on quince. Here, at least sometimes, the influence of the stock did not worsen the quality of the fruits of the grafted hybrid seedling.

Success in considerably accelerating the onset of bearing in a seedling has also been obtained by applying the mentor method, i.e., by whipgrafting to its small stem springs with fruit buds of an old, particularly prolific variety. Nevertheless, in many respects, neither of these methods yields satisfactory results.

Much better and more reliable results are obtained from breeding new varieties with a special inclination toward earlier bearing. This is achieved by the expedient selection for crossing of parental pairs already possessing the qualities we require. The fact is that in examining the diverse qualities of all varieties of fruit plants in general, and of apple and pear trees in particular, I paid attention to those which are most suitable for solving the problem facing us. I shall explain in greater detail. All our apple-tree varieties and, in part, our pear trees, have to be divided into four groups: the first group covers varieties whose trees form fruit buds when the wood of the sprouts is three years old; the second group covers trees which form fruit buds when the wood is two years old; the third group covers those which form buds on the previous year's one-year-old shoots, and the fourth group covers varieties, extremely rare, it is true, whose trees produce fruit buds on young sprouts that have grown in the spring of the same year.

Well then, the trees of the varieties of the fourth group are distinguished for their regular, annual and abundant yield. Two-year-old bud grafts of these varieties already bear fruit. Pippin Shafranny, the new variety which in the first bearing year bore fruit on a young sprout of that

year's growth belongs, in part, to this category. In the following years fruit buds were also

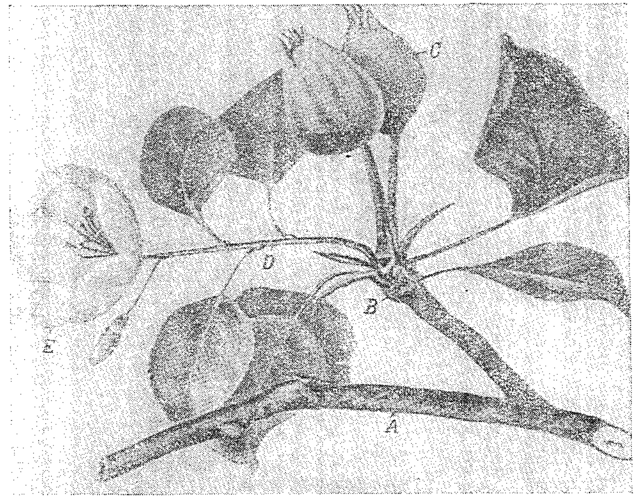

Fig. 1. Development of a fruit bud of Shafran-Kitaika:
A—Growth shoot with two-year-old wood; *B*—fruit bud formed on one-year-old wood; *C*—fruit set on one-year-old wood; *D*—growth shoot in spring of same year formed from fruit bud alongside fruit; *E*—blossoming of upper part of this young shoot

formed on the wood of the previous year. This variety is notable to this day for its abundant yield year in and year out. An analogous property is also met with in the Shafran-Kitaika (see

Fig. 1), a new variety bred by me. From this variety's fruit bud, marked with the letter B, after the blossoming and the formation of the fruits C, there appears next to the fruits a new sprout D on which blossoms E develop anew, and fruits are formed for a second time.

We find this property to a still more considerable degree in the Golden Delicious apple tree, a chance growth from a seed in West Virginia.

By selecting such and similar varieties to serve as paternal and maternal parents and crossing one with the other we can select from the hybrid seedlings specimens with the most strongly developed property of early bearing in varieties that can yield fruit on two-year-old grafts.

This is the only method by which we will fulfil that very worthy task: "To breed early- and abundantly-bearing varieties."

To fulfil this task seeds of the original fruits of Golden Delicious apples brought from America by Academician N. I. Vavilov were planted in the spring of 1933. A hundred seedlings were obtained possessing identical habit both as to form of leaves and their petioles and as to form of sprouts and the buds on them, which proves that here selfing, i.e., self-fertilization, took place. Further observations will show whether this assumption is correct or not. This is particularly important to us, if for no other reason than that otherwise we shall be unable to obtain this orig-

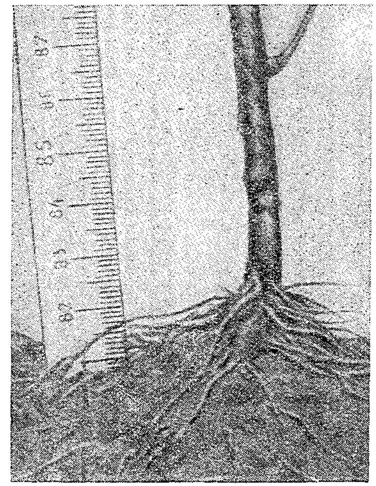

Fig. 2. One-year-old seedling of Golden Delicious apple in loose, rich soil

inal American variety, inasmuch as the dozen trees of this variety received from America have leaves of different forms, and hence raise a doubt as to the genuineness of the variety. Besides, their resistance to the climatic conditions of our locality will be much lower than that of our own seed-bred variety.

