Extended summary

of

(Sunflower breeding in the USSR).
Pisceprom izdat. Moscow 1947:
Pp.272. bibl.518.

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633.854.78:575.12(47)
633.854.78:575.42(47)
633.854.78-1.524:578.08(47)

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General (Introduction and Chapter I)

History of the sunflower in Russia.

The genus Helianthus, which was introduced to Europe from the American Continent, comprises over a hundred species of which only the perennial Jerusalem artichoke, Helianthus tuberosus, and the sunflower, H. annuus, have economic importance. The history of the cultivation of the sunflower in Russia, where most of the selection work was done, is outlined. Reference is made to recently selected varieties with high oil content and resisting Orobanche B.

CHAPTER II.

Popular cultivation of the sunflower.
(Popular selection of the sunflower).

Scientific breeding was preceded by extensive selection work of the sunflower growers, particularly in the Voroněž and Saratov provinces. As a result of this so-called "popular selection" sunflower became an economic oil seed plant, and many useful varieties were obtained.

CHAPTER III.

Results of the work of the departments in charge of the study of the cultivation of the sunflower.

(Results of the work of the research institutes engaged in selection of sunflower).

The growing scope of scientific selection which began only in 1910, is described and the principal Soviet institutes and outstanding breeders engaged in the work are named. The distribution of 35 named sunflower

varieties released before or in 1940 is considered. Mention is made of 42 varieties undergoing further trials.

Descriptions are given of the following described as "the best selected varieties": Saratovskiĭ [Saratov] 169 and 19, Pioner Sibiri [Pioneer of Siberia], Omskiĭ Skorospelyĭ [Omsk Early Ripening], Kruglik A/41, 1975 and 1846, VNIIMK 3519 and 4036, Armavirskiĭ [Armavir] 1646 and 1813, Zelenka [green] 76 and 61, Harjkovskiĭ [Harjkov] 22/82, Fuksinka 62, 10 and 3, Černjanka 35, Ždanovskiĭ [Ždanov] 6432 and 8281, Stepnjak [Steppe] K-1483 P-10, Saratovskiĭ Gryzovoĭ [Saratov Cracking], and P-27. The descriptions were borrowed from F.S. Venclavovič (1941), who also compiled the most satisfactory classification of the sunflower. The author's system is described and a scheme for her classification of sunflower is attached. A key to determination of characters is also given.

CHAPTER IV.

Biological data on the sunflower.

The following aspects are considered: the use the sunflower makes of nutrients and water at different growth phases, the development of the seed head, the effect of meteorological conditions upon yield, biology of flowering and fertilization, selective fertilization and the effect of external conditions upon fertility. Varietal differences concerning the points studied under the different subheadings are pointed out. Several practical hints for sunflower growers are given.

CHAPTER V.

Pests and diseases of the sunflower.

(Breeding sunflower for resistance to sunflower moth and Orobanche)

The moth, Homoeosoma nebulella is the most important pest of sunflower, and Orobanche cumana, Puccinia Helianthi and Sclerotinia Libertiana cause its principal diseases.

Breeding for resistance to moth was facilitated by the useful plant material obtained in popular selection. Most of these varieties possessed the dominant character of coated seed. The solution of the problem presents no difficulties today.

Breeding for resistance to O. cumana was also helped by the wide range of sunflower varieties, some of which showed resistance to the disease. Selection work at Saratov, in the Kubanj and at the Don Breeding Station is described, with references to the resistant varieties. The methods employed in breeding for resistance include vegetative hybridization and other Mičurinite principles.

CHAPTER VI.

Growth of the sunflower.
(Breeding for earliness)

Early varieties are needed for cultivation in cold and arid districts. Varieties evolved under arid climatic conditions are regarded as useful plant material. One such variety is Saratovskii 169 from which were bred several very early varieties. The phasic requirements of the sunflower are discussed in some detail. It is shown that earliness in sunflower is usually associated

with thick husk, low oil content of the kernel and low yield. Some evidence is presented that these properties can be changed by continued selection.

CHAPTER VII.

Methods to ensure high oil yield in sunflower.

(Breeding sunflower for high oil content).

