USDA-TEXAS COOPERATIVE SUNFLOWER BREEDING AND GENETIC RESEARCH PROGRAM AT COLLEGE STATION, TEXAS

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Since 1950 the U. S. Department of Agriculture in cooperation with the Soil and Crop Sciences Department of the Texas Agricultural Experiment Station has conducted a small program of sunflower breeding and genetic research here at College Station. Originally, the major purposes of this program were to provide a nucleus of germ plasm and information should funds and facilities ever become available for a comprehensive research program and to provide some information in order to answer the large number of letters from farmers, housewives and industrialists who ask questions about this interesting species. Much of our original material was supplied through the courtesy of Dr. E. D. Putt and the few others who were interested in sunflower work at that time.

During the period 1950 through 1961 most of our small efforts in sunflower breeding involved testing Canadian hybrids (which performed surprisingly well here in some years), production of a very few F_1 hybrids for experimental testing and attempting the transfer of rust resistance and dwarf internodes to the large-seeded types grown in California. We also "purified" for rust resistance material from a wild *Helianthus annuus* population collected by Dr. I. M. Atkins near Denton, Texas; seed of this population has had almost world-wide distribution.

During this early period, we also initiated studies of the inheritance of petal color and floral morphology. We were able to confirm the earlier report by Cockerell (1) that inheritance of the gaillardia pattern of red pigment was conditioned by a simple dominant gene (we suggest the symbol "G" for this mutant) and that lemon yellow petal color is recessive to normal yellow ("ll" is the symbol suggested for lemon). The extension of red in the gaillardia pattern appears to be inherited in a quantitative manner. We have also worked with another locus ("oo"), which conditions orange petal color; it is also recessive to normal yellow. The "ll" condition is epistatic to "oo." Thus, we have identified 3 independent loci conditioning petal color. In one population, which we have not been able to repeat, the segregation suggested a fourth dominant factor which we have tentatively designated "C;" it may be necessary that dominant "C" be present for expression of "ll" and "oo." If this is true and dominant "C" is of relatively infrequent occurrence in domestic types, it could explain the appearance of lemon and orange petals in the progeny of outcrosses to wild *H. annuus*.

We have also studied the inheritance of the chrysanthemum flower type (in which even the fertile disk florets have petals) in crosses with normal sunflowers. This study proved very difficult because of the extreme lack of fertility in the original chrysanthemum type and most of its hybrid progeny, and we cannot report a definite genetic pattern for this interesting floral type. We now have some relatively self-fertile chrysanthemum flowered lines derived from these crosses, and this material is available for further study if anyone is interested. Many of the petal color combinations and variations in floral morphology are strikingly beautiful and have possibilities as ornamentals. Last winter we released seed of 14 lines or populations for this purpose. A fairly complete sample of this material is growing in the nursery this season, and you will be able to see them tomorrow. We will probably not be able to pursue this work any further, and I hope that some of you will be interested in taking over this material.

As Dr. Putt mentioned earlier, we have been primarily interested in the compositae type of self-incompatibility for production of female parents of hybrids in order to make use of heterosis in sunflowers. Our measure of self-incompatibility has been simply to count the number of seed produced by unmanipulated bagged heads. Certainly we do not claim that this is a precise method, but it seems to have been effective. This work was begun with S-37-388, the Canadian line which has been used as the female parent of all North American hybrids produced commercially to date. After one cycle of recurrent selection for increased self-incompatibility and seed size at this location and three generations of isolated increase, this modified line called S-37-388T1 was compared with S-37-388 and its rust resistant counterpart S-37-388RR obtained from Canada in 1962. The results are shown below:

Pedigree	Total heads bagged	Range in number of seed per head	Mean number of seed per head
S-37-388T1	40	0-54	3.8
S-37-388	40	2-220	34.2
S-37-388RR	76	0-858	179.8

The S-37-388 type of self-incompatibility appears to be influenced by environment. This is illustrated by the data on number of seed per bagged head presented below when S-37-388T1 was grown under a variety of conditions in 1963.

Site	Planting date	Plants bagged	Seed per head	
			Range	Mean
Isolated increase	3/21	72	0-279	45.2
Nursery rows	3/20	66	0-212	24.7
Greenhouse	1/25	9	14-191	84.0
Nursery rows	5/10	84	0-15	1.2

The late planted nursery rows were actually planted to the selfed seed produced by the rather fertile plants grown in the greenhouse. Level of fertility under any particular set of growing conditions should be taken into consideration in establishing the acceptance level of fertility when selection pressure is used to maintain a satisfactory level of self-compatibility.

S-37-388T1, when used as the female parent, has resulted in excess of 90% hybrids at College Station, Texas, when flowering of the two parents coincided in 2 × 2 crossing blocks. However, there is some evidence that

that self-fertility of this line increased after a few generations of isolated increase following the original selection for high self-incompatibility. You will see the recombination phase of the second cycle of recurrent selection of this line, S-37-388T2, during the field trip.

