YIELD EVALUATION OF SUNFLOWER GENETIC RESOURCES IN RELATION TO WATER SUPPLY

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I INTRODUCTION

Sunflower breeders deal with a lack of variability for drought tolerance in the cultivated germplasm of *Helianthus annuus* (RAWSON and BEGG, 1980, a and b). The interest of wild relative species, mainly annual *Helianthus*, for this breeding purpose have been assessed. *H. argophyllus* is of interest for its vigour, its high leaf area duration and its low foliar desiccation (SERIEYS, 1991). Other annual species, like *H. anomalus, H. niveus* or *H. debilis* present an high water use efficiency (SERIEYS, 1993). In this programme, the INRA breeding team of Montpellier studied more accurately interspecific issues from annual species crossed with cultivated types for their drought tolerance.

II MATERIAL AND METHODS

1 Material

We tested hybrids whose female parent were inbred lines: HA89 and 887. The list of male parents from INRA Montpellier in Table 1. They are divided into cultivated and inter specific genotypes, polymorphic gene pools and inbred lines. They were compared with inbred lines from Arlesa Semillas : 138, 1801, 1802,1813, 2082, 2802, 2803, 2804, 2806, 2807, 3802, 852, 880 and 890. We tested also two inbred lines from Udine, Baccara 5 and Baccara 41, only in 1994 at Montpellier

2) Treatments and design.

Trials were performed at INRA breeding stations of Montpellier and Toulouse in 1993 and 1994, both in rainfed and irrigated fields.

At Montpellier in 1993, the plants were sown on 20th April at a density of 8 pl/m2; the so-called rainfed plots got just 20 mm irrigation after flowering, while watered plots got weekly 40 mm irrigation from bud appearance to physiological maturing. The plants were harvested between 1st and 13th September. In 1994, the plants were sown on 6th April at a density of 6.7 pl/m2; rainfed plots got quite no irrigation and watered plots received twice 30 mm irrigation from bud appearance to 5 cm bud stage, then weekly 40 mm from this stage to physiological maturing. The plants were harvested fully mature between 25 September and 10th October.

At Toulouse in 1993, the plants were sown on 8th April at a density of 6.2 pl/m2; rainfed plots received no irrigation while watered plots got once 35 mm irrigation at flowering. The plants were harvested on 8 and 9th September. In 1994, the plants were sown on 27th April at the same density; the so-called rainfed field received 27mm irrigation at flowering while the watered plots received 40mm irrigation at bud stage, then 40 mm irrigation at flowering and 40mm two weeks later. The harvest took place in September.

For each year, each treatment and each location, all hybrids were grown with three replications according to lattice designs.

GENOTYPES FROM INRA MONTPELLIER		
genotype code	type	origin
T+	gene pool	*Helianthus annuus* * *H. argophyllus*, selected for high foliar desiccation (SERIEYS, 1991)
T-	gene pool	*H. annuus* * *H. argophyllus*, selected for low foliar desiccation (SERIEYS, 1991)
Arg-rec	gene pool	*H. annuus* * *H. argophyllus*, selected for general combining ability through recurrent selection
AA\7.2.4	inbred line	*H. annuus* * *H. argophyllus*, from the Arg-rec gene pool
Ann-ano	gene pool	*H. annuus* * *H. anomalus*
PNRM 6.5.1	F4 family	*H. annuus* * *H. anomalus, in vitro* selected on a mannitol medium (AZPIROZ *et al.*, 1988)
Ann-nit	gene pool	*H. annuus* **H. niveus tephrodes*
91T608	inbred line	*H. annuus* **H. niveus tephrodes*
91T622	inbred line	*H. annuus* * *H. niveus canescens*
Deb-Deb	gene pool	*H. debilis debilis* * *H. annuus*
89-1471-12	F3 family	*H. debilis debilis* * *H. annuus*, from the Deb-Deb gene pool
Gizzeh 91	gene pool	Gizzeh and Gabbes populations, North Africa, H. argophyllus
Gizzeh 53-3	gene pool	maternal issue from a plant from the Gizzeh 91 gene pool
89B1	inbred line	pedigree including a cross with *H. praecox Runyonii*
89B2	inbred line	pedigree including a cross with *H. niveus canescens*

3) Traits measured

We measured an estimated leaf area index (LAI) on each plot after the method described by POUZET and BUGAT (1985), dry matter grain yield and oil content in percent (measured by NMR)

III RESULTS

1) Influence of water stress

In 1993, a severe and early water stress occurred in Montpellier in rainfed fields, which strongly reduced LAI (Figure 1), and thus grain yield (Figure 2). Watering at grain filling had increased slightly oil content in "rainfed", compared to the irrigated control (Figure 3). In Toulouse, almost not water stress provided any effect on grain yield (Figure 2) and on oil content (Figure 3).

