SELECTION FOR SELF-FERTILITY AND OIL PERCENTAGE IN DEVELOPMENT OF SUNFLOWER HYBRIDS

By

G.N. Fick, SIGCO Sun Products, Breckenridge, Minn.

Slide 1

Sunflower hybrids produced by the cytoplasmic male sterility and fertility restorer system were first introduced for commercial production in the United States in 1972. This present season, six short years later, hybrids have been planted on nearly all of the near 3 million acres of sunflowers grown in the U.S.

Slide 2

The rapid transition to the hybrids has occurred primarily because of higher yield potential which has been estimated to be as high as 20 to 25% more than that of previously grown open-pollinated varieties.

Slides 3, 4 and 5

Other advantages of the hybrids and factors that contribute to the higher yields include resistance to the major diseases of sunflower, greater uniformity for plant height and maturity which has greatly facilitated harvesting, and improved self-fertility or self-pollination. It is this latter trait that I wish to discuss in some detail in this report.

Slide 6

Sunflowers have normally been considered a highly cross-pollinated crop relying heavily on bees for pollination and good seed set. However, as more and more acres of sunflower are planted there are fewer bees per unit of area to affect cross-pollination, and it has been estimated that nearly 75 percent of the fields in our area have fewer bees than are needed to obtain maximum yields.

Slide 7

An obvious solution is to introduce bees into sunflower fields although in many cases it is questionable whether the increased returns would be enough to offset the costs.

Slide 8

To alleviate the dependency on bees and to improve pollination most breeders in the United States, including the speaker, have selected strongly for self-fertility in developing inbred lines for production of hybrids. This selection has been highly effective.

Slide 9

Estimates of self-fertility for certain hybrids, such as the widely grown 894, are as high as 80 to 90 percent, which compares with less than 10 percent for most previously grown open-pollinated varieties.

Slide 10

Although it is generally believed that estimates of self-fertility are directly related to yield performance, at least when bee populations are limiting, very few test results are actually available. The objectives of this study were to obtain information on the associations of self-fertility with yield and other characteristics, and also to identify source populations having a high frequency of self-fertile genotypes that might be useful in future breeding efforts. Because high oil percentage is also an important selection criterion, information was also obtained on the variability for this trait that occurs among and within selected populations.

Slide 11

Information on the associations of self-fertility with yield and other plant and seed characteristics was obtained from F_3 and F_4 lines from two crosses grown at Casselton, ND in 1976. Sixth-three F_3 lines from corss no. 1 and 50 F_4 lines from cross no. 2 were evaluated in replicated trials.

Slide 12

The lines from each cross were arbitrarily classified for self-fertility as high, intermediate, or low on the basis of the amount of seed produced on individual self-pollinated plants. Those classified as high produced more than 50 grams of seed per plant from selfing, those classified as intermediate 30 to 50 grams, and those as low less than 30 grams. As can be seen, the highest yields in cross no. 1 were obtained from lines with high self-fertility and the lowest yields from those with low self-fertility.

Slide 13

Similar results were obtained for cross no. 2 with the highly self-fertile lines producing about 100 and 400 lbs per acre more than those classified as intermediate and low, respectively. Although precise counts were not made, the number of bees in the field during pollination was generally observed to be relatively low with fewer than 25 bees per 100 flowering plants. Thus the data from these two crosses strongly support the assumption that higher seed yield may be obtained with self-fertile genotypes when insect pollinator populations are less than optimum. The results also indicate that the procedure of measuring the amount of seed that is produced on heads isolated with light cloth bags does in fact provide a useful guideline in selection of genotypes with high yield potential.

Slide 14

Calculation of the correlation coefficients showed that the association between self-fertility and seed yield was highly significant for both crosses.

Although several of the other correlations were also significant, generally there was a lack of consistency for the associations between self-fertility with other traits suggesting that a wide range of self-fertile types could be developed.

Slide 15

For selection of self-fertility and also high oil percentage to be most effective, it is necessary that the source population available to a breeder possess variability for these traits and that selection is practiced within populations having the highest frequency of desirable genotypes.

