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SELECTION OF NEW SUNFLOWER (*Helianthus annuus* L.) SYNTHETIC VARIETIES ADAPTED FOR PRODUCTION AREAS OF MOZAMBIQUE

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SUMMARY

In Mozambique, there exist large differences in soil and climatic conditions, but it is the particular farming system (a subsistence type) that principally justifies the use of varieties on which this program of sunflower genetic improvement focuses.

The present the program involved the selection of a series of experimental populations with different characteristics. Comparative tests were performed at the experiment station of the Instituto Nacional de Investigação Agronómica (INIA) in Umbeluzi (Mozambique). The different susceptibilities to rust (*Puccinia helianthi*) and charcoal rot (*Sclerotium bataticola*), by which it is possible to distinguish the different synthetics, are discussed in relation to the different source material and to the possibilities of performing new cycles of recurrent selection.

Key words: **Mozambique, *Puccinia helianthi, Sclerotium bataticola,* sunflower, synthetic varieties**

INTRODUCTION

Sunflower (*Helianthus annuus* L.) crop was introduced in Mozambique by the Portuguese in the 1960's. The first cultivated area was located in the central province of Manica (Honwana, 1996). In Mozambique, sunflower is usually grown as a summer (January-June) and winter (August-December) crop following cotton, corn and sorghum cultivation. Local populations, coming from open pollinated varieties

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like Record and Black Record, often represent the only seed source for farmers (Davolio Marani *et al.*, 1999). Studies on genetic improvement for sunflower cultivation in Mozambique have been carried out by Olivieri *et al.* (1999), Vannozzi and Baldini (1999) and Zazzerini *et al.* (1999). The results obtained indicate that drought and disease resistance are important limiting factors. Considering that large differences exist in climate and agricultural farming systems, genetic improvement for the constitution of open pollinated varieties may be a good strategy for developing this crop in the country. Varieties have better adaptation ability and may tolerate the different climatic conditions while the costs of their seed production are lower than those required for hybrid seed production. The aim of this work was the improvement of sunflower productivity through the selection of synthetic varieties using new genetic sources.

MATERIAL AND METHODS

Table 1: Codes of source material

Code	Origin	Type
Fa1	Italy	B line
Fa2	Italy	B line
Fa3	Italy	B line
Fa4	France	B line
Fa5	France	B line
Fa6	France	B line
Fa7	Argentina	B line
Fa8	Argentina	B line
Fa9	Argentina	B line
Fa10	Argentina	B line
Rfa20	Australia	A×(a×r)
Rfa21	Australia	A×(a×r)
Rfa22	Argentina	A×(a×r)
Rfa23	Argentina	A×(a×r)
Rfa24	Argentina	A×(a×r)
Rfa25	Argentina	A×(a×r)

Sixty hybrid combinations obtained by crossing 10 maintainer lines with 6 different sunflower populations coming from six different experimental hybrids have been used to select the source material for our selection program. All genotypes used in the experiment were chosen from the sunflower collection of the Department of Crop Biology, Genetic Section, the University of Pisa (Italy). The selection was made for maximum exploitation of genetic variability (Cecconi and Baldini, 1991). Source material codes are given in Table 1.

Crosses were made on 2001 at the experiment farm of Pisa University. Plants of each maintainer line were emasculated and crossed with 6 experimental populations following North Carolina II mating system (Mather and Jinks, 1971).

On May 2002 at the INIA experimental farm in Umbeluzi (Maputo, Mozambique), the 60 hybrids were planted in 2 randomized blocks for comparison against the two best varieties used in Mozambique (Record and Black Record). The experimental unit was constituted of 3 rows 5 meters long planted 70 cm apart; interplant spacing was 25 cm. Data were collected in the central row for the following characters:

- I susceptibility to *P. helianthi* and *S. bataticola*,
- II plant height,
- III days to flowering,

IV days to physiological maturity,
V seed production.

Twenty plants from each cross were self-pollinated.

On the basis of the breeding value of the lines and the specific combining ability of each cross, 17 hybrids were selected.

