# Selection of sunflower genotypes for sowing dates in August/September in Southern region of Brazil

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## ABSTRACT

The choice of adapted cultivars to different environments is meaningful to sunflower crop. The objective of this study was to select sunflower genotypes for sowing dates in August/September in Southern region of Brazil. Experiment data from 2005/2006 to 2006/2007 were obtained by the National Sunflower Trials, coordinated by Embrapa Soja. The evaluated traits were seed and oil yields (kg ha$^{-1}$). The criterion used for selection of genotypes was the general mean obtained from different environments. For grain yield, the open pollinated varieties Catissol (1,775 kg ha$^{-1}$), BRSGira 02 (1,687 kg ha$^{-1}$) and BRSGira 01 (1,531 kg ha$^{-1}$) surpassed the open pollinated varieties used as control (1,510 kg ha$^{-1}$). The general mean for grain yield of the hybrids Helio 253 (2,498 kg ha$^{-1}$) and Helio 360 (2,427 kg ha$^{-1}$) surpassed the hybrids used as control (2,368 kg ha$^{-1}$). For oil yield, the hybrids Exp 1441 (1,136 kg ha$^{-1}$), Helio 360 (1,129 kg ha$^{-1}$) and Helio 253 (1,127 kg ha$^{-1}$) surpassed the controls.

**Key words:** *Helianthus annuus* – interaction genotype x environment – release of genotypes – sunflower breeding.

## INTRODUCTION

The interest of farmers from the Southern region of Brazil in sowing sunflower (*Helianthus annuus* L.) in August/September is increasing for many reasons. Sunflower plays an important role as a new option for crop rotation or succession. It also contributes with raw material to the production of biological fuel and also for high quality oils for human consumption. In the states of Rio Grande do Sul and Paraná, for example, between 2001/02 and 2004/05, the sowed area increased around 200% and 1000%, respectively (Embrapa Soja, 2005).

For being a relatively new culture in the country, it is very important to obtain information on the available genotypes to recommend the most suitable ones for specific producing regions. These conditions are necessary to increase the possibility of a successful sunflower production to obtain a more competitive economic response.

Since 1989, the Embrapa Soybean has been coordinating a network of evaluation and selection of hybrids and varieties developed by diverse companies through a program called National Sunflower Trials. This network counts with the contribution of several public and private institutions. The objective of this work was to select sunflower genotypes evaluated in the Trial Network carried out between 2005/06 and 2006/07 during the August/September sowing season.

## MATERIALS AND METHODS

Experiment data were obtained from the National Sunflower Trials between 2005/2006 and 2006/2007, in several locations of the states of Rio Grande do Sul (RS) and Paraná (PR).

Sowing was done in August/September according to a randomized block design with four replications. Each plot consisted of four lines 6.0 m long, spaced from 0.7 m to 0.9 m. At harvest, two border lines and 0.5 m from each extremity were discarded, resulting in 7.0 m$^2$ to 9.0 m$^2$ per plot, depending on the spacing adopted. Soil fertilization, weed control and other agronomic management practices were provided in order to allow good plant development.

The evaluated genotypes were hybrids (simple and triple) and open-pollinated varieties (populations) developed by the companies Advanta, Dow AgroSciences, Embrapa Soja, La Tijereta, and Helianthus do Brasil. Commercial hybrids M 734 (Dow AgroSciences) and Agrobel 960 (La Tijereta) were used as controls. The evaluated traits were grain and oil yields (kg ha$^{-1}$). The groups of genotypes were evaluated in the network during two years in Final Trials of the First Year of Evaluation (FTF) and in Final Trials of the Second Year of Evaluation (FTS). Thirteen genotypes were evaluated. In the FTF, the evaluated locations and the respective institutions responsible were Campo Mourão (Cooperativa Mista Agropecuária do Brasil) and Ijuí (Cooperativa Regional Tritícola Serrana Ltda). In the FTS, the locations and institutions were Santa Rosa (Cooperativa Mista São Luiz Ltda-Coopermil), Passo Fundo (Universidade de Passo Fundo), Encruzilhada do Sul (Fundação Estadual de Pesquisa Agropecuária-Fepagro).

