Methods of Sugar Beet Selection in the U.S.S.R.

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Selective breeding of sugar beets in Imperial Russia was very well developed. At the end of the eighties and in the beginning of the nineties certain firms had introduced individual selection. The size of the parent stock selected increased every year. At. the beginning of the first World War, almost two thousand pedigree varieties were selected annually at the several breeding stations. For evaluation of the quality of the generations, complex methods of mathematical analysis of test data were used. In making up the seed for commercial release, crosses from carefully studied families were used (16) ".

During the revolution of 1917 most of the breeding stations were destroyed. Reconstruction of some of them began *in* 1919. In 1920 the Sakharo-trest (Sugar Trust) set up the office of varietal breeding and seed production management for the purpose of directing their activities. The first steps *in* selective breeding in Soviet Russia were carried out under very difficult conditions because the breeding stations and laboratories had been ruined, the seed stocks mixed up, the breeding records destroyed. To this should be added that many Polish breeders, to save their lives, had moved to Poland during the revolution.

Mass Selection

During the early years of activity of the Soviet Breeding Stations, mass selection was generally used.

During the winter of 1921-22, more than one million roots were analyzed at 12 breeding stations of Sakharotrest (Sugar Trust) .

As regards the makeup of the seed released by factories for commercial planting, Soviet selections had received a sudden setback by several dozen years except for the fact that the original stock for Soviet breeding was not accidental material, as was the case in the early years of selective breeding of sugar beets in Imperial Russia, but consisted of varieties which were the result of long selection during the pre-revolutionary period. The products of mass selection were propagated once and the seed obtained was then released to the factories. This method was in use until 1925.

During the years 1925 to 1931, the practice was to propagate for commercial release without selection the best numbers of elite varieties from breeding stations, i.e., numbers which had received high rating in varietal tests. After 1930 this method was gradually replaced by a new one which involved the growing of several elite strains from breeding stations which had been given good ratings in varietal tests. Whenever a lot of seed was released it was compounded in such a way that in the next generation cross pollination would take place. This method enables the breeder to study combinations which manifest the effects of heterosis, in order that he may produce such combinations at will. However, Soviet literature contains no references pointing to the finding of such combinations.

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Early in the history of Soviet selective breeding, mass selection was used by experienced men (Sempolovsky, Lebedinsky, Hellmer, Goodwill) ; this method was of positive value because it preserved the basic nucleus of breeding material in the possession of the breeding stations. In contrast to this, young scientists *in* charge of other breeding stations were carried away by methods of analytical selections which resulted in excessive splitting of the original materials of the station without retaining the original core. Most of the varieties released by stations Uladovka, Ivanovka, Ramon and Lgov were the result of mass and group selection.

Individual Selection

Soon after the reactivation of breeding stations, some of them began to change over to individual selection. In 1923 there were approximately 2,500 strains which were being studied at all breeding stations.

The methods of selection used at that time have been described in the publications by B. Lebedinsky (6) and I. Voitkevich (15) , and also in a special volume devoted to a description of breeding stations (14) .

The number of selected parents continued to grow and, in 1938, 7,765 numbers were planted out at all the breeding stations in varietal breeding tests (3) . The parents selected each year arc planted out in groups for seed production. In selecting the groups, the origin of the parent stock or the direction of selection is used to guide the breeder in his choice. Since only a small quantity of seed is obtained from each parent, great care is given to preliminary vegetative propagation—the dividing of roots in order to obtain clones by the method of Nowoszek.

In this method the clones are also set out in groups for cross pollination. The amount of seed obtained by this method from one parent is quite sufficient for making tests of the progeny for two years in succession and for subsequent propagation of the best among the progeny. With this kind of propagation, distance isolation is used. To begin with, individual strains are grown between rows of high-growing plants (southern hemp) at a distance of 5 to 10 meters between groups. In producing subsequent generations the distances between groups are increased to tens or even hundreds of meters; the groups are placed between plantings of field crops. In any case, as pointed out by Savitsky (10) , beginning with the F_2 generation, propagation takes place within a circle of forms related in their origin and, as a result, there is a gradual decrease in yield of the progeny (regression) .

This circumstance was taken into account in making up lots of seed for commercial release by mixing several strains for cross pollination. Beginning with 1927, products of individual selection (7) were among the lots of seed released.