In 1994, water stress occurred moderately and late in Montpellier. It affected weakly LAI (Figure 1) and yield (Figure 2), but oil content was strongly reduced (Figure 3) . In Toulouse, water stress occurred severely and affected also the irrigated field considering yield (figure 2) and oil content (Figure 3).

2) Ranking of tested varieties

Years, locations and treatments effects were highly significant (Table 2), so that genotype, genotype*treatment and genotype*location effects for yields. For oil content, all effects were also highly significant, excepted genotype*year interaction (although significant at $p<0.05$).

TABLE 2 : ANALYSIS OF VARIANCE ON 1993 AND 1994

	Grain yield	Oil content
treatment	***	***
year	***	***
location (year)	***	***
genotype*treatment	***	*
genotype*year	***	***
genotype*location(year)	***	***

***=P<0.001, *=P<0.05

We present here the ranking of germplasm tested through their average value in combination with HA89 and 887. The cultivated line 83HR4 is used as control.

In rainfed (table 3), the best male parents for yield were 83HR4, AA\7.2.4, Arg-rec, 2803 and T-. Oil content of AA\7.2.4 and 2803 was high, but this can be partly due to the male sterility of their hybrids combinations. On the opposite, oil content of T- hybrids was lower than of 83HR4 ones.

In irrigated (table 4), the best male parents for yield were AA\7.2.4, Baccara 5, 852, Gizzeh91 and 83HR4. AA\7.2.4 yielded significantly more than 83HR4. Gizzeh91 had a low oil content.

In average of rainfed and irrigated, the best male parent for yield were AA\7.2.4, 83HR4, Gizzeh91, Arg-rec, and 880 (table 5), although we found again the low oil content of Gizzeh91.

When we consider the dry/irrigated ratio (figure 4), the most interesting parents were actually low yielding germplasms. Among high yielding parents, Arg-rec (n°27) and 2803 (n°11) were the most regular.

IV DISCUSSION AND CONCLUSION

In Montpellier, the trials were performed in different fields in 1993 and 1994. In 1993, the water capacity of soil equalled 70 mm. In 1994, it was closed to 160 mm. In 1993, we just brought 20 mm watering on dry field to provide a relevant yield. In 1994, we got 50 mm rainfall at beginning of flowering, this induced a good yield, but was not sufficient to provide a high oil synthesis. This year, trials got enough water to provide a LAI of 2.8 which did not limit grain yield. In Toulouse, water availability in soil were also different between the two years. The meaning of rainfed and irrigated treatments has to be considered relatively to location and year.

The most interesting germplasms for drought tolerance were
-on one hand two cultivated lines used as parents of commercial hybrids, and known to give regular yielding combinations: 83HR4 bred by INRA and 2803 bred by Arlesa.
-on other hand germplasm derived from *Helianthus argophyllus* through several selection and intercrosses cycles: Arg-rec and its issue AA\7.2.4. Arg-rec is peculiarly interesting for its yield stability. In this case, we succeeded in introducing some drought tolerance in sunflower from a wild species.

Gizzeh91 is issued from North African landraces and *H. argophyllus*, and has to be improved for oil content. Other interspecific germplasm (from *H. debilis, H. anomalus, H. niveus*) can produce biomass, but they present a low ability to yield grain. Among this material, gene pools (Ann-nit, Deb-Deb) have to be submitted to moderate selection for productivity and oil content, and inbreds like PNRM 6.5.1 (from *H. anomalus*) can be used as genitors in crosses with elite lines.

This study was performed in the frame of an co-operation with University of Giessen (Germany), University of Udine (Italy), CNRS-IBMP of Strasbourg (France) and private companies Rustica Prograin Génétique (Blagnac, France) and Arlesa Semillas (Sevilla, Spain): "Improving water valorisation in sunflower by the creation of drought tolerant varieties".

