HELIA, **21**, Nr. 28, p.p. 55-68, (1998) UDC 631.527.54:633.854.78

PERFORMANCE OF HIGH AND LOW OLEIC ACID HYBRIDS OF SUNFLOWER UNDER DIFFERENT ENVIRONMENTAL CONDITIONS. Note II

Salera E.[1], Baldini M.[2*]

[1] *Department of Agronomy and Agro-Ecosystem Management, Pisa University, via San Michele, 2, 56100 Pisa, Italy*
[2] *Crop Production Department of Udine University, via delle Scienze, 208, 33100 Udine, Italy*

Received: July 24, 1997
Accepted: March 30, 1998

SUMMARY

Trials were carried out in two years (1992 and 1993) and two different locations in the centre of Italy (Pisa and Grosseto) and the main objective was to evaluate the influence of four different environmental conditions (Pisa, 1992; Grosseto, 1992; Pisa, 1993 and Grosseto, 1993) and the effects of two different water availabilities (without and with irrigation) on six sunflower hybrids: Ares, Cisa, Granada and Oleica, with high oleic content and Gloriasol and Select, conventional hybrids (high linoleic), used as controls. The experimental scheme adopted was a split-block experimental scheme with 5 replications. The main yield characteristics, seed and oil yield, mechanical hull extraction and oil fatty acid profile were analyzed.

No significant difference in achene yield potential was observed among the hybrids analyzed in all environments, except at Pisa 1993, where, under high temperature during flowering period and limited water availability, the conventional hybrids showed higher yield potential than the high oleic hybrids. The high oleic hybrids showed a significant lower achene oil content than the Select. Of the high oleic hybrids present in the Italian national varieties register an influence of the different environments on fatty acid composition was found only in Ares, which presented an oleic acid content lower and more unstable than the other genotypes, with an elevated range of variability (about 14%) by its oleic content mean (72.3 %) calculated across environments and water managements. This confirms that the genetic control of the high oleic could be different among the genotypes analyzed. Achene mechanical dehullability was affected both by genetic characteristics and environmental conditions.

Key words: Sunflower, environmental conditions, oleic acid content, yield potential, mechanical hull extraction.

* Corresponding author

INTRODUCTION

Recently seed companies have been trading new high oleic hybrids in many countries of the world, encouraged by the results of many years of research that have underlined the important properties of this mono-unsaturated fatty acid. The properties of oleic acid are attributable partly to its good stability at the high temperatures involved in the cooking process and its low susceptibility to oxidation during the process of refining and preservation for use as a human foodstuff (Fuller *et al.*, 1967; Benvenuti and Vannozzi, 1988). In addition, oleic acid is also known to possess therapeutic properties such as the ability to reduce blood cholesterol levels, with a consequent decrease in the risk of coronary disease (Grundy, 1986; Grundy, 1989). High oleic oils from these new hybrids have also found interesting applications in various industrial processes (Bossio and Tronchi, 1990; Riva, 1992). Industry has therefore favored their diffusion by adopting incentives for farmers to produce oil seed with more than 80% oleic acid.

However, these hybrids often present the disadvantage of not maintaining over time the standard qualitative characteristics required by industry. Furthermore, their oleic acid content appears to be linked to certain important plant agronomic characters, with negative consequences on yield stability (Fernandez-Martinez *et al.*, 1993). The genetic inheritance of oleic acid content in sunflower has often given contrasting results; thus Fick (1984) reported a single dominant gene with partially dominant gene action with maternal effect; Urie (1985) a fully dominant gene action by a single dominant gene; Miller *et al.* (1987) a partially dominant gene and a modifier gene acting recessively and Fernandez-Martinez *et al.* (1989) two to three complementary dominant genes. These results indicate that the high oleic gene(s) utilized from different germoplasm sources and present in the new commercialized hybrids may also vary (Miller and Vick, 1995).

It is also well known that fatty acid composition is affected by environmental conditions, in particular by temperature during the oil accumulation period (Harris *et al.*, 1978; Goyne *et al.*, 1979; Silver *et al.*, 1984; Benvenuti *et al.*, 1984; George *et al.*, 1988; Merrien *et al.*, 1993). More specifically, a partially dominant gene for high oleic acts as a fully dominant gene under particular temperature conditions (Alonso, 1988), as confirmed by Tatini (1995), who showed that an increase in temperature from 10 to 20°C during grain-filling period produced an increment from 45% to 80% of oleic acid content in a genotype with a partially dominant gene.