Inbreeding

Inbreeding was initiated at certain breeding stations as soon as self fertile races were discovered. An outstandingly large number of these was found at the Ivanovka breeding station. Subsequent generations were obtained either by the use of selfing (4) or by the method of sister crosses after Munerati (1) . In the experiments of Grinko (4) , the material was carried to I_6 generation in 1940.

In regard to yield, the products of segregation were predominantly low in tonnage. In regard to sugar the inbred strains segregated into forms which were both high and low in sugar. Selection for increase in sugar content gave positive results (4) . The morphological characters (especially shape of the leaves and the leaf rosette) exhibited diverse forms in the first inbred generations, but beginning with I_3 a marked morphological uniformity was observed in the progeny, and in 1_4 and I_5 the progeny became practically uniform. A considerable number of cases developed deformities and abnormalities in structure of the leaf lamina, petioles, the flower and the seed balls (1,4).

On the positive side, some races manifested relative resistance to *Cercospora* (4) . The progeny of crosses between inbred lines showed occasional heterosis but these forms did not become of commercial significance. A study of the progeny of self fertile races and of crosses between self fertile and self sterile races showed that the character of self fertility is inherited as dominant (1, 4). Investigations by H. Savitskaya demonstrated that the manifestation of the character of self fertility depends to a great degree on the temperature of the air at the time of flowering (11).

The Hybridization **Method** of **Breeding**

To increase the scope of original breeding material for subsequent work in selection, Savitsky carried out a series of crosses between sugar beets and other cultivated beet forms—fodder beet, semi-sugar beet, table beet and mangold. The results of these crosses proved very interesting both in the theoretical and practical sense. The cross of the sugar beet with the wild *Beta vulgaris* L. showed great promise for the purpose of increasing resistance to *Cercospora.* Hybrids of the sugar beet with the green varieties of the mangold and with the wild *Beta vulgaris L.* of northern Europe proved to be very interesting for purposes of further increasing the sugar content. Hybrids from sugar and fodder beets proved to be very promising for further increasing the tonnage of the sugar beet (10).

To prevent uncontrolled hybridization between different materials and also to eliminate the tendency to degeneration caused by crossings of related strains, Savitsky worked out a whole series of crossing methods (diallel, saturation, double crosses) between populations, products of individual selection, inbred lines, clones obtained by continuous vegetative propagation, etc. (10) . Shortly before the beginning of the second World War, some of these plans were being realized at the All-Union Institute of the sugar industry and at certain breeding stations. Orlovsky in 1947 (8) reports considerable progress resulting from a method of selection proposed by V. Savitsky after tests of the hybrids.

Control of Pollination

By controlled pollination we understand a system of measures designed so that pollination of previously selected material or material propagated with the use of selection takes place *in* the desired direction. The first attempts to regulate pollination consisted of certain group arrangements of the elite stock or of lines at the time of their propagation. Before the second World War, the attention of many breeders was aimed at a study

of certain populations, strains and clones to be used as pollinizers for making diallel and other types of crosses. Of no less importance was the need to work out a system of technical methods which would assure pollination *in* a predetermined direction such as self pollination, pollination between related individuals, crosses in a selected combination, etc.

This includes the study of the role played by wind and insects in the transfer of pollen, the use of present isolators and the construction of new types, a study of methods of crosses inside the isolators and under free-blooming conditions, a study of the effectiveness of distance isolation, etc. There is no need to discuss here the results of research done in this direction because these results have been discussed in sufficient detail in a special summary by the present writer (2) .

Special Methods in Sugar **Beet Selection**

Among the special methods used in sugar beet selection, methods which were or still are in use by Soviet breeders, the following should be noted:

1. Before 1930, many breeders used the indirect method of selection by the morphological characters of leaf rosette and root, for purposes of increasing the percent of sugar and the weight of the root. Numerous calculations were made in order to determine correlations between morphological and utilitarian characters. For selection purposes and for descriptions of populations and progenies, various classifications of shape of root, leaf, leaf rosette and steckling were worked out. This method did not yield any positive results and interest in it has decreased.

2. Selection for vigor during early development. Savitsky proposed that in selection for increased root weight special attention should be paid to the rate of maturing of the developing root. Group selections which he carried out in 1936 have fully confirmed the value of his method (9) . Mazlumov (7) at Ramon station also made use of this method and has produced certain varieties at the station with the aid of it. Goodwill (5) at Lgov station has made use of the method of evaluating progenies by rate of growth during the earliest stages of development under laboratory conditions. He finds it practical to discard on this basis about one-third of all the progeny intended for use in tests under field conditions and in this manner to greatly reduce the area to be used for varietal tests.