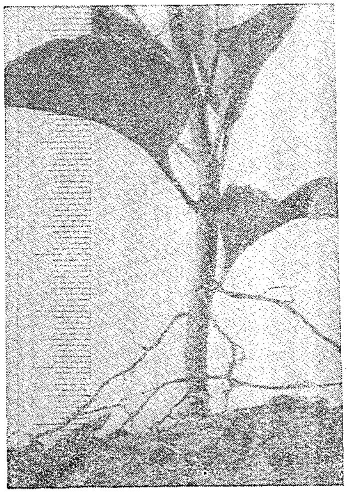

Fig. 3. One-year-old seedling of Golden Delicious apple in poor, dry soil

In addition, as may be seen from the illustrations (Figs. 2 and 3), a hitherto unknown phenomenon can be observed in the Golden Delicious seedlings. It is expressed in an especially vigor-

ous development of the root system, as a matter of fact so vigorous that the roots develop even above the surface of the ground along the lower part of the stem not only above the spot where the cotyledons are found but also between the lower true leaves of the seedling. This already indicates the specific structure of this type of apple tree, a fact extremely important for hybridization in the future, for crossing it with other varieties, for breeding by selection particularly prolific and precocious varieties.

PROOF THAT THE STOCK INFLUENCES THE GRAFTED VARIETY

In 1888, a hybrid was obtained from the seed of a Vladimirskaya Rannaya sour cherry which had been fertilized with a Winkler White Cherry. In 1891 the hybrid produced its first fruits, which were of a uniformly white colour, but for a scarcely noticeable pink hue on the side turned to the light. In 1892 and 1893 the fruits were altogether white. In 1893 I proceeded to bud this variety on seedlings of the common red sour cherry, for which purpose all the shoots on the tree were removed for cuttings in July. In the middle of August the tree began to produce a second growth, and in November while in full sap it was caught by 10° of frost, which caused it to perish. In 1897 all the bud grafts began to bear, but the fruits were all of a uniform pink colour.

Subsequently, when further propagation was performed by bud grafting from cuttings, this time taken from the first grafted individuals, the bud grafts on reaching maturity produced fruits of an even darker colour and increased the height of the tree. This change of colour was obviously due to the influence of the stock of the red sour cherry.

Another graphic example was the process, described below, of producing a hybrid of the attar rose, the flowers of which, again owing to the influence of the stock, lost their yellow colour.

FORCEFUL INFLUENCE OF QUINCE STOCKS ON YOUNG HYBRID PEAR SEEDLINGS

As is commonly known, some cultivated pear varieties develop splendidly when grafted on quince, yielding fruits of even better quality than on pear stocks, while the stature of the tree is considerably lower on quince.

This is due principally to the influence of the quince stock with its weakly developed root system, whose natural rate and limit of growth are far lower than those of the pear. The stock cannot absorb all the substances elaborated by the luxuriantly developing scion, and they accumulate in the latter, chiefly in the form of carbohydrates (for the most part sugars and starch), "crowding tighter" into the fruits, which as a result grow better and are sweeter on dwarfed trees. But even though quince is the very best, unexcelled stock for pears, yet such a distant stock (belonging not only to a different species, but to a different genus, though some botanists mistakenly class it in the same genus, as *Pyrus Cydonia L.*) cannot supply the place of the pear's own roots, and pears grafted on quince seem to "feel" the poisoning with alien saps and bear fruit with great intensity until they finally perish. Such pears perish nearly ten times sooner than own-rooted trees; the latter live to about 200 years, while those grafted on quince have a life span of only some 20-25 years.[1] It has to be said that the

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[1] The grafting operation itself, even if onto pear seedlings, and even if carried out to perfection, usually reduces the scion's length of life by more than half, as it is too great a shock for the organism.

number of pear varieties which grow effectively and fruit better on quince is not as large as is usually believed.[1] Most varieties of pears have an "antipathy" to quince. These varieties do not thrive on quince—they either cannot grow on it at all, or if their buds or cuttings do take on it, they develop poorly, are sickly and perish before long. However, the majority of these "antipathetic" varieties can be made to grow on quince by means of intermediate grafting. This is done by first grafting on the quince a variety that does thrive on it (a "sympathetic" type), and it is onto the stem produced by this type that the "antipathetic" variety is then grafted. And alien as the quince organism is to the pear, factors in favour of using it as stock are that the fruits of pear on quince are frequently improved and that a greater percentage of the energy and sap goes for fruiting than for vegetative growth.

It is known, further, that an organism accustoms and adapts itself to environmental changes very much more easily at an earlier age, before it is completely formed. As far as I was able to study the point in my practical work, fruit-plant hybrids at an early age are particularly plastic

[1] Naturally, these varieties too are adversely affected by unfavourable conditions of soil and climate.

and susceptible to change, and adapt themselves with remarkable ease to the various external conditions of their environment and to symbiosis with other species when grafted.[1] In grafts of pear on quince, this is also to be observed. And if, let us say, an old pear variety that is "antipathetic" to quince cannot be made to grow satisfactorily on the latter because the two are not "used" and adapted to each other and because of the (in all likelihood mostly chemical) unconformity between them, there is immeasurably more hope of doing so if one works with infant plants.

