

SUNFLOWER BREEDING IN THE UNITED STATES

F. K. Johnson, Research Agronomist
Vegetable Oils Division,
Cargill Incorporated,
Box 253, Fisher, Minnesota.

It certainly is a pleasure for me to have the opportunity to speak to this group. In review of the sunflower breeding research in the United States, I think it might be well to back up and take a look at what has been done in the recent past.

In a report which was presented before the Oilseed and Peanut Research and Marketing Advisory Committee of the United States Department of Agriculture by M. L. Kinman in February, 1963, a few small scale sunflower research programs, in addition to his own work, aimed primarily at the development of large-seeded varieties and hybrids were in progress at the California Agricultural Experiment Station at Davis, the Minnesota Agricultural Experiment Stations at St. Paul and Crookston, and at Northrup King and Company at Woodland, California. The Co-operative USDA, Texas Agricultural Experiment Station breeding program which was initiated in 1951 had been designed primarily to provide a source of breeding materials should the need arise and the facilities become available for a comprehensive sunflower research program. Other state experiment stations such as North Dakota, Oklahoma, North Carolina, Arizona, Kansas, Nebraska and Utah, as well as others, have at times tested different varieties and hybrids as they were developed elsewhere. The Northern Regional Plant Introduction Station at Ames, Iowa, has had an active program of evaluating and collecting sunflower varieties from other countries. In addition to the programs which were directed primarily toward improved varieties, Dr. Kinman also reported of the work of Dr. Heiser at Indiana State University which covers some very interesting fundamental taxonomic investigations of the sunflower species. In the report summary Dr. Kinman stated, and I quote:

"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."

Between the time of this 1963 report of Dr. Kinman's and the First International Sunflower Conference, the only expansion in sunflower breeding that I am aware of was that which I began at the Crookston Experiment Station of the University of Minnesota.

Sunflower breeding research being conducted in 1964 was reported in some detail at the First International Sunflower Conference.

1. Mr. Deryl Bondshu told of the work with several commercial firms in California which consisted largely of roguing, selection, and the growing of plots in isolation. They were also making a few crosses with the S-37-388 line.

2. Mr. Dale Grissom of Northrup King and Company of California had commented to me at that time that he was doing only limited work in sunflower breeding.

3. Dr. R. G. Robinson, University of Minnesota, St. Paul, reported that most of his efforts were with the confectionery and bird-feed-type varieties.

4. My report gave in detail some of the hopes and aspirations which I had in starting a breeding program, though I too, as almost everyone else, was limited to part-time research.

5. In our tour of the breeding plots at College Station, I could see that Dr. Murray Kinman was conducting substantial amounts of breeding research with sunflowers -- doing perhaps more than anyone else in the United States. However, he, too, was limited to a part-time sunflower research position.

Late this spring in preparation for this report, I sent letters to those researchers whom I knew or suspected were conducting sunflower breeding work. From replies I have compiled a few statistics and some information concerning their work. It is a pleasure for me to bring the good news that research effort on sunflowers has increased greatly since Dr. Kinman's 1963 report. It is my estimate that this increase approaches the 300 figure. In other words, instead of having one man full-time working on sunflowers, we now have four. However small, this is a definite step forward.

A listing of sunflower researchers and their time devoted to the crop is as follows:

Dr. Bob Robinson	25%
Dr. Murray Kinman	50%
Dr. Dale Grissom	25%
Mr. Deryl Bondshu	15% (estimate)
Dr. P. F. Knowles (Un. of Calif.)	50%
Mr. Ralph Taylor	10%
Myself	25% up to July 1
	70% now with Cargill, Inc.

The rest of my time is now used for farmer-grower contracts, production of certified seed and promotion of the sunflower crop.

Additionally there are others involved in the Regional Variety Testing Programs, some soils work being done at the University of Minnesota and elsewhere, bringing the total estimate to nearly 4 professional men.

To give a more detailed picture of the current sunflower breeding programs underway in the United States, I would like to share some ideas with you that were expressed to me in correspondence by those of whom I had contacted.