The 340 progenies (20 for each selected hybrid) were used to perform the progeny test. Seeds of each progeny were subdivided in 2 parts: one part for progeny test, another for the constitution of synthetic varieties.

Progeny test 1. All 340 progenies were planted in single rows 5 m long with two replications on November 2002 at the INIA experiment farm in Umbeluzi. The progeny test was performed for the following characters:

I percentage of branching plants,
II susceptibility to *P. helianthi* and *S. bataticola*,
III plant height,
IV days to flowering.

The progenies that did not show segregation for branching were manually sib pollinated as follows: pollen was collected from 50% of the plants from each progeny and used to pollinate daily the remaining 50% of the same progeny.

Progeny test 2. On the basis of the first progeny test, 33 progenies with superior performance have been selected for the second evaluation test. For each progeny the seeds obtained by sib pollination procedures have been used. The trial was organized in 3 randomized blocks at the INIA experiment farm in Umbeluzi (Maputo) in July 2003, including commercial hybrids and varieties as testers. The experimental unit was constituted of 5 rows 7 m long planted 70 cm apart; interplant spacing was 25 cm. Data were collected in the 3 central rows for the following characters:

I susceptibility to *P. helianthi* and *S. bataticola*,
II plant height,
III days to flowering,
IV days to physiological maturity,
V seed production.

Pathological observations were made during grain filling.

Charcoal rot incidence caused by *S. bataticola* was calculated as percentage of plants showing stem desiccation.

Assessment of rust disease severity (percentage of infected leaf area by *P. helianthi*) was performed as described by Gulya *et al.* (1990). According to these authors, rust severity ranges from 0.1 to 40%; the pustules covering 40% of leaf surface in the latter case. Furthermore, rust severity was separately assessed on lower, middle and upper sunflower leaves.

Soil and crop management was performed according to the standard protocol used at the INIA experiment station. Fertilization was done with 12:24:12 NPK at the rate of 200 kg/ha, applied in one turn at seeding time. Water was supplied in the amount of field capacity soon after seeding and two more times during the growing season. All cultural practices from seeding to harvest were performed manually.

RESULTS AND DISCUSSION

The analysis of variance of the source material is reported in Table 2. The additive gene effects seemed to represent the major part of genetic variability for all analyzed characters with greater importance for the female lines (the mean squares values between females were higher than the mean squares values between males).

Table 2: Analysis of variance for the 6 agronomic traits (mean squares)

Source	Degrees of freedom	Seed yield (kg/ha)	Rust severity (i)	Charcoal rot incidence (ii)	Plant height (cm)	Days to flowering	Days to phys. maturity
Between males	5	21290.79**	1266.12**	7565.86**	8546.32*	644.04**	1794.85**
Between females	9	8060.87**	832.78**	2820.68**	6189.60*	377.87**	1228.67**
Male × female	45	2391.43	481.29**	1098.66*	4238.71**	155.76*	411.37*
Within families	60	1563.34	122.65	639.27	1843.76	88.32	256.21

(i) Rust severity is based on the percentage of leaf area infected (Gulya *et al.*, 1990)
(ii) Charcoal rot incidence is calculated as percentage of infected plants
* Significant at 0.05 level
**Significant at 0.1 level

The mean squares values for the male × female interaction provided an estimate of the dominance deviation effects: rust disease severity and plant height were more significant, indicating the importance of dominant genes for the genetic control of these characters. The male × female interaction was not significant for seed production, indicating that in that case, the observed genetic variability was determined only by the additive gene effects.

The breeding values of the source material calculated as the mean value of the half-sib families are reported in Table 3. As expected, seed production results negatively correlated with charcoal rot incidence (r=-0.72). Fungus attack began on the stem at flowering or soon after, resulting in early seed maturation and poor grain filling. Concerning the genetic origin of the source material, it could be noticed that the first 5 lines, those derived from French and Italian materials, were most susceptible. The line Fa10 was particularly interesting: all hybrids with this line showed no symptoms, presenting the stay green character of the stem till late after physiological maturity. The line Fa8 combined the best productivity result with a low level of susceptibility.

