# COLLECTION, EVALUATION AND CONSERVATION OF WILD SPECIES AND THEIR USE IN SUNFLOWER BREEDING PROGRAMMES (PROGRESS REPORT, 1980—1981)

**DRAGAN ŠKORIĆ (Yugoslavia)**

This co-operation topic was established by the Third Consultation of the F.A.O. Research Network on Sunflower, sponsored by the FAO Regional Office for Europe, held at INRA, Versailles, in October 23—26, 1979. Yugoslavia, France, the U.S.A., and Romania agreed to take part in the joint research programme. Bulgaria joined the programme later on. The Novi Sad Institute of Field and Vegetable Crops is acting as Liaison centre of this subnetwork.

## IMPORTANCE AND OBJECTIVES

Domesticated sunflower has a narrow genetic variability, especially regarding the most important characters. High oil varietal populations have outstandingly narrow genetic variability. Local populations are similar in this respect, only their agronomic characters are inferior. Narrow genetic variability hampers the progress in the majority of programmes.

A wealth of wild species within the genus *Helianthus* and variability within each of the wild species offer possibilities of increasing genetic variability in domesticated sunflower by applying interspecific hybridization. The feasibility of this method is confirmed by the presence of a number of natural interspecific hybrids between wild sunflowers.

Wild sunflower have been used hesitantly in breeding programmes although their use invariably rendered good results, especially with sunflower breeding for disease resistance, the major limiting factor in sunflower production. Reviewing the results of sunflower breeding for disease resistance, it is evident that all resistance genes discovered so far have come from wild sunflowers.

According to Putt (1957) the first discovery of a genetic source of resistance in wild sunflower was made when breeding for resistance to *Puccinia helianthi*. Domesticated and annual wild sunflowers were crossed to obtain lines which carried the genes of resistance to rust, $R_1$ and $R_2$. Putt and Sackston (1975) elaborated and published the results of sunflower breeding for resistance to rust.

A great breakthrough in the breeding for resistance was the discovery of *Pl* genes which bring genetic resistance to downy mildew. The line AD-66 was the first source of $Pl_1$ genes. Vrânceanu et al. (1970) derived the line from Canadian material (Advent) which had been developed on the basis of wild sunflowers. The sources of $Pl_2$ gene were also wild sunflowers (Zimmer and Kinman, 1972) as well as the sources of $Pl_3$ and $Pl_4$ genes (Vear and Leclercq, 1971 ; Vear, 1974).

Pustovoit (1978) found a possibility of developing new varietal populations on the basis of *H. tuberosus*. One of them was the variety Yubilejnaya 60 which incorporates genes of resistance to *Puccinia helianthi, Plasmopara helianthi, Phoma* sp., and *Orobanche cumana*. This and the other varieties (Progress, October), developed by interspecific hybridization, enlarged the genetic variability of domesticated sunflower.

The first source of genetic resistance to *Verticillium alboatrum*, discovered in the line CM-144, came from an interspecific hybrid developed by Putt (1958).

The genetic sources of resistance to *Orobanche cumana* were derived mostly from wild sunflowers. Pustovoit et al. (1978) developed several varieties on the basis of *H. tuberosus* which were resistant to the new population of broomrape, Yubilejnaya 60 being the most prominent among those varieties. Vrânceanu et al. (1980) determined five different genes which bring resistance to the population of *Orobanche cumana* present in Romania. Some of the genes originate from interspecific hybrids.

Pustovoit et al. (1978) reported the existance of sources of resistance to *Verticillium dahliae* in *H. tomentosus*.

The results of Shaw-Ming Yang (1981) indicated the probable presence of sources of resistance to Rhizopus head rot in four species of *Helianthus* spp.

Studies of Rogers (1981) showed a possibility of breeding for resistance to insects using wild sunflowers.

This brief review of the results achieved in sunflower breeding for resistance to diseases and pests on the basis of wild sunflowers indicates clearly that there exist large possibilities of enriching the genetic basis of domesticated sunflower. The introduction of wild sunflowers into the programmes of sunflower breeding for disease resistance should be encouraged, especially when we take into account that domesticated sunflower still misses genes of resistance to several major diseases.

Compared with corn, the practical utilization of heterosis in sunflower started much later because of its bisexual flowers. First CMS hybrids were developed by using interspecific hybridization. The major contribution in this field was made by Leclercq (1969) who discovered the first source of cytoplasmic male sterility in a cross of *H. petiolaris* (Figure 1)

*Fig. 1 — Helianthus petiolaris*

and domesticated sunflower. All sunflower hybrids available have been developed on the basis of this CMS source. More recently, Anaschenco discovered another CMS source coming from *H. lenticularis*. A comparative study of the the two CMS sources undertaken by Leclercq (1981) confirmed that those were two separate CMS sources. Another comparative study is necessary to determine the situation of CMS sources obtained by Whelan and Dedio (1980) from *H. petiolaris, H. giganteus* and *H. maximiliani.*

The determination of new CMS sources is an important activity because all institutions engaged in the development of sunflower hybrids use the same source. There exists a possibility of mutual dependence between sterile cytoplasm and genes carrying susceptibility to a disease. Since all hybrids grown have the same CMS source, the pathogen's population may increase and cause devasting yield reductions. It is therefore a must to intensify the work on the determination of new CMS sources and new sources of restorer genes in wild sunflowers.

Having succeded in discovering CMS sources on the basis of interspecific hybridization, attention was turned to the discovery of Rf genes in wild sunflowers. Leclercq (1971) reported the existance of restorer genes in *H. petiolaris.* Fick et al., (1974) found restorer genes in populations of wild *H. annuus* and *H. petiolaris.*

Vrânceanu and Stoenescu (1976), discussing different sources of restorer genes, mentioned restorer lines derived from *H. tuberosus. H. tuberosus* — based restorer lines resistant to downy mildew were developed by Škorić et al., (1978).

The work on the determination of restorer genes in wild sunflowers is in due course in a number of research centres around the world. It may be expected that restorer genes will be found in a large number of wild sunflowers. Interesting results were obtained regarding the differences among wild sunflowers in oil and protein content in seed, variability in the composition of higher fatty acids and aminoacids, maturity, etc. It would be, therefore, commendable to intensify the use of wild sunflowers in the breeding for oil and protein content and quality, as well as the other parameters of biochemical quality of seed.

