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AN EVALUATION OF EARLY GENERATION TESTING FOR GENERAL COMBINING ABILITY IN SUNFLOWER

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Abstract

It is generally recognized that breeding methods used to evaluate inbred lines at an early stage of their development are efficient with crops such as maize. There is limited data regarding the suitability of these methods for use on sunflowers. The objectives of this experiment were to evaluate an early generation gesting scheme for its usefulness in sunflower breeding.

Twelve families derived from different source populations were evaluated at four levels of inbreeding for seed yield, oil % and oil yield. Differences among families for general combining ability were significant and detectable at the S_0 generation of inbreeding for all characters evaluated.

A hybrid sunflower breeding method that could evaluate the general combining ability of inbred lines at an early stage in their development would clearly be valuable. As the number of inbred lines in a breeding program increases, size and financial limitations prevent the testing of all possible hybrid combinations. And unfortunately, regardless of the care with which inbred lines are developed, certain combinations will produce superior F_1 hybrids, while equally promising parents combine to produce only average hybrids. Therefore, a testing scheme that would allow the breeder to eliminate inferior combining lines before a great deal of resources are expended in their development, would increase the probability of finding superior combinations in the remaining material.

Maize breeders faced this problem in the early 1930's and a method of early testing was first suggested by Jenkins (2). Under this scheme, inbreeding and testcross evaluations of combining ability proceeded concurrently. Standard methods of maize breeding at the time deferred tests for combining ability until the third, fourth, or fifth selfed generation. By the Jenkins method, unselfed (S_0) or first generation selfed (S_1) plants were topcrossed to a tester stock and the resulting progeny evaluated for yield and general agronomic performance. Lines with poor combining ability were discarded and only the promising lines were inbred further. Supportive experimental data presented by Sprague (4,5) and Lonnquist (3) indicated that large differences in combining ability exist between the progeny of individual open-pollinated plants, giving firm support to the Jenkins' system.

The breeding method proposed by Jenkins was modified for use in sunflowers. Due to differences in flower structure, sunflower inbreds cannot be tested in

the same manner as maize. Sunflowers cannot be directly testcrossed at S_0 or succeeding generations because flower parts are perfect and complete. S_0 plants can either be emasculated manually or chemically prior to topcrossing or crossed to a cytoplasmic male sterile (cms) line. The cms F_1 hybrid can then be topcrossed and the progeny of that cross evaluated for combining ability. The timing of manual and chemical emasculation is of crucial importance to the prevention of selfed seed. To avoid the possible selfing and/or time-consuming emasculation of each plant, cms was incorporated into the breeding method.

S_0 plants are selected on the basis of agronomic type from open-pollinated varieties or other breeding populations and are covered with bags prior to ray flower emergence. At anthesis, pollen is colelcted from the S_0 plant and transferred to a cms plant on a paired basis. Selection is practiced at harvest on the S_0 plants for agronomic type. The field selected S_0 plants are then evaluated for self-fertility and oil percentage and the best S_0, cms x S_0 pairs are then replanted in adjacent rows. Selection is applied for agronomic type within S_1 progeny rows and selected plants are bagged prior to anthesis. At anthesis, pollen is removed from the S_1 plants and crossed to the paired cms F_1. Again, selected pairs are harvested and evaluated for self-fertility and oil percentage. Of these, selected pairs are then replanted in adjacent rows and the scheme is repeated on the S_2, BC_1F_1 pairs with selection applied both within and among families.

When the first set of developing lines reached S_4 and BC_3F_1, remnant seed of the cmsBC_3F_1, cms BC_2F_1, cmsBC_1F_1, and the cms F_1 generations was planted in isolation with a broadbased restorer geen pool (RGP) to produce hybrids for evaluation of general combining ability. The resulting hybrids representing progressive stages of early generation analysis were evaluated at three locations for yield, oil percentage and agronomic characteristics. The objective of the experiment was to determine at which stage differences in general combining ability could be detected during the concurrent inbreeding and sterilization procedure.

Materials and Methods

Twelve families derived from seven different source populations were chosen for the early generation combining ability analysis. Four families were derived from Peredovik, three families from VNIIMK 6540 and one family each from VNIIMK 8931, Smena, Luch, Salyut and Issanka.

Remnant cms seed of the original F_1 and succeeding backcross generations from each family were planted in isolation and topcrossed to a broadbased restorer gene pool (RGP). The resulting hybrid seed was harvested and then planted in yield trials in 1976. Test locations included one planting date at Casselton, North Dakota and an early and a late planting date at Woodland, California. This report deals only with yield characters from the early Woodland planting date.