Although sunflower is still most important for its oil content, improvement in the qualitative characteristics of its meal could represent an interesting proposal. An increase in meal protein content from the present 26-33% up to at least 40% could be obtained in modern sunflower if part (60%) of the hull were removed by the dehulling process prior to oil extaction (Burghart, 1992; Simic *et al.*, 1992; Denis *et al.*, 1994a). This would also lead to a notable decrease in fibre content (lignin and cellulose), thereby making the nutritional characteristics of sunflower meal very similar to those of soybean meal (Piva, 1992). Previous studies showed that achene dehulling is a highly complex character, in which numerous factors are involved. First, appropriate technology is required, and various seed pre-treatments and conservation methods may influence dehullability. Moreover both pedoclimatic conditions and husbandry practices, together with genetic influence, exert a considerable effect on the seed characteristics that determine sunflower hullability (Beauguillaume and Cadeac, 1992; Merrien *et al.*, 1992; Simic *et al.*, 1992; Denis *et al.*, 1994a; Denis *et al.*, 1994b; Baldini *et al.*, 1994).

For these reasons, further experiments are required to verify the qualitative and agronomic characteristics and yield potential of these new high oleic hybrids in different environments (Monotti *et al.*, 1994; Monotti *et al.*, 1995). The main aim of this research was therefore to evaluate the influence of different environmental conditions and the different water availabilities on qualitative and yield characters of high oleic acid sunflower hybrids as compared with conventional hybrids used as standard controls.

MATERIALS AND METHODS

The research was carried out at the Experimental Center of the University of Pisa, (latitude 43° and 41' North, longitude 10° and 23' East), and at the experimental farm of the Tuscan Agricultural and Forestry Development Board, near Grosseto (latitude 42° and 48' North, longitude 11° and 04' East).

The experimental scheme adopted was a split-block design with five replications. The effects of four different environments (Pisa, 1992; Grosseto, 1992; Pisa, 1993 and Grosseto, 1993) and two water managements (with and without irrigation) on the main characters of four high oleic sunflower hybrids (Ares, Cisa, Granada and Oleica) and two conventional hybrids (Gloriasol and Select) were evaluated. The latter hybrids were used as controls due to their high yield potential and stability in the above environments (Vannozzi *et al.*, 1990; Monotti *et al.*, 1995).

Plots were plowed after cereal harvest to a depth of 50 cm. The basal dressing consisted of 100 kg/ha of P_2O_5 and 80 kg/ha of K_2O. In addition, 120 kg/ha of N was distributed during seed bed preparation.

Sowing took place on April 15 at Pisa and April 14 at Grosseto in 1992, and on April 21 in both environments in 1993. In 1993, sowing was repeated on May 27 at Pisa due to adverse climatic conditions during the first sowing. All the experiments were thinned at 2-4 true leaves to the population of 5 plants/m^2. Each plot consisted of eight rows of plants, 9 m in length and interrow spacing was 50 cm. The irrigated treatments consisted of two irrigations of 50 mm each, the first at the flowering time of the hybrid Select and the second 15 days later.

The irrigated treatments received two irrigations of 50 mm each, the first at the flowering time (F_2 phase, as reported by Merrien, 1986) of the earliest hybrid (Select) and the second 15 days later.

An appropriate weeds control was done (Salera, 1991).

All observations were carried out on the four central rows of each plot, eliminating the last four plants at each end. Data on the following characteristics were obtained in each environment and from each replication:

• head diameter (HD) measured on ten randomly selected plants at maturity (mm);

• sterile area in the head (HSA), measured on ten randomly selected plants at maturity (%);

• seed number (SN) per head, calculated by thrashing ten randomly selected plants at maturity and counting full seed number;

• 1000 seeds weight (SW) (g);

• mechanical hull extraction (MHE). It was performed on seed with approximately 6-7% moisture content; by using a laboratory dehuller and a laboratory separator that divided dehulled products into three fractions: fine kernel fragments (smaller than 2.5 mm); industrial kernels (a mixture of kernels and partially hulled achenes); free hulls (hulls only) (%). This variable was analyzed and calculated from Baldini *et al.* (1994):

$$MHE = \frac{\text{weight of free hulls}}{\text{weight of sample before hulling}} \times 100$$

• grain yield per hectare (GYH). Yield (with 10% seed moisture) was obtained from the central 5 m of the two middle rows of the 8 rows per plots. Heads were hand harvested and thrashed (t/ha);

• oil percentage in the seed (OIL). Seed samples from harvested seed were dried to 0 % of moisture, and oil was determined by nuclear magnetic resonance (NMR) (%);

• oleic acid content (OAC) in the oil. Fatty acid composition was determined by gas chromatography, following the method adopted by Conte *et al.* (1989). A 10 seed- sample obtained by plant isolation at flowering was analyzed (%);

• oil yield per hectare (OYH). Seed yield was multiplied by seed oil percent (t/ha).

For analysis of variance, locations and years were combined and considered as environments. All data acquired were submitted to analysis of variance following an ANOVA model in accordance with the experimental design adopted.