Wild sunflowers have recently been included in a number of research programmes dealing with the determination of sources of drought resistance in sunflower. Serieys (1980) recommended the use of *H. argophyllus* in sunflower breeding for drought resistance. This species is also used by Spanish and Romanian breeders as a source of resistance to drought.

North American wild sunflowers incorporate well-expressed polyploid series in which $x = 17$. The annual species are diploid ($2n = 34$), while the perennial ones are di-, tetra-, and hexaploid ($2n = 34$, 68, and 102, respectively). In view of the differences in the number of chromosomes and genetic divergence, it is necessary to know precisely their possibilities to be crossed with domesticated sunflower or one wild species with another. This subject was studied extensively by Georgieva-Todorova (1972) and Anaschenco (1981).

Shandler and Beard (1978) worked on the development of a suitable technique of embryo culture and they succeeded in crossing domesticated sunflower (as the pollen parent) with *H. angustifolius, H. argophyllus, H. bolanderi* (exilis), *H. giganteus, H. grosseserratus, H. hirsutus, H. maximiliani,* and *H. petiolaris* ssp. *fallax* (as the maternal parents).

Georgieva-Todorova et al., (1980 and 1981) developed a technique of tissue culture suitable for interspecific hybridization within the genus Helianthus.

Wild sunflowers may also be used for the designing of new ideotypes of domesticated sunflower. Large variability among wild sunflowers may be used to increase self-fertility in domesticated sunflower by interspecific hybridization. Determination of marker genes in wild sunflowers may certainly be helpful to breeding.

The expansion of agricultural, industrial, and construction land, especially in the native land of wild sunflowers, threatens certain wild species with extinction. This is an important reason which compels us to collect and maintain the germplasm of wild sunflower species.

Since the only wild sunflower species in Europe is *H. tuberosus* which was introduced from America a few centuries ago and there is a number of sunflower breeding centres, it is necessary to take a serious approach to the realization of the programme of this subnetwork.

## PRELIMINARY RESULTS OF THE STUDIES CONDUCTED IN THE PERIOD 1979—1981

The programme of work proposed in 1979 could not be completed in two years because we placed emphasis on the gathering of samples for the collection of wild sunflowers.

It should be mentioned at this point that the members of the subnetwork achieved a high level of cooperation in the compilation of the collection and the exchange of previously collected wild sunflower species.

USDA experts made an important contribution to the completion of the collection. They organized a several-months collecting trip in 1980. Dr. G. J. Seiler, Bushland, TX, and L. Ćuk, M. Sc., Novi Sad, YU, realized the trip and collected 484 samples of 42 wild sunflower species (Table 1). A distinguishing feature of the collection is a large number of populations within each species collected, especially *H. annuus, H. petiolaris, H. praecox, H. debilis* (Figure 2), *H. argophyllus, H. neglectus, H. niveus, H. angustifolius, H. rigidus, H. tuberosus,* and *H. maximiliani.*

Seed lots of the collection are stored and multiplied in Bushland (the U.S.A.) and Novi Sad (Yugoslavia).

*Table 1*

**Collection of North American wild sunflower species gathered in 1980 in the U.S.A.**

| Species | No. of samples | Species | No. of samples |
|---|---|---|---|
| 1. *H. agrestis* | 4 | 23. *H. silphioides* | 1 |
| 2. *H. annuus* | 193 | 24. *H. divaricatus* | 1 |
| 3. *H. anomalus* | 6 | 25. *H. eggertii* | 2 |
| 4. *H. argophyllus* | 12 | 26. *H. hirsutus* | 7 |
| 5. *H. bolanderi* | 1 | 27. *H. mollis* | 8 |
| 6. *H. debilis* | 17 | 28. *H. occidentalis* | 3 |
| 7. *H. deserticola* | 7 | 29. *H. rigidus* | 10 |
| 8. *H. exilis* | 5 | 30. *H. strumosus* | 8 |
| 9. *H. neglectus* | 12 | 31. *H. tuberosus* | 12 |
| 10. *H. niveus* | 11 | 32. *H. giganteus* | 4 |
| 11. *H. paradoxus* | 4 | 33. *H. grosseserratus* | 5 |
| 12. *H. petiolaris* | 50 | 34. *H. maximiliani* | 12 |
| 13. *H. praecox* | 20 | 35. *H. nuttallii* | 5 |
| 14. *H. radula* | 9 | 36. *H. resinosus* | 5 |
| 15. *H. gracilentus* | 4 | 37. *H. salicifolius* | 1 |
| 16. H. *pumilus* | 1 | 38. *H. glaucophyllus* | 1 |
| 17. *H. angustifolius* | 11 | 39. *H. laevigatus* | 3 |
| 18. *H. floridanus* | 2 | 40. *H. longifolius* | 1 |
| 19. *H. simulans* | 2 | 41. *H. microcephalus* | 8 |
| 20. *H. atrorubens* | 6 | 42. *H. smithii* | 4 |
| 21. *H. carnosus* | 1 | TOTAL : | 484 |
| 22. *H. heterophyllus* | 5 | | |

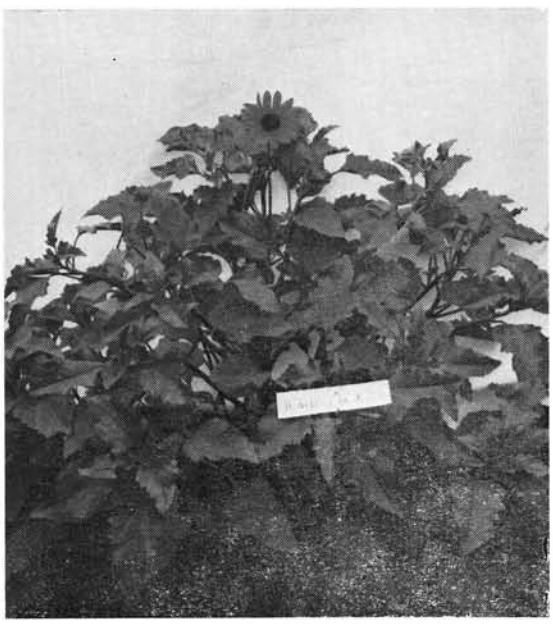

*Fig. 2 — Helianthus debilis*

Prof. Dr. Ch. B. Heiser of Indiana University assisted in the determination of wild species collected during the trip.

