# TRENDS IN SUNFLOWER BREEDING THROUGH GENETIC GAINS

**A. V. VRÂNCEANU, F. M. STOENESCU, GABRIELA SOARE**

Research Institute for Cereals and Industrial Crops, 8264 Fundulea, Romania

## INTRODUCTION

World sunflower seed and oil production have increased considerably in the last 10—15 years. As in the case of other crops, there is a continuing question of how much of the increased yield per area unit is due to increased genetic gains and how much is due to a reduction in constraints to yield using progressively improved crop management, pest and weed control, mechanization etc. If improvement in genetic potential has been a major component of yield improvement, is genetic improvement being sustained ?

Uniform evaluation of data for different entries and for a long-time check cultivar, experimented in the frame of the F.A.O. Research Network on Sunflower, permitted the estimation of the genetic contribution to seed and oil yields, as well as to oil content, in the period of 1976—1985. Beside of this, the present paper attempts to assess genetic progress concerning the most important morphological and physiological plant traits, resistance to pests and to unfavourable environmental conditions. Valuable germplasm sources are tabled.

## MATERIALS AND METHODS

The sources of data and observations reviewed included five experimental biennial cycles of trials carried out in a wide range of environments from Europe, Near and Middle East, Africa, Latin America and U.S.A., in the period of 1976—1985. The respective data and observations were published in the Scientific Bulletin HELIA, numbers 1, 2, 3, 5, 7 and 9 (Vrânceanu and Stoenescu, 1978, 1979, 1980, 1982 ; Vrânceanu et al., 1984, 1986).

The number of entries (up to 34) and the number of locations (up to 46) varied from year to year. The biological material in each experimental cycle represented the most recent achievements of sunflower breeders from all over the world. The experimental design was the Latin rectangle for the first three cycles and randomized blocks for the last two, the replication number being of 4 or 5.

All seed and oil yield data and also seed oil content values were converted to a percentage of the appropiate long-time check cultivar, and graphs were constructed on that basis. An assumption was made that constraints were almost similar for all entries, taking into account the results of analysis of variance for seed and oil yields performed for the trial cycle 1976—1977 (Vrânceanu and Stoenescu, 1978). So, the "F" values of "cultivar × location" and "cultivar × year" interactions were much smaller than the "F" values for the other sources of variation. In order to reduce the year effects, two-year averages were used.

The long-time check cultivar was the well-known open-pollinated variety Peredovik, which proved to be higher yielding and to possess a larger ecological plasticity.

Along with the evaluation of genetic gains, genotypes as valuable gene sources for important plant and seed characteristics are presented.

## RESULTS

Seed yield trends for the highest yielding entries, as well as for the trial averages are presented in Fig. 1. In comparison with the top hybrid cultivar of the cycle 1976—1977, the regression line showed an upward trend, but at a slow rate (0.32% per year). The positive, but unsignificant coefficient of correlation ($r = 0.42$) evidenced a rather erratic upward. Lower yielding levels in the period of 1980—1983, especially in the cycle 1980—1981, were determined in a large measure by the environmental constraints such as : drought, short growing seasons, low annual precipitations, strong winds determining plant lodging, which were recorded in many locations. At the same time, Peredovik check cultivar proved to be widely adapted and productive in many adverse environments, and performed rather consistently through the testing period.

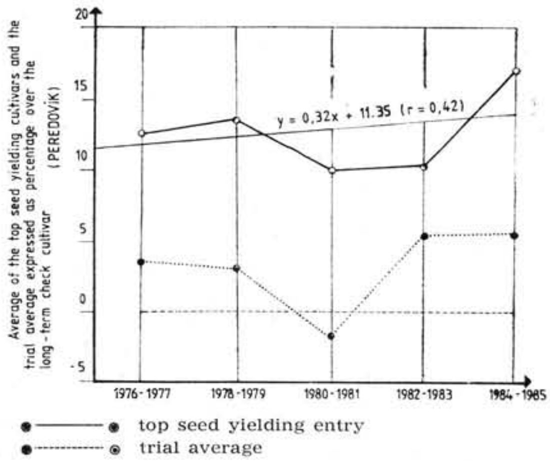


*Fig. 1* — Genetic contribution to sunflower seed yield improvement expressed as percentage changes from the performances of the long-time check cultivar Peredovik, evaluated in five F.A.O. biennial competitive trials