1. Mr. Deryl Bondshu, Lyng and Company, Modesto, California, states that their program started in 1957 at which time they established isolated

plots and began making selections. This continued until about 1960. One of these selections had gained a good deal of uniformity with a superior plant and seed size needed for their trade. From this they have established foundation stocks from which the certified seed is produced for their commercial field production. In 1963 through advice from Dr. Knowles, University of California, Dr. Murray Kinman and Dr. Eric Putt, they became interested in working with hybrids and inbred lines. Using some of their previous selections as male pollinators and the incompatible lines from Drs. Kinman and Putt as females, they were successful in developing a rather attractive hybrid line. This, however, has not met the qualifications necessary for their trade largely because of seed size, and thus has not been put into commercial production. They have a number of very fine uniform lines which are in the testing stage. He comments that they plan to continue their breeding program even though as yet they have not found material equal to that in commercial production. Mr. Bondshu comments that they do not have any professionally trained personnel on the program even though some of them have had a few courses in plant breeding. He wanted to acknowledge the help and suggestions they have received from Drs. Knowles, Kinman and Putt.

2. Dr. Dale B. Grissom of Northrup King and Company wanted to extend his regrets at being unable to attend this conference and was kind enough to describe the program they have underway in sunflower breeding research. Their major interest is in edible and confectionery-type sunflower seed with only a minor interest in oils. Most of their effort currently is being spent putting rust and Verticillium resistance into the lines they already have and increasing seed size. They are looking for thin-hulled material with a higher shelling percentage. A number of their lines have been converted to rust-resistant forms. They are testing a few synthetics of high oil content, one of which is in the regional program. Additionally they are doing some work with sunflowers as an ornamental plant for their package trade. They are particularly interested in the factors affecting hybrid combinations; for this they are studying methods of maintaining these lines to get high crossing percentages. In this work they have been selecting with different number of seed set, selfing, and isolating these in the crossing blocks of the pollinator and checking percent of crossing. They then are advancing a generation or two in seed stock build up and growing in a crossing block to check for this crossing percentage. They hope to be able to determine how seed stock will be maintained and yet give a high percentage of crossing.

3. A letter from Dr. Ralph Matlock, University of Oklahoma, in which he comments that from time to time they had attempted to isolate some inbred lines and worked with breeding work with sunflowers, but because of the lack of funds they have not been able to continue this work.

4. Dr. Martin from Clemson University of California responded that their sunflower program consisted only of the regional test from Dr. Kinman.

5. Dr. P. F. Knowles, University of California, Davis, reports as follows:

Sunflower research at Davis has declined over the last 10 years due to the pressure of safflower research and the development of hybrid varieties

by commercial seed companies.

At present I am growing only the following:

- (a) Regional test
- (b) A few selections of desirable seed type
- (c) A few selections high in oil
- (d) A few types with unusual characteristics.

Mr. Elmer C. Carlson of the Entomology Dept. University of California, is conducting tests of insecticides to determine their effectiveness in the control of insects, particularly the sunflower moth (Homoeosoma electellum). This will be followed up with residue determinations.

The total amount of time spent on sunflower research by the professional staff at Davis would be no more than one-half of one person's time.

6. Dr. Murray Kinman's reply which follows in part, gives more detail because of the substantial size of program he is covering.

As you know, this is only our second season of sunflower research under the "Rachel Carson funds." Prior to that (the work you saw here in 1964 at the time of the First Conference) the sunflower project was only a sustaining program designed to provide materials to this program and others when funds finally became available. The primary objectives of the current program is to develop material resistant to insects and diseases so that pesticides are not required. In addition, we have the responsibility of servicing other programs by providing seed and assembling results of the U.S. Regional Sunflower Yield Tests and, when requested, of providing advice and breeding material to other programs.