The analysis of variance was performed on grain and oil yields for each environment (location and year). As the locations of the trials included in the FTF were not exactly the same ones as those chosen for the FTS, a joint analysis of environment was carried out for each group of genotypes. For this reason, a test to verify the homogeneity of residual variances was applied. In this test, variances were considered as homogeneous when the ratio between the larger and the smaller residual mean square was smaller than seven (Pimentel Gomes, 1985). Moreover, trials with coefficients of variation higher than 20% (Pimentel Gomes, 1985; Carvalho et al., 2003) and experiments with major problems (bird attacks, drought and serious incidence of plant diseases, such as Alternaria) were not included in the joint analysis of variance.

Two criteria were used for genotype selection: 1) the general mean obtained from different environments; 2) partitioning of general mean in favorable and unfavorable environments. A favorable environment was considered to be that with superior general means, and an unfavorable one those with inferior general means (Verma et al., 1978).

In the analysis of the general mean, Duncan test at 5% of probability was performed to verify significance of differences between genotypes, as well as the comparison of means among each evaluated genotype and the controls. The calculations were done by the computational program Genes (Cruz, 2001).

## RESULTS AND DISCUSSION

Significant effect was observed for the genotype x environment interactions (Table 1). This demonstrates that performance of genotypes depends on the different environments where they are cultivated, so that an analysis in specific environments is required, as reported by Allard and Bradshaw (1964). The presence of GxE interaction in sunflower yield tests has also been reported by Embrapa Soja (1996, 1997, 1998, 1999, 2000), Lúquez et al. (2002) and De la Vega and Chapman (2006). The coefficients of variation (CV) of the analysis were between 14.58% and 16.54% for grain yield, and between 15.47% and 17.02% for oil yield. According to the criteria suggested by Pimentel-Gomes (1985) and Carvalho et al. (2003), those experiment precision levels were satisfactory. In most of the assessed years, the average yield of the trials was higher than the yields of commercial field crops, which were approximately 1,500 kg ha$^{-1}$ (Conab, 2005).

**Table 1.** Joint analyses of variance for grain and oil yields (kg ha$^{-1}$) of sunflower genotypes evaluated in the National Sunflower Trials, coordinated by Embrapa, in the period from 2005/2006 to 2006/2007

| Year[1] | Yield (kg.ha$^{-1}$) | | | | | |
|---|---|---|---|---|---|---|
| | Grains | | | Oil | | |
| | MSGE[2] | CV[3] | Mean[4] | MSGE[2] | CV[3] | Mean[4] |
| 2005/2006 | 281,663,48** | 14,58 | 2,328,58 | 90,933,65** | 15,47 | 1,040,99 |
| 2006/2007 | 262,336,33** | 16,54 | 2,003,16 | 60,302,97** | 17,02 | 912,16 |

** Significant at 1% of probability by the F test.
[1]Evaluations made in 2005/2006 (sowing date on August/September) include the experimental data obtained in the Final Trials of First Year of Evaluation and Final Trials of Second Year of Evaluation 2006/2007.
[2]MSGE: Mean square for the interaction genotypes x environments.
[3]CV: Coefficient of variation (%).
[4]General mean, in kg ha$^{-1}$

Despite the acceptable values of CV, Scott-Knott test at 5% of probability only detected significant differences between genotypes when the distance between such means was very large (Table 2). In most cases, genotypes did not differ from each other for the two evaluated traits, as reported by Embrapa Soja (1996, 1997, 1998, 1999, 2000). Due to the absence of differences for this test, genotypes had been indicated through the comparison of the performance of each one of them in relation to the mean of the experimental controls. Therefore, the material whose general mean was higher than the controls was recommended. The discrimination of genotypes through this criterion is more rigorous than the one based on the Duncan's test, resulting in a smaller group of selected genotypes. This criterion is used by the

Brazilian Ministry of Agriculture, Cattle and Supplies for the new soybean, wheat and beans cultivar registration (Ministério da Agricultura, 2006), but it is important to emphasize that no criterion has been established yet for sunflower.