Prompted by such considerations, I made the experiment of grafting upon young two-year-old quince seedlings twenty-eight new and not yet bearing pear varieties selected for their outward characteristics. This was done in order to "accustom" these pear types to quince, and also in order to study the influence of quince upon young, only just forming varieties and find out how the latter react at an early age to quince stocks—whether they are sympathetic or antipathetic to them. On

[1] And also "adapt" and "accustom" themselves to the natural method of propagation by grafting, and, being more pliable in all respects, endure the actual process of union more easily, assimilating saps of alien origin and composition.

an average, twelve buds of each variety were grafted. The results were as follows:

100% of the buds took in	9	varieties
50% „ „ „ „ „	12	„
25% „ „ „ „ „	7	„
Year-old growth from buddings 1 metre in	7	„
„ „ „ „ „ 0.5 „ „	14	„
„ „ „ „ „ 1.15 „ „	7	„
Shoot ends thicker than in original plant in	4	„
„ „ of equal thickness with original plant in	11	„
„ „ thinner than in original plant in	13	„

Some interesting points are revealed here. Propagating hybrids at an early age by grafting them on quince[1] for the most part greatly injures their properties. This is readily discernible even to the eye, by the outward appearance of the year-old growth. It is also partially indicated by the figures I have quoted, which show that in the largest group of varieties in this experiment, the one-year-old shoots are thinner than in the original plant (and thickness of shoot ends is one of the major characteristics of "culture," it is connected with the valuable properties of a variety). Evidently we see manifested here the

[1] To say nothing of grafting them on wildings, which in most cases hopelessly corrupts the young variety's properties.

vegetative influence of the stock upon the young organism of the hybrid, which is still far from having developed the stability possessed by an adult, fully established variety. Only a very few of the pear types exhibited a deviation for the better; in the overwhelming majority of cases, the quince seedlings proved unsatisfactory mentors. The influence of the quince stock also manifests itself very differently in different varieties as regards various details of outward appearance. Besides the thickness of the shoots, the degree and sharpness of the serration of the leaf margins becomes greater or less, and so does the pubescence on the leaf blades, the thickness of the blades, the density of venation, the size and roundness of the buds, the length of the petioles, etc.

In succeeding years, as the growth from the buds develops further, there may be certain changes, though most probably they will be slight. The matter is also complicated somewhat because, as I have observed, the adaptation of plants to symbiosis requires a certain period of time, the length of which depends in no small measure on external conditions too. Things like injuries of various kinds, affliction with fungous diseases, etc., not only retard the development of plants, sap their vitality and tend to make them run wild, but also hinder such "adaptation."

Among the one-year-old bud growths we are examining, none proved to have a particularly dwarfed, squat habit or sufficiently thick shoot ends. The reason is principally that, as mentioned above, the stock was not a layer-propagated, but seed-grown quince—seedlings, which on account of their youth could not exercise as strong an influence as is usually exercised by an adult organism or parts of it, as, for example, layers or cuttings.

In passing I must remark that more dwarfed and hardier types of the quince itself should be bred by hybridization and selection. That is quite possible, as proved, for example, by the Severnaya quince bred by myself—a choice hybrid seedling obtained by crossing the wild Caucasian *Cydonia oblonga Mill.* with the Sarepta quince *Cydonia vulgaris Pers.* The Severnaya quince is more resistant to frost and evidently to dry soil too, and is particularly interesting because it can be propagated much more easily than any other quince variety by planting cuttings straight in the ground in the spring or even in early autumn.[1]

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[1] Evidently, this is due largely to the fact that I trained it from an early age to vegetative propagation by cuttings; and besides force of habit, selection too exerted its powerful influence both in grafting and in propaga-

Then we must take into account that, suited as is the quince—*Cydonia pyriformis Kirchn.*—to serve as stock for pears, it is nearly as well suited, in the form *Cydonia maliformis Mill.,* to serve as a dwarf stock for apples; particularly if we begin to graft new hybrid apple varieties onto it while they are still young and each year make new bud grafts from the shoots put out by bud grafts of the year before. Accustoming apples gradually to symbiosis with quince, we shall in the end evolve new apple varieties capable of growing well on a quince stock.

Further, an experiment has also been undertaken in producing dwarf apples and pears by using as stock the Juneberry *Amelanchier vulgaris Moench.*

In addition, the experiment has been made of budding young hybrid pear and apple seedlings on seedlings of *Sorbus melanocarpa Neynhold* × *S. aucuparia L.*, which have a bushlike form of growth no taller than two metres.

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tion by cuttings, in view of the diversity of properties between different plants, however closely akin, and even between different parts of the same plant (cuttings, portions of them and even individual buds). The specimens less suited to vegetative propagation perished, while those better fitted and accustomed to it survived and multiplied.

And, lastly, we have obtained a new northern Paradise variety of undoubted complete hardiness; it was bred by crossing *Pyrus Malus paradisiaca L.* with the low-growing *Pyrus prunifolia W.*

Experiments in grafting cultivated apple varieties on this stock have yielded quite acceptable results.

PHOTOPERIODISM

Photoperiodism is a powerful factor in advancing the cultivation of subtropical species of perennial fruit trees northward.

Only in 1930, after the publication of the work of Garner and Allard on the importance of the length of sun illumination to plants, was the experimental study begun of this extremely important factor influencing the life of plants, as is vividly demonstrated in the recent work of Comrade Lysenko on the cultivation of cereal crops.

In 1932, photoperiodism proved to be extremely useful in the production of new varieties of fruiters, because of the possibility of shortening with its help the vegetation period of certain species of plants, this resulting in fuller maturation of the summer growth of the branches, which,

in its turn, considerably enhances the resistance of these plants to winter cold.

