USE OF THE HETEROSIS IN SUNFLOWER IN BULGARIA

Peter Petrov
Institute for Wheat and Sunflower, General Toshevo, Bulgaria

INTRODUCTION

The classical methods of improving sunflower varieties proved very effective regarding the increase of oil content in seeds but not as effective in seed yield increase. The latter can be achieved if the Heterosis effect appearing in hybrids produced by crossing of inbred lines, is used.

Sunflower hybrids are an important factor for the increase of both seed and oil yields and therefore all sunflower growing contries carry out enormous research work for establishing the best methods for developing such hybrids.

Bulgaria, and the IWS in particular, were among the first to apply the Heterosis method in sunflower breeding. A numerous group of scientists - breeders, phytopathologists and biochemists - work on that subject at the IWS. Dr Yordanka Stoyanova, Dr Peter Petrov, Dr Velko Velkov, Dr Fota Tsvetkova, Dr Aleksander Piskov, Dr Mihail Hristov, Dr Peter Ivanov, Dr Pepa Shindrova, Dr Valentina Encheva, Dr Veselina Nikolova, Mr Dimiter Petakov, Mrs Nina Nenova, Mrs Yulia Encheva, Mr Neno Nenov and Mr Vencislav Venkov have already achieved considerable results in both inbred lines production and new hybrids breeding.

BREEDING OF INBRED LINES

Successful development of hybrids with high productive abilities as well as good economical characters, is determined by the efficient breeding of inbred lines.

The larger part of the lines we work with at present, about 94%, have been obtained from the high oil Russian varieties, but there are also some created in Argentina, USA, Egypt, Poland, Hungary, South Africa and Australia.

Selection in breeding of inbred lines is being conducted in accordance with the following characters: combining ability, plant height, head diameter, period of vegetation, shelling, resistance to lodging, seed yield per plant, seed mass per 1000 seeds, content of oil, fatty acids and proteins as well as resistance to broom-rape and different diseases.

In comparison with the initial lines and populations from which the inbred lines have been obtained, a certain biological depression resulting from the forced self-polliation and affecting mainly the plant height and seed yield characters, is observed. (Stoyanova-Velkov, 1974). There is, however, an exception to that rule. With a certain number of lines, the inbreeding depression is less expressed and at the same time their productivity is close to that of the initial varieties (Line 1607 -2.2t/ha, variety Peredovik -3.48t/ha).

With the exception with their combining ability and immunity, the inbred lines developed at the IWS near General Toshevo, show big variations in their basic characters. (Table 1).

TABLE 1

Characteristic of sunflower inbred lines

Characters	Values
1.Plant height (cm)	52 - 154
2.Period of vegetation (days)	86 - 120
3.Oil content in the seeds (%)	36 - 50
4.Seed mass per 1000 seeds (g)	28 - 62
5.Seed yield per plant (g)	32 - 68

The practical realization of the Heterosis effect is acquired by hybrid seed production.This process passes through two main stages. At the beginning hybrid seed production was carried out by using gene male sterility(GMS).Lines with a genetic marker were developed thus providing the easier recognition and elimination of the fertile lines from the mother line(Stoyanova,1973).

Gene male sterility,however,could not find practical application in sunflower breeding.

After CMS in sunflower had been developed,hard work began for creating new sterile lines and fertility restorer lines,aimed at their application in hybrid seedbreeding.

Our research work and the investigations done abroad indicate that this CMS source is a promising one and can therefore be successfully used in the development of sterile analogues.It fully sterilizes most of the lines and is also steadily inherited by the further generations and not affected by the breeding conditions.

Sterile analogues produced on the basis of that type of sterility possess normal female fertility.That is why if there is pollen enough and a good honey bee visitation,they give high seed yield.Under natural conditions,pollination of CMS lines in the Dobroudja region, is in the interval of 68-92% which ensures effective seedproduction. (Petrov,1978).

After BC_6 the sterile analogues reach the original lines regarding seed yield per plant,kernel and seed oil contents,plant height,head diameter,leaf number,etc.(Petrov,1978).

Bulgaria was among the first countries in the world to receive CMS from P.Leclercq and apply that type of sterility in hybrid seed production.For that we are much obliged to the French scientist.

Our breeding practice has proved that developing sterile analogues is not that difficult,in case an effective CMS source and sunflower lines free of restorer genes,are available.The necessary thing to do is to B cross repeatedly a given line using the CMS source as a mother component.

When sterile analogues are being created for the needs of heterosis breeding,it is obligatory to select lines of a very good general combining ability and important economical qualities,such as high oil content,resistance to prasites and diseases,etc.

BREEDING OF RESTORER LINES

Along with the development of new sterile analogues,hybrid seed production requires breeding of restorer lines as well.

The first restorers were received from France. In the period of 1973-1974 in the collection of the IWS, new sources of fertlity restorer genes were obtained in the following varieties: Mesten Pastar, Pioneer Sibiri and Barnaulskii from Russia, Valay from Canada. In the recent years new Rf sources have been created by interspecific hybridization.

Restorer lines in sunflower are developed by Erchardt's method (1954). Applying this method on the basis of sterile cytoplasm, provides the opportunity to obtain within a short time restorers that are genetically perfect analogues of the best sunflower lines with a fixed combining ability.

Erchardt's method is based on B crossing and selection. It is easy to apply and ensures development of sterile analogues together (along) with that of restorer lines.

Homozygous lines by the restorer gene can be obtained in the course of 4-5 self-pollinations.

In the recent years in Bulgaria, sunflower lines of restoring ability are being developed by self-pollination of F_1 hybrids - carriers of a restorer fertility gene.