The negative correlation between rust severity and seed production was lower (r=-0.49), but significantly different from zero at 0.5 level (data not shown). In that case, the fungus attack began late after flowering, when grain filling was almost complete. Australian and Argentinean materials were best, particularly the line Fa8 (rust severity=1.12), all the hybrids obtained with this line showed very low rust symptoms.

Table 3: Breeding values for the 6 agronomic traits

Code	Seed yield (kg/ha)	Rust severity (i)	Charcoal rot incidence (ii)	Plant height (cm)	Days to flowering	Days to phys. maturity
Fa1	534.77	26.87	57.26	156.72	57.5	90.2
Fa2	400.45	15.91	45.29	160.39	56.7	87.5
Fa3	632.57	16.25	59.51	152.38	55.4	93.3
Fa4	500.31	14.76	60.97	140.52	62.8	95.3
Fa5	678.09	28.6	56.8	158.91	62.7	90.7
Fa6	1032.71	20.2	10.75	179.77	66.2	102.8
Fa7	1430.92	1.91	8.44	183.07	71.4	115.6
Fa8	1534.56	1.12	7.01	210.55	78.6	122.5
Fa9	980.45	4.26	28.27	197.34	65.2	101.7
Fa10	1372.67	2.99	0	220.41	70.4	114.1
PRfa20	980.32	20.4	36.5	166.30	67.2	100.5
PRfa21	749.56	15.63	45.62	163.71	71.7	103.7
PRfa22	980.72	18.92	33.09	165.35	65.2	102.9
PRfa23	1245.67	7.2	16.96	210.25	62.6	113.4
PRfa24	782.02	11.66	21.9	178.04	59.1	89.3
PRfa25	718.21	4.28	45.39	172.59	62.9	98.5
Record	623.63	18.71	10.63	210.43	84.4	125.0
Black Record	895.45	26.62	3.96	218.72	86.9	132.2
Mean	892.95	14.24	30.46	180.31	67.5	104.4
LSD	143.35	8.72	18.63	16.42	8.7	10.2
r. with Yield		-0.59	-0.74	0.64	0.39	0.59

(i) Rust severity is based on the percentage of leaf area infected (Gulya *et al.*, 1990)
(ii) Charcoal rot incidence is reported as percentage of infected plants

As far as the two local varieties are concerned it seems that both were less susceptible to *S. bataticola* than *P. helianthi*. The yields were near the average with superior performance of Black Record.

Taking the general mean as the lower limit for selection and combining the best performances for disease resistance and seed yield, it was possible to select 4 genotypes: the lines Fa7, Fa8 and Fa10 and the experimental population Prfa23. Among the 25 hybrids obtained with these lines, 17 were selected on the basis of specific combining ability (data not shown).

Twenty plants of each hybrid were used in the progeny test (see Material and Methods). As expected, about 50% of the progenies segregated for branching plants, in agreement with the origin of the 6 experimental populations used for the initial crosses. The behaviour of the genetic combinations made with the line Fa8 was particularly interesting: most of the progenies derived from this line were tolerant to *S. bataticola* and/or *P. helianthi* (data not shown). On the basis of these results it was possible to select 33 progenies without branching plants that showed superior performance with regard to both, *P. helianthi* and *S. bataticola* tolerance.

Table 4: Trial results for the 6 agronomic traits (mean values)