Of course, the influence of photoperiodism on annual field crops differs considerably from its effect on perennial fruit plants. In the former case, its influence is limited to certain alterations in the details of growth of the plants in the year of its employment, and needs to be repeated annually. In the latter case—the case of perennial hybrid fruit plants—shortening of the vegetation period may be fixed all through the life of the hybrid variety, provided that photoperiodism was employed for several years in succession beginning with the moment of the hybrid shoot's germination. This may be quite feasible, because all hybrid seedlings, and especially hybrids, the habitat of whose parents, i.e., father and mother, were geographically far apart, at the time of their development from the seed and in the earliest period of their life possess the faculty of vigorously adapting themselves to environmental conditions, and correspondingly build up a constitution adapted to the shorter vegetative period. This latter property is fairly satisfactorily retained later if propagation is performed vegetatively, by graftage or layerage, but is not fully transmitted if propagation is performed sexually (from seed).

Example: A hybrid peach seedling fertilized with pollen from Posrednik (*Amygdalus nana mongolica* × *Pr. Davidiana Franch.*), when the day was shortened to twelve hours, shortened its vegetation period by a whole month.

INFLUENCE OF ECOLOGICAL FACTORS ON THE DEVELOPING STRUCTURE OF ONE-YEAR-OLD HYBRIDS

In certain unfavourable years in respect to the sum-total of harmful environmental factors which (because of insufficient study of the nature of many of them) still cannot be eliminated, or changed, or ameliorated, the constitution of that year's seedlings of fruit plants irresistibly deviates towards the wild forms, or rather, towards various defects as regards culture qualities. In such years the work of the hybridizer on some species of plants is entirely wasted. Not only do the seedlings run wild; sometimes they all fail to grow and remain in a dwarfed condition, with only three to five leaves, throughout the vegetation period of that year and the years following. Furthermore, favourable years for development occur very rarely with hybrids of certain species of fruit trees. For example, crosses of the mountain ash with pear and apple did not yield successful results for seven years in succession, and only in the eighth year did the crossings succeed —every one of them—and yielded hybrid seedlings fully fitted for healthy development and growth.

ATTEMPTS TO ACCELERATE THE ONSET OF BEARING IN HYBRID SEEDLINGS OF FRUIT TREES

In the beginning of the third part of this book,[1] and many times earlier, I have referred to the erroneous method of attempting to accelerate bearing in hybrid seedlings by grafting them as cuttings onto the crowns of adult tree stocks.

One is positively astonished at the persistence of this view. It springs from ignorance of the most elementary truths of biology, one of which is that the leaves of every plant transform the raw material supplied by the root system into that particular composition from which the structure of the given plant is built up.

Take, for example, the origin of the Kandil-Kitaika apple, the hybrid seedlings of which

[1] The reference here is to I. V. Michurin's *Results of Sixty Years' Work*, published in 1934.—*Ed.*

proved to be insufficiently resistant to frost. In order to enhance hardiness, a cutting of a two-year-old hybrid was grafted onto the crown of the mother plant—a cultivated Kitaika which was already bearing. The result was that the graft began to bear fruit several years later, i.e., at the same time as the hybrid growing on its own roots. Furthermore, the fruits on the graft were no larger than those of the ordinary Kitaika. Only in the course of time, as the branches of the Kitaika were partly removed every year, consequently reducing the influence of the work of its leaves, and as the leaf system of the graft itself increased, did the fruits on the graft gradually grow in dimensions and in the end assumed the form and size of Sinaps generally.

There have been any number of such hybrids in my many years' practice, and every time the results observed were the same. Never was the beginning of bearing accelerated; on the contrary, it was delayed, and, in the second place, a substantial deterioration of the quality of the fruits was observed, in spite of the fact that cultivated, not wild varieties of trees were taken as the stock.

It will thus be clearly seen from what has been said how utterly futile is the method of

grafting cuttings of young apple hybrids, the constitution of which is still incapable of contending with the influence of the leaf crown of the stock. But, it should be remarked, if we do not allow the influence of the leaves of the stock to develop by removing all the ungrafted[1] branches from the crown of the stock, leaving only the stem for a cleft graft, for instance, or if not one cutting is grafted, but as many as possible on the main branches of the crown, then, it goes without saying, the picture will be different and the results better. Nevertheless, a grafted hybrid variety when on its own roots is sometimes of far better quality, and more effectively retains the better culture properties.

This method often has to be resorted to when the structure of the hybrid's root system happens to be poor. This was observed, for example, in the case of a new variety of the attar rose Slava Sveta. The hybrid seedlings obtained from ferti-

[1] But this method sometimes results in killing all the parts of the stock, due to the disturbed equilibrium between the strong root system and the small amount of leafage, as a result of which, the first winter frost strikes both the roots and the stem of the stock at a time when they are filled with superfluous sap which the leaves have not yet managed to process, and the stock completely perishes.

lizing the yellow Persian rose with the pollen of the Damask rose rapidly perished, even before they attained a height of 5 cm., owing to the poor development of the root system.

These seedlings were saved only by grafting them on one-year-old seedlings of the *Rosa canina*. But owing to the influence of the stock the flowers of the new variety completely lost their yellow colour. The same thing happened with the Krasa Severa cherry.

