

## ACHIEVEMENTS OF SUNFLOWER BREEDING IN THE USSR

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The origin of sunflower plant as a species pertains to America. At the same time it is Russia that has become the motherland of tame sunflower; the sunflower in this country has been bred into crop and has become a source of valuable vegetable oil and protein. It has become possible due to intuitive and then man's conscious breeding. A series of varieties -- populations of this valuable crop with unique productivity, high oil content and resistance to a number of pathogens has been created.

The progress in sunflower breeding in the USSR promoted the wide spread of sunflower over Europe and other countries of the world.

Nowadays the world commercial sunflower acreage is more than 10 million hectares.

In the USSR sunflower is cultivated at the area of 5 million hectares for commercial seed production and at the area of about 3 million hectares as a silo crop.

Speaking of the achievements in sunflower breeding, we can't but mention affectionately and proudly the name of Vasily Stepanovich Pustovoit, an outstanding scientist plant-breeder whose life was wholly devoted to creating matchless in oil content and high productivity varieties of this crop.

In the history of sunflower cultivation there has been and is many a difficult situation the majority of which is connected with the immunity problem.

The first thing to handicap the introduction of sunflower was sunflower moth (g. Homoeosoma) and broomrape (g. Orobanche).

These pathogens are still extremely damageful for sunflower in many countries.

The Soviet breeding science has solved these problems by creating varieties-populations and hybrids resistant to these pathogens, duly using the classic method of variety-population breeding worked out by V.S. Pustovoit.

The oil content of sunflower varieties was raised from 28 p.c. to 53 and more p.c. in their huskness was brought down from 45 p.c. to 20 p.c., i.e., to half as much.

An outstanding merit of Academician V.S. Pustovoit was a creation of scientific ground for and a development of a method of seed-production of sunflower

as a cross-pollinated plant. The method is based on incessant improvement of biological properties of a variety which is confirmed by the data presented in Table 1.

TABLE 1. Improvement of Sunflower Varieties in the Process of Seed Production  
VNIIMK, Krasnodar

Varieties	Acreage Under Variety th. ha.	1961 - 1963		1976 - 1977		Oil Yield, % to 1961-1963
		Oil Content %	Seed Yield q/ha	Oil Content %	Seed Yield q/ha	
VNIIMK 8883	693	46.9	22.9	53.6	35.6	182
VNIIMK 1646	172	47.4	23.2	53.4	34.4	170
Armaviraki 3497	975	48.0	23.2	55.3	33.5	170
VNIIMK 6540	596	49.0	24.0	54.4	34.1	161
Peredovik	1044	50.2	23.7	54.4	33.7	158
Smena	119	49.9	23.4	54.9	33.0	158
VNIIMK 8931	40	49.1	23.5	53.8	32.8	157

Owing to seed production improvement method the varieties commercialized in the USSR have considerably grown in productivity: in yielding capacity, in oil content and in yield of oil per hectare.

As a matter of fact, they are already new, more productive varieties whose development has become possible due to the use of the effect of heterosis not only in breeding but also in seed production, owing to the annual addition of new biotypes to the population, the biotypes possessing a high general combining ability.

The varieties cultivated in the USSR contain 52 to 53 p.c. of oil in absolutely dry seeds vs. 30 to 32 p.c. in the best varieties cultivated in the thirties.

Today more than 20 new varieties are under State Trials. Among them the new ultra-early variety; it ripens 14-16 days earlier than Peredovik and is the highest-productive variety in its group; the variety Vostok ripens 7-9 days earlier than middle-maturing varieties with equal productivity (Table 2). This variety has the highest oil content of seeds -- 54-56 p.c. Under favorable weather conditions the percentage of seed oil in this variety may be as high as 59.

For us, as well as many other countries, the creation of early maturing, highly productive varieties is of extra special importance.