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Figure 1 : LAI means in Montpellier

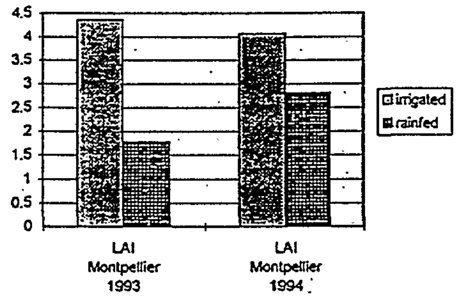


Figure 2 : Yield means in the four environments

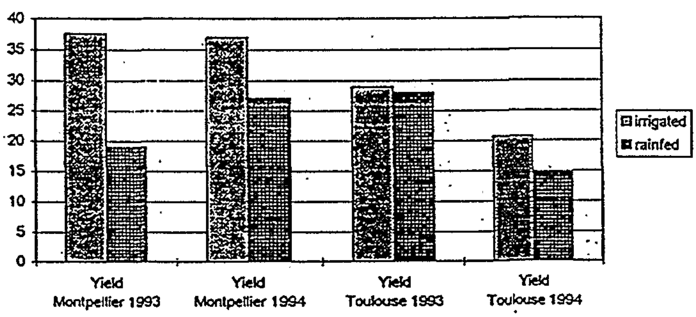


Figure 3 : oil content means in the four environments

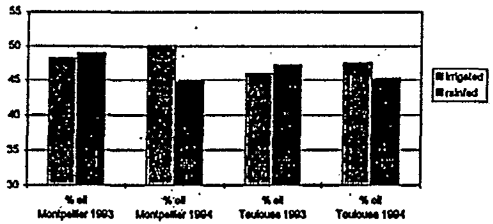
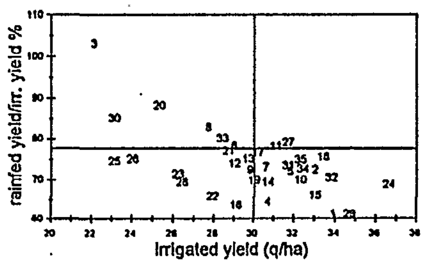


Figure 4 : yielding ability
and stability of studied gerplasm



ies of entries : 1 : 852, 2 :880, 3 : 890, 4 : 1801, 5 : 1802, 6 : 1803, 7 : 1813, 8 : 208 :2, 2801, 10 : 2802, 11 : 2803, 12 : 2804, 13 : 2806, 14 : 2807, 15 : 3081, 16 : 3802, 17 : 13B, : 83HR4, 19 : 89-1471-12, 20 : 89B1, 21 : 89B2, 22 : 91T608, 23 : 91T622, 24 : AA\7.2.4, Ann-ano, 26: Ann-nit, 27: Arg-rec, 28: Baccara 41, 29: Baccara 5, 30: Deb-Deb, Gizzeh 53-3, 32: Gizzeh 91, 33 : PNRM 6.5.1, 34: T+, 35: T-
rizontal line within figure corresponds to mean of rainfed/irrigated ratio (78.3%)
rtical line corresponds to mean of irrigated yield (29.9 q/ha)

TABLE 3: GENERAL COMBINING ABILITIES IN RAINFED

MALE PARENT	YIELD q/ha	≠83HR4	OIL %	≠83HR4
83HR4	25.3	NS	46.5	NS
AA\7.2.4	25.2	NS	49.2	+
Arg-rec	25.1	NS	46.9	NS
2803	24.4	NS.	50.8	+
T-	24.3	NS	45.5	-
Gizzeh91	23.8	NS	43.9	-
880	23.8	NS	48.0	+
T+	23.6	NS	44.9	-
Gizzeh 53-3	23.3	NS	44.6	-
13B	23.2	NS	52.2	+
2802	23.1	NS	51.7	-
2082	23.0	NS	50.2	+
1802	23.0	*	46.9	NS
890	22.9	NS	49.3	+
PNRM 6.5.1	22.8	*	42.5	-
1803	22.8	NS	46.5	NS
89B1	22.4	*	49.2	+
1813	22.4	*	48.1	+
2806	22.4	*	45.9	NS
89B2	22.2	*	48.4	+
3801	21.8	*	46.7	NS
2801	21.7	*	49.0	+
2804	21.5	*	50.7	+
2807	21.4	*	47.4	NS
Baccara5	21.3	*	45.3	NS
89-1471-12	21.1	*	46.3	NS
852	21.0	*	48.7	+
1801	19.8	*	45.8	NS
Deb-Deb	19.8	*	44.0	-
91T622	18.8	*	48.0	-
3802	18.5	*	47.8	NS
91T608	18.4	*	43.3	-
Baccara41	18.4	*	46.7	NS
Ann-nit	18.1	*	41.3	-
Ann-ano	17.3	*	44.0	-
FEMALE PARENT		≠HA89 p<0.05		≠HA89 p<0.05
887	22.7	*	46.7	*
HA89	21.2		47.4	

