STATUS OF SUNFLOWER RESEARCH IN THE U.S.A.

By

Murray L. Kinman
Research Agronomist and Leader (USDA, ARS)
Sunflower, Crambe, Sesame and Guar Investigations
Department of Soil and Crop Sciences
Texas Agricultural Experiment Station
College Station, Texas; U.S.A.

Reports presented earlier in this conference cover much of the work which could be discussed under the broad heading of this paper (Status of Sunflower Research in the U.S.A.). My remarks will be confined primarily to the efforts of the U.S. Department of Agriculture's modest sunflower breeding program with headquarters in the Soil and Crop Sciences Department of Texas A & M University with yield testing cooperative with a number of other state agricultural experiment stations and commercial companies. I will also attempt to briefly summarize and add to the previous reports where possible.

The U.S. Regional Sunflower Yield Tests began in 1962 with tests at 9 locations in 6 states. In 1968, we provided seed for 51 tests in 18 states. These are adaptive tests designed to compare, under a wide range of environmental conditions, commercially available varieties with newly introduced varieties and experimental varieties or hybrids developed by both public and private agencies. Entries in these tests include both oilseed and large seed type varieties; eventually, it will probably prove desirable to conduct separate yield tests for the different types of sunflowers. This is by no means a uniform yield testing program since cooperators choose only entries in which they are interested, and no attempt is made to dictate a uniform experimental design for use at the various locations. Personnel of both public and private agencies participate in this regional testing program. Assembling and distributing seed and the report of these tests requires considerable effort on the part of the small staff located at College Station, Texas. The report of the 1967 regional tests has not yet been distributed since we are still awaiting oil analyses of samples from a few late reporting locations. This is about the usual situation. However, we usually have adequate data available by planting time of the following season to know which entries can be deleted (to make room for new entries) without seriously impairing the value of this adaptive testing program. These regional tests have been of value in identifying which of the high oil introductions from the U.S.S.R. are best adapted to U.S. agriculture. (Actually, this has been more a matter of confirming U.S.S.R. and Canadian results.) These tests have also indicated that adapted, rust resistant, F_1 hybrids can be expected to produce higher seed yields than any of the open-pollinated varieties (either domestic or introduced) at most locations.

Soviet sunflower breeders, using the method developed by Academician Pustovoit, have made remarkable progress in breeding high oil sunflowers. Pustovoit's method (a form of recurrent selection) depends largely upon utilization of additive gene action for improvement of most plant characteristics. The oil content of seed of such varieties as Peredovik, VNIIMK 8931, Smena, and even of the somewhat lower oil content early maturing varieties, Krasnodarets and Armavirec, appears attractive to domestic oilseed processors. However, there seems to be considerable question of whether yields are high enough so that American farmers can afford to produce seed of these varieties at prices the oilseed processing industry can afford to pay under present economic conditions. The presence of hybrid vigor in seed yield of sunflowers has been demonstrated repeatedly, and it is unnecessary to cite specific examples to this audience. Suffice to say that increases in yield of 25 to 30% in adapted hybrids compared to varieties appear relatively easy to obtain, and much larger increases have been reported. In addition, some forms of resistance to at least two potentially serious sunflower diseases, rust and Verticillium wilt, appear to be conditioned by dominant genes so that only one parent of an F_1 hybrid needs to be homozygous for resistance to produce a resistant hybrid commercial crop. Further, when even one of the parents is a relatively pure line, F_1 hybrids flower much more uniformly than open-pollinated varieties. Control of the larvae of the sunflower head moth (Homoeosoma electellum), which is a serious hazard to sunflower production in many areas of the United States, should require fewer applications of insecticides for uniformly flowering hybrids than for variable open-pollinated varieties.

For these reasons, the limited facilities of the cooperative U.S. Department of Agriculture-State Agricultural Experiment Station breeding program have been devoted almost entirely to the isolation of inbred lines to be tested for use as parents of F_1 hybrids. It is not my intention to infer that I believe the additive genetic variance for yield and seed characteristics have been exhausted in the sunflower populations which provide sources of germ plasm for our breeding program. We simply believe that increased value of product per acre can be attained more quickly by going the F_1 hybrid route.

Isolation of male parents of F_1 hybrids does not seem to pose any serious difficulties. We have been able to isolate agronomically satisfactory, highly self-fertile lines (both high oil and large seed), which produce an abundance of pollen, from a number of sources (directly from existing domestic and introduced varieties, from early generation hybrids obtained from the Canadian and Argentinian breeding programs, and from hybrids produced in our own program). Some of these potential male parents are rust resistant and some even appear to possess a degree of resistance to insect attack. Two rather high oil, rust resistant, potential male parental lines, TAM-CRD HA 60 and TAM-CRD HA 61, were released cooperatively by the Texas Agricultural Experiment Station and the U.S. Department of Agriculture to the U.S. seed growers

in the spring of 1968. A number of other potential male parents are being tested in hybrid combinations in replicated tests for the first time in 1968. These hybrids may be seen here on the Crookston Station during the tour scheduled for this evening.