TABLE 2. Characteristics of Sunflower Early Ripen Varieties  
VNIIMK, Krasnodar, 1976-1977

Varieties	Vegetation Period, Days	Seed Oil Content %	Seed Yield q/ha	Oil Yield, q/ha
VNIIMK 8883	94	53.0	34.6	16.6
Vostok	95	57.2	32.0	16.5
Zenit	92	52.9	29.5	14.0
Peredovik (check)	98	54.0	33.4	16.2

Of late there have appeared in some sunflower cultivation areas new more aggressive broomrape races which noticeably affect the commercialized varieties. In connection with this we brisked up the work on selection for immunity to these more virulent races. The variety start was the first variety resistant to the new broomrape races.

Among the varieties transmitted to State Variety Trials the variety Niskorosly 60 is of interest. On the average for a period 1974-1977 this variety exceeded in seed yield the check Armavirski 3497 improved by 15.5 p.c. The plant height is 110-120 cm. compared to 170-185 cm. for the check. Its vegetative period equals 121 days as against 124 days for the check. There exist some other varieties with a complex of valuable characters: increased yielding capacity, early ripening and others.

At present a new phase of sunflower breeding has begun as the rate of oil content increase has reduced due to the approaching its biological limit.

Biological characters defining the sunflower seed oil and protein accumulation levels were estimated for a possibility of the oil yield increase per area unit and scientific substantiation of selection methods. As a result it was found possible to further increase the oil yield by plant selection according to the achene kernel and plant oil yields.

The interspecific hybridization using wild species of genus *Helianthus* among which sources of immunity to a number of pathogens have been established is a new highly effective line in sunflower breeding and in creating principally new basic material.

As a result of studies of 46 wild sunflower species conducted by Dr. G.V. Pustovoit wide opportunities were opened up for their use in selection -- in developing hybrids with group immunity to main sunflower pathogens. It was found that the autohexaploid group of species ( $2n=102$ ) is of a special interest for its immunity to downy mildew (*Plasmopara helianthi* novot), rust (*Puccinia Helianthi* Schw.), charcoal rot (*Sclerotium bataticola* Taub), Phoma black stem (*Phoma* sp.), verticillium wilt (*Verticillium Dahliae* Kleb). On the basis of interspecific hybrids for the first time in the history of world breeding two highly productive varieties were developed in VNIIMK and in 1974 transmitted under State Trials -- Progress and Novinka that stand out in high resistance to downy mildew (98-100 p.c.), charcoal rot (40-50 p.c.), verticilliosis (97-98 p.c.) and are never affected by sunflower moth (100 p.c.).

Under ordinary conditions these hybrid varieties are not inferior to the best commercialized varieties in productivity, and in the areas where downy mildew is widespread they exceed the latter by 25-30 p.c.

In 1976 the variety Progress was recognized promising and since 1977 it was commercialized in the regions of mass spread of downy mildew.

The commercialized variety Progress has a drawback of weak resistance to new races of broomrape. In this connection a task was set to develop varieties based on the interspecific hybrids that would combine the positive characteristics of the commercialized variety Progress with resistance to the new races of broomrape.

An interspecific hybrid of *H. tuberosus* (maternal form) with cultured sunflower served as a basic material for breeding the varieties with high resistance to broomrape. The hybrids were once backcrossed with the cultured sunflower. Further breeding was conducted by way of double and group crossings and selection of the plants resistant to downy mildew and less affected by broomrape. As a result some new promising varieties have been developed and are now under State Trials.

According to Station Variety Trial (1976-1977) new varieties are not inferior to Peredovik in productivity against the uninfected background (Table 3). According to vegetation period they are classified as middle-maturing.

TABLE 3. Comparative Characteristics of Sunflower Varieties  
Jubileyni 60 and Oktyabr with Peredovik Taken as a Check

Varieties	Vegetation Period, Days	Oil Content, %	Seed Yield, q/ha	Oil Yield q/ha	Susceptibility to	
					Downy Mildew %	Broomrape %
Jubileyni 60	101	52.7	33.7	16.0	1.3	2.0
Oktyabr	102	54.3	33.6	16.4	1.5	2.0
Peredovik	100	53.4	33.1	15.9	100	100

The development of the varieties with group immunity to the main pathogens will undoubtedly be a stimulus for an extension of the sunflower acreage in the regions where its production has been deterred due to diseases.