APPEARANCE OF GYNANDROMORPHISM IN A CROSS BETWEEN A PEACH (*PRUNUS PERSICA SIEB. ET ZUCC.*) WITH THE ALMOND POSREDNIK (*AMYGDALUS NANA MONGOLICA* × *PRUNUS DAVIDIANA FRANCH.*)

In 1931 flowers of the Iron Kanzler peach were pollinated with the pollen of a Posrednik almond. The fruit that set was of an extremely original form: Half of the pericarp was, both in size and in flavour of the flesh, identical with the peach; the other half was half the size of the former and resembled in everything an almond; the flesh was of a bitterish flavour, like the almond.

When the fruit, after it had been removed from the tree, was opened, the walls of the stone inside proved to be divided into several parts, and at a slight touch it broke up into those parts, as may be distinctly seen in the drawing. [See Fig. 4.]

Inside the stone there was a healthy and well-filled kernel. It was immediately planted into a flower pot, where it germinated under the constant application of ionization and photoperiodism of a 12-hour day. In the spring of the next year, 1932, the seedling was planted together with the clod of earth into a bed in the ground.

As in 1932, photoperiodism continued to be applied to the hybrid seedling in 1933 and 1934, and as a result its vegetation period of growth was reduced by a whole month.

The seedling stood well the winters of 1932/33 and 1933/34, and is still developing quite normally. We are looking forward with great interest to the first fruiting of this hybrid seedling.

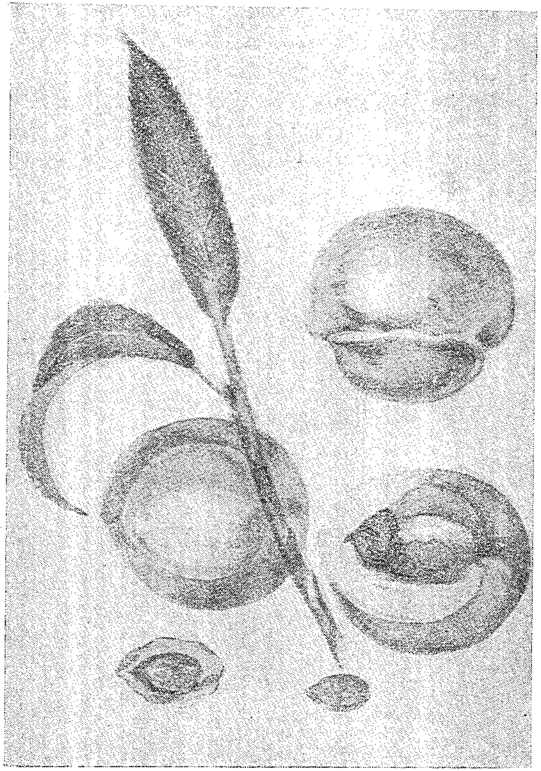

Fig. 4. A striking case of the appearance of xenia in an apricot hybrid which was fertilized by a pollen of the almond Posrednik

THE DANGER TO OUR HORTICULTURE FROM IMPORTING AMERICAN PLANTS

It is generally known that the ordinary European varieties of apples, pears, plums and cherries are not cultivated in Japan, due to its unsuitable insular climatic conditions. Even the local Japanese varieties of these plants yield fruits of very poor flavour there. Moreover, the country teems with countless varieties of parasitic fungi, the result, apparently, of the constant violent motion of the moist surrounding air. These parasites have recently made their way to our Far Eastern Territory, where we are beginning to observe the rapid spread of the disease afflicting fruit plants known as fire blight (caused by the fungus *Bacillus amylovorus* and *Namonia pyrivorella Morzum*). As for the United States of America, it has long been so overrun with all kinds of parasitic fungi and various other plant pests that our horticulture is really being endangered by the import of plant varieties and seeds from America. We risk contaminating our orchards with many pests, as in the case of mildew (*Sphaerotheca Mors-uvae*) which affected all our gooseberry varieties; as a matter of fact, fire-blight has already made its appearance in several orchards. It is also in place to recall the fact of phylloxera having been imported into Europe from America. Besides, most American fruit varieties, especially the stone fruits, are unsuitable for our orchards, if only for the reason that although they grow and blossom profusely under our climatic conditions, yet they either altogether fail to set fruit, or if they do so occasionally, the fruits are small and have a tasteless pulp.

In a word, the importation from America, and particularly from Japan, of live plants and of seeds that have not been disinfected should be prohibited in view of the danger of introducing infection. Unfortunately, however, this measure will only enable us partially to prevent this plant scourge being transmitted to our orchards. However strict the quarantine we introduce, this Japanese poison will be carried over to us, if not through the medium of plants, then of the various other articles which we import from America and Japan.

MEANS OF SHORTENING THE VEGETATIVE PERIOD OF NEW PLANT VARIETIES

The ten new hybrid varieties of hardy grape—which stand the winter without any artificial protection—that I have produced in late years make it possible to extend the zone of cultivation

of the grape another five hundred kilometres northward.

Besides winter-hardiness, what is needed of the grape for the advancement of its cultivation northward is later flowering, because of the spring morning frosts, and earlier ripening of the fruit, because of the early autumn frosts. All this together presents a difficult problem, namely, how to shorten the vegetative period of the grape.

Already in the 1900's, when working on hybrid varieties of yellow cigarette tobacco, the Kommunarka early-ripening melon and hardy grape seedlings—the first to be produced in those days—I was agreeably surprised, when selecting seedlings that completed their vegetative development earlier than the others, to find that some of the seedlings that had germinated from seed later than others, namely, at about the beginning of July, managed to complete their growth and mature even earlier than those that had germinated in the middle or the beginning of May.