The Liaison Centre in Novi Sad received in 1980 59 samples of 36 wild species from France (Table 2) and nine wild species from Bulgaria (Table 3).

*Table 2*

**Wild sunflower species received from France in 1980**

| Species | No. of samples | Species | No. of samples |
|---|---|---|---|
| 1. *H. niveus* | 1 | 19. *H. eggertii* | 1 |
| 2. *H. debilis* | 6 | 20. *H. strumosus* | 1 |
| 3. *H. praecox* | 3 | 21. *H. rigidus* | 1 |
| 4. *H. petiolaris* | 5 | 22. *H. giganteus* | 1 |
| 5. *H. neglectus* | 1 | 23. *H. grosseserratus* | 1 |
| 6. *H. annuus* | 10 | 24. *H. nuttalli* | 3 |
| 7. *H. argophyllus* | 2 | 25. *H-maximiliani* | 2 |
| 8. *H. bolanderi* | 1 | 26. *H. salicifolius* | 1 |
| 9. *H. pumilus* | 1 | 27. *H. californicus* | 1 |
| 10. *H. paradoxus* | 1 | 28. *H. resinosus* | 1 |
| 11. *H. cusickii* | 1 | 29. *H. microcephalus* | 1 |
| 12. *H. arizonensis* | 1 | 30. *H. glaucophyllus* | 1 |
| 13. *H. ciliaris* | 1 | 31. *H. smithii* | 1 |
| 14. *H. mollis* | 2 | 32. *H. atrorubens* | 1 |
| 15. *H. occidentalis* | 1 | 33. *H. carnosus* | 1 |
| 16. *H. divaricatus* | 1 | 34. *H. orgyalis* | 1 |
| 17. *H. hirsutus* | 1 | TOTAL : 34 | 59 |
| 18. *H. decapetalus* | 1 | | |

*Table 3*

**Wild sunflower species received from Bulgaria in 1980**

| Species | No. of samples | Species | No. of samples |
|---|---|---|---|
| 1. *H. argophyllus* | 1 | 6. *H. nuttallii* | 1 |
| 2. *H.mollis* | 1 | 7. *H. hirsutus* | 1 |
| 3. *H. tuberosus* | 1 | 8. *H. scaberimus* | 1 |
| 4. *H. rigidus* | 1 | 9. *H. divaricatus* | 1 |
| 5. *H. debilis* | 1 | TOTAL : 9 | 9 |

In 1981, the Liaison Centre received 24 samples from Romania (Table 4), eight samples of seven wild species from Bulgaria (Table 5), and five samples of two wild species from Argentina (Table 6).

*Table 4*

**Wild sunflower species received from Romania in 1981**

| Species | No. of samples | Species | No. of samples |
|---|---|---|---|
| 1. *H. annuus* | 1 | 15. *H. giganteus* | 1 |
| 2. *H. maximiliani* | 1 | 16. *H. divaricatus* | 1 |
| 3. *H. californicus* | 1 | 17. *H. angustifolius* | 1 |
| 4. *H. nuttallii* | 1 | 18. *H. trachelifolius* | 1 |
| 5. *H. dowelianus* | 1 | 19. *H. argophyllus* | 1 |
| 6. *H. occidentalis* | 1 | 20. *H. decapetalus* | 1 |
| 7. *H. strumosus* | 1 | 21. *H. tomentosus* | 1 |
| 8. *H. grosseserratus* | 1 | 22. *H. laetiflorus* | 1 |
| 9. *H. multiflorus* | 1 | 23. *H. tuberosus* | 1 |
| 10. *H. orgyalis* | 1 | 24. *H. scaberimus* | 1 |
| 11. *H. parishii* | 1 | TOTAL : 24 | 24 |
| 12. *H. brachelifolius* | 1 | | |
| 13. *H. mollis* | 1 | | |
| 14. *H. salicifolius* | 1 | | |

*Table 5*

**Wild sunflower species received from Bulgaria in 1981**

| Species | No. of samples |
|---|---|
| 1. *H. argophyllus* | 1 |
| 2. *H. tomentosus* | 1 |
| 3. *H. macrocephallus* | 1 |
| 4. *H. salicifolius* | 1 |
| 5. *H. californicus* | 1 |
| 6. *H. decapetalus* | 1 |
| 7. *H. scaberimus* | 2 |
| TOTAL : 7 | 8 |

*Table 6*

**Wild sunflower species received from Argentina in 1981**

| Species | No. of samples |
|---|---|
| 1. *H. annuus* | 4 |
| 2. *H. petiolaris* | 1 |
| TOTAL : 2 | 5 |

During 1981, the Liaison Centre sent 24 samples of 18 wild species to Romania (Table 7), 11 samples to France (Table 8), and 12 samples of seven wild species to Bulgaria (Table 9).

Since 1978, INRA — Station d'Amélioration des Plantes, Montpellier, has a collection of 125 samples of wild sunflowers received from the U.S.A. and the U.S.S.R. The collection includes :

— 22 annual species and subspecies ;

— 36 perennial species and subspecies.

The Institute in Fundulea (Romania) has a collection of 21 wild sunflower species (Table 10).

*Table 7*

**Wild sunflower species received from Romania in 1981**

| Species | No. of samples | Species | No. of samples |
|---|---|---|---|
| 1. *H. annuus* | 5 | 11. *H. maximiliani* | 1 |
| 2. *H. petiolaris* | 2 | 12. *H. nuttallii* | 1 |
| 3. *H. debilis* | 2 | 13. *H. agrestis* | 1 |
| 4. *H. niveus* | 1 | 14. *H. deserticola* | 1 |
| 5. *H. atrorubens* | 1 | 15. *H. exilis* | 1 |
| 6. *H. microcephalus* | 1 | 16. *H. smithii* | 1 |
| 7. *H. praecox* | 1 | 17. *H. angustifolius* | 1 |
| 8. *H. floridanus* | 1 | 18. *H. grosseserratus* | 1 |
| 9. *H. mollis* | 1 | TOTAL : 18 | 24 |
| 10. *H. giganteus* | 1 | | |