*: significant difference at p=0.05, + higher than 83HR4 (p<0.05), - lower than 83HR4 (p<0.05)

TABLE 4 : GENERAL COMBINING ABILITIES IN IRRIGATED

MALE PARENT	YIELD	≠83HR4 p<0.05	OIL ≠ 83HR4 p<0.05	
AA\7.2.4	36.7	+	51.7	+
Baccara5	34.8	NS	46.8	NS
852	34.3	NS	50.0	NS
Glzzeh91	33.9	NS	45.0	-
83HR4	33.5	NS	49.1	NS
3801	33.1	NS	49.1	NS
880	32.8	NS	50.0	NS
T+	32.5	NS	46.3	-
2802	32.4	NS	52.7	+
T-	32.4	NS	46.3	-
1802	31.9	NS	48.0	NS
Arg-rec	31.8	NS	48.5	NS
Glzzeh 53-3	31.8	NS	46.0	-
2803	31.2	NS	52.1	+
2807	30.8	NS	48.7	NS
1801	30.8	NS	49.2	NS
1813	30.7	NS	49.1	NS
13B	30.3	-	53.9	+
89-1471-12	30.1	-	49.1	NS
2801	29.9	-	49.6	NS
2806	29.8	-	46.8	-
3802	29.2	-	50.4	NS
2804	29.1	-	52.9	+
1803	29.1	-	46.9	-
89B2	28.8	-	50.4	+
PNRM 6.5.1	28.5	-	43.1	-
91T608	28.0	-	46.2	-
2082	27.8	-	51.5	+
Baccara41	26.5	-	48.9	NS
91T622	26.3	-	49.0	NS
89B1	25.4	-	50.4	+
Ann-nlt	24.1	-	41.9	-
Deb-Deb	23.2	-	44.5	-
Ann-ano	23.2	-	44.8	-
890	22.2	-	51.5	+
FEMALE PARENT		≠HA89 p<0.05		≠HA89 p<0.05
HA89	30.4		49.3	
887	29.4	*	47.9	*

ignificant difference at p=0.05, + higher than 83HR4 (p<0.05), - lower than 83HR4 (p<0.05)

TABLE 5: MEAN GENERAL COMBINING ABILITY

MALE PARENT	YIELD	≠83HR4 p<0.05	OIL	≠83HR4 p<0.05
AA\7.2.4	30.9	NS	50.4	+
83HR4	29.4	NS	47.8	NS
Glzzeh91	28.8	NS	44.4	-
Arg-rec	28.4	NS	47.7	NS
880	28.3	NS	49.0	+
T-	28.3	NS	45.9	+
T+	28.1	NS	45.6	-
2803	27.8	NS	51.4	+
2802	27.8	NS	52.1	+
Glzzeh 53-3	27.6	NS	45.3	-
Baccara5	27.6	NS	48.1	NS
852	27.5	NS	49.3	+
3801	27.4	NS	47.9	NS
1802	27.3	*	47.4	NS
13B	26.9	*	53.1	+
1813	26.4	*	48.6	NS
2807	26.2	*	48.0	NS
2806	26.0	*	46.3	-
2801	25.8	*	49.3	+
1803	25.8	*	46.7	NS
PNRM 6.5.1	25.7	*	42.8	-
89B2	25.7	*	49.4	+
89-1471-12	25.5	*	47.7	NS
2082	25.5	*	50.9	+
1801	25.2	*	47.5	NS
2804	25.2	*	51.8	+
89B1	24.2	*	49.8	+
3802	24.0	*	49.1	+
91T608	23.2	*	44.7	-
890	22.7	*	50.4	+
91T622	22.6	*	48.5	NS
Baccara41	22.3	*	47.8	NS
Deb-Deb	21.5	*	44.3	-
Ann-nlt	21.0	*	41.6	-
Ann-ano	20.3	*	44.4	-
FEMALE PARENT		≠HA89 p<0.05		≠HA89 p<0.05
887	26.1	NS	47.3	*
HA89	25.8		48.3	

*: significant difference at p=0.05, + higher than 83HR4 (p<0.05), - lower than 83HR4 (p<0.05)