I made a note of this marked, and at the same time rather paradoxical, phenomenon, and in subsequent years I never failed to keep watch for similar manifestations in interspecific hybrids of other plants. It turned out that this phenomenon is in most cases to be met with in hybrids from parents whose habitats were very far apart, and that, on the contrary, it is practically never encountered in simple seedlings or in hybrids from varieties of one and the same species coming from mutually close places of origin. This, of course, could only be explained by the fact that hybrids of parents of mutually remote places of origin are always far more susceptible to alteration of their properties under the influence of the environment than are simple seedlings or hybrids from parents whose birthplaces were not far apart. It is more difficult to find convincing reasons for the acceleration of the vegetative period in seedlings that germinate late from the seed. An exception, perhaps, is the hypothesis that the higher temperature in July, as compared with May, has an influence in accelerating cellulose formation in the shoots. But is this so? We know that in our parts shoots from later plantings usually result in plants which mature late, or which are still completely immature by the autumn. Moreover, everyone is familiar with the influence of equal quantities of heat on northern and southern plants: to equal amounts of heat northern plants react far more quickly than southern, a fact which was noted already in the seventies of the last century by A. de Candolle. This phenomenon is very natural and does not need experimental verification—it has nothing to

do with our problem. What we are speaking of now is the faster rate of cellulose formation in late, July, shoots under the influence of a greater sum-total of heat, as compared with that of earlier, May, shoots, resulting in the latter case in a slower rate of growth. Well, this accelerated building of the organism in the very earliest stage of development of hybrids obtained from parent plants of mutually remote places of origin, sometimes becomes fixed and remains unaltered throughout the subsequent life of the plants. In this way varieties of plants are obtained with a shorter vegetative period, a feature of extreme importance for the northward advancement of the cultivation of southern species, e.g., grape, apricot, peach, etc.

Let us try to analyze the problem by successively examining the whole life cycle of a plant, beginning with the earliest stages of its development. Let us start with the seed and consider what it represents. Its most essential part is the embryo of the seedling, which harbours within it the rudiments of a multitude of properties hereditarily transmitted to their offspring from the parents and their forebears, and, secondly, the cotyledons, which consist of a stock of nourishing substances needed for the initial development of the shoot and its radicle. The composition of this stock is not a dominating factor, as is shown by the experiment of removing the cotyledons and grafting those of a different seed in their place.

As to the large number of properties hereditarily transmitted to the embryo by the parents, only a few of them, as I have said before, will develop in one degree or another, those, namely, to which the environmental conditions of the given period of the year are favourable. Furthermore, some of the properties which under the influence of the environment acquire the ability to develop, more or less undergo alteration, while from the totality of the interaction of others, absolutely new properties result, properties not possessed by the parents, as can be seen in the given case. It is because of this process that mutational deviations are manifested more strongly in the early period of development of the plant organism, and more feebly in the later stages. Shortening of the vegetative period in some hybrid seedlings that germinated late from the seed must be regarded as one of these mutational deviations.

Further work in this direction will show whether this is so or not. The essentially important thing for us is that this phenomenon provides a base for the creation of many species of plants with a shortened vegetative period. The absence

of such species of plants in the past made it impossible to introduce for commercial cultivation in the central regions and the north of Russia many southern plants with a long vegetative period. One of these southern plants is the grape. The new, precocious varieties of grape do not suffer from the winter frosts, it is true, but late spring morning frosts may kill their blossoms, and, moreover, the early frosts, which in the northerly regions sometimes occur at the end of August, likewise do not spare the fruit of the grape. What we need are hardy varieties which begin to vegetate late, to blossom late, and to ripen early.

For the solution of this problem we, in our nursery, have planted for the spring and summer of 1935 seeds of new varieties of hardy grape which needs no protection against winter frosts and which ripens early. These seeds were taken from the first fruits of the new varieties, which were completely isolated from the chance pollen of any late-ripening cultivated varieties. Seedlings obtained from the seeds of a new variety of plant at the time of its first bearing are most amenable to alteration. The last two conditions are of immense importance. The shoots from such seeds should be pricked out from the boxes and planted in the beds in rows in strict succession as they germinate, thus artificially helping to lengthen the period between the early ones and late ones. In the autumn, selection should be made by picking out the seedlings, wood formation along the vines of which has reached the greatest height. The results of the experiment should then be assessed. In this way we shall obtain already in this first generation a sufficient deviation towards later beginning of growth in the spring and earlier termination of growth in the autumn.

It should furthermore not be forgotten to terminate growth artificially at the end of the summer (beginning with August 25) by nipping off the ends and the spurs of the vine.

When selecting one- and two-year-old hybrid and simple seedlings according to habit, it should be borne in mind that in the case of the grape, as of all species of plants at a young age in general, the constitution of all parts of the organism in its infancy has an inherent tendency to deviate towards the form of the wild progenitors.

This deviation is one of the manifestations of the so-called biogenetic law, according to which every organism in its embryonic and infant development repeats all the alterations of form through which its race had passed.