Back to our current sunflower breeding program. You are familiar with our "shot gun" backcrossing program to introduce rust resistance into both large-seeded and high-oil types; backcrossing programs (involving Peredovik, Smena, Mingren and Commander) are nearing completion. Personally, I am inclined to think that our eventual aim with both the oilseed and large-seed types will be development of high yielding F₁ hybrids in various maturity groups. For this reason, we are doing as much work as possible with the various forms of male sterility and the self-incompatibility system in sunflowers. Controlled sibbing in the nursery is also a big help in maintaining self-incompatible lines. Since this forces us to open the bags, it also helps to locate new male steriles. We are looking for genetic backgrounds in which these male steriles may prove to be under cytoplasmic-nuclear control. We are also looking for cytoplasmic male sterility in H. petiolaris x annuus crosses but have not found anything as yet (incidentally, the H. petiolaris ecotype we are using appeared almost immune to Homoeosoma electellum and carries recessive resistance to our races of rust).

I spend 1/3 or 1/2 of my time on sunflower research and service to other workers (1/3 if Congress restores part of the sesame funds as now

seems likely); a full-time senior agricultural research technician (actually 2 such men during the busy season since sunflower and guar work do not overlap much and they work together) is also assigned to sunflower research; and Mrs. Flynt's time is split the same as mine (she handles most of the analyses and assembling of data, prepares field books, etc.).

In addition to an expanded regional yield test, we have 573 self-fertile progenies, 969 self-incompatible progenies and 549 progenies involving male sterility at College Station this season; in addition, we have 15 isolated increase or crossing blocks. We are also handling a regional test at Temple, Texas, 2 regional tests (one sprayed to control insects and the other unsprayed) and 240 progeny rows at McGregor, Texas. The work at Temple and McGregor is primarily for evaluation and screening for reaction to Homoeosoma electellum and rust. We are also co-operating with the entomologists in insecticide tests at McGregor where larvae of the head moth can be counted upon to give almost 100% loss in highly susceptible material.

7. Dr. Bob Robinson who heads the research for the University of Minnesota is concerned primarily with the confectionery and birdseed types and is continuing breeding of lines derived from his Arrowhead and Mingren programs, checking these as hybrids with S-37-388-RR-T1 and HA 6 or 7. Increase in seed yields is the primary goal. In 1961 he had tested the first Russian variety, but commented that when I began the sunflower breeding work at Crookston, that he had cut back this phase of his program.

8. Mr. Mel Stolquist of Sun Plant Products, Inc. at Convick, Minn. has been working with myself the last three years in a selection program within Mennonite for large-seeded types and resistance for downy mildew and Sclerotinia. This work was done largely by planting the material in successive years on the same spot in which a high incidence of Sclerotinia has been noted. This year they are initiating a purification process of this selected population.

9. Mr. Ralph Taylor of Dahlgren's, Inc. at Crookston has been doing some work the past couple of years primarily with Mingren and using a back-crossing technique to move Verticillium resistance from Dr. Putt's CM 144 into the Mingren background. Additionally he has been doing some breeding and selection work for rust resistance in the large-seeded type sunflowers.

10. The program which I currently have under way has three primary goals. First, higher percentage of oil; Second, improved yields; and Third, disease resistance. It might be summarized by saying higher sustained yield oil per acre. I have a number of items from the program which I have had the last couple of years.

A. First I have been evaluating and increasing quite a collection of different lines and evaluating the world collection. I have grown the world collection in two different years. These entries are currently being analyzed for hull percentage, percent of protein in the meats and percent of oil in the meats. Selected lines from this world collection will be analyzed for fatty acid composition.

B. A second set of materials are those which I have been inbreeding and selecting in the S₃ and S₂ generations and work being done in the varieties Peredovik, VNIIMK 8931, and Ienissei. This program has been undertaken primarily for development of inbred lines of high oil content. However, at the University I did not have access to oil analyses; so the only selection made has been that of plant type. It has been particularly interesting to note the diversity of types coming from these varieties as well as the uniformity that is beginning to appear.

C. A third line of research has been the crossing of high oil varieties to higher yielding types such as T-36-02 and the component inbreds to give a new genetic base with a potential for a large yield. These same varieties have been crossed with some of the disease resistant inbreds such as CM 144 with Verticillium resistance.

D. Fourth, I have been evaluating the number of topcrosses to give their potential both as parents and for direct use as varieties in themselves.