**Table 2.** Means of sunflower genotypes evaluated in the National Sunflower Trials, coordinated by Embrapa, 2005/2006 and 2006/2007, for grain and oil yields (kg $ha^{-1}$).

| Grain yield (kg $ha^{-1}$) | | | | | | |
|---|---|---|---|---|---|---|
| Genotype | Mean | Ijuí[1] | Campo Mourão[1] | Encruz. do Sul[2] | Santa Rosa[2] | Passo Fundo[2] |
| M 734 (H)[3,4] | 2,553 a[6] | 2,390 (1) | 2,220 (4) | 2,360 (4) | 2,975 (1) | 2,821 (3) |
| HELIO 253 (H) | 2,498 a | 1,651 (7) | 2,093 (6) | 2,865 (1) | 2,847 (2) | 3,034 (1) |
| HELIO 360 (H) | 2,427 a | 1,768 (6) | 2,456 (1) | 2,692 (2) | 2,562 (6) | 2,655 (5) |
| EXP 1441 (H) | 2,349 a | 2,126 (2) | 2,232 (3) | 2,197 (6) | 2,642 (5) | 2,547 (6) |
| BRSGira 06 (H) | 2,323 a | 1,833 (5) | 2,243 (2) | 1,971 (7) | 2,775 (3) | 2,793 (4) |
| Agrobel 960 (H)[4] | 2,183 a | 1,548 (9) | 2,127 (5) | 2,202 (5) | 2,644 (4) | 2,393 (7) |
| HELIO 362 (H) | 2,183 a | 1,440 (11) | 1,923 (7) | 2,363 (3) | 2,292 (7) | 2,896 (2) |
| BRSGira 05 (H) | 1,918 b | 1,949 (3) | 1,819 (10) | 1,845 (9) | 1,903 (10) | 2,074 (13) |
| BRSGira 07 (H) | 1,886 b | 1,877 (4) | 1,653 (12) | 1,927 (8) | 1,819 (12) | 2,154 (11) |
| Catissol (V) | 1,775 b | 1,590 (8) | 1,822 (9) | 1,533 (12) | 1,959 (8) | 1,970 (15) |
| BRSGira 04 (H) | 1,747 b | 1,493 (10) | 1,917 (8) | 1,668 (11) | 1,534 (14) | 2,122 (12) |
| BRSGira 02 (V) | 1,687 b | 957 (14) | 1,750 (11) | 1,777 (10) | 1,657 (13) | 2,294 (8) |
| BRSGira 01 (V) | 1,531 b | 998 (13) | 1,075 (15) | 1,516 (13) | 1,905 (9) | 2,159 (10) |
| Embrapa 122 (V)[5] | 1,510 b | 1,351 (12) | 1,416 (13) | 1,263 (15) | 1,240 (15) | 2,280 (9) |
| BRSGira 03 (V) | 1,473 b | 927 (15) | 1,088 (14) | 1,428 (14) | 1,855 (11) | 2,066 (14) |
| GM[7/] | 2,003,16 | 665 | 887 | 950 | 961 | 1,095 |
| CHM[7/] | 2,368,4 | - | - | - | - | - |
| CVM[7/] | 1,510,4 | - | - | - | - | - |