*Table 8*

**Wild sunflower species sent to France in 1981**

| Species | No. of samples |
|---|---|
| 1. *H. anomalus* | 1 |
| 2. *H. agrestis* | 1 |
| 3. *H. debilis* | 1 |
| 4. *H. strumosus* | 1 |
| 5. *H. laevigatus* | 1 |
| 6. *H. angustifolius* | 1 |
| 7. *H. floridanus* | 1 |
| 8. *H. silphioides* | 1 |
| 9. *H. heterophyllus* | 1 |
| 10. *H. radula* | 1 |
| 11. *H. deserticola* | 1 |
| TOTAL : 11 | 11 |

*Table 9*

**Wild sunflower species sent to Bulgaria in 1981**

| Species | No. of samples |
|---|---|
| 1. *H. heterophyllus* | 1 |
| 2. *H. atrorubens* | 1 |
| 3. *H. angustifolius* | 1 |
| 4. *H. niveus* | 1 |
| 5. *H. giganteus* | 1 |
| 6. *H. petiolaris* | 2 |
| 7. *H. annuus* | 5 |
| TOTAL : 7 | 12 |

*Table 10*

**Wild species collection of I.C.C.P.T. Fundulea and results of their crosses with the cultivated *H. annuus* L.**

| No. | Species | | 1979 | | | 1980 | | | 1981 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | no. of emasc. and crossed heads | no. of seeds | no. of hybrids | no. of emasc. and crossed heads | no. of seeds | no. of hybrids | no. of emasc. and crossed heads | no. of seeds |
| 1 | *H. petiolaris* ssp. *petiolaris* Nutt. | 17 | — | — | — | — | — | — | 1<br>2 | 18<br>20 |
| 2 | *H. petiolaris* ssp. *fallax* Heiser | 17 | | | | | | | | |
| 3 | *H argophyllus* Torrey and Gray | 17 | 4 | 35 | 24 | 1 | 40 | 31 | 1 | —<br>83 |
| 4 | *H. annuus* L. | 17 | — | — | — | 2 | 63 | 28 | | |
| 5 | *H. angustifolius* L. | 17 | — | — | — | — | — | — | 6 | 18 |
| 6 | *H. californicus* DC. | 17 | — | — | — | 3 | 4 | — | 4 | 17 |
| 7 | *H. decapetalus* L. | 17,34 | 4 | 3 | — | 25 | 74 | — | 5 | 20 |
| 8 | *H. doronicoides* Lam. | | | | | | | | | |
| 9 | *H. debilis* Nutt. | 17 | | | | | | | | |
| 10 | *H. divaricatus* L. | 17 | 3 | 10 | — | 16 | 33 | — | 22 | 232 |
| 11 | *H. grosseserratus* Martens | 17 | — | — | — | 5 | 25 | — | 19<br>1 | 137<br>2 |
| 12 | *H. giganteus* L. | 17 | 8 | 4 | — | 5 | 37 | — | 19 | 108 |
| 13 | *H. maximiliani* Schrader | 17 | — | — | — | 6 | 50 | — | 28<br>2 | 94<br>17 |
| 14 | *H. mollis* Lam | 17 | — | — | — | 4 | 11 | — | 15<br>2 | 16<br>11 |
| 15 | *H. nuttallii* T. and G. | — | — | — | — | 11 | 34 | — | 32 | 225 |
| 16 | *H. occidentalis* Riddell | 17 | — | — | — | 1 | 2 | — | 14 | 14 |
| 17 | *H. parviflorus* T. and G. | | | | | | | | | |
| 18 | *H. salicifolius* A. Dietr. | 17 | 7 | 15 | — | 7 | 40 | — | 18 | 119 |
| 19 | *H. rigidus* (Cass/Desf.) | 51 | — | — | — | 6 | 21 | — | 18 | 6 |
| 20 | *H. strumosus* L. | 34,51 | — | — | — | — | — | — | 11<br>2 | 92<br>26 |
| 21 | *H. tuberosus* L. | 51 | — | — | — | 5 | — | — | 2 | 3 |

The Institute of Genetics in Sofia (Bulgaria) has a collection of 25 wild species :

— Annual diploid species (2n = 34) : *H. annuus* and *H. debilis ;*

— Perennial diploid species (2n = 34) : *H. grosseserratus, H. maximiliani, H. divaricatus. H. salicifolius, H. argophylus, H. nuttallii, H. eggertii, H. mollis, H. tomentosus, H. californicus ;*

— Perennial tetraploid species (2n = 68) : *H. decapetalus, H. scaberimus, H. hirsutus, H. strumosus ;*

— Perennial hexaploid species (2n = 102) : *H. resinosus, H. tuberosus, H. rigidus ;*

— Perennial aneuploid form (2n = 85) from *H. tomentosus.*

The Institute in General-Toshevo (Bulgaria) also has a rich collection of wild sunflowers.

Besides the collection, all centres are engaged in the following activities :

### a) MAINTENANCE AND MULTIPLICATION OF WILD SUNFLOWER SPECIES

It does not suffice to merely put together a collection — it should also be maintained. Some wild species brought from North America to Europe quickly lose germinability due to different agroecological conditions. This phenomenon makes the maintenance of a collection difficult. Furthermore, some American species reach the stage of flowering in late fall when grown in Europe and frequently it is impossible to obtain seed (e.g., *H. salicifolius*, etc.) (Figures 3, 4).

