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YIELD STABILITY OF SUNFLOWER HYBRIDS AND OPEN-POLLINATED VARIETIES

Sunflower (Helianthus annuus L.) hybrids produced by cytoplasmic male sterility and genetic fertility restoration have been grown commercially in the United States since 1972. Hybrids are estimated to account for more than 70% of the acreage in 1976. Most of the hybrids possess resistance to rust (Puccinia helianthi), downy mildew (Plasmopara halstedii), and Verticillium wilt (Verticillium dahliae), which has lessened the risks associated with sunflower production in the US.

As part of our sunflower research program we have evaluated numerous sunflower hybrids and varieties over a wide range of environments. We have also conducted tests to determine the influence of certain diseases and lack of insect pollinator populations on the relative performance of selected hybrids and varieties.

Sunflower performance trials were conducted in 14 environments in North Dakota and Minnesota during 1973-75. These trials involved plantings of at least 20 entries at 7 locations during one or more years of the three-year period. The data we have summarized were for 13 single-cross hybrids, 3 three-way hybrids, and the 2 open-pollinated varieties Peredovik and Sputnik. All entries were grown in all environments except for 4 of the single-cross hybrids which were included in a minimum of 11 environments. The hybrids tested were produced from parental lines developed and released by the US Department of Agriculture in cooperation with the North Dakota and Texas Agricultural Experiment Stations since 1971.

Differences in planting dates, row spacings, fertilizer applications, inherent soil fertility, and climatic conditions resulted in a wide range of yields from 1410 to 2569 kg/ha for the different environments. Mean yields over all environments for the single crosses, three-way hybrids, and open-pollinated varieties were 2097, 1952, and 1795 kg/ha, respectively. The range in yields of the hybrids was from 103% to 124% of Peredovik.

There is evidence in several crops (A. Patanothai, R. Atkins, 1974; G. Sprague, W. Federer, 1951) indicating that because of a lack of genetic heterogeneity single-cross hybrids may not be as stable as three-way hybrids or varieties in yield performance over a range of environmental conditions. To determine the relative stability of the sunflower hybrids and varieties in this study, we calculated stability parameters according to the procedure described by Eberhart and Russel (1966). This procedure involves the regression of the mean yields of each entry in each environment upon an environmental index, which in our case was the mean yield of all entries in each environment. The resultant regression coefficient (b) and deviation from regression mean square are parameters for evaluating the stability of yield over the environments. A stable entry is one that has a regression coefficient near 1.0 and small deviations from regression. A high mean yield is also a desirable attribute, although not necessarily an indicator of yield stability.

The regression coefficients near 1.0 and relatively small deviation mean squares indicated that the varieties Peredovik and Sputnik were relatively stable over the environments (Table 1). Wide variation for these parameters occurred among the hybrid entries. The large regression coefficients and deviation mean squares for high-yielding hybrids, such as Hybrid 901, indicated a lack of yield stability,

but high productivity in the more favourable yield environments. Seed yields and stability parameters for hybrids such as Hybrid 244 and the widely grown Hybrid 894 indicated that they yielded moderately in the high-yield environments but exceptionally well in the low yield environments.

Comparisons of the average regression coefficients and deviation mean squares for the single-cross hybrids, three-way hybrids, and open-pollinated varieties suggested that the hybrids, as a group, were slightly less stable in yield performance. However, stable single-cross hybrids were also apparent, indicating that certain genotypes are widely adapted and that yield stability is not necessarily dependent on the greater genetic heterogeneity attainable in open-pollinated varieties.

Severe disease problems were not encountered in the environments of this study. Where the major diseases of rust, downy mildew, or Verticillium wilt occur, the hybrids with improved resistance would be expected to show higher yields and greater stabilities than currently available varieties. Previous results have shown that these diseases are major factors contributing to yield and seed quality (G. Fick, D. Zimmer, 1975; D. Zimmer, D. Zimmerman, 1972).

Sunflowers are a highly cross-pollinated crop and rely heavily on insects, primarily bees, for pollination and good seed set. Because the parental lines used to produce the hybrids have been developed and maintained with some selection for self-fertility, it was expected that the hybrids might also be more self-fertile than the open-pollinated varieties. To determine the self-fertility of selected hybrids and varieties, the heads of 10 plants of each of 12 hybrids (selected from Table 1) and 3 open-pollinated varieties (Peredovik, Sputnik, and Luch) were covered with light

cloth bags shortly before flowering to prevent pollination by insects. The seed from the 10 self-pollinated plants for each of the entries was compared with the seed from 10 plants that were allowed to cross-pollinate. The hybrids on the average produced 23 grams more seed per plant from self-pollination than was produced from self-pollinated plants of the 3 open-pollinated varieties. The mean seed yields per plant from self-pollination expressed as a percentage of the seed from cross-pollination was 67% for the hybrids as compared to 10% for the open-pollinated varieties.

Preliminary observations suggest that the greater degree of self-fertility is advantageous for production of high yields when insect pollinator populations are less than optimum, a situation that occurs commonly in our area.

Conclusions

Seed yields of sunflower hybrids were significantly greater than those of open-pollinated varieties in replicated trials conducted during 1973-1975. Yield stability parameters suggested a slightly more stable yield performance for the opem-pollinated varieties than for the single-cross and three-way hybrids as a group over the environments of the study. However, stable single-cross hybrids were also identified, suggesting that yield stability can be attained with individual genotypes as well as with the genetic heterogeneity inherent in varieties or populations. Because most of the hybrids have improved disease resistance and are highly self-compatible they will likely show greater yields and greater yield stabilities than currently available varieties where disease epiphytotics or low insect pollinator populations are encountered.

Table 1

Mean Seed Yields, Regression Coefficients, and Deviation Mean Squares for 18 Sunflower Hybrids and Varieties Grown in 1973-75

Hybrid or variety	Seed yield, kg/ha	Regression coefficient	Deviation mean square[x]
Single-cross hybrids			
Hybrid 901	2223	1.33	50.6
Hybrid 241	2220	1.22	30.9
Hybrid 904	2214	1.06	41.2
Hybrid 893	2175	1.16	101.3
Hybrid 894	2175	0.82	12.3
Hybrid 243	2171	0.86	29.3
Hybrid 903	2169	1.25	38.5
Hybrid 244	2112	0.69	8.3
Hybrid 344	2069	1.15	44.4
Hybrid 891	1990	0.80	22.9
Hybrid 896	1948	1.02	36.7
Hybrid 341	1919	1.15	66.7
Hybrid 343	1871	0.98	48.1
Mean	2097	1.04	40.9
Three-way hybrids			
Hybrid 8944	2050	0.92	7.6
Hybrid 8941	1962	1.31	61.5
Hybrid 8946	1844	1.11	36.3
Mean	1952	1.11	35.1

Table 1 (continued)

Hybrid or variety	Seed yield, kg/ha	Regression coefficient	Deviation mean squaret
Varieties			
Peredovik	1799	1.01	34.3
Sputnik	1790	0.97	31.3
Mean	1795	0.99	32.8

^{x} X 10^{-3}

References

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