Interspecific hybrids present a good basic material for the development of varieties with resistance to even broader range of pathogens, charcoal rot among them. (Table 4)

TABLE 4. The Best Sunflower Interspecific Hybrids (H. Tuberosis x VNIIMK 8931) Resistant to Charcoal Rot  
VNIIMK, Krasnodar, 1977

Hybrids	Vegetation Period, Days	Seed Oil Content, %	Seed Yield, q/ha	Oil Yield q/ha	Susceptibility to Charcoal Rot, %
45599	98	54.4	36.4	17.8	1.9
45953	98	53.9	36.7	17.8	3.9
45840	97	56.7	34.7	17.7	1.9
VNIIMK 8931 (Check)	96	51.9	33.0	15.4	50.5

An important problem at present is breeding for oil quality that is the development of new sunflower varieties and hybrids with an improved fatty acid composition of oil.

The fatty acid ratio of the vegetable oil is very important for its food quality.

The oil of modern sunflower varieties shows the prevalence of linoleic acid (55-60%) the oleic acid ranking the second (25-30%).

The utilization of the chemical mutagenesis for alteration of the fatty acid composition of oil resulted in a selection material with a medium content of oleic acid (about 75%) as against 30-35% for common commercialized varieties.

Basing on this high-oleic material, produced with the help of Nitroso-Methyl Urea, Dimethyl Sulphate and others a new sunflower variety Pervenets was performed and commercialized in 1977. Its seed oleic acid content amounts to 70-75%. Essentially this is a new sunflower plant type producing oil with a fatty acid composition close to that of olive oil.

As a result of alteration in the fatty acid composition the oil of Pervenets gained new valuable properties, among them an increased thermal stability and resistance to oxidation in long term storage.

Seed yield of Pervenets is somewhat lower than that of Peredovic but its oil is of much higher quality (Table 5).

TABLE 5. The High Oleic Sunflower Variety Pervenets Productive Capacity  
VNIIMK, Krasnodar, 1975-1977

Characters	Pervenets	Peredovic (Check)
Seed oil content, %	51.1	53.8
Oil yield, q/ha	14.0	15.5
Oleic acid content in oil, %	75.3	31.3
Yield of oleic fatty acid, q/ha	10.5	4.8

In oleic acid percentage in oil the Pervenets twice exceeds the Peredovik variety. This characteristic is constantly held at a high level for years.

This line of breeding is being continued. The forms are already obtained whose oleic acid content comes to 89.5%.

One of the new lines of breeding varieties-populations that have developed in the recent years is creating the varieties of intensive type that make the maximum use of environment factors and are responsive to fertilizers. The dwarfish forms of sunflower with vertical leaf location (the erectoids) are of special interest for developing the intensive type varieties with yield potential 40-50 q/ha. This type of plants are well adapted to thickness of sowing up to 100 thousand plants per hectare.

The world plant science shows that the use of tererosis is a strong factor of increasing the agricultural crop productivity.

As it was mentioned above, one of the ways of making use of heterosis effect is a method of breeding and seed growth worked out by Academician V.S. Pustovoit that helps to develop and annually improve the high-heterosis Soviet varieties.

V.S. Pustovoit paid serious attention also to the heterosis breeding itself. As early as in the 20's he pointed out the necessity of working out a method of developing lines with high combining ability as one of the major stages in heterosis sunflower breeding. He developed interline hybrids exceeding the best varieties in seed yield by 21-41%. But since male sterility had not yet been found in sunflower by that time, the hybrids failed to find practical applications. But in spite of that the search of the ways to use heterosis in this crop was continued.

At the end of the 50's the Soviet plant breeders developed hybrids based on gene male sterility that exceeded the seed yield of the standard varieties by 15-17%. The above hybrids could be used in production but they proved susceptible to the main pathogens of sunflower: downy mildew, broomrape and some others.

An attempt to single out hybrids suitable for commercial use among the hybrids of foreign selection was a failure. They appeared to be at the level of Soviet varieties in productivity (Table 6).

Nowadays the Soviet breeders dealing with heterosis breeding face the problem of a rapid development of highly productive interline and variety-line hybrids resistant to the main pathogens spread in sunflower cultivation zone.