*Fig. 3 — Helianthus giganteus*

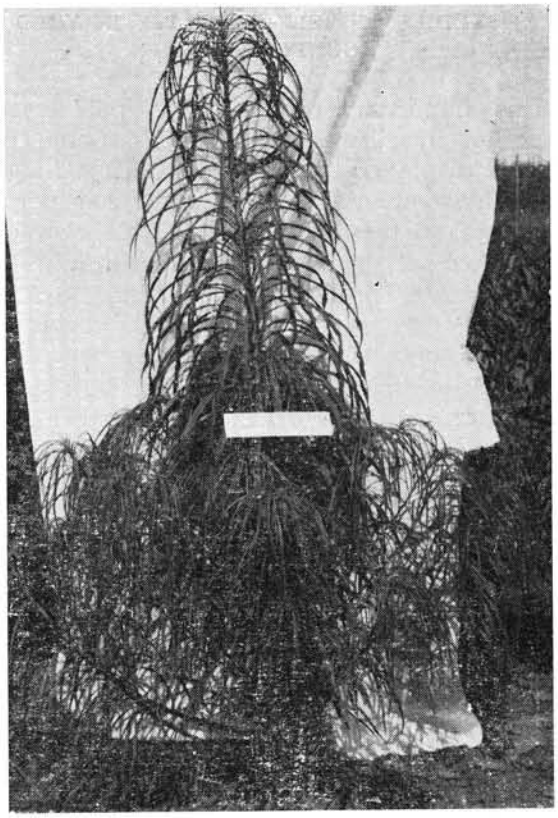

*Fig. 4 — Helianthus salicifolius*

The following methods are used in the research centres to multiply wild sunflowers : selfing, sib-cross technique and microisolation technique. The first method is unacceptable by a number of wild sunflowers due to incompatibility, but the last two techniques are rather successful.

### b) STUDIES OF MORPHOLOGICAL CHARACTERS AND IMPORTANT AGRONOMIC CHARACTERS

The Institutes in Bushland, Novi Sad, Montpellier, Sofia, and Fundulea conducted studies of different morphological characters in wild sunflowers. Most of the Institutes studied parallelly the vegetation length, branching, period from emergence to flowering, length of flowering from central to furthermost lateral heads, characteristics of florets and ray flowers, type and size of head, size, form, and color of seed, etc.

The Institute in Novi Sad conducted a detailed study on the content of oil in seed of the wild sunflowers in the collection. Determinations of protein contents and higher fatty acids composition are in due course.

Wild sunflowers were examined for the weight of 1 000 seeds in Montpellier and for protein content and higher fatty acids composition in Sofia.

### c) STUDIES OF SELF-FERTILITY IN WILD SUNFLOWERS

This important problem was paid special attention in all research centres. Some wild species displayed full incompatibility in selfing. Environmental factors bear considerable influence on the expression of this character.

The low self-fertility in wild sunflower may be illustrated by the results obtained in Montpellier — 83% of the selfed wild species produced no more than two seeds per head.

The degree of pollen vitality in wild species and interspecific hybrids in $F_1$ and $F_2$ was examined at the Institute in Sofia.

### d) POSSIBILITIES OF CROSSING WILD AND DOMESTICATED SUNFLOWER

Since wild sunflowers play an important role in breeding programmes, it is essential to study possibilities of crossing them with domesticated sunflower. The Institute in Sofia has the most extensive data on this subject because Georgieva-Todorova has studied this character in wild sunflowers for more than two decades.

Extensive programmes on this subject have been started in Novi Sad (Tables 11 and 12), Fundulea (Table 10), and Montpellier. Back-crossings with cultured forms are performed at all Institutes.

### e) DETERMINATION OF NEW SOURCES OF CMS AND RESTORER GENES (Rf)

In Montpellier, Serieys crossed *H. petiolaris fallax*×*H. annuus* and obtained 57% of sterile plants in $F_1$. He also found 3% of sterile plants in $F_2$ generation of the cross *H. argophyllus*×*H. annuus*. The objective of this study is the determination of new CMS sources.

Ćuk and Macura made several crosses of wild and domesticated sunflower in Novi Sad and found some sterile plants. The study continues.

Similar studies have been undertaken by Georgieva-Todorova in Sofia and Iuoraş in Fundulea.

Serieys (Montpellier) found restorer genes in *H. argophylus, H. bolanderi, H. neglectus, H. rigidus,* and some populations of wild *H. annuus.* Ćuk (Novi Sad) reported to have found a restorer gene in *H. tuberosus.*

The work on the determination of restorer genes is conducted in all participating research centres.

*Table 11*

**Back-crossing in $F_2$ generation cultured x wild sunflower, 1981 (Novi Sad)**

| Species | No. of samples | | No. of emerged plants | No. of samples in crossing | |
|---|---|---|---|---|---|
| | planted | emerged | | cult. × wild | wild × cult. |
| 1. *H. annuus* | 76 | 73 | 329 | 65 | 51 |
| 2. *H. petiolaris* | 10 | 2 | 5 | 2 | 2 |
| 3. *H. debilis* | 11 | 10 | 38 | 7 | 7 |
| 4. *H. praecox* | 8 | 6 | 25 | 6 | 6 |
| 5. *H. argophyllus* | 2 | 2 | 10 | 2 | 2 |
| 6. *H. neglectus* | 5 | 1 | 1 | 1 | 1 |
| 7. *H. niveus* | 2 | 0 | 0 | 0 | 0 |
| 8. *H. exilis* | 3 | 1 | 1 | 0 | 0 |
| 9. *H. deserticola* | 5 | 0 | 0 | 0 | 0 |
| 10. *H. anomalus* | 3 | 0 | 0 | 0 | 0 |
| 11. *H. paradoxus* | 2 | 1 | 3 | 0 | 0 |
| 12. *H. agrestis* | 2 | 2 | 15 | 0 | 0 |
| 13. *H. salicifolius* | 1 | 1 | 7 | 0 | 0 |
| 14. *H. californicus* | 1 | 0 | 0 | 0 | 0 |
| 15. *H. pumilus* | 1 | 1 | 4 | 1 | 1 |
| 16. *H. divaricatus* | 1 | 0 | 0 | 0 | 0 |
| 17. *H. carnosus* | 1 | 1 | 1 | 0 | 0 |
| 18. *H. longifolius* | 1 | 0 | 0 | 0 | 0 |
| 19. *H. gracilentus* | 3 | 0 | 0 | 0 | 0 |
| 20. *H. nuttallii* | 5 | 5 | 26 | 2 | 2 |
| 21. *H. maximiliani* | 3 | 2 | 7 | 1 | 1 |
| 22. *H. mollis* | 3 | 2 | 9 | 1 | 0 |
| 23. *H. hirsutus* | 3 | 0 | 0 | 0 | 0 |
| 24. *H. grosseserratus* | 3 | 2 | 5 | 0 | 0 |
| 25. *H. angustifolius* | 4 | 0 | 0 | 0 | 0 |
| 26. *H. tuberosus* | 5 | 4 | 17 | 0 | 0 |
| 27. *H. resinosus* | 3 | 1 | 1 | 0 | 0 |
| 28. *H. strumosus* | 3 | 2 | 7 | 0 | 0 |
| 29. *H. heterophyllus* | 2 | 0 | 0 | 0 | 0 |
| 30. *H. radula* | 5 | 1 | 1 | 0 | 0 |
| 31. *H. floridanus* | 2 | 1 | 2 | 0 | 0 |
| 32. *H. simulans* | 1 | 1 | 1 | 0 | 0 |
| 33. *H. microcephalus* | 2 | 2 | 2 | 0 | 0 |
| 34. *H. atrorubens* | 5 | 1 | 5 | 0 | 0 |
| 35. *H. smithii* | 3 | 1 | 1 | 0 | 0 |
| 36. *H. glaucophyllus* | 1 | 0 | 0 | 0 | 0 |
| 37. *H. giganteus* | 3 | 3 | 22 | 0 | 0 |
| 38. *H. loevigatus* | 3 | 3 | 4 | 0 | 0 |
| 39. *H. eggertii* | 1 | 1 | 2 | 0 | 0 |

