IMPROVEMENT OF YIELD IN SUNFLOWER UTILIZING RECIPROCAL FULL-SIB SELECTION.

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Abstract

A reciprocal full-sib selection scheme was initiated in 1977 utilizing two populations of sunflower (Helianthus annuus L.). The first population was comprised of a diverse collection of B-lines, whereas the second population was comprised of branched R-lines. Gibberellic acid (GA_3) at a rate of 50 ppm was used to sterilize the male flowers on the main head of the branched R-lines. Pollen from selected B-line plants was applied to the male-sterilized main head of the branched R-line to make hybrid seed. Hybrids were tested and selections made to continue the next cycle of selection. Three cycles of testing have been completed. Yield increased 70 kg/ha per cycle compared with the standard check representing a gain of 6.3% for each two year cycle. Inbred lines were derived from the parents of the 15 highest yielding hybrids in cycle 1 and evaluated for yield and other agronomic characteristics. Five male lines and five female lines had excellent general combining ability as well as high performance in specific combinations. The reciprocal full-sib selection scheme is an effective method to improve basic breeding populations while simultaneously identifying material which will produce inbred lines with high yield and improved general combining ability.

Introduction

Sunflower breeders are continually looking for new breeding procedures to improve the efficiency of selection for yield and/or quality. The reciprocal full-sib selection method developed for maize (Zea mays L.) (Hallauer, 1967; Hallauer, 1973; Hallauer and Eberhart, 1970; Lonnquist and Williams, 1967) is being used in the development of inbred lines and improvement of populations. The following study was undertaken to evaluate this method for sunflower improvement of two basic breeding populations and development of lines.

Materials and Methods

Effective pollen control, in one of two populations, on the perfect and complete flowers of the sunflower influorescence is necessary for utilization of the reciprocal full-sib selection scheme. Miller and Fick, 1978, determined that 50 ppm gibberellic acid (GA_3) controlled pollen on the main head of branched sunflowers. Self-pollinated seed was obtained from secondary heads of treated plants that possessed the recessive branching characteristic.

Two populations were developed for use in this program. The female population was named the Verticillium wilt resistant B-line synthetic (VWRBS) and the male population was named the Downy mildew resistant restorer line synthetic (DMRRS). All plants used to formulate the B-line synthetic were resistant to verticillium wilt, incited by Verticillium dahliae Klebahn, and all plants used to formulate the R-line synthetic were branched, and resistant to race 2 downy mildew, incited by Plasmopara halstedii (Farl.)

Berl. & de Toni. Initial crosses among lines within each population were made by hand emasculation and random pollination.

Three cycles of hybrid testing and recombining seed from the respective selected parents were completed. Hybrids were formed by transferring pollen from a B-line selected plant to the sterilized main head of an R-line selected plant. Self-pollinated seed was obtained from the B-line plant and from a secondary head of the branched R-line plant. The hybrids were tested the following year using a simple lattice experimental design with two repetitions, including the check hybrid 894, assigned to each block. Based on the performance of the hybrids, parent seeds of selected combinations were bulked within each population and random-mated to initiate the next cycle. From the first cycle of hybrid testing, the top fifteen hybrids and their male and female parents were selected for inbred line development. The restorer lines were inbred for five generations, with selection based on plant height, profuse branching, moderate to small neck length, and absence of root lodging. The female lines were inbred for six generations and after the third generation, three backcrosses to cytoplasmic male-sterility were performed to convert the B-lines to A-lines. Selection was based on plant height, oil percentage, self-fertility, and plant morphology. After inbreeding was completed, the restorer lines were crossed with their corresponding female lines and also with other female lines selected randomly. The hybrids were planted in a lattice experimental design with two repetitions. Three check hybrids, hybrid 894, hybrid 821/274, and hybrid 290/273, were included in each block of the lattice design.

Results and Discussion

The performance of hybrids of the initial combinations of the reciprocal full-sib selection scheme compared to hybrid 894 is shown in Figure 1. In the first cycle, the mean of the hybrids was 97 kg/ha lower in yield than the check. Twenty-six hybrids were selected for their parents to be random-mated and to initiate the second cycle. Fifteen hybrids were two standard deviations above the mean in yield and were selected for inbred line development. In the second cycle, the mean yield of the hybrids was only 10 kg/ha lower than hybrid 894. Thirty-five hybrids were selected for their parents to be random-mated and to initiate the third cycle. Twenty-two parents were selected for inbred line development. In the third cycle, the mean yield of the hybrids was 115 kg/ha above the mean of hybrid 894. This was the first cycle that the mean of the hybrids was higher than the check.