E. A fifth line of research has been that of utilizing what I call a "High Oil Composite". This is developed from some of the original high oil lines which were brought into Minnesota and tested by Dr. Robinson. They were grown in isolation in the first year by reason of dates of planting. I have increased the 10 higher-oil lines of these in a random pollinating isolation block for three and four generations, with the only selection being a mild selection for seed size and for maturity which occurred.

F. I have been co-operating in the Regional Sunflower Tests as well as the Canadian Co-operative Test. I have attempted a few interspecific crosses but have not had a great deal of success in this endeavor because of the problems of flowering dates.

G. Lastly and not particularly on breeding have been a series of cultural practices I have been studying. Work with flame cultivation has been particularly interesting. I have a third year's data being collected this season, and it appears that flame cultivation in and of itself probably will not be a great value in sunflowers, largely because it seems to set back the plants in maturity. It can control weeds, and I think if one went about it properly, might be of some value; as a general practice I question it.

11. Dr. Soine of the Northwest Experiment Station, Crookston, has also been doing research in sunflowers and should be noted at this time. He has been working with herbicides for control of weeds in sunflowers. A number of herbicides work rather well, and we are hopeful of working through chemical companies who might be able to help get clearances for some of these for commercial production.

Since taking this new job with Cargill and putting my full-time thinking into sunflowers and how to improve them as an oilseed crop, I have initiated a number of new lines of endeavor.

A. A first line has been that of initial selection, inbreeding and selfing in which I will be able to also run oil analyses (including the use of NMR equipment through the University of Illinois) from some of the high oil

varieties which have been introduced from the Soviet Union. Additionally, some others such as the "High Oil Composite" I have been running are included in this work.

B. I have been making selection in Peredovik to try to bring about greater uniformity of the seed materials which we have.

C. I have been making a series of backcrosses and three-way crosses from the variety Peredovik trying to concentrate genes for high oil content, to give a genetic base for a new cycle of selection and inbreeding.

D. A fourth item is the use of nuclear magnetic resonance analysis or NMR for individual seed selection prior to planting and then breeding of the selected plants. I have analyzed over 1,000 seeds for oil content this year. These are being grown and each will be self-pollinated. Seed will be harvested from each plant and again analyzed by NMR to obtain a parent-progeny regression and test the usefulness of a pre-selection via seed analysis for oil content. Beyond these breeding programs we have undertaken (and when I say "we" I think of Dr. Soine and myself at the Northwest Experiment Station along with Dr. Robinson) several cultural studies with an extensive study in row spacing and plant spacing within rows, a study of nine different herbicides and evaluation again, of course, of the flame cultivation work as well as three fertilizer trials. It is hopeful that improvement of the cultural practices as well as breeding programs will aid in bringing about increased yield and oil content of this crop for the Northwestern Minnesota and Eastern North Dakota Region.

To summarize and take a brief look ahead for sunflower breeding in the United States I see, definitely, an increased interest in sunflowers, particularly as an oilseed crop, but then too as a speciality crop for the feeding of birds and for confectionery purposes. We should certainly have, with an increased interest, additional plant breeding. I know that Cargill is interested in putting effort beyond my own time, backing this with adequate facilities for oil analyses, for computation of data, and I am certain as our Company makes progress with the sunflower crop, others too will be interested and work with it. I see with these increased efforts a great deal more progress being made. It's hopeful that some of the breeding techniques that have been well established with corn, sorghum and other crops that we may be able to make similar progress with sunflowers. I feel just as confident, and perhaps more so, and just as enthusiastic as I did two years ago that the sunflower breeding certainly is one of a very bright future and is a crop in which we have great potential. I feel that we are just on the threshold of opening doors to marked improvement and that sunflowers have the potential of becoming an important crop in the United States. By the time we have the Third International Sunflower Conference I would anticipate not only a 200% increase in research efforts on the crop, but perhaps twice this amount.

I certainly wish to extend an appreciation to those who responded to my request for information that I might summarize some of the work that is being done in the United States. I recognize that there have been omissions. These were unintentional. I want to thank you for your kind attention. I wish to express my appreciation to Dr. Eric Putt for the opportunity of speaking at this conference and for the attention which he has given me in this breeding report.