The genetic contribution to oil content may be evaluated from Fig. 2. Trials average values were placed under the check levels in all cycles. This situation proved that many hybrids were substantially inferior to the check. Although the top entries presented averages with 2.5—5.9% higher than the check, the regression line indicated an entry tending to plateau, the annual rate being of only 0.13%. Improvement since 1976—1977 has not been important, perhaps levels are already high, over 50% oil in dry matter, and therefore significant advances may be more difficult to attain.

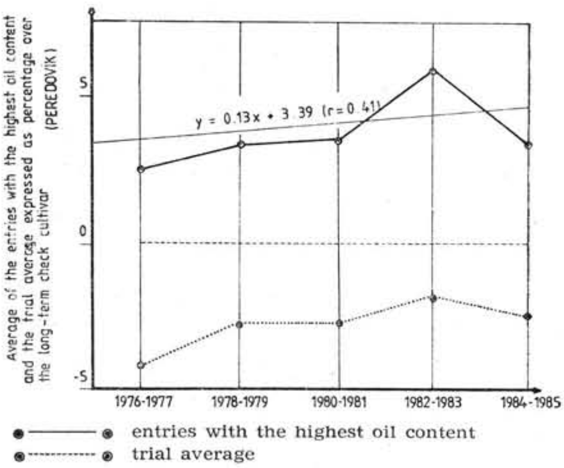


*Fig. 2* — Genetic contribution to oil content in sunflower seeds expressed as percentage changes from the performances of the long-time check cultivar Peredovik, evaluated in five F.A.O. biennial competitive trials

The upward trend in performance concerning oil yield per hectare is an evidence that the breeding work in this direction has been more successful, high seed yielding hybrids with very high oil content at the same time being created (Fig. 3). The calculated annual rate of improvement was of 1.1%, and the theoretical values were much closer to the recorded ones, the coefficient of correlation being significant and positive (r = 0.86).

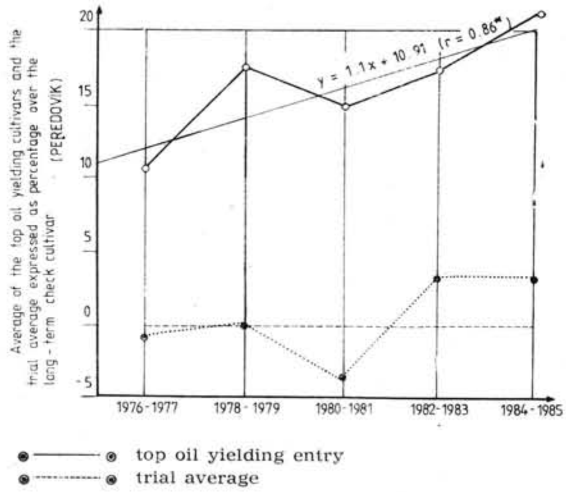


*Fig. 3* — Genetic contribution to sunflower oil yield improvement expressed as percentage changes from the performances of the long-time check cultivar Peredovik, evaluated in five F.A.O. biennial competitive trials

In comparison with open-pollinated varieties, hybrids proved to be superior not only for seed and oil yielding capacity but also for their plant and seed uniformity, for the most important morpho-physiological and biochemical characteristics and especially for resistance to the attack of pests.