*Table 12*

**Back-crossing in $F_1$ generation cultured x wild sunflower, 1981 (Novi Sad)**

| Hybrid $F_1$ | No. of samples | | No. of emerged plants | Crossing | |
|---|---|---|---|---|---|
| | planted | emerged | | cult. $F_1^{\times}$ | $F_1$× cult. |
| CMS 104 x *H. petiolaris* | 4 | 3 | 20 | 3 | 3 |
| x *H. debilis* | 1 | 1 | 20 | 1 | 1 |
| x *H. rigidus* | 11 | 11 | 96 | 8 | 7 |
| x *H. maximiliani* | 1 | 1 | 2 | 1 | 1 |
| x *H. resinosus* | 1 | 1 | 1 | 1 | 1 |
| x *H. orgyalis* | 1 | 1 | 1 | 1 | 1 |
| x *H. tuberosus* | 1 | 1 | 20 | 0 | 1 |

### f) TESTING WILD SUNFLOWERS FOR RESISTANCE TO DISEASES AND PESTS

The use of wild sunflowers as sources of resistance to diseases and pests is the primary task of this cooperative programme. All participants conducted studies in this field in the period 1979—1981. The resistance of wild sunflowers was studied in field conditions, applying inoculation methods.

The work in Montpellier is directed towards the determination of resistance to *Sclerotinia sclerotiorum* in wild sunflowers, primarily in *H. tuberosus* and *H. rigidus*.

The work in Novi Sad is directed towards the determination of resistance to several pathogens (*Plasmopara helianthi, Phoma* sp., *Sclerotinia sclerotiorum, Alternaria helianthi, Phomopsis helianthi,* etc.). Preliminary results indicated varying degrees of susceptibility, tolerance, and resistance to certain pathogens in the examined wild sunflowers. For example, the majority of the populations of wild *H. annuus* was found to be susceptible to *S. sclerotiorum* infection of medium leaves and stem. There are prospectives of determining a source of resistance to the disease caused by *Phomopsis helianthi.*

In the USA, wild sunflower species are routinely used for the determination of sources of resistance to diseases (*Plasmopara helianthi,* Rhizopus head rot, powdery mildew, *Alternaria helianthi, Phoma* sp.). Yang (1981) reported four wild species to offer possibilities of breeding for resistance to Rhizopus head rot.

We learned in personal contacts with Dr. Rogers that *H. paradoxus* is a potential source of resistance to the new American race of rust.

The Institute of Genetics in Sofia uses wild sunflowers to determine resistance to *Plasmopara helianthi, Orobanche cumana,* and *Sclerotinia sclerotiorum.*

The Institute in Fundulea also uses wild sunflowers in their work on the determination of sources of disease resistance.

According to the results of Rogers (1981) wild sunflowers may successfully be used for the determination of sources of resistance to pests (Tables 13 and 14). His results indicate wild species to be resistant to *Zygogramma exclamationis, Bothynus gibbosus, Masonaphis masoni* and *Empoasca abrupta. H. tuberosus* and *H. maximiliani* displayed the widest spectrum of resistance to the above pests of all wild sunflowers which may be crossed with domesticated sunflower.

*Table 13*

**Relative resistance of *Helianthus species*, Section *Annui*, to four species of insects in laboratory feeding tests (acc. to Rogers, 1981)**

| *Helianthus* species[a] | Insect species[c] | | | |
|---|---|---|---|---|
| | *Zygogramma exclamationis* | *Bothynus gibbosus* | *Masonaphis masoni* | *Empoasca abrupta* |
| *agrestis Pollard* | +++ | 0 | 0 | 0 |
| *annuus* | ++ | 0 | 0 | 0 |
| *argophyllus* | ++ | + | — | — |
| *bolanderi* | +++ | 0 | ++ | |
| *debilis debilis* Nuttall | | | — | |
| *debilis silvestris* | 0 | + | | 0 |
| *deserticola Heiser* | | — | | |
| *exilis* | +++ | 0 | +++ | + |
| *neglectus* | ++ | + | — | + |
| *niveus canescens* | +++ | ++ | 0 | |
| *niveus tephrodes*[b] | | | ++ | + |
| *paradoxus* | ++ | | — | 0 |
| *petiolaris fallax* Heiser | | | 0 | 0 |
| *petiolaris petiolaris* | ++ | 0 | | |
| *praecox hirsutus* | ++ | 0 | — | + |
| *praecox praecox* | | | — | |
| *praecox runyonii* | | + | | |
| Hybrid 896 (check) | 0 | 0 | 0 | 0 |

a) All these species are cross compatible with *annuus* cultivars.

b) Perennial, all other species and subspecies are annuals.

c) +++ = Plants immune to attack or caused 100% mortality to insects ;
++ = Plants significantly more resistant than hybrid check LSD 1% level ;
+ = Plants significantly more resistant than hybrid check LSD 5% level ;
0 = Plants no more resistant than hybrid check.

### g) TESTING WILD SUNFLOWERS FOR DROUGHT RESISTANCE

It is a common knowledge that domesticated sunflower is sensitive to drought, a feature which limits the introduction of sunflower to arid regions. The Institutes in Montpellier and Fundulea established research programmes to study drought resistance in wild sunflowers. *H. argophyllus* was mostly used in the first stage of work, but other wild species will be included later on, too.