This method has been widely applied in our breeding practice and and we have already created a number of restorer lines which possess a restoring ability as well as genes of resistance to downy mildew and broom-rape.

BREEDING OF LINES OF HIGH GENERAL AND SPECIFIC COMBINING ABILITIES

The development of new inbred lines which are to produce a high heterosis effect in crossing, is an important step on the way to creating new simple and three-way hybrids. Unlike maize, combining ability in sunflower should be determined by both seed yield and oil content.

Seed oil content is estimated on the basis of the per cent proportion between husk and kernel on one hand and the kernel oil content on the other. These two characters manifest different inheritance. The per cent of husk in F_1 is of intermediate inheritance and hybrids value in that character is directly determined by the parential lines so that it is unnecessary to test the combining ability but to perform breeding aimed at reduction of the per cent of husk even in the first generations.

Kernel oil content is a polygenic character with which the dominant effect of the gene influence is observed, providing the possibility to obtain high oil hybrids even when only one of the parential lines is of high oil content.

General combining ability is determined by using 2 lines (1607 and 2607) and a simple hybrid as testers. About 800 lines are being tested annually.

Specific combining ability is determined by applying either a partial or a full diallel scheme on a limited number of lines (60-80).

HYBRID SEED PRODUCTION

In Bulgaria, at the IWS near General Toshevo, new simple and 3-way hybrids are being developed. Both types present similar average values in seed yield, mass per 1000 seeds and head diameter. The biggest difference observed is in plant height with the 3-way hybrids being considerably higher than the simple ones.

Properly conducted hybrid seed breeding is a basic condition for the successful introduction of sunflower hybrids into practice. In case of mistakes in seed production, hybrids are not able to realize their potential abilities and the heterosis effect is reduced.

Our experience shows that the best way to avoid this is by strictly observing the following basic regulations:

1. Spatial isolation of 5000 m at parential lines reproduction and of 3000m at the time of breeding hybrid seeds from other regular or voluntary plants should be observed.

2. Early in the mornings by the time of the intensive honey bee visitation, fertile plants which have appeared in the sterile line under both hybrid seed production and parential lines reproduction, should be regularly removed in order to prevent them from participating in the process of pollination.

3. A sufficient number of honey bee colonies (4-5 per ha) should be provided, to ensure proper pollination.

4. After flowering, father rows should be removed in order to avoid mechanical mixing.

5. Immediately before harvesting, diseased plants should be removed.

6.Combines should be properly regulated in order to avoid injuring of plants while harvesting.

7.Efficient dressing and preparation of seeds should be conducted.

ACHIEVEMENTS IN BREEDING

By interline hybridization with CMS applied,a series of hybrids differing in their period of vegetation,have been created.

1.Early hybrids - with a period of vegetation from germination to full technical maturity.They reach maturity 8-10 days earlier than variety Peredovik.Hybrids belonging to that group are of productivity 5-8% lower than that of Peredovik,yet their seed oil content is approximately the same.Hybrids 602,612,613 arise a particular interest. They reach maturity 10 days earlier than Peredovik.They are considerably lower than it and are resistant to downy mildew.Regarding conditions in Bulgaria,hybrids included in that group can cover about 10% of the total area under sunflower in our country.

2.Middle hybrids - this group includes hybrids with a period of vegetation either the same or approximately the same as that of variety Peredovik.They,however,considerably exceed Peredovik in both seed yield and amount of oil obtained from the seeds.

3.Late hybrids - from that group only those reaching maturity no later than 7 days if compared to variety Peredovik can be used in production provided they possess resistance to downy mildew.Hybrids HB 785,HB 709 and HB 761 belong to that group.

In 1982 in the course of competitive trials at the IWS, hybrid HB 761 gave a record-breaking seed yield of 26% higher than that of variety Peredovik. Its seed yield content was 2.9% higher, too.

Hybrid Start was the first hybrid registered in Bulgaria in 1979. Hybrids Albena, Super Start and Dobrich followed it and now they cover 95% of the total area under sunflower in our country. These hybrids are of high productive abilities. In seed yield per ha they exceed variety Peredovik by 10.6-14.3%. They are also resistant to downy mildew and broom-rape and tollerant to phomopsis and phoma (table 2).

TABLE 2

Seed yield and oil content of some hybrids (the average for 5 years)

Hybrids	Seed yield (t/ha)	B% of st	Oil content of the seeds(%)
Super Start	3.73	114.3	48.3
Albena	3.56	109.2	47.6
Dobrich	3.61	110.7	48.4
Fundulea-206	3.35	102.8	48.1
NS-H-26	3.29	100.9	47.3
Peredovik	3.26	100.0	48.9

Hybrid Albena was registered in France in 1988. It has already gained a leading place in sunflower breeding in that country. It has also been determined a check in the group of early hybrids (table 3).

TABLE 3

Characteristic of variety Albena

Characters	Values
Period of vegetation	early
Seed yield (t/ha)	3.18-3.87
Seed oil content (%)	46.3 to 48.6
Mass per 1000 seeds (g)	54.6 to 59.3
Downy mildew	resistant
Broom-rape	resistant
Phomopsis	tollerant
Sclerotinia of the head	tollerant
Sclerotinia of the stem	susceptible

Hybrid Albena is a hybrid of both high productivity and high oil content. It belongs to the group of early hybrids. It is resistant to downy mildew and broom-rape, tollerant to phomopsis and sclerotinia of the head.

Bulgarian hybrids have proved very successful in the course of series of trials in different countries such as Turkey, Moldova, Russia, Germany, Czechoslovakia, China and South Africa.

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