Over the first three cycles, a gain in yield of 212 kg/ha was observed over the yield of hybrid 894 or 70 kg/ha per cycle. This represents a gain of 6.3% for each two year cycle.

The best crosses of inbred lines derived from the parents in the first cycle of testing indicated excellent improvements in yield and oil percentage (Table 1). The highest yields were from combinations other than hybrids designated as selected by selected parents (recreating the original hybrid cross). Only the selected by selected combinations 4 by 4, 2 by 2, and 15 by 15 were in the top performers. However, the highest oil percentage of 46.2% was in the selected by selected combination 15 by 15.

The performance of the selected by selected combinations (Table 2) indicated a large range of yield, rather than the expected general higher yielding performance. However, the lowest yielding selected by selected combination of 12 by 12 was 88 kg/ha over the lowest selected by non-selected combination. It is possible that during the inbred line development phase, specific selections among plants over the six generations may have been for a lower yielding genotype. This is indicated, for example, by observing the relative performance of the male lines over several combinations (Table 2). The male line 12 performed quite well and shows good general adaptation, but the female line 12 is the poorest performer of the female group, not only with the male line 12, but with all male lines. Male lines 15 and 4 were not only the best performers in selected by selected combinations, but also showed the best general combining ability, as did the female 2. The top five male lines and female lines will be used in future crossing schemes for utilization of their excellent general combining ability.

The reciprocal full-sib selection scheme has been demonstrated to be efficient in improving two basic breeding populations and will enhance the opportunity for developing new hybrids in successive cycles of selection. The scheme also demonstrated that it is effective in identifying and producing lines which will be excellent in specific hybrid combinations and also have good general combining ability. The scheme is also useful for identifying outstanding hybrids before effort is invested in developing their respective inbred parents.

References

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Table 1. Performance of hybrids derived by crossing male and female inbred lines developed after identification through high performing hybrids in cycle 1 of the reciprocal full-sib selection scheme.

Male Line	Female Line	Yield	Oil %	FLW	HT	1000 Seed WT
		kg/ha	%	Days to 50% Anthesis	M	g.
15	2	3030	41.4	70	1.7	10.7
4	5	2910	41.7	74	1.9	10.0
15	10	2850	43.7	71	2.0	9.1
15	5	2845	40.0	79	1.9	8.5
14	10	2840	42.7	75	1.9	9.2
14	13	2800	45.0	71	1.9	12.4
11	8	2765	41.1	69	1.7	9.2
14	7	2760	43.2	72	1.7	11.2
13	6	2755	45.3	71	1.8	10.7
7	2	2735	39.2	76	1.8	11.5
4	4	2700	44.0	71	1.9	11.3
4	9	2660	42.1	70	1.6	11.5
14	5	2640	41.3	72	1.9	9.6
4	1	2620	42.5	70	1.7	12.3
4	2	2585	40.8	74	1.9	11.1
15	6	2575	42.4	77	1.9	11.2
4	11	2575	42.3	71	1.6	12.0
13	15	2570	40.3	75	1.9	9.1
3	1	2560	42.3	69	1.7	10.2
14	6	2540	39.3	75	2.0	11.8
2	2	2540	44.8	75	2.0	11.1
14	1	2540	42.1	75	1.9	11.0
15	15	2535	46.2	70	1.6	9.0
2	14	2530	41.0	70	1.8	11.9
Hybrid 89/274		2355	40.3	74	1.8	10.3
Hybrid 821/244		2310	44.0	75	1.8	11.8
Hybrid 290/273		2015	40.9	73	1.8	11.5
		LSD .05	522			
		CV	11.8			

Table 2. Yield of the selected male inbred by selected female inbred hybrids, overall hybrid performance of male lines, and overall hybrid performance of female lines derived from high-performing parents of cycle 1 of the reciprocal fullsib selection scheme.

Selected X Selected Hybrid Performance			Overall Male Performance		Overall Female Performance	
Male Line	Female Line	Yield	Male Line	Yield	Female Line	Yield
		kg/ha		kg/ha		kg/ha
4	4	2700 a †	15	2460 a †	5	2440 a †
2	2	2540 ab	4	2455 a	2	2380 ab
15	15	2540 ab	14	2410 ab	14	2340 abc
1	1	2385 abc	3	2345 abc	9	2320 abcd
11	11	2380 abc	13	2330 abc	1	2310 abcd
14	14	2360 abc	12	2285 bcd	15	2260 bcde
7	7	2360 abc	2	2250 cd	13	2240 bcde
3	3	2310 abc	11	2250 cd	8	2205 cde
13	13	2305 abc	1	2225 cd	10	2190 cde
10	10	2210 bc	9	2215 cd	6	2190 cde
9	9	2110 bc	7	2200 cd	3	2170 de
5	5	2100 bc	6	2170 de	7	2135 e
6	6	2090 bc	5	2070 ef	11	2110 ef
8	8	2010 c	8	2050 ef	4	1980 f
12	12	1940 c	10	2010 f	12	1975 f
Hybrid 89/274		2355				
Hybrid 821/274		2310				
Hybrid 290/274		2015				

† Means not followed by the same letter differ significantly at 0.05 probability level as tested by Duncan's multiple range test.