3. Selection for early maturing is of particular importance for northern regions of beet cultivation because of the short vegetative season (Kursk, Voronezh regions, western Siberia) . However, early maturing beet varieties are more important in the Soviet Union than all other regions where beets are grown. This is true because the work of harvesting sugar beets in the USSR takes such an inordinate amount of time that it is not always possible to complete it before the advent of frost. For this reason, sugar beet harvesting begins very early, usually from September **10th** on, and therefore the early maturing varieties are found to be very valuable. Certain varieties from the Ramon breeding station (Voronezh district) are especially early in maturing.

4. Selection for resistance to fungus diseases. Among the causal agents of fungus infection of sugar beets which are most wide-spread in USSR are: *Phoma betae* Frank, *Cercospora beticola* Sacc. and *Botrytis cinerea* Pers. No great progress in the work of producing varieties which would be comparatively resistant to these fungi can be noted for the USSR. Among other varieties, those from the Uladovka breeding station are slightly outstanding in their resist ance to storage rot (*Botrytis cinerea* Pers.) Phytopathologist V. Shevchenko of Belaya Tzerkov breeding station proposed a method for determining the resistance of individual roots to this infection **(13).**

5. Selection for decreasing the percent of "harmful nitrogen" content and for increasing the good quality (purity) of beet juice is being carried on at Pervomaiskaya (May First) breeding station in Northern Caucasus, at the Veselo-Podol station in the Ukraine and the Ramon station in the district of Voronezh, since the beets of these stations are outstandingly high in content of "harmful nitrogen" and ash. Up to the present time special attention has been given to working out a method of selection but no tangible practical results have been achieved in this direction (12) .

Aims of Selection

Before the revolution the basic aim of selection at many of the breeding stations was toward increasing the sugar content. For this reason many varieties were outstandingly high in sugar. The same varieties served as original material in the beginning of selective work at Soviet breeding stations. To these belonged materials from the Nemercha agricultural station (formerly belonging to Buszczynski and Lazynski) , the Verkhniachka station, Kalnik and Oudychsky breeding stations and also the Polish breeding station of A. Janacz. Thus the first lots of sugar beet seed released by certain Soviet breeding stations were definitely of the sugar type.

Soon, however, the type of sugar beet seed released was abruptly changed in the direction of the high tonnage type. The reason for this change was the shortage of raw material at the sugar factories. Varieties from stations Uladovka, Ivanovka, Ramon. Belaya Tzerkov and Lgov may be characterized as high tonnage beets. Sugar beet material of the high sugar type from Nemercha station and the stations Kalnik and Oudychsky were preserved and turned over for further breeding work to stations Vesely Podol and Yaltushkovsk, where the varieties continued to be of the high sugar type.

At the station Verkhniachka, a normal type of beet was produced by crossing the high sugar types of this station with high tonnage beets.

From 1934 on, the normal type of sugar beet which combined sufficiently high sugar content with sufficiently high tonnage took on great importance in the USSR. First among varieties of this type is the varietal material from Station Verkhniachka. Soon afterward a number of other breeding stations began to release lots of seed of the normal beet type, together with high tonnage types. Among these were the stations Uladovka, Lgov and Ramon.

The following breeding stations are active at present in the USSR: *In* the Ukraine Station Uladovka—selective breeder Dr. L. Sempolovsky (since 1898) ; Station Verkhniachka-breeder T. Grinko; Station Nemercha and Substation Yaltushkovsk—formerly directed by breeder L. Fedorovich, now by A. Popov; Station Belaya Tzerkov—breeder V. Yegorov; Ivanovka Breeding Station—formerly under B. Lebedinsky (died in exile) , now under O. Helmer; Station Veselo-Podoliansk formerly under breeder 1. Voitkevich (perished in the cellars operated by NKVD) , now under V. Sukachev. In RSFSR—Station Ramon, under breeder A. Mazlumov (since 1922) ; Station Lgov—under breeder G Goodwill.

New regions of sugar beet culture are located in these areas: Pervom-aiskaya (May First) station in northern Caucausus; Bijsk station in western Siberia; Kirghiz station in middle Asia.

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