# METHODS OF SELECTION TO IMPROVE THE PRODUCTION OF SUNFLOWER *(HELIANTHUS ANNUUS)* IN ZAMBIA

G. M. RAVAGNAN
(Zambia)

Durring the last 10—15 years very little attention was paid to sunflower as a source of valuable edible oils and protein in Zambia.

In 1972—73 a breeding programme was started to isolate or combine superior adapted varieties with the aim of making the crop more profitable and attractive to farmers. Following the experience gained after several cycles and methods of breeding studies on maize in East Africa and elsewhere, a recurrent selection method has been proposed on sunflower in Zambia. This choice allows either a rapid detection of germ plasm, sufficiently reliable to deal with the immediate needs of the commercial seed production, or the making of gene pool or populations, with large genetic variability, where it is possible to isolate increasingly superior varieties in the following years and in a medium term programme.

Improved mass selection methods to increase or maintain the uniformity of some desirable traits, as height, time of maturity, quality of seed etc. have also been suggested for the new open pollinated varieties produced.

The expected output of the recurrent selection methods is :

i — sunflower "composites", or synthetic varieties, with good general combining ability to provide also variety hybrids, suitable for small scale farmers ;

ii — variety x inbred line, or inbred x inbred line hybrids with noticeable uniformity in ripening and higher seed and oil production, for larger scale farms where skill and expensive machines are available.

## BREEDING METHODS

200 chosen varieties and inbred lines (entries), from various genetical sources and possessing some of the required agronomic characters, have been crossed

to a tester, as female parent line, during the dry season in 1972. The tester, although low seed yielding, has been selected among several inbred lines, from the variety VNIIMK 8931 which has shown a good general combining ability in previous topcrosses (1).

In this inbred line, which we have called *fs* in this experiment, cytoplasmic male sterility has been incorporated by backcrossing. A sister line *ff* has been used, as sterility maintainer, whereas restorer fertility genes are present in several male parent lines, although at low frequency.

The harvested seed of the $F_1$ crosses together with the seed of each selfed male parent line were grown in a simple lattice design field experiment of four replicated blocks of 10 x 10 in four climate representative localities. Each plot consisted of two rows with 24 hills oversown and thinned to 24 plants. 239 kg of triple super (44% $P_2O_5$) per ha and 88 kg per ha of ammonium nitrate were applied at planting time.

At harvest a synthetic population (ZCA) made from the top 10% higher yielding entries, remnant seed, was grown under irrigation in a random mating. Only a mild agronomic selection was carried out, before flowering, to avoid losses of desirable genes due to the finite size of the population.

A second group of higher yielding entries (ZCB), but restricted only to the exotic introductions with high oil content, was recombined in isolation. Both of these, after a few generations of random mating and increasing selection intensity to reduce the variation among each entry until a uniform composite is obtained, can be released to commercial production.

During the last rainy season „composite A" was grown again, and within each row, representative of the original entries the best plants having desirable highly heritable agronomic traits were selected. These selected plants are now planted in an irrigation nursery to be crossed with the fs pollen sterile female lines to start the second recurrent selection cycle.

To maintain and improve the uniformity of the recommended open pollinated varieties of sunflower, without impairing the yield due to inbreeding depression, an improved mass selection methods has been suggested. Yield trials can be carried out in two to four localities. In one locality the best plants, having desirable characters, can be selected from the trial grown in isolation to make the new plant-row trials.

This selection is also based on the average yield performance of the other plant-row locality trials.

## RESULTS AND DISCUSSION

The mean yields are presented in table 1 for each entry grouped according to their origin and their related $F_1$'s together with the fs female p. sterile line. The superiority of the local entry over the exotic ones, in seed yield, is noticeable. However this superiority is greatly reduced when we compare the oil percentage and the total oil per ha

(1) N.A.R.S. Kitale Annual Reports 1969—70.

*Table 1*

**Sunflower evaluation trials 1972/73. Combined mean yield of 4 localities, 2 replications according the exotic and local entries and their $F_1$**

| Variety | Seed yield q/ha | | | Oil % D. M. | Tot. oil kg/ha |
|---|---|---|---|---|---|
| | av. | min. | max. | | |
| Exot. entries | 8.41 | 4.90 | 14.1 | 35.4 | 268 |
| Local entries | 10.12 | 5.80 | 15.40 | 30.4 | 277 |
| Exot. $F_1$ | 11.86 | 9.40 | 13.70 | 43.1 | 460 |
| Local $F_1$ | 13.49 | 11.20 | 21.10 | 40.4 | 563 |
| Tester | 9.4 | — | — | 42.6 | 360 |

of the parent lines. The picture is more evident on the $F_1$'s crosses. The average of the seed yield of the first generation of the fs line crossed by the local entries is markedly higher than the crosses with the exotic ones. This gap is further increasing for the local $F_1$'s crosses when we examine the total oil per ha.