Results are reported which include most recent selection work at various Soviet research institutes. Oil content of several varieties could be increased by as much as 5-10%. The USSR Scientific Research Institute for oil crops selected a variety (3519) which yields as much oil as linseed. Mention is made of many other varieties obtained at this and other institutes combining high oil content with other economic characters. The techniques for determinations of husk and oil contents are described. It is shown that a variety may combine high yield with high oil content of the kernel and low husk content. The breeding for high oil content and low husk content is helped by the varietal range regarding these characters and comparatively small influence of metereological conditions upon their husk and oil content. The selection for low husk is particularly promising for technical reasons which are given.

CHAPTER VIII

Methods to ensure high yield of sunflower.

(Breeding for productiveness).

Empty seed is due to uneven distribution of nutrients and moisture and inadequate fertilization. The methods for partial control of empty seed comprise improved agricultural technique and complementary cross pollination by Musiiko method. Selection of sunflower for the size and shape of the seed

heads is discussed. Single seed head sunflower was hitherto the desirable type in Russian selection, but it is thought that plants with two to five inflorescences growing at the same height as the central seed head and maturing at the same time as this might be promising in breeding, if external conditions for the cultivation are favourable.

Selection for a high 1000 seed weight has great scope, but in view of slight positive correlation between seed weight and husk content, simultaneous selection for low husk character is advocated. The effect of diseases upon productiveness of the sunflower is recorded. Rust (Puccinia Helianthi) is shown to reduce the yield of seed and the oil content of the kernel. There are no marked differences between the varieties in their resistance to the disease, but within the varieties susceptibility varies appreciably. Sclerotinia Libertiana causes economic losses, particularly in some areas of the USSR. In arid districts the disease breaks out in years with ample rainfall. The disease varies in its severity according to age and vigour of the sunflower plants. The resistance of the sunflower to the disease has been little studied. There appear to be no varietal differences in susceptibility. Selection of plants resistant to a disease caused by Verticillium Bahliae gave positive results. The study of resistance of sunflower to several other diseases and pests was inconclusive. For resistance to Orobanche an earlier chapter is referred to. It is pointed out that in breeding for productiveness zonal research is essential because of the regional importance of the different aspects of the work.

CHAPTER IX

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This chapter deals apparently with a non-oily variety of sunflowers.

(Breeding of the "gryzovoĭ" [cracking] sunflower).

Sunflower varieties grown for "cracking seed", which is a national dainty, are considered from the viewpoint of this economic usefulness. The importance of these varieties is shown by statistics of the cultivated areas. Their value in breeding is considered greater than has been accepted both regarding the production of cracking seed and oil seed varieties. Many of these varieties have high percentages of coated seed and oil high content in the kernel and are resistant to Orobanche race A. Their other useful characters are great quantities of well developed seed and a high 1000 seed weight. Saratovskiĭ Gryzovoĭ is among the best of the cracking seed group of varieties. In comparative trials at Saratov conducted for four years it yielded 1.6 centners more seed per hectare than Saratovskiĭ 169 (standard) and gave 45 kg. more oil per hectare.

In order to improve the oil content of Saratovskiĭ Gryzovoĭ it was hybridized with VNIIMK 3519, Saratovskiĭ 19, 808 and other varieties noted for their high oil content. Selection of the hybrids is in progress the aims being to obtain firstly, highly productive cracking seed forms with high oil content, and secondly, oil seed sunflower with larger seed. Great importance is attached to the second objective.

CHAPTER X

Method of selection of sunflowers. (Methods for breeding sunflower).

Mass selection is regarded as the most useful method in breeding sunflower for all characters determining the yielding capacity of the sunflower and its biological adaptation to external conditions. The popular selection, which was dealt with in chapter III, created by the method the economic oil seed sunflower and a large number of local varieties of cultivated sunflower mass selection gave such varieties as Faksinka 3 and 10, Pioner Sibiri and Skorospelyĭ Omskiĭ.

Multiple and continued individual selection has its uses in selection for individual characters. The different schemes for individual selection are described. The family group selection scheme of individual selection gave nearly all Russian standard varieties including Saratovskiĭ 169, Zelenka 76, 22-82, Kruglik A/41 Ždanovskiĭ 8261 and 6432. Examples are given of the efficacy of the method in breeding for coated seed character, Orobanche resistance, low husk and increased oil contents.