### h) CYTOGENETIC STUDIES

Cytogenetic studies on wild sunflowers were conducted in the USA and Bulgaria. In the U.S.A., attempts were made to overcome incompatibility in interspecific hybridization by applying embryo culture. Especially interesting were the studies of linked genes, chromosome map, and barriers in gene transfer during interspecific hybridization.

*Table 14*

**Relative resistance of *Helianthus species*, Section *Divaricati* to four species of insects in laboratory feeding tests (acc. to Rogers, 1981)**

| *Helianthus* species | Cross compatible w/annuus | Insect species[b] | | | |
|---|---|---|---|---|---|
| | | *Zygogramma exclamationis* | *Bothynus gibbosus* | *Masonaphis masoni* | *Empoasca abrupta* |
| *Angustifolii* | | | | | |
| *angustifolius* | no | ++ | 0 | ++ | + |
| *floridanus* | no | +++ | 0 | +++ | |
| *simulans* | no | +++ | + | ++ | ++ |
| *Atrorubentes* | | | | | |
| *atrorubens* L. | no | +++ | + | +++ | + |
| *carnosus* | no | +++ | + | +++ | |
| *heterophyllus* Nuttall | no | +++ | ++ | ++ | |
| *radula* | no | +++ | + | +++ | ++ |
| *silphioides* | no | +++ | | | + |
| *Divaricati* | | | | | |
| *divaricatus* L. | no | +++ | | ++ | + |
| *mollis* | no | +++ | ++ | ++ | + |
| *occidentalis occidentalis* | no | | ++ | ++ | ++ |
| *occidentalis plantagineus* | no | | + | ++ | |
| *rigidus* × *laetiflorus* | no | +++ | | +++ | |
| *strumosus* | yes | +++ | | | |
| *tuberosus* | yes | +++ | + | +++ | + |
| *Gigantei* | | | | | |
| *californicus* | no | | | | 0 |
| *giganteus* | yes | | | 0 | |
| *grosseserratus* | no | +++ | ++ | ++ | + |
| *maximiliani* | yes | +++ | + | ++ | ++ |
| *nuttallii nuttallii* | no | ++ | ++ | ++ | + |
| *resinosus* | no | +++ | | ++ | |
| *salicifolius* | no | +++ | ++ | ++ | — |
| *Microcephali* | | | | | |
| *glaucophyllus* | no | | | | + |
| *longifolius* Pursh | no | +++ | + | ++ | + |
| *porteri*[a] | no | | +++ | ++ | ++ |
| Hybrid 896 (check) | | 0 | 0 | 0 | 0 |

a) Annual, all other species are perennial.

b) +++ = plants immune to attack or caused 100% mortality to insect ;
++ = plants significantly more resistant than hybrid check 1% level ;
+ = plants significantly more resistant than hybrid check 5% level ;
0 = plants no more resistant than hybrid check
— = plants more susceptible than hybrid check.

Intensive cytogenetic studies on wild sunflowers, which were started earlier at the Institute of Genetics in Sofia, brought prominent results. Mitosis of 10 wild species was studied in detail and ideograms were completed. Meiotic analyses for the character of chromosome conjugation and frequency of chiasma per cell and per bivalents were made for all wild species (25) used.

## PROGRAMME OF WORK FOR THE PERIOD 1982—1984

The collecting of wild sunflower species has not been completed in the period 1980—1981. The work should thus be continued, placing emphasis on the collecting of those species from Mexico and the U.S.A., which have not been found so far. In view of a large variability within each wild sunflower species, we should continue collecting as many populations of wild species as possible. Furthermore, we should try to find and collect natural interspecific sunflower hybrids.

It would be advantageous to include into the subnetwork several scientific institutions from South America and with their help, organize collecting trip there.

It is also necessary to undertake yet another collecting trip in Mexico and southern regions of the U.S.A. in order to complete our collection of wild sunflowers. The trip could be realized by two investigators, one from the U.S.A., another one from Yugoslavia, with assistance of corresponding Mexican institutions. Financial aid will be requested from International Board of Plant Genetic Resources (IBPGR) for the realization of this part of the programme.

The members of the subnetwork agreed that in the next period they should work cooperatively on the following problems :

1. Determination of morphological and botanical characters in order to complete the basic data on wild sunflower species (Participants : A, B, D, F, G, J and L) * ;

2. Determination of important agronomic characters aimed at increasing the genetic variability of the breeding materials (Participants : A, B, and L) ;

3. Tests of wild species to discover sources of genetic resistance to diseases and insects (Participants : A, B, D, G, H, J and L) ;

4. Determination of the degree of self-fertility in wild sunflowers (Participants : B, G, D, J, K and L) ;

5. To examine possibilities of interspecific hybridization between wild and cultured sunflowers (Participants : B, D, G, H, J, K and L) ;

6. To examine the possibilities of interspecific hybridization between wild species (Participants : B and G) ;

7. Determination of new sources of male sterility and restorer genes from wild sunflowers (Participants : A, B, D, H and L) ;

8. Use of wild sunflowers in breeding for increased oil and protein yield and quality (Participants : A, B, F, G, J and L) ;

9. Determination of marker genes in wild sunflowers (Participants : C) ;

* See list of participants

10. Use of wild sunflowers in breeding for drought resistance (Participants : D, E, G, H, I and J) ;

11. Finding suitable methods (tissue culture, embryoculture, etc.) of crossing cultured and wild sunflowers in cases where conventional procedures are not applicable (Participants : B and K) ;

12. Cytogenetic studies on wild sunflowers (Participants : B, F, K and L).

The members of the subnetwork also agreed to send progress reports for the current year and programmes of work for the next year to the liaison centre not later than the end of December of the current year.

## LIST OF PARTICIPANTS :

A. Institute for Wheat and Sunflower, General Toshevo, Tolbuhin, Bulgaria (Dr. F. Stoyanova-Tzvetkova).

B. Bulgarian Academy of Sciences, Institute of Genetics, Sofia 1113, Bulgaria (Dr. J. Georgieva-Todorova and N. E. Bohorova).

C. Research Institute for Crop Production, Ruzyne 507, Prague 6, Czechoslovakia (Prof. Dr. A. Kovačik, V. Vlčkova and Dr. V. Skaloud).