It appears that a remarkable heterosis is present in some of these crosses not only in the seed yield as was earlier thought (1), but also in oil content (see table 2).

*Table 2*

**Indicative means of some characters from combined sunflower evaluation trials 1972/1973. Four localities, two reps**

| Variety | seed yield q/ha | crude oil D.M. % | tot. oil/ha D.M. kg | Iod. % | 50% flower. days | pollen % |
|---|---|---|---|---|---|---|
| LOCAL | | | | | | |
| fs × k 112 | 18.20 | 46.0 | 753.5 | 1 | 65 | 4 |
| k 112 | 13.20 | 32.8 | 389.7 | 1 | 72 | 100 |
| fs × k 030A—8 | 21.10 | 37.6 | 714.0 | 1 | 67 | 5 |
| k 030A—8 | 10.90 | 30.4 | 298.2 | 3 | 69 | 100 |
| fs × (kw × 69) | 15.0 | 48.3 | 650.7 | 0 | 67 | 3 |
| k (kw × 69) | 7.4 | 46.9 | 312.4 | 0 | 70 | 100 |
| fs × z003 | 18.6 | 30.3 | 507.2 | 2 | 65 | 6 |
| z003 | 10.5 | 28.9 | 273.1 | 2 | 65 | 100 |
| EXOTIC | | | | | | |
| fs × GOR101 | 13.2 | 48.8 | 579.7 | 1 | 63 | 0 |
| GOR 101 | 8.3 | 45.4 | 339.1 | 0 | 61 | 100 |
| RECORD | 7.2 | 49.0 | 317.5 | 4 | 62 | 100 |
| fs × RECORD | 12.2 | 44.7 | 490.8 | 1 | 63 | 7 |
| fs × VNIIMK8931 | 11.6 | 43.9 | 458.3 | 2 | 64 | 4 |
| VNIIMK 8931 | 7.1 | 49.8 | 318.2 | 4 | 63 | 96 |
| fs × PERDOVIK | 13.1 | 34.0 | 400.9 | 0 | 65 | 4 |
| PERDOVIK | 10.2 | 43.3 | 397.5 | 1 | 64 | 100 |
| fs | 8.5 | 44.7 | 342.0 | 0 | 64 | 0 |
| LSD 0.5 | 4.45 | | | | 3.7 | |

The percentage of head flowers with normal pollen is rather low on the $F_1$'s due to the recent incorporation of restorer fertility genes in the male parents without further selection.

As indicated above, following the result of the evaluation trials in 1972—73, two composites have been formed as a source either of an improved variety for the farmes or a population which possess sufficient genetic variability to allow a progressive quick increase in yield by recurrent selection. To predict the mean of a composite, made from various varieties, a formula is available (2) provided epistatic effects are negligible :

$$C = \overline{F}_1 - \frac{(\overline{F}_1 - \overline{E})}{(n)}$$

where $\overline{F}_1$ is the mean of all crosses between the entries, $\overline{E}$ is the mean of the entries and n is the number of the entries which have been composited. A test trial made with $F_1$'s of all the possible crosses of the parent lines (in Hardy-Weinberg equilibrium) as well as the parent lines themselves provide the required data.

The increase of the genetic variance in a composite lengthens the period when progress ends, following the negative effect of the inbreeding. The gene frequency at each locus is related to the average frequency of the entries which have formed the composite. Consequently the gene frequency of several loci tend to become intermediate. To increase the genetic variability we have to increase the number of different entries. Our composite A has been made with 21 different entries.

## COMMERCIAL HYBRIDS

In table 2 the mean yied of a few representative $F_1$'s and their parents is given. Some of the $F_1$'s are showing impressive yield increase. To release them for commercial production as hybrids, stable cytoplasmic male sterile lines together with restorer fertility genes must be available.

In our breeding programme we have grown two generations of *fs*'s lines with the aim of improving the seed set of the flowers. We expect to have heads of the *fs* lines with nearly 80% of normal seed at harvest. On the other hand we are progressively increasing the percentage of restorer genes on the male parents of the chosen commercial hybrids.