Code	Source	Seed yield (kg/ha)	Rust severity (i)	Charcoal rot incid. (ii)	Plant height (cm)	Days to flowering	Days to phys. maturity
MZT-1	(Fa6 × Prfa20)-4	759.33	2.89	8.12	176.34	67.3	105.4
MZT-2	(Fa6 × Prfa23)-11	853.64	4.73	15.36	182.55	70.2	105,1
MZT-3	(Fa7 × Prfa22)-8	602.32	2.94	25.48	193.69	75.4	105.5
MZT-4	(Fa7 × Prfa23)-3	804.72	1.02	7.47	188.41	74.7	108.3
MZT-5	(Fa7 ×Prfa23)-16	734.67	4.13	16.23	190.18	73.1	105.9
MZT-6	(Fa7 × Prfa25)-2	567.33	1.93	32.12	178.61	69.0	104.0
MZT-7	(Fa8 × Prfa20)-7	863.33	0.6	2.98	193.57	70.8	107.6
MZT-8	(Fa8 × Prfa20)-13	1108.67	0.77	6.71	203.49	73.5	104.9
MZT-9	(Fa8 × Prfa21)-11	962.67	2.29	11.73	201.57	73.2	105.7
MZT-10	(Fa8 × Prfa22)-1	1230.67	1.12	2.9	183.94	76.8	111.3
MZT-11	(Fa8 × Prfa22)-18	830.67	0.69	22.83	196.76	69.5	101.8
MZT-12	(Fa8 × Prfa23)-1	1308.64	1.0	5.69	211.62	68.1	105.7
MZT-14	(Fa8 ×Prfa23)-8	961.08	1.08	16.47	206.85	78.4	106.2
MZT-15	(Fa8 × Prfa23)-12	1433.33	0.72	3.62	203.59	74.7	104.4
MZT-16	(Fa8 × Prfa23)-19	767.33	1.27	18.77	193.62	72.2	105.5
MZT-17	(Fa8 × Prfa24)-6	1045.86	5.14	14.82	207.13	72.6	118.1
MZT-18	(Fa8 × Prfa24)-12	935.44	4.64	8.58	190.86	75.6	118.0
MZT-19	(Fa8 × Prfa25)-16	1238.82	2.48	7.35	210.59	80.8	119.1
MZT-20	(Fa8 × Prfa25)-20	1080.67	0.91	2.96	196.51	84.1	120.8
MZT-21	(Fa9 × Prfa22)-8	1317.33	2.58	1.83	205.63	75.4	105.4
MZT-22	(Fa9 × Prfa22)-17	802.67	5.44	25.39	183.81	77.4	113.2
MZT-23	(Fa9 × Prfa23)-4	884.67	0.72	16.57	210.39	81.6	119.9
MZT-24	(Fa9 × Prfa23)-14	897.33	1.11	8.49	201.48	80.7	120.0
MZT-25	(Fa10 × Prfa20)-2	791.33	3.75	21.04	208.42	76.5	113.7
MZT-26	(Fa10 × Prfa20)-5	928.67	6.29	7.8	205.81	80.0	115.2
MZT-27	(Fa10 × Prfa22)-11	1277.33	8.74	4.63	211.52	79.9	119.3
MZT-28	(Fa10 × Prfa22)-20	700.24	2.29	26.71	198.73	84.6	120.6
MZT-29	(Fa10 × Prfa23)-3	1103.33	1.88	3.02	220.12	80.2	108.9
MZT-30	(Fa10 × Prfa23)-7	773.33	8.42	15.6	215.96	70.9	105.0
MZT-31	(Fa10 × Prfa23)-15	637.33	6.98	21.82	207.71	76.0	113.4
MZT-32	(Fa10 × Prfa24)-8	695.33	4.41	17.4	201.96	69.7	105.1
MZT-33	(Fa10 × Prfa24)-12	474.67	1.11	31.52	210.84	67.1	105.4
SFZ-3-02	Semoc Hybrid	748.67	1.76	2.77	174.78	72.9	103.2
SFZ-4-02	Semoc Hybrid	954.34	1.9.0	8.13	169.11	69.5	102.7
Ala	Italian Variety	899.33	10.42	35.82	185.72	71.3	104.8
Black Record	Local Variety	538.67	7.18	5.02	221.83	79.6	118.4
Record	Local Variety	400.24	13.2	7.24	215.55	87.8	119.3
Mean value		889.57	3.47	13.27	198.89	75.2	110.25
LSD		117.57	0.73	5.2	14.34	4.76	5.34
r. with Yield			-0.28	-0.55	0.11	0.05	0.02

(i) Rust severity is based on the percentage of leaf area infected (Gulya *et al.*, 1990)
(ii) Charcoal rot incidence is reported as percentage of infected plants

These progenies were manually sib pollinated. The resulting 33 experimental populations were compared against commercial hybrids and open pollinated varieties as testers. These results are reported in Table 4.