Slide 16

To identify populations of potential value more than 50 diverse germplasm sources were evaluated. These consisted primarily of cultivars from the USSR, Eastern Europe, South Africa, Argentina, recent USDA introductions and several synthetic populations formed from plants or inbred lines selected previously for other traits. Most of the germplasm sources are available from the USDA world sunflower collection maintained at Ames, Iowa.

Slide 17

Each of the germplasm sources was planted at Breckenridge, MN in 1977 in small plots and hand thinned to populations of about 20,000 plants per acre.

Slide 18

Heads of at least 20 plants of each entry were isolated with light cloth bags prior to flowering to insure self-pollination. Self-fertility was measured as the weight of seed that was produced on individual self-pollinated plants.

Slide 19

Oil percentage of seeds was determined by nuclear magnetic resonance (NMR) for those plants that produced 10 grams or more of seed. Determinations were made on clean seed samples that had been dried and allowed to equilibrate to about 4 percent moisture.

Slide 20

Self-fertility of the different source populations ranged from an average of about 5 to near 70 grams of seed per plant. The majority of the populations produced an average of more than 10 but less than 30 grams of seed. Only 10 of 52 populations had averages of more than 30 grams of seed per plant from self-pollination.

Slide 21

The highest frequency of self-fertile plants occurred in two synthetic populations, both of which were formed by inter-crossing of plants or inbred lines that had undergone some selection previously for high self-fertility. Other sources that were relatively self-fertile included Peredovik selections 308,

437, and 428, all of which produced an average of more than 40 grams of seed. Most of the high oil Soviet cultivars, which have been used extensively by U.S. sunflower breeders in developing inbred lines of hybrids, were quite self-incompatible. Of 26 sources and 21 cultivars that were evaluated 19 sources produced an average of less than 20 grams of seed per plant. However, wide variation occurred within populations, and we have extracted from several populations lines that are essentially 100 percent self-pollinating producing more than 100 grams of seed per head from selfing during each of several generations of inbreeding.

Slide 22

Mean oil percentage of seed from selfed plants ranged from near 50 to about 30 percent for the different populations. Thirteen of the 52 populations had oil percentages exceeding 46 percent and 36 of 52 exceeded 42 percent. Thus, mean oil percentages were relatively high and it is obvious that many of these populations could be very useful in breeding efforts to improve seed oil percentage.

Slide 23

The highest oil percentages occurred among plants of a branched restorer line synthetic with seed oil values of individual plants ranging as high as 63 percent. The seeds from branched plants are generally smaller in size, and previous investigations have shown that they contain significantly more oil than seeds from single headed types of similar genetic background. Generally the source populations or cultivars with the highest oil percentages were those introduced from the USSR since 1970. Wide variation occurred among individual plants within populations suggesting that lines with oil percentages exceeding the mean of the population could be selected from most sources.

Slide 24

Estimates of heritability for self-fertility and oil percentage were determined for two populations for which both S_1 and S_2 data were available. The estimates were obtained by the parent-progeny regression method. Heritability values for oil percentage were relatively high and of similar magnitude to those reported in a previous investigation. Estimates for self-fertility were lower although past experience suggests that considerable progress can be realized by selection for self-fertility in early generations.

Results of other researchers suggests that high self-fertility may be controlled primarily by recessive genes. Thus to produce hybrids with the highest degree of self-fertility it is likely that both parents must possess the high self-fertility trait. Additional studies on the inheritance of self-fertility are desirable.

Slide 25

In summary, self-fertility as measured by the weight of seeds of self-pollinated plants was positively and significantly correlated with seed yield in two crosses involving F_3 and F_4 lines. These results suggest the importance of selecting for high self-fertility when developing inbred lines for use in

production of high yielding hybrids. Self-fertility of more than 50 diverse sunflower populations varied widely ranging from an average of 5 to near 70 grams of seed per self-pollinated plant. Variability within populations was also high indicating that highly self-fertile types can be isolated from many different source populations. Mean oil percentage of seeds from selfed plants ranged from 32.6 to 48.4 percent with the highest oil percentage occurring most commonly among recently introduced cultivars from the USSR. Heritability estimates for self-fertility and oil percentage were of sufficient magnitude to encourage selection for those traits in early generations on an individual plant basis.