When selecting seedlings, those with the shortest vegetative period should be considered the best. From these seedlings a selection should be made according to sturdiness of development, thickness and length of the vines, and largeness of the leaf laminae, and also, of course, according to frost-hardiness and immunity to disease and parasites. Later, at the time of the first bearing, selection should be made according to yield and the taste and external qualities of the fruits.

When selecting seedlings it should be remembered that not only in some hybrids, but also in pure species of grape, sometimes as many as sixty per cent of the seedlings develop into staminate plants. Such seedlings should be destroyed, since they cannot bear fruit.

COVERING THE SOIL UNDER PLANTS

I have long observed that if the soil under plants, after having been thoroughly loosened, is covered in spring and summer, and especially in dry years, with leaves, straw, moss or other, more compact, material, the plants develop nearly twice as fast and better than those where the soil is not covered. All this has been fully confirmed by recent work of foreign horticulturists.

In North America, for example, good results are being obtained by covering the soil with thin cardboard impregnated with asphalt, which they call thermogen. Large apertures are made in the thermogen at considerable distances from one another to permit free access of air and rain water, as well as apertures for the plants. Soil of crumbly structure facilitates penetration of air, thus promoting the bacteriological processes which enrich the soil with various nutritious substances. When the soil is covered, these processes proceed more intensely; moreover, moisture is better preserved, the soil does not get so heated from the sun's rays, and is protected from sharp falls of temperature.

SELECTION OF HYBRID SEEDLINGS

Selection of seedlings for hardiness should not be made from one-year-old individuals, since at this age growth development depends on the time of germination of the seed, which may sometimes be half a month or more later than the initiation of growth in adult plants of the same species; as a result in the first year the wood of the seedlings in most cases fails to mature well by the autumn. Different is the case when selection is made from two-year-old seedlings or from one-year-old grafts, the plants having been able in the summer of the second year to make use of

the full vegetation period. In this case error in the selection of the more frost-hardy is precluded. But even when selecting seedlings for hardiness at the end of their second year, consideration must be given to whether the summer was not unusually humid, or whether there were not unusually severe frosts in the winter (such as, for instance, in the winter of 1928/29). In such cases strictness in roguing the seedling should be somewhat relaxed.

TRAINING HYBRID SEEDLINGS OF THE SECOND GENERATION

Seedlings of the second generation of new hybrid varieties of apples and pears, obtained as the result of fertilization with the pollen of the same varieties or the pollen of local old varieties, will in their overwhelming majority inevitably produce varieties inferior both as regards flavour and the time of early summer maturation. This is a consequence of the repeated influence of the climatic conditions in our section of the country and of the influence of our local varieties in the role of fertilizers. The originator who works with fruit varieties of apples and pears should therefore always give preference to the planting of first-generation hybrids. Where good local winter varieties of fruit trees exist under local climatic conditions, as, for example, on the South Crimea coast, in France, Belgium, South Germany and "Burbank's" California, it is quite in place to train the second generation, and the results should be good. But this should not be done in our parts, under our severe climatic conditions, whose repeated influence has a deteriorating effect on the structure of the seeds and seedlings.

INHERITANCE OF ACQUIRED CHARACTERS

Even before the beginning of the present century all naturalists were very much interested in solving the question as to whether acquired characters are transmitted by inheritance or not. In studying this question scientists divided into two camps, one of which used every kind of argument to refute this possibility, while the other recognized that such transmission by inheritance must actually exist, arguing that without this there could be no evolutionary movement in the structure of living organisms.

The controversy on this question remains unsettled to this day. With us fruit growers our entire case is usually based on the propagation of new hybrid varieties by the vegetative method

of grafting or cutting. And even if partial changes do occur in the propagated varieties of plants they are so insignificant that ordinarily they are not even noticed. It will be a different matter should we decide by the vegetative method to propagate these hybrid varieties in their youth, when they have not as yet developed stability. In such cases we will, as in cases of sexual propagation, inevitably meet with the following phenomenon: the varieties may apparently lose or change their properties and acquire absolutely new characters as a result of the influence of external factors.

But all this, nevertheless, cannot induce one to agree with Spencer's extremely erroneous postulate that either there has been inheritance of acquired characters, or there has been no evolution. I would say that properties acquired hereditarily by hybrids are, as a matter of fact, not lost when these hybrids are propagated sexually (by seeds) in the second generation; what actually takes place is a change in the type of their combination, some of these properties remaining latent,[1] while others, grouping themselves with

[1] It sometimes happens that latent properties which do not for a long time meet in the outside environment with conditions favourable for their development, gradually weaken and are destroyed altogether.

the hybrid's formerly latent but now emerging properties, become dominant in the types of grouping that vary for every separate seedling.[1] Hence, the conception of short- and long-lived modifications is in the given instance entirely irrelevant, for between the false notion that acquired properties completely disappear and the notion that they exist latently in the progeny, lies too wide a gap; and everywhere the visible evolutionary change of the forms of living organisms, caused by the inheritance of acquired characters, is so obvious that it definitely removes all doubts in this respect. Thus, the changes in the combinations of the properties of plants do not in the least hinder the evolutionary change of the forms of living organisms.

'All the distinctive characters of any variety of fruit plant are a result of hereditary transmission and a combination of the influences of external factors[2], both in the embryonic period of the formation of the seed and in the postembryonic

[1] Besides, these new combinations of the hybrids' former properties are sometimes distributed in every part of the organism of each hybrid seedling not evenly but in various forms of build, hence the appearance of sport variations.