Information comprised in Table 1 can represent an useful guide for sunflower growers, but mainly for breeders interested in identification of cultivars as gene-sources for different traits : high seed yielding potential, high oil content, earliness, short stem, self-fertility, and resistance to *Sclerotinia sclerotiorum*, *Phomopsis helianthi*, *Botrytis cinerea*, *Sclerotium bataticola*, *Verticillium* sp., *Puccinia helianthi*, leaf spots and *Orobanche cumana*. It is worth mentioning that most hybrids contained *Pl* genes which were effective against different races of downy-mildew *(Plasmopara halstedii)*. This pathogen used to be considered the most important for the sunflower crops up to the period of 1972—1976, when resistant hybrids began to be extended in the large production.

## DISCUSSION AND CONCLUSION

The methods used up to now for estimating the genetic potential for yield improvement and determining yield trends are more or less relative, because of the difficulties encountered in removing completely the different environmental constraint effects. The method used in this study has the same defficiency,

*Table 1*

**Gene-sources for the most important plant and seed traits (sunflower cultivars evaluated in F.A.O. trials, 1976—1985)**

| Traits | Cultivars | Supplying country | Trail cycle |
|---|---|---|---|
| High seed yielding capacity | Romsun 52 | Romania | 1976—1977 |
| | Sorem 82 | Romania | 1976—1977 |
| | Romsun 59 | Romania | 1978—1979 |
| | Sorem HT-116 | Romania | 1978—1979 |
| | P.O.I.-301 A | U.S.A. | 1978—1979 |
| | Ro 22 | Romania | 1980—1981 |
| | Ro 29 | Romania | 1980—1981 |
| | Contiflor | Argentina | 1980—1981 |
| | Ro 25 | Romania | 1982—1983 |
| | Select | Romania | 1984—1985 |
| High oil content | Helios 322 | Bulgaria | 1976—1977 |
| | Sorem HT-117 | Romania | 1978—1979 |
| | Sungro 380 A | U.S.A. | 1978—1979 |
| | Ro 27 | Romania | 1980—1981 |
| | Ro 34 | Romania | 1980—1981 |
| | Ro 45 | Romania | 1980—1981 |
| | Ro 100 | Romania | 1980—1981 |
| | Ro 25 | Romania | 1982—1983 |
| | Ro 44 | Romania | 1982—1983 |
| | Select | Romania | 1984—1985 |
| Earliness | Sorem 80 | Romania | 1976—1977 |
| | Sorem HT-58 | Romania | 1976—1977 |
| | Issanka | France | 1976—1977 |
| | Romsun 20 | Romania | 1976—1977 |
| | Vera | F. R. Germany | 1980—1981 |
| | Ro 18 | Romania | 1980—1981 |
| | Ro 26 | Romania | 1980—1981 |
| | Iregi 816 B | Hungary | 1980—1981 |
| | NS-H-36 | Yugoslavia | 1980—1981 |
| | Ro 36 | Romania | 1982—1983 |
| | IH-155 | Hungary | 1982—1983 |
| | Stauffer 3 101 | U.S.A. | 1982—1983 |
| | Citosol F-1 | France | 1984—1985 |
| | IH-51 | Hungary | 1984—1985 |
| | NS-Shine | Yugoslavia | 1984—1985 |
| Short stem | Airelle | France | 1976—1977 |
| | Issanka | France | 1976—1977 |
| | Wielkopolski | Poland | 1976—1977 |
| | Romsun 18 | Romania | 1976—1977 |
| | Ro 26 | Romania | 1980—1981 |
| | Ro 46 | Romania | 1980—1981 |
| | Sunbred 265 | U.S.A. | 1980—1981 |
| | Cerneanka | Italy | 1982—1983 |
| | NSH-3 | Yugoslavia | 1982—1983 |
| | Ro 36 | Romania | 1982—1983 |
| | NSH-40 | Yugoslavia | 1982—1983 |