The remnant system is shown to be an unreliable method when applied to sunflower breeding, the evaluation of the principal characters of the plant material (yield, oil and husk ratios, oil content in the kernel) being inaccurate and depending a great deal on metereological conditions of the season. Individual family selection is difficult because of the occurrence of cross pollination on the nursery plots isolated by distance only from other plants. The variety 3519 noted for high oil content in the kernel

was obtained by this method. Individual selection when continued for a long period of time is said to lead to a deterioration of the plant material. Furthermore it fails to give varieties which are more productive than the original mass selected sunflower varieties.

Inbreeding was first applied to sunflower in Russia in 1918. Much research has been done in this respect, account being taken of various existing theories on inbreeding methods. The results did not justify the efforts. Not one useful variety was obtained. The failure is attributed to the theoretical flaw of Morganism, since inbreeding produces either homozygous plant organisms that suffer from degeneration or else they are biologically adapted organisms, but heterozygous. The use of the inbreeding method is limited to fixation of individual economic characters such as coated seed, oil content etc.

The method of diallelic crosses was found to be useless in its application to sunflower except in some crossed lines in which heterotic effect was obtained in F_1.

The top cross method has given some families of sunflower which yield nearly as much as the standard 169.

The double cross method gave better results than the single cross method. An inbred line from a double cross is mentioned which yielded 24.3% more seed and 35.6% oil than its parent plants. Other data on usefulness of double crosses is lacking. In reviewing the work done it is stated that inbreeding gave a large number of depressed inbred lines, which have no practical significance, and that all the known uses of pure lines were tried and failed to give anything useful. Experiments with hybrid offspring of inbred lines provided evidence

in support of Darwin's and Lysenko's teachings that hybrid organisms have greater vitality and are more productive. The principle of heterosis and the use of hybrid seed are discussed in this light. Mention is made of higher yield records obtained with intervarietal cross pollination at various research stations, and with ecologically mixed populations of a single variety of sunflower (169). The latter experiment is based upon Lysenko's thesis of acquired differences in sex cells which is said to be supported by evidence of Mičurin, M.F. Ivanov and N.V. Cicin. The efficacy of selection and the lack of sunflowers with uniform varietal characters until quite recently delayed the beginning of the hybridization work, which is now in progress at various institutes. Some work in the field of distant hybridization between H. annuus and other species of sunflower showed that the method is slow and brings poor return, but it is nevertheless regarded as necessary method for breeding sunflower with entirely new properties. The technique of O.N. Arnoljdova (1926) now widely accepted in the USSR is described.

Intervarietal hybridization of sunflower being of comparatively recent date has so far given variety 2999 bred at Barnaul, Siberia from Pioner Sibiri x VNIIMK 3519 and Petrovskiĭ 2 from Pioner Sibiri x Kruglik 1975 bred at Petrovskaja State Breeding Station. However, the work with intervarietal hybrids has already given a mass of evidence on the inheritance of characters in the hybrid offspring. The inheritance of the following economic characters is mentioned: coated seed character is usually dominant over non-coated seed; the hybrids from crosses between parents with different dates of maturation inherit intermediate maturity. Regarding the characters of husk and oil ratios the hybrids also inherit the intermediate character, but in respect

of the oil content in the kernel the F_1 is nearer its parent with the higher oil content in the kernel. The character of resistance to Orobanche race A is dominant over susceptibility and the character of partial resistance to race B dominates over non resistance. The number of the resistant F_1 plants varies in different crosses and depends largely on resistance capacity of the female parent. Sometimes absence of segregation in the F_2 was observed regarding resistance to Orobanche B. External conditions had some influence upon the inherited resistance of the hybrids.

The problems of distant hybridization of sunflower were studied by Sacyperov (1946), Plaček and Arnoljdova (1930), Cockerell (1929), Wagner (1932), Ščibrja (1938), Marcenko (1937), Davidovovič (1936), et alia, but most of the work had only theoretical interest. Interspecific hybridization in Russia included the crosses between H. annuus and species H. divaricatus, scaberrimus, strumreosus and with species forming tubers H. tuberosus, H. macrophyllis and H. subcanescens. Some intergeneric crosses were also made.