Isolation of female parents of hybrids or even deciding the most desirable type of functional female to utilize has been much more difficult. Earlier success in increasing the self-incompatibility of the Canadian line S-37-388 led us to believe that this approach might be feasible. S-37-388T (the modified line) was used as the female parent of the experimental hybrids T 56002 and T 64001 (the male parent was a mixture of the three closely related rust resistant lines, HA 6, HA 7 and HA 43) which have been used as check strains in the U.S. Regional Sunflower Yield Tests. All of these lines were released in 1965 in hopes that a rust resistant hybrid suited to the birdseed trade would result. However, the parents did not flower simultaneously in this area where demand for such a hybrid exists. Furthermore, we increased the self-incompatibility of S-37-388T to such a degree that it was nearly impossible to maintain in a pure form. Work with self-incompatible high oil and large seed lines was facilitated by alternate generations of selfing and sibbing. However, we have shelved the self-incompatible material, at least for the present, and are not using it in experimental hybrids at this time. We have done no work with the partial male sterility (pollen abortion) described by Putt and Heiser (3). We intended to use the partially male-sterile Canadian line CM 90RR as a female tester parent this season but were unable to do so because of rain all during the pollinating season.

At present we are concentrating most of our efforts upon isolation of male-sterile lines to be used as female parents of hybrids. To date, we have had 18 sources of male sterility. Thirteen of these were identified in the breeding nursery at College Station, Texas (the first one by Dr. E.D. Putt in 1964 during the first of these conferences). Some of these male steriles were found in highly self-incompatible backgrounds; one has definitely been lost and two others may be lost because of this. All except three sources trace directly or indirectly to introductions from the U.S.S.R. It may be interesting to speculate that Pustovoit's method of breeding may have been responsible for accumulation of genes conditioning male sterility in the Russian varieties. Obviously, we have been searching for cytoplasmic male sterility but have not as yet identified this situation. Attempts to establish a genetic system controlling male sterility (as suggested by Kinman and Putt at the 1964 conference) have not been very fruitful, and we have shelved most of this work in order to expend more effort on practical phases of developing materials which may be useful in the development of hybrid sunflowers. As we reported in 1966, the Morden, Bloomington, HA 55, and Peredovik-21 male steriles differ by at least one gene locus. Since that time we have learned that one male sterile isolated from Smena, two from VNIIMK 1646, and one from Ienissei differ from P-21 ms in genes conditioning male sterility. Two others, Peredovik-23 and

Ienissei-8-1-1-1, are of the same genetic constitution as P-21 ms.

Most of our breeding work with these genetic male-sterile lines has been concentrated on sublines of P-21 ms. While more than one gene appears to condition expression of male sterility, it has been possible (by alternate selfing of male-fertile heterozygotes and sib-crossing of male steriles with heterozygotes) to isolate sublines which segregate 1 male fertile: 1 male sterile with either individual or bulk sibbing. TAM-CRD P-21 ms, as released to American seed growers in the spring of 1968, resulted from two generations of isolated mass sib-pollination of a number of sublines believed to be of the same genetic constitution as regards male sterility. This potential female parent of commercial hybrids is vigorous but is known to be heterogeneous for time of flowering and maturity, seed size, oil content of the seed, and Verticillium wilt reaction. It was released at the same time as the two rust resistant male parents mentioned above to learn whether this method of hybrid seed production is practical for the American seed trade. We have not established a usable linkage with the recessive gene for male sterility in P-21 ms (as indicated earlier by P. Leclercq for his material). Experimental hybrids have been made successfully by hand pollination or by growing alternate rows (40-inch rows) of P-21 ms and the pollen parent under isolation. In the latter case, all P-21 ms heads have been bagged before flowering; bags are left on when male-fertile plants are rogued; bags are removed from male-sterile plants as soon as they are identified. In this manner, 100% hybrid seed is obtained. This method would probably be too expensive for commercial hybrid seed production. Small-scale experimental and commercial crossing fields are being grown this season to determine whether roguing male-fertile plants from the female rows early in the morning will result in a high percentage of hybrid seed.

The two P-21 ms sublines whose seed are highest in oil content and resistant to Verticillium wilt are under small-scale increase this season. We visualize using the F_1 of the line cross between these two sublines as the female parents of hybrids in the future in order to provide a vigorous seed parent.

In most crosses involving sunflowers exhibiting armored seed coat, this characteristic has been dominant to the nonarmored condition. P-21 ms reacts in a peculiar manner in this respect. With some nonarmored male parents such as HA 60, only nonarmored hybrids are obtained. In other instances as when inbred lines from Mennonite RR are the male parent, some of the hybrids are pure armored or nonarmored, and others are mixed in this respect. We have not investigated the genetic implications of this unusual situation. If anyone here has an explanation, I would be glad to hear it.