| | Stauffer 3 101 | U.S.A. | 1982—1983 |
| Self-fertility | Koflor 1 | Hungary | 1982—1983 |
| | NSH-5 | Yugoslavia | 1982—1983 |
| | H9 P1 | France | 1982—1983 |
| | IH-56 | Hungary | 1982—1983 |
| | Ro 131 | Romania | 1982—1983 |
| | Stauffer 3 101 | U.S.A. | 1982—1983 |
| | Pacific 308 | U.S.A. | 1984—1985 |
| | H. No. 617 | Bulgaria | 1984—1985 |
| | NS-Condor | Yugoslavia | 1984—1985 |
| Field resistance to *Sclerotinia sclerotiorum* | Remil | France | 1976—1977 |
| | Relax | France | 1976—1977 |
| | H-894 | U.S.A. | 1978—1979 |
| | Ro 22 | Romania | 1980—1981 |
| | Ro 40 | Romania | 1980—1981 |
| | Halcon | Spain | 1980—1981 |
| | H9 P1 | France | 1982—1983 |
| | Ro 25 | Romania | 1982—1983 |
| | NS-H-4 | Yugoslavia | 1982—1983 |
| | Ro 44 | Romania | 1982—1983 |
| | Ro 134 | Romania | 1982—1983 |
| | Select | Romania | 1984—1985 |
| | Triumph 570 | U.S.A. | 1984—1985 |
| | H-219/79 | F. R. Germany | 1984—1985 |
| | Sigco 448 | U.S.A. | 1984—1985 |
| | NS-Shine | Yugoslavia | 1984—1985 |
| Field resistance to *Phomopsis helianthi* | Ro 36 | Romania | 1982—1983 |
| | Select | Romania | 1982—1983 |
| | Felix | Romania | 1982—1983 |
| | NS-Shine | Yugoslavia | 1982—1983 |
| | NS-Flower | Yugoslavia | 1982—1983 |
| | NS-Condor | Yugoslavia | 1982—1983 |
| | NS-Helios | | 1982—1983 |
| Field resistance to *Botrytis cinerea* | Remil | France | 1976—1977 |
| | YU NS-65 | Yugoslavia | 1976—1977 |
| | H-27/77 | F. R. Germany | 1980—1981 |
| | Ro 40 | Romania | 1980—1981 |
| | Ro 45 | Romania | 1980—1981 |
| | Ro 100 | Romania | 1980—1981 |
| | Ro 25 | Romania | 1982—1983 |
| | NS-Condor | Yugoslavia | 1984—1985 |
| Field resistance to *Sclerotium bataticola* | Sungro 380 A | U.S.A. | 1978—1979 |
| | NS-Flower | Yugoslavia | 1984—1985 |
| | NS-Helios | Yugoslavia | 1984—1985 |
| | Select | Romania | 1984—1985 |
| | Ro 36 | Romania | 1982—1983 |
| | Ro 70 | Romania | 1982—1983 |
| | Ro 44 | Romania | 1982—1983 |
| | Ro 134 | Romania | 1982—1983 |
| Field resistance to *Puccinia helianthi* | SH-S-690 | Spain | 1980—1981 |
| | SH-3 000 x 2 | Spain | 1980—1981 |
| | Contiflor | Argentina | 1980—1981 |
| | H9 P4 | France | 1982—1983 |
| | Cargill 207 | U.S.A. | 1984—1985 |
| Resistance to leaf spots | DO-704 | U.S.A. | 1980—1981 |
| | Ro 29 | Romania | 1980—1981 |
| | Ro 45 | Romania | 1980—1981 |
| Resistance to *Orobanche cumana* | Romsun 53 | Romania | 1976—1977 |
| | Sorem 80 | Romania | 1976—1977 |
| | Ro 70 | Romania | 1982—1983 |

but its main value lies in the large amount of results used to construct the graphs. Some conclusions can be drawn and the following needs for future sunflower breeding research can be outlined.

Genetic increases of hybrid sunflower yielding ability and oil content had slow annual rates, and the trends in certain periods appeared to near a plateau. This was true especially in the areas where environmental constraints were the largest and the yield base the lowest, or where the long-term check variety proved to be better adapted. A more optimistic note represented the continuous gains of oil yield per area unit.