Charcoal rot susceptibility was very low for all varieties indicating the goodness of the selection methods: only the Italian variety ALA had more than 35% of plants with *S. bataticola* attack. Higher variability was found for susceptibility to *P. helianthi*, the best source material resulting from the line Fa8, in agreement with the results of the first progeny test.

Variability for seed production was high, from 400 to 1433 kg/ha. The local variety Record performed much below the trial mean values: it had poorest seed production and highest rust resistance. The productivity of the other two varieties, Black Record and ALA, was near the trial mean. Yields of the two commercial hybrids were not as high as expected. Their earliness may explain the low performance. Their productivity potential has probably not been expressed because of the poor cultivation inputs used at the INIA experiment farm. It is worth noting that this is the normal situation in Mozambique, especially in many central and northern areas, where fertilization is not a normal practice and in this situation productivity potential may be better expressed by open pollinated varieties.

It is interesting to note that the best result was achieved by the combination of the line Fa8 and the experimental population Prfa23, which is in agreement with the results of the first progeny test. The 10 genotypes with the yield significantly higher than the trial mean have been used to constitute 4 synthetic varieties: UEM-1, which included all the genotypes, UEM-2, which included only (Fa8 × Prfa23)-12 (code MZT-15 in Table 4), UEM-3, which combines equal amounts of MZT-8, MZT-10, MZT-15, MZT-17, MZT-19 and MZT-20, and UEM-4, which combines equal amounts of MZT-21, MZT-27 and MZT-29. At present these 4 synthetic varieties are planted in multiplication plots at the INIA experiment station in Maputo. The next step of the program will be their evaluation in different localities of Mozambique, particularly in the provinces of Tete, Manica and Nampula where sunflower is traditionally cultivated.

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SELECCIÓN DE NUEVAS VARIEDADES SINTÉTICAS DE GIRASOL (*Helianthus annuus* L.) ADAPTADAS A LAS CONDICIONES DE CULTIVO EN MOZAMBIQUE

RESUMEN

En Mozambique existen grandes diferencias en las condiciones pedoclimáticas, pero no obstante, el sistema de labranza (labranza mínima) es el sistema que en el primer rango determina el modo de utilización de las variedades en cuya selección está orientado el programa del mejoramiento genético de girasol que se está considerando en este elaborado.

Actualmente, el programa se está realizando por medio de selección de poblaciones experimentales, que poseen diferentes características. Los ensayos comparativos fueron realizados en la estación experimental del Instituto Nacional de Investigaciones Agronómicas (INIA) ubicado en el lugar Umbeluzi (Mozambique). Diferentes niveles de sensibilidad hacia la roya negra de girasol (*Puccinia helianthi*) y la podredumbre carbonosa (*Sclerotium bataticola*), sobre la base de los cuales resulta posible diferenciar las variedades sintéticas investigadas, se consideran en relación con diferentes materiales iniciales y las posibilidades de sacar nuevos ciclos de selección recurrente.

SÉLECTION DE NOUVELLES SORTES DE TOURNESOL DE SYNTHÈSE (*Helianthus annuus* L.) ADAPTÉES AUX CONDITIONS DE CULTURE DU MOZAMBIQUE

RÉSUMÉ

En Mozambique, il existe de grandes différences dans les conditions pédologiques et climatiques mais c'est tout de même le système agricole (culture minimale) qui détermine la manière d'utiliser les variétés sur lesquelles se penche ce programme d'amélioration de la génétique du tournesol.

En ce moment, le programme est effectué par la sélection de populations expérimentales qui possèdent différentes caractéristiques. Les tests comparatifs sont faits à la station expérimentale de l'Institut national de recherche agronomique (INIA) située dans la localité de Umbeluzi, Mozambique. Différents niveaux de sensibilité à la rouille (*Puccinia helianthi*) et à la pourriture du charbon (*Sclerotium bataticola*) qui permettent de distinguer les différentes variétés synthétiques sont observés en relation avec différents matériaux initiaux et la possibilité d'effectuer de nouveaux cycles de sélection récurrente.