The crosses between the annual sunflower, H. annuus and the perennials divaricatus, scaberrimus and strumosus were achieved with ease, yielding 10% successful crosses. The F_1 had perennial habit, was sterile, resistant to rust and had an intermediate phenotype. In the second year fertile plants appear and the percentage of fertile plants increases from year to year (21% in the fourth year of growth). As the F_1 hybrids mature they also become fertile. There is an appreciable difference between the clones in

this respect. The hybrid seed had poor germinability (2%) but it could be improved (60-70%) by treatment with superoxide 0.2% solution. The hardiness of the hybrids increased in three years as indicated by respective losses of 50%, 25% and 6% in the first, second and third year. The second vegetative generation obtained from natural cross pollination showed a tendency of developing like oil seed sunflower. The plants included 15% perennials, which resisted rust. One of these plants was highly fertile in its first year of growth.

A great variety of forms was found among large quantities of the F_2, F_3 and F_4 seed sown. Some of the characters were economically important. Mention is made of sunflowers with luxuriant foliage promising as an ensilage crop.

Crosses between H. annuus and H. tuberosus gave hybrids resembling either one of the parent forms or of intermediate type. Some of the hybrids were found to produce more tubers than H. tuberosus, to be resistant to rust and to give good quantities of leaves and stems for ensilage. Back crosses of the hybrids to sunflower did not yield anything useful. A fertile perennial hybrid was obtained from H. annuus x H. subcanescens and back cross to sunflower, which yielded 840 seeds in a single inflorescence and was immune from all diseases.

The cross between the cultivated sunflower and the Texan H. ruderalis gave several families in the offspring which surpassed the existing varieties of sunflower in yielding capacity and resistance to rust. Intergeneric hybrids were obtained from crosses and reciprocal crosses between the cultivated

sunflower and Carthamus tinctorius or Onopordon acanthium, both of which are plants resistant to drought and adaptable to external conditions. The incompatibility of the genera was overcome by vegetative rapprochement. The stocks and scions of the vegetative grafts and their reciprocal grafts fruited. Reference is made also to sunflower scions worked on Cirsium arvense and C. palustre, which also took and fruited. The F_1 and F_2 offspring from sunflower x Carthamus and those from sunflower x Onopordon showed similar characters as their female parent sunflower, while no influence of sunflower was visible in the hybrids from crosses which Carthamus or Onopordon was the female parent.

Principles ruling the selection of sunflowers.

(Methods of selection of sunflower)

The varieties most needed in the northern and eastern parts of the USSR must be very early and resistant to Sclerotinia. The southern districts of the country need varieties resistant to Orobanche B. In other arid districts varieties are desired combining resistance to the disease with resistance to drought. Lastly, in the woody steppe districts rust resistant varieties are looked for. The other desirable economic characters looked for in all new varieties include high yield, high oil content, good oil quality, growth habit enabling mechanized harvesting and earliness.

In breeding new varieties an important role is attached to the biological groups of the cultivated sunflower resisting races A and B of Orobanche.

In hybridization work wild and ornamental forms of sunflower can be useful, particularly the Texas group in breeding for resistance to rust.

In breeding for immunity from rust and Orobanche and resistance to cold crosses can be made between the cultivated and the perennial sunflower. The material contained in this section is critically examined in the light of more recent research work, which led to the following conclusions. In breeding for high oil content the isolation of varieties is only necessary if some of the plant material has a very high husk content. In all other instances isolation does more harm than good. Unisolated plant material gives usually increased yields of seed and oil, while its oil content in the kernel remains unaltered. Abolition of the isolation is advocated between families selected for the same characters but having different origins. There is no need for isolation of sunflower varieties having similar economic properties. The study of most useful neighbours is recommended for every variety. The remnants system is referred to as useful to fixation of the selected plant material.

In recent years the Institute of Agriculture for South-eastern SSR, Saratov, developed a new breeding method called the population method. It consists of mixed cultivation of plant material selected for the same characters but differing regarding its time and place of origin. The principles upon which the work was based are confirmed by T.G. Genkin, (1931, 1937), L.E. Kirk (1933, 1937), T.M. Stevenson (1939), S.C. Harland (1944) using the method of strain building. Several promising new varieties were obtained by the method at Saratov, one of which, Saratovskiĭ P-10 [Saratov P-10], is undergoing state trials. The new varieties yield 1.2 to 2.2 centners more seed per hectare than the standard Saratovskiĭ 169, and yield 22.6 to 35.2% more oil per hectare.

The bibliography numbers 518 papers.