All hybrids were grown on a Yolo fine clay loam at the Northrup King Research Center, Woodland, California. The experiment was planted on 25 April, 1976 in a randomized complete-block design with four replications. Plots were two rows 6.1 m long and 76 cm apart. Plants within plots were thinned 14 days after emergence to a uniform spacing of approximately 25 cm with one plant/hill.

Preplant fertilizer (4-10-10) was applied at a depth of 15 cm down the center of each bed at a rate of 60 L/ha. Trifluralin was band applicated to the top of each bed at a rate of 0.3 L/ha. and incorporated to a depth of 6 cm. One irrigation, consisting of approximately 5.0 cm, was applied immediately after planting to insure uniform emergence. The experiment was irrigated again at the same rate 14 days after emergence. Aqua ammonia (NH_3+) was side-dressed 28 days after emergence at a rate of 85 L/ha. A 7.5 cm irrigation was applied 30, 45 and 60 days after emergence. All other cultural practices, including cultivation and insect control, were conducted as required.

The following characteristics were measured on a plot basis after hand harvesting:

1. Seed yield - total weight of clean threshed seed in g/plot at 5% moisture.

2. Oil content - % oil by a nuclear magnetic resonance procedure (1) on a 40 cm^3 sample.

Results and Discussion

The F values from the analysis of variance of yield characters for the hybrids representing four levels of inbreeding in 12 families are shown in Table 1. Differences between families were highly significant for seed yield, oil % and oil yield. This indicates that differences for general combining ability exist between families for all three characters.

TABLE 1. F values from the combined analysis of variance of 12 sunflower families and four levels of inbreeding.

Character	Family	Generation	Family x Generation
Seed yield	5.91**	4.59**	1.53
Oil %	8.44**	2.48	2.87**
Oil yield	5.39**	4.41*	1.50

*,** Significant at the 0.05 and 0.01 levels, respectively

The highly significant generation effect for seed yield indicates that combining ability averaged over families, changes over generations. These results are unexpected but may in part be due to the fact that as inbreeding and backcrossing proceed, families become more distinct and are represented at greater levels in the backcross generations. The non-significant generation effect for oil % suggests that family differences remain stable over generations. Significance at the 0.05 level for oil yield reflects the generation effect for seed yield because it is the simple product of the two primary characters. The non-significance of family x generation interactions for seed yield suggests that the behavior of families over generations is consistent. Family x generation significance for oil % is somewhat disturbing because family differences are not consistent over generations. However, despite the presence of a significant interaction, the highly significant family term implies that family dif-

ferences are large compared to the interaction. Therefore, early generation analyses may still give good predictions of potential family value.

The F values for the analysis of variance of yield characters for the four levels of inbreeding over the 12 families are shown in Table 2. The significant values for yield are consistent with Table 1 and indicate that large, useful differences can be detected at the S_0, cmsF_1 generation. Oil % values are also consistent with Table 1 and differences appear to be detectable by early generation testing. The lower significance for oil yield is also consistent with Table 1 and is likely a reflection of small sample size because when oil yield is averaged over all generations the value is highly significant.

TABLE 2. F values for differences among 12 sunflower families at four levels of inbreeding.

Character	F_1	cms BC_1F_1	cms BC_2F_1	cms BC_3F_1
Seed yield	2.36**	1.97*	3.42**	2.64**
Oil %	3.65**	5.31**	2.08*	2.89**
Oil yield	2.35*	2.72*	2.38*	1.42

*,** Significant at the 0.05 and 0.01 levels, respectively.

On the basis of these preliminary results, it is apparent that early generation testing for general combining ability can be a useful tool in a sunflower breeding program. Identification of superior combining genotypes early in the course of inbreeding would permit the breeder to concentrate his efforts on the most desirable material at the stage of development when selection would be most effective.

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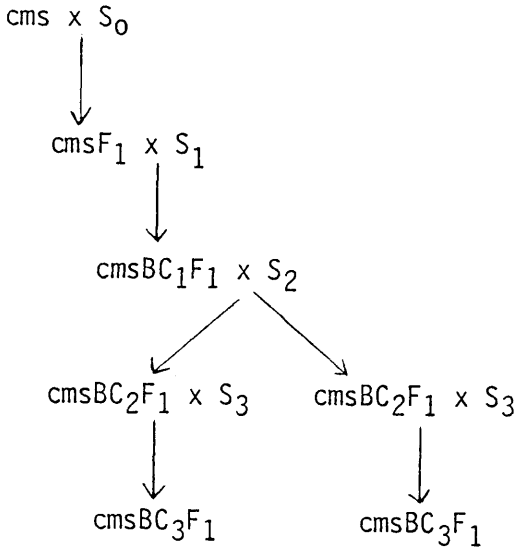

Fig. 1. Schematic representation of a typical family structure.