D. I.N.R.A. — Station d'Amélioration des Plantes, Place Viala 9, 34 060 Montpellier, France (H. Serieys).

E. I.N.R.A. — Station d'Amélioration des Plantes, Domaine de Crouelle, Route de Pont du Château, 6300 Clermont-Ferrand, France (Dr. P. Leclercq).

F. Institute of Plant Breeding, University of Bari, Via Amendola 176, 70126 Bari, Italy (Dr. E. Alba).

G. Istituto di Agronomia, Fac. di Agr., Via S. Michele d/Scalzi, 2, 56100 Pisa, Italy (Dr. G. P. Vannozzi, R. Paolini).

H. Research Institute for Cereals and Industrial Crops, 8264 Fundulea, Jud. Călărași, Romania (Monica Iuoraș).

I. I.N.I.A. — National Research Centre for Oil Crops, Apartado 240, Cordoba, Spain (Dr. J. Dominguez and Dr. J. Fernandez-Martinez).

J. USDA-SEA, South Western Great Plains-Research Center Bushland, Texas 79012, U.S.A. (Dr. Ch. Rogers, Dr. G. J. Seiler, Dr. R. E. Stafford and Dr. S. M. Yang).

K. Dept. of Agronomy and Range Sciences, University of California, Davis, Ca., 95616, U.S.A. (Dr. B. H. Beard, Dr. C. C. Jan and Mr. J. Chandler).

L. Institute of Field and Vegetable Crops, 21000 Novi Sad, M. Gorkog 30, Yugoslavia (Dr. M. Škoric, Mr. L. Cuk and Mrs. J. Macura).

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## RAPPORT D'ACTIVITÉ CONCERNANT LA COLLECTION, L'ÉVALUATION ET LA CONSERVATION DES ESPÈCES SAUVAGES DE TOURNESOL ET LEUR UTILISATION DANS LES PROGRAMMES D'AMÉLIORATION DU TOURNESOL (1980—1981)

*Résumé*

La 3e Consultation F.A.O. (Versailles, octobre 1979) concernant le Réseau d'études pour le tournesol, a décidé d'organiser un sous-réseau pour la collection, l'évaluation et la conservation des espèces sauvages, ainsi que pour l'utilisation de ces formes dans les programmes d'amélioration du tournesol. Actuellement, aux travaux de ce sous-réseau participent plusieurs instituts ou stations de recherches de Bulgarie, Tchécoslovaquie, France, Italie, Roumanie, Espagne, U.S.A. et Yougoslavie. Le centre coordonateur se trouve à l'Institut pour les cultures en champ et pour les légumes de Novi-Sad. Le présent ouvrage comprend l'historique des études sur les espèces du genre *Helianthus* et leur utilisation pour l'amélioration du tournesol. A la suite des études cytogénétiques et morpho-physiologiques et de l'étude de la compatibilité entre les différentes formes, la classification systématique a pu être précisée. Au cours de la période 1980—1981, de nombreuses espèces et provenances ont été trouvées et étudiées. Dans le cadre du sous-réseau, un large échange de semences a eu lieu. Les plus importantes collections sont conservées et multipliées à Bushland (U.S.A.) et Novi Sad (Yougoslavie). A Montpellier (France), Krasnodar (U.R.S.S.) et Fundulea (Roumanie) se trouvent aussi des collections de formes de tournesol. Au cours de la période mentionnée, chez de nombreuses espèces et provenances, l'étude a porté sur les caractères morpho-physiologiques et agronomiques ayant une importance potentielle pour l'amélioration du tournesol. L'étude de l'autofertilité des espèces sauvages et leur capacité de croisement avec les formes cultivées a été approfondie. En même temps de nouvelles formes de stérilité mâle cytoplasmique ainsi que de nouveaux gènes de restauration de la fertilité, de résistance aux maladies, aux ravageurs et à la sécheresse, ont été détectées. Le programme de travail de sous-réseau est présenté pour la période 1982—1984.

## INFORME DE ACTIVIDAD EN EL PERÍODO 1980-1981 CON RESPECTO A LA RECOGIDA, EVALUACIÓN Y CONSERVACIÓN DE LAS ESPECIES SALVAJES, ASÍ COMO EL EMPLEO DE ÉSTAS EN LOS PROGRAMAS DE MEJORA DEL GIRASOL

*Resúmen*

La subred de investigaciones para la recogida, evaluación y conservación de les especies salvajes así como su empleo en los programas de mejora del girasol se ha establecido en octubre de 1979 en Versailles, con motivo de la 3ª consultacion F.A.O. concerniente a la Red de Investigaciones para girasol.

Presentemente participan en esta subred varios institutos o estaciones de investigaciones de Bulgaria, Checoslovaquia, Francia, Italia, Rumanía, España, los E.E.U.U. e Yugoeslavia ; el centro de coordinación siendo el Institute para culturas de campo y hortalizas de Novi Sad (Yugoslavia).

El presente papel abarca una historia del estudio de las especies de la variedad *Helianthus* y de su utilización en la mejora del girasol.

Como resultado de las investigaciones citogenéticas, de los estudios morfo-fisiológicos de compatibilidad al cruce, se precisan algunos aspectos de su clasificación sistemática. En el período analisado se han recogido numerosas especies y proveniencias y se ha desarrollado un gran cambio de semillas dentro de esta subred de investigaciones. Las más amplias colecciones se conservan y se reproducen en Bushland (los E.E.U.U.) y Novi Sad (Yugoeslavia). Colecciones importantes se hallan tambien en Montpellier (Francia) Krasnodar (la U.R.S.S.) y Fundulea (Rumania). En dicho período se ha intensificado el estudio de los caracteres morfo-fisiológicos y sobre todo, él de los agronómicos con importancia potencial para la mejora del girasol, en numerosas especies y proveniencias.

Se han extendiddo los estudios de autofertilidad de las especies salvajes del cruce de las mismas con el girasol cultivado. Paralelamente, se ha persequido la detección de nuevos formas con androesterilidad citoplasmática, de genes para la restauración de la fertilidad del poleno, para resistencia a enfermedades, factores dañinos y sequía.

Finalmente, está presentado el programa de trabajo de estasubred en el período 1982—1984.