The slow up-trends in seed yielding ability and oil content could be explained taking into consideration the conclusions of the paper „Genetic resemblance of sunflower cultivars tested in international trials" (Vrânceanu and Stoenscu, 1985). The respective study revealed a relative reduced genetic diversity of most sunflower hybrids tested in the period of 1976—1983. So, they could not fit all environmental variations and minimize the genetic vulnerability of sunflower crops. The limiting factors are connected primarily with the utilization of the same type of cytoplasmic male sterility, the genetic similarity of many female parents originating from high oil open-pollinated varieties, and of many related pollen fertility restorer lines.

In order to enlarge the genetic diversity of sunflower hybrids breeders have to develop source populations with various genetic backgrounds and interspecific hybrids, which could be used successfully as initial breeding material. Identification and use of new cms and *Rf* gene sources are also needed.

For a continuous genetic progress new orientations and methods of the breeding work have to be found with the purpose of creating new super-yielding ideotypes, widely adapted to all environmental and agronomical conditions.

When hybrids are compared with open- pollinated varieties, it is obvious that inbreeding and heterosis exploration is more effective than classical methods, as massal or individual selection, for improving the main seed and plant characteristics, especially disease resistance.

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## TENDANCES DANS L'AMÉLIORATION DU TOURNESOL ÉVALUÉES À PARTIR DU PROGRÈS GÉNÉTIQUE

*Résumé*


L'analyse des résultats de l'évaluation des divers variétés et hybrides de tournesol et de la variété-témoin Peredovik, dans le cadre du Réseau F.A.O. de Recherche sur le Tournesol, a permis l'estimation de la contribution génétique à l'augmentation du rendement en graines et en huile et aussi de la teneur en huile des graines de tournesol dans la période 1976—1985. Les lignes de régression ont indiqué une faible tendance d'amélioration de la capacité de production (taux annuel d'augmentation de 0,32% pour le rendement en graines et de 1,1% pour le rendement en huile). En ce qui concerne la teneur en huile, le taux annuel a été seulement de 0,13%. A partir de ces résultats, on fait des considérations sur le matériel génétique et les méthodes d'amélioration utilisées jusqu'à présent et on souligne la nécessité de nouvelles orientations et méthodes permettant d'enregistrer des progrès génétiques plus importants. Les hybrides, par comparaison aux variétés, se sont avéré néanmoins supérieurs pour la majorité des traits morpho-physiologiques, notamment pour la résistance aux maladies. On met en évidence les génotypes valeureux comme sources de gènes pour les principaux traits.


## TENDENCIAS EN LA MEJORA DEL GIRASOL APRECIADAS CONFORME AL PROGRESO GENÉTICO

*Resúmen*


La evaluación uniforme de los resultados del test de los diferentes híbridos y variedades de girasol y de la variedad de largo plazo Peredovik dentro de la Red de investigaciones F.A.O para el girasol, permitió estimar la contribución genética al aumento de la producción de semillas y aceite y al crecimiento del contenidó de aceite en semillas en el período 1976—1985. Las líneas de regresión indicaron una leve tendencia al mejoramiento de la capacidad de producción (tasas anuales de 0,32 por ciento para la producción de semilla y de 1,1 por ciento para la producción de aceite). En el caso del contenido en aceite la tasa anual fue de sólo 0,13 por ciento. Partiendo de estos resultados se hacen consideraciones con respecto al material genético y los modelos de mejora empleados hasta el presente y se evidencia la necesidad de unas orientaciones y métodos nuevos que permitan registrar progresos genéticos más importantes. Los híbridos, en comparación a las variedades se mostraron netamente superiores en cuanto a la mayoría de las características morfo-fisiológicas y especialmente la resistencia a enfermedades. Del material genético estudiado se evidencian los genotipos que representan fuentes valiosas de genes para los principales caracteres.