[2] Plus the correlative influence due to the mutual influence of one on the other

period of the development of the seedling from the seed. But since, as time passes, these combinations of the different external factors constantly change, and since we cannot at will create anew exactly the same groups of external factors that existed when the variety was obtained, we shall, in planting the seed of the hybrid, never secure the same variety but always a completely new one. These new varieties will only possess a residue of the properties of the former ones, properties that were preserved because they were in the organism of the plant itself, in the sex cells and did not originate from the external influence of the environment. But even these latter are frequently absent in the progeny of interspecific hybrids. As an example let us take the seedlings of the interspecific hybrid Krasa Severa cherry, a product of the cross between the sweet and the sour cherry. Among these seedlings there is never a single specimen possessing the pure specific characters of the sweet cherry. All of them, after many plantings over a period of forty years now, are entirely new varieties of cherry that always differ from one another, with a predominating tendency towards the structure of the maternal parent, i.e., the sour cherry, but with a more luxuriant development of all parts of the organism. And this manifests itself particularly fully if the maternal plant was not own-rooted, but was grafted on the stock of ordinary cherry seedlings. If, however, the tree was own-rooted or was grafted on the seedlings of cultivated varieties of the sweet cherry, then the seedlings of the hybrids manifest a more luxuriant structure. Nevertheless, there will not be found among them an individual with marked characters of the sweet cherry.

CULTURE OF SUBTROPICAL PLANTS

I am not sufficiently acquainted with the local conditions of culture and the peculiar properties of subtropical plant species, particularly citrus (and with their parthenogenesis); owing to this there may be some errors in my judgments. Nevertheless, since I should like to render plant breeders in the subtropical sections of our country all the assistance I can, I offer, on the basis of my many years of work and experiments, the conclusions I have arrived at with regard to the main task—that of increasing the frost-hardiness of subtropical species of economic plants in general and, particularly, of citrus fruits, the tea tree, the cork-oak and other species of economic value. It must be said that, in view of the structure of the leaf system in

all species of plants with evergreen leaves, it is so far possible to obtain but a slight improvement in the direction of frost-hardiness. Nevertheless, it is a possibility which should be made the most of. By training two or three generations of hybrid seedlings it is quite possible gradually to obtain frost-hardy forms of subtropical crops by employing the only correct method, which consists in the breeding and strict selection of new exclusively hybrid varieties trained by bringing the action of photoperiodism to bear upon them from the earliest stage of the development of their organism from the seed. Here a more detailed explanation of the method I recommend is needed.

First of all it is necessary firmly to remember the following.

1. All hybrid seedlings which have come from crosses between parent plants (father and mother) distant from each other as regards their geographical habitat, are, from the earliest stage of their development from the seed, particularly until they reach the age of five years, endowed in an exceptionally strong degree with the property of adapting themselves to all the ecological conditions of the locality where they are growing and under the influence of which they are building up their organism. Therefore all the alterations they

acquire at this early age are retained in their entirety, without changing, in their subsequent life—something which never occurs in old varieties, where the alterations are temporary and gradually disappear in the years immediately following. It follows from the above that if by applying photoperiodism in the earliest stage of the development of hybrid seedlings, even if only in the course of three years, we shorten their vegetation period and thereby make them more resistant to frost, this property will become permanently fixed in them. This will occur because of the fact that the very structure of each hybrid seedling will—to some or other extent—present various deviations from the usual structure of the old varieties, and this will make it possible to select specimens of seedlings with more useful properties both as regards frost resistance and as regards superior quality of fruits, etc. Such selected individuals of first-generation seedlings should be employed in the second generation already in the role of male or female parents for the production of hybrids with still better and more useful deviations. By following this procedure we should have long since created new varieties of various species of plants in the subtropical sections of our country.

2. To obtain first-generation seedlings for training, five or six combinations of parent pairs should be properly selected and the seed obtained from the cross of each separate pair of parents should be planted into a row, care being taken, under *all* circumstances, that their germination and sprouting should occur when it is already warm, when there is no longer any danger of morning frosts. The observance of this condition is of major importance. The point is that the shoots of seeds which germinated in a warm period develop at an accelerated rate, whereas those that germinated in a cold, early spring grow at a slow rate. In the subsequent life of the seedling this function of late spring vegetation sometimes becomes a permanent property, which is very beneficial, because thereby the danger of the young growth being injured by early morning frosts is avoided, and, besides, a strain with early ripening of fruits is obtained as the result of the subsequent accelerated rate of development of all the details of the hybrid.

In choosing combinations of plant pairs for crossing, the role of the female parent should be assigned to individuals with relatively better qualities, because the maternal plant always more fully transmits its properties by heredity to the hybrid.

3. In the first and second years after germination from the seed, seedlings should be trained in meagre soil and, without fail, in a place well protected from winds. Otherwise the young hybrids, with their small foliage, will not be in a position fully to utilize the carbon dioxide of the air, because the gas will be blown away by the wind from the surface of the soil. As a result the constitution of their organism will sharply deviate towards the side of wild forms. Superfluous moisture in the soil should be avoided. Nor should the development of group growth of several shoots from the root neck be permitted; side branchings from the main shoot should be left in a limited quantity, so that they may better develop in thickness, which helps to increase the size of the fruits of hybrid seedlings.

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I. V. Michurin, *Results of Sixty Years' Work*