A number of hybrids in which various sublines of P-21 ms are female parents are under test on this station. These are divided into two tests.

The larger test involves crosses with high oil lines. The other test involves large-seeded, rust resistant inbred lines as male parents since the possibility exists that such hybrids could be useful to the bird food or decortication trade.

The U.S. Department of Agriculture's Regional Sunflower Research Program is designed to be of service to the American public. We stand ready to help research workers in State Agricultural Experiment Stations or other public agencies and in industry to the limit of our abilities and facilities within the framework of the policies of the organizations involved. Our policy has been to release promising new breeding material to the public as soon as it shows promise without waiting for completion of a set number of years of testing.

Since this paper was given a rather all inclusive title in regard to sunflower research in the U.S.A.--and since at the time it was written I could not be sure of the coverage to be given in the previous papers, an attempt will be made to cover some of the research activities which may or may not have been taken care of by previous speakers.

To me, the most interesting current research is that of the biology and control of the sunflower head moth (Homoeosoma electellum) being conducted by Mr. George L. Teetes under the supervision of Professor Neal M. Randolph, Department of Entomology at Texas A & M University. This work is largely supported by a grant from the Entomology Research Division of ARS, USDA. We have worked very closely with Mr. Teetes, and he has provided answers to many of our questions in regard to what I consider the most serious insect pest of our crop in this country. Among these answers are the egg laying habits of the female moth, identity of early flowering alternate hosts which provide such a tremendous number of moths during June (in Texas), and (to me as a plant breeder) the indication that this insect can be controlled by fewer applications of insecticides on uniformly flowering F_1 hybrids than on open-pollinated varieties. Mr. Elmer Carlson's work at the University of California at Davis led to the clearance of endosulfan for control of the head moth; his data is published (1).

At Texas A & M University, both Dr. Carl Lyman in Biochemistry and Nutrition and Dr. E. E. Burns in the Food Technology group have students working on the isolation of sunflower proteins for possible food and industrial uses. The major problem seems to be that of color of the protein due to chlorogenic acid. Dr. I. A. Wolff, Chief, Industrial Crops Laboratory, Northern Utilization Research and Development Division; ARS; U.S.D.A.; Peoria, Illinois--who is present at this conference--has a chemist working full time on the color problem in sunflower protein.

Northrup, King and Company has had a small but active sunflower breeding program at their Woodland, California, research farm for many years under the direction of Dr. D. B. Grissom. This company has produced the synthetic

variety HO 1 which has been promising in some of our regional tests. Anderson, Clayton and Company has initiated sunflower research under the direction of Mr. D. Gene Lorance with headquarters at Phoenix, Arizona. Pacific Oilseeds, Inc. has launched some sunflower research at Woodland, California. Dr. Donald L. Smith is their Director of Research. I do not know the scope of the efforts of either of these latter companies.

I am reasonably sure that I have missed some important new work not mentioned elsewhere. If anyone here has knowledge of such work, I hope there is enough time for them to bring it to the attention of this group.

In February of 1963, I presented a report on the current status of sunflower production, research and possibilities in the United States (2) before the Oilseed and Peanut Research and Marketing Advisory Committee at Peoria, Illinois. I would like to repeat the closing paragraph of that report: "I would estimate that during the past several years only about one professional man-year per year has been spent on sunflower production research in the United States by public and private agencies combined. Without an adequate and effective research program, designed to control insects and diseases by genetic or other means and to utilize the breeding material available to obtain the maximum hybrid vigor possible in this species to produce high-yielding, high oil commercial hybrids, the outlook for a permanent sunflower oilseed industry is rather poor. Hazards from diseases and insects are so great and the commercial benefits from combining maximum hybrid vigor and maximum oil content are so promising that a team approach, including efforts of geneticists, plant breeders, plant pathologists, entomologists, and chemists, would be required." It should be noted that I was speaking of the United States as a whole rather than any specific area. I am happy to report that the situation in regard to sunflower production research has changed considerably since 1963. I would like to hazard the guess that 4 or 5 professional man-years per year are now devoted to sunflower production research by public and private agencies combined. An even wilder guess would place about 3 or 4 professional man-years per year in processing, nutrition, chemical and economic research with this crop. Unfortunately, these 7 to 9 total professional man-years are distributed among about 50 men, and I know of no individual research worker who can devote his entire efforts to sunflowers alone. On the plus side, we now have a few well-trained sub-professional research technicians, most of whom devote essentially full time to the routine of sunflower research programs, and research facilities are markedly superior to those available in 1963. We are still far from the goal I wished for in 1962, but progress is being made. Personally, I like to feel that the first two International Sunflower Conferences (the small beginning made at College Station, Texas, in 1964, and the superior conference held at Morden, Manitoba, in 1966) have had a marked influence on the improvement of sunflower research in the United States. May this and succeeding conferences have even more beneficial results.

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