Self-incompatibile plants are very frequent in open-pollinated populations and appear sporatically even in highly inbred self-fertile lines. Highly self-incompatible plants produce so few selfed seeds under bags that maintenance of the line is often very difficult. Increasing the seed of highly self-incompatible lines to the point where an adequate number of plants are available for testing combining ability is extremely difficult without resorting to isolated increase. Since such lines usually produce a reasonable amount of seed when allowed to sib-pollinate in isolation, we have begun using a technique which we call selfing and sibbing. In this technique a plant in the self-incompatible line is self-pollinated and pollen is collected from it to sib-pollinate a sister plant. In 1963 we used this technique on varying numbers of plants in 5 lines tracing to 953-102-1-1-22-12-T1 and in 2 lines derived from the (Sunrise × Wild)-02-02-2 source. All 7 of these lines are rust resistant to some degree. They varied considerably in self-fertility since the mean number of seed per unmanipulated bagged head varied from 1.0 to 52.7. The mean for all 21 unmanipulated selfed heads was 33.5 seed. The 16 selfed plants used as male parents in sib-pollination averaged 48.7 seed, while the 16 sib-pollinated plants produced an average of 126.3 seed. In every case the sibbed heads produced more seed than the selfed heads, and fortunately the percentage increase of seed production due to sibbing was greatest for the most self-incompatible lines.

Prior to 1962 the sunflower breeding work at College Station was somewhat isolated. At the beginning of that year I was asked to survey the sunflower situation in the United States in order to report to the Oilseed and Peanut Research and Marketing Advisory Committee which met at Peoria, Illinois, February 7, 1963. This report (2) has been made available to most of you, and a more comprehensive report of the work done that year (3) is in press. During the 1962 season we assembled seed of as many of the Russian varieties as were available at that time for testing at a few locations, and this was the beginning of the U. S. regional testing program which will be reported on later in this meeting. It was during the travel connected with this survey that I met many of you and that the idea of this conference was first conceived.

The larvae of the sunflower head moth, Homoeosoma electellum, is perhaps the most serious hazard to sunflower production in the southern half of the United States. This insect does not always appear in damaging numbers here at College Station where the wild sunflower population is rather sparse. In 1962 the entire collection was planted at McGregor, Texas, where wild Helianthus annuus is a serious weed even in row crops. Practically all varieties and lines grown were destroyed by this insect pest; only very early plants which had hard seed by the time of the first moth flight on about June 1 and a few which flowered after about June 15 escaped complete destruction. No indication of genetic resistance to this insect was apparent. Certainly, the armored (phytomelanin) layer in the achene wall (which is reported to provide protection from the European insect Homoeosoma nebullela) which is present in most of the high oil Russian material and in some of our own lines which trace to wild parentage did not provide any measurable protection from Homoeosoma electellum. If resistance to this insect is found, it will probably be in wild H. annuus or some of the related species.

A fairly large number of early generation inbred lines varying from S_1 to S_4 have been isolated from the high oil Russian varieties. As would be expected, some extremes in visual variability have been observed, but a few of these lines are quite vigorous and uniform. Some of this material is moderately resistant to rust, especially some of the early maturing lines derived from Tchernianka 66. Most of the plants in the Russian varieties are highly self-incompatible, and the lines derived from these present the problems of maintenance mentioned above, but some lines are quite self-fertile. Unfortunately, no analyses of oil content has been possible for these lines; and, as yet, no tests for combining ability have been conducted.

We have begun some work in transferring rust resistance to high oil and large-seeded material. All except the very early maturing Russian varieties were crossed with the rust resistant lines HA 6, a 953-102-1-1-22-12-Tl selection; and HA 8, derived from (Sunrise × Wild)-02-02, in 1963; F_1's were grown in the greenhouse; and rust resistant F_2 plants were self-pollinated this season. Smena and Peredovik are being backcrossed to rust resistant F_1 and F_2 plants from these crosses. Large-seeded S_1 progenies from Mingren and the variety Commander were crossed to Mennonite RR this season in hopes of isolating large-seeded rust resistant material. The appearance of at least two additional races of Puccinia helianthi at this location has complicated the program of breeding for rust resistance, but presence of these additional races should improve our chances of developing hybrids which will be resistant in other areas where a different race complex may exist.

The collections of rust resistant wild H. annuus made by Mr. Luciano in 1963 have been distributed to those who have requested them. We are growing an isolated block in which the most resistant of these collections are being allowed to intercross (susceptible plants have been removed); this should provide an additional pool of genes for rust resistance.

This research project has enjoyed excellent cooperation with other sunflower research projects both in this country and abroad. We are particularly grateful for the help received from our Canadian friends, Dr. E. D. Putt and Dr. John Hoes at Morden, Manitoba, and Dr. W. E. Sackston at MacDonald College, Quebec, in regard to breeding material and information on sunflower diseases and from those in the Southern Hemisphere for off-season evaluation of some of our material, particularly Ing. Agr. Aurelio Luciano with INTA at Pergamino, Argentina, and

Mr. J. A. M. Leviseur with Oilseeds Development Corporation (Pty.) Ltd. (a subsidiary of Pacific Oilseeds Inc.) at Potchefstroom, Transvaal, South Africa. We also recognize the contribution of the sunflower breeders in the USSR whose high oil varieties have come to us through the New Crops Research Branch, Beltsville, Maryland, the North Central Regional Plant Introduction Station at Ames, Iowa, and our Canadian friends. It is to be hoped that the free exchange of ideas and materials can continue without regard to national boundaries or to whether the research is financed by private or public funds. I believe that conferences of this type will help to foster continuation of the wonderful cooperative spirit that exists among those interested in sunflower research, production and processing.

This sunflower research project was designed to be of service. Any time that we can be of any help to any of you or others we will strive to do so within the limits of our facilities, capabilities and policies of the agencies we represent.

Literature Cited

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