| Oil yield (kg.$ha^{-1}$) | | | | | | |
|---|---|---|---|---|---|---|
| Genotype | Mean | Ijuí[1] | Campo Mourão[1] | Encruz, do Sul[2] | Santa Rosa[2] | Passo Fundo[2] |
| EXP 1441 (H)[3] | 1,136 a[6] | 942 (1) | 1,140 (2) | 1,123 (3) | 1,259 (2) | 1,218 (4) |
| HELIO 360 (H) | 1,129 a | 751 (5) | 1,176 (1) | 1,354 (1) | 1,162 (6) | 1,202 (5) |
| HELIO 253 (H) | 1,127 a | 684 (7) | 1,003 (5) | 1,353 (2) | 1,284 (1) | 1,312 (1) |
| Agrobel 960 (H)[4] | 1,035 a | 683 (8) | 1,061 (3) | 1,094 (5) | 1,204 (4) | 1,131 (6) |
| BRSGira 06 (H) | 1,027 a | 712 (6) | 1,059 (4) | 910 (9) | 1,193 (5) | 1,259 (3) |
| M 734 (H)[4/] | 1,019 a | 915 (2) | 928 (7) | 964 (6) | 1,208 (3) | 1,080 (8) |
| HELIO 362 (H) | 977 a | 601 (11) | 887 (9) | 1,096 (4) | 996 (7) | 1,306 (2) |
| BRSGira 05 (H) | 893 b | 821 (3) | 895 (8) | 951 (7) | 844 (9) | 956 (12) |
| BRSGira 04 (H) | 864 b | 664 (9) | 986 (6) | 880 (10) | 718 (13) | 1,071 (9) |
| BRSGira 07 (H) | 855 b | 752 (4) | 827 (11) | 931 (8) | 818 (12) | 948 (13) |
| Catissol (V) | 780 b | 662 (10) | 829 (10) | 694 (13) | 821 (11) | 895 (15) |
| BRSGira 01 (V) | 771 b | 485 (13) | 558 (14) | 811 (12) | 891 (8) | 1,107 (7) |
| BRSGira 02 (V) | 751 b | 386 (14) | 827 (12) | 854 (11) | 690 (14) | 1,001 (11) |
| BRSGira 03 (V) | 665 b | 381 (15) | 506 (15) | 670 (14) | 838 (10) | 930 (14) |
| Embrapa 122 (V)[5/] | 646 b | 540 (12) | 629 (13) | 563 (15) | 495 (15) | 1,003 (10) |
| GM[7/] | 912 | 665 | 887 | 950 | 961 | 1,095 |
| CHM[7/] | 1,027 | - | - | - | - | - |
| CVM[7/] | 646 | - | - | - | - | - |

[1]Final Trials of the First Year of Evaluation 2005/2006.
[2]Final Trials of the Second Year of Evaluation 2006/2007
[3] H: hybrid, V: open pollinated variety.
[4]Test genotype to compare hybrids.
[5]Test genotype to compare open pollinated variety.
[6]Means followed by the same letter did not differ significantly by the Scott-Knott test ($P \leq 0.05$).
[7]MG = General mean; CHM= Control hybrids mean; CVM = Control open pollinated varieties mean.

The hybrids selected for having presented superior general means in relation to the mean of controls for grain yield were HELIO 253 and HELIO 360 (Table 2). The hybrids EXP 1441, HELIO 253 and HELIO 360 showed the best performances for oil yield. Thus, only the hybrids HELIO 253 and HELIO 360 presented good results for both evaluated traits. The open pollinated varieties selected for having presented superior general means in relation to the mean of controls for grain yield were Catissol, BRSGira 02 and BRSGira 01 (Table 2). All the open pollinated varieties presented better performances for oil yield than the controls. When a genotype is superior for only one of these characteristics, the choice of cultivars to be sown by farmers should be based on the commercial policy practised by sunflower industry. Currently, genotypes with oil contents above 40% receive a bonus at the moment of purchasing. Therefore, the higher the bonus, the greater the preference for genotypes with outstanding oil content instead of giving priority to grain yield.

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