The gene pool developed by Dr. G.V. Pustovoit with interspecific hybrids possessing high productivity along with group immunity and fertility restoring genes represents a valuable basic material for the creation of self-pollinated lines.

TABLE 6. Productivity of Sunflower Hybrids Created in USA and Romania USSR, Krasnodar, 1976-1977

Hybrids	Origin	Vegetation period, days	Plants Height cm.	Seed Yield		Seed Oil Content %	Oil Yield	
				q/ha	% to Check		q/ha	% to Check
H 8971	USA	100	196	33.4	106.0	50.5	15.2	99.3
H 8944	USA	97	176	32.6	103.5	48.7	14.3	93.3
H 895	USA	100	211	30.6	97.1	50.8	14.0	91.5
H 894	USA	98	172	30.1	95.5	48.5	13.1	85.6
HS 201	USA	100	184	29.3	93.0	50.2	13.2	86.3
H 896	USA	100	181	26.8	85.1	49.9	12.0	78.4
HS 80	Romania	98	193	32.4	102.8	48.3	14.1	92.2
HS 301	Romania	98	176	32.3	102.6	51.2	14.9	97.0
HS 53	Romania	100	188	32.1	101.9	50.8	14.7	96.1
HS 90	Romania	98	128	30.6	97.0	53.4	14.7	96.1
Peredovik: (Check)	USSR	101	206	31.5	100.0	54.0	15.3	100.0

S  $\bar{x}$  % - 3.6

LSD - 2.7

Basing on the source of CMS produced by the crossing *H. lenticularis* x *H. annuus* in the All-Union Plant Growing Institute after N.I. Vavilov they have completed the development of a number of sterile counterparts of the lines. In the All-Union Selection-Genetics Institute there have been developed lines resistant to downy mildew, and broomrape, on which basis they developed experimental hybrids with high productivity and resistance to some diseases. The variety-line hybrid Rassvet has been transmitted by this institute under the State Trials. On the average for a period of two years trial this hybrid for sure exceeds the check in seed yield at the most of the Ukraine testing stations. The seed outyield is 6 q/ha. The hybrid is resistant to broomrape.

At VNIIMK we are completing the work on the development of an interline hybrid ML 3 which, according to the two years trial data, is 15 p.c. better than the check in seed yield and 19 p.c. better in oil yield per hectare (Table 7). Earlier ripening is characteristic of this hybrid if compared to the variety Peredovik.

TABLE 7. Productivity of Interline Sunflower Hybrid ML 3 VNIIMK, Krasnodar, 1976-1977

Hybrid	Vegetation period, days	Plants height, cm.	Seed Yield		Seed Oil Content %	Oil Yield	
			q/ha	% to check		q/ha	% to check
ML 3	97	190	33.3	115.3	55.9	16.7	119.1
Peredovik (Check)	100	203	28.9	100.0	54.5	14.1	100.0

Along with the utilization of male sterility VNIIMK breeders are developing new hybrids on the basis of fertilization selectiveness.

Since 1978 the sunflower hybrid Priziv is under a State Trial. The maternal component of this hybrid, "the Dwarf mutant" has been developed from the variety VNIIMK 8931 after the seed treatment with the 0.01 p.c. solution of Nitroso-Methyl-Urea mutagen. It possesses, alongside with a high GCA a pronounced self-incompatibility which allows to produce hybrid seeds at the hybridization plots without using male sterility or castration, gaining hybridity percentage at that close to a hundred.

The annual seed and oil per hectare yields of the hybrid Prasiv greatly exceeds those of the variety Salute which is close to the former in vegetation period.

In conclusion we would like to mark our great satisfaction with the progress in sunflower breeding many countries have made: the USA, Romania, Bulgaria, Yugoslavia, Spain, France, Argentina and a number of others.

This was, certainly, promoted by the ever-growing contacts between the scientists working on sunflower.

We are especially pleased by the fact that it was the contribution of our country owing to the outstanding works of Acad. V.S. Pustovoit that served as a basis for progress in breeding this crop.

Thank you for your attention.