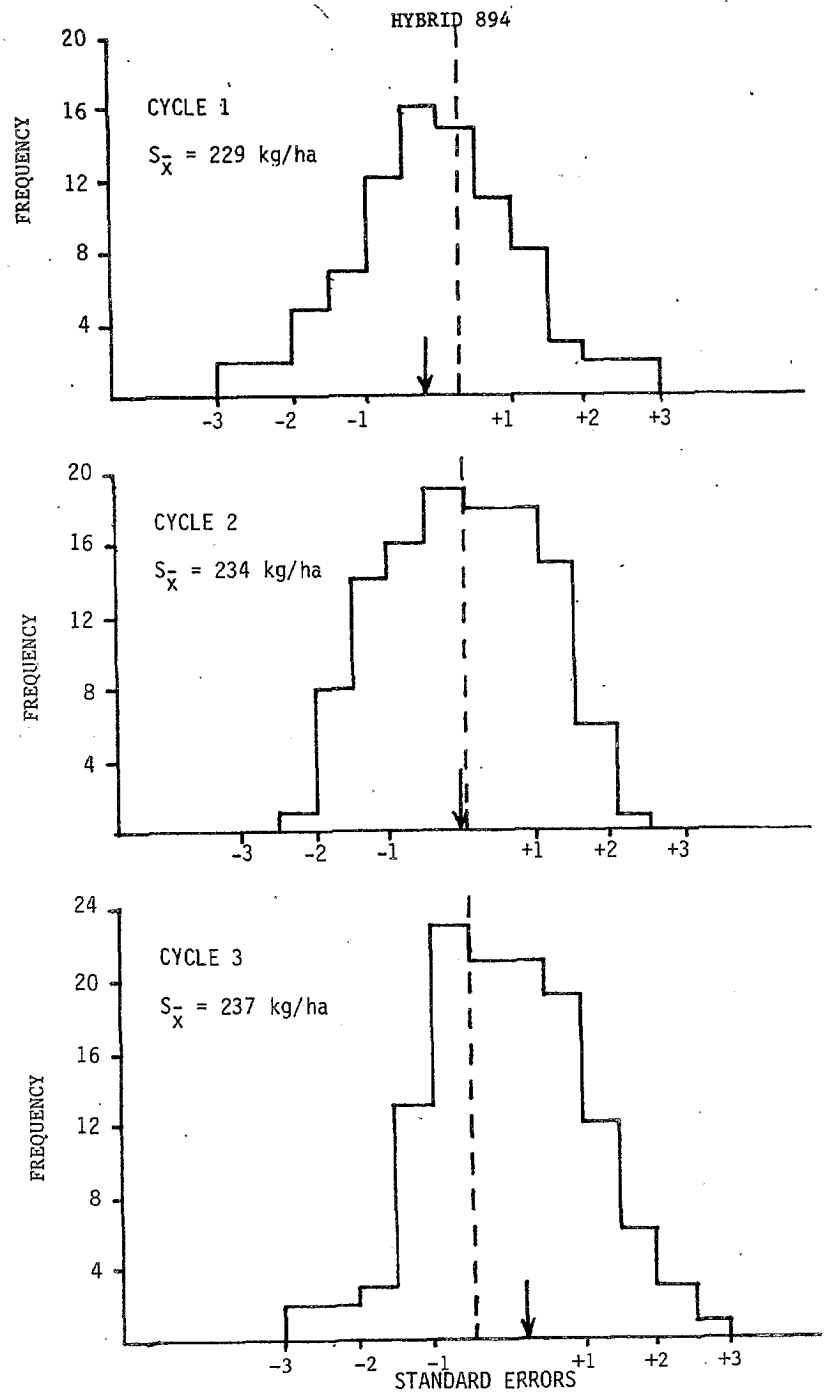

Figure 1. Yield frequency distributions of cycle 1, cycle 2, and cycle 3 reciprocal full-sib hybrids relative to the mean of the check 894 with arrows indicating the mean of each distribution.