A variety x inbred line hybrid was produced in 1973 dry season by growing 2 male rows alternated with 6 female rows in a ordinary seed production. The seed harvested from female p. sterile rows was grown in several trials.

(2) S. A. Eberhart — Workshop Conference 1965. Kitale-Kenia.

In table 3 the results of a variety trial carried out last season are shown.

*Table 3*

**Variety trials 1973/74 — Four replications, one locality. Mean of eight characters**

| Variety | Seed yield q/ha | Crude oil D.M. % | Tot. oil/ha kg | Stand count | Iod % | Pollen % | 50% flower. days | Height cm |
|---|---|---|---|---|---|---|---|---|
| fs × K112 | 22.19 | 41.10 | 819.8 | 97.9 | 10 | 10.0 | 78 | 203 |
| ZCA $C_1$ | 20.56 | 32.70 | 605.1 | 98.6 | 6 | 100.0 | 80 | 260 |
| fs × K030A—8 | 20.06 | 32.80 | 592.2 | 63.9 | 10 | 11.6 | 80 | 220 |
| LOCAL B. GIANT | 19.36 | 33.10 | 576.7 | 86.1 | 17 | 100.0 | 91 | 272 |
| fs × K093—2 | 16.89 | 36.58 | 556.1 | 100.0 | 9 | 4.9 | 78 | 190 |
| fs × K041—2 | 16.68 | 37.28 | 559.6 | 86.8 | 11 | 4.2 | 72 | 174 |
| INRA 4701 | 16.65 | 40.95 | 613.6 | 93.7 | 5 | 100.0 | 82 | 197 |
| SAFFOLA HYB. 321 | 15.63 | 34.88 | 490.7 | 96.5 | 8 | 100.0 | 77 | 204 |
| fs × (KW × 69) | 15.43 | 36.90 | 512.4 | 91.7 | 6 | 4.1 | 76 | 185 |
| KW $C_5$ | 15.14 | 31.23 | 425.5 | 66.0 | 8 | 100.0 | 82 | 227 |
| SOREX | 13.72 | 28.48 | 351.7 | 84.7 | 17 | 100.0 | 67 | 154 |
| Z—VNIIMK—A | 13.69 | 35.33 | 435.3 | 87.5 | 14 | 100.0 | 71 | 202 |
| fs × K008 | 13.10 | 33.33 | 393.0 | 100.0 | 11 | 2.1 | 71 | 176 |
| K030A—8 | 12.32 | 30.93 | 343.2 | 48.6 | 11 | 100.0 | 72 | 224 |
| VNIIMK 8931 | 9.96 | 34.28 | 307.8 | 68.1 | 10 | 100.0 | 71 | 169 |
| Cmz HA 89 × 266 (USA) | 9.14 | 33.40 | 274.7 | 85.4 | 17 | 100.0 | 75 | 186 |
| HS 52 | 8.15 | 34.48 | 252.9 | 95.1 | 9 | 100.0 | 73 | 157 |
| PEREDOVIK | 6.40 | 34.03 | 196.0 | 60.4 | 24 | 100.0 | 70 | 151 |
| LSD 0.5 | .96 | 5.2 | | | | 3.7 | 1.7 | 10.4 |
| C.V. | 5.28 | 10.3 | | | | 3.6 | 1.6 | 3.8 |

Although only in one locality, the seed yield is following the same trend as noticed on the evaluation trials of the previous year. In this trial we have compared our entries with well known varieties from temperate countries. However the test crosses between *fs* (exotic) and local selcted varieties (*fs* x K112) are exhibiting high seed yield and total oil per ha. Hybrids, such as INRA 4701 from France, are also showing a remarkable performance in different climatic conditions.

Its yield is below some of the local top $F_1$'s.

Further results from other trials which we are now harvesting, should give more information on the yield of composite and hybrids selected from the evaluation trials 1972—73.

## CONCLUSIONS

At this stage it is too premature to draw final conclusion on the methods adopted in this country for a breeding research programme.

However, with limited amount of funds and trained staff it appears that provided cytoplasmic male sterile lines are available, methods such as recurrent selection can release to the growers superior varieties of sunflower in quite a short period. Similarly in other annual crops, where sterility inheritance can be controlled, recurrent selection method can detect improved genotypes useful for the local agriculture.