RESULTS AND DISCUSSION

Yield and qualitative characters

Analysis of variance (Table 1) indicated significant differences in the main yield and qualitative characters among treatments, with the exception of mechanical hull extracted (MHE), which varied according to the water mamagement adopted (with or without irrigation), and oleic acid content, which varied according to the environment. The highest values of head diameter (HD) and the lowest values of the sterile area on the head (HSA) (Table 2) were founded in the environment Pisa 1992, where the elevated water availability during the sowing-flowering period (Salera and Baldini, 1998), permitted the accumulations the major amount of dry matter (Merrien *et al.*, 1981; Merrien, 1986). Water availability and elevated temperature during anthesis strongly influenced the HSA of the head, as confirmed at Pisa in 1993, where low water use (Salera and Baldini, 1998) corresponded to an increase in the HSA of the head (Table 2). Irrigation treatments determined a small increase in HD (+ 3%), but at the same time a strong reduction in the HSA of the head (- 69.9%) (Table 2). All hybrids showed a significant decrease in SN and the highest achene weight (SW) at Pisa 1993 (Table 2) (where the flowering period developed under high temperature and limited water availability) following a compensation process well known in sunflower (Merrien, 1986), with the exception of the high oleic hybrid Cisa (Table 2). An elevated SW was also found at Pisa 1992, due to the particular environmental conditions (Table 2). Heavy rainfall at Pisa in 1992 favoured fertilization of an elevated number of flowers, the development of many full achenes per head (SN) and at the same time, an elevated SW (Table 2).

The quantity of mechanically removed hull (MHE) was influenced by the different environmental conditions and by the environment x hybrid interaction. This interaction, shown in Figure 1, resulted in lower MHE of the hybrid Select as compared to the other genotypes, and gave the lowest value in the environment Pisa 1992 (14.8%). Select and Gloriasol showed a significant increase in MHE at Grosseto 1992 (18% for Select and 20.5% for Gloriasol). In this environment the high oleic hybrids Oleica, Cisa and Ares showed their lowest values of MHE (18%, 16.3% and 17.5 % respectively). MHE was intermediate in the Pisa 1993 environment, where no significant differences were found among hybrids with the exception of the hybrid Select, which presented the lowest value (16.5%). All hybrids showed an increase in MHE at Grosseto in 1993, where Select, Oleica and Cisa showed the lowest values (21.0%, 21.8% and 22.1% respectively). In 1993, Gloriasol presented the highest MHE (19.0% at Pisa and 24.5% at Grosseto), even though this value was not significantly different from the other hybrids. SW showed a negative correlation with MHE for the pooled data (-0.41**), across genotypes and treatments, in the four environments analysed (Table 4), apparently in contrast with the results obtained by Merrien *et al.* (1992), Denis *et al.* (1994b) and Baldini and Vannozzi (1996), who found positive or no correlation between SW and MHE. But when the

Table 1: Summary of statistical significance for treatment and interaction effects on qualitative and quantitative characters in sunflower hybrids

Source of variation	HD	HSA	SN	SW	MHE	GYH	OIL	OAC	OYH
Environments (E)	**	**	**	**	**	**	**	NS	**
Water management (W)	**	**	**	**	NS	**	**	NS	**
Hybrids (H)	**	**	**	**	**	**	**	**	**
E x W	**	**	*	**	NS	**	*	NS	**
E x H	**	**	**	**	**	**	**	**	**
W x H	NS	**	NS	**	NS	NS	NS	NS	NS
E x W x H	**	**	NS	NS	NS	NS	NS	NS	NS

*, ** $P < 0.01$ and 0.05 respectively. NS = not significant
HD= head diameter in mm; HAS= sterile area in the head in %; SN= seed number per head; SW= 1000 seed weight in g; MHE= mechanical hull extraction in %; GYH= achene yield in t/ha; OIL= oil content in the achene in %;OAC= oleic acid content in the oil in %; OYH= oil yield in t/ha

Table 2: Mean effects of environments, water management and hybrids on qualitative and quantitative characters in sunflower hybrids

Treatment	HD	HSA	SN	SW	MHE	GYH	OIL	OAC	OYH
Environment									
Pisa 1992	233 a	0.51 c	1149 a	63.6 b	19.5 b	4.01 a	47.1 c	70.7	1.70 a
Grosseto 1992	195 b	1.26 b	1015 c	54.4 c	18.5 b	3.01 c	48.3 b	70.5	1.31 c
Pisa 1993	194 b	1.76 a	665 d	75.5 a	17.9 b	2.79 d	49.4 a	65.9	1.25 c
Grosseto 1993	191 b	0.71 c	1094 b	55.3 c	22.7 a	3.34 b	49.0 ab	68.5	1.47 b
Water management									
Rainfed crop	200 b	1.63 a	957 b	60.9 b	20.2	3.14 b	47.9 b	68.7	1.36 b
Irrigated crop	206 a	0.49 b	1005 a	63.5 a	19.2	3.43 a	49.0 a	69.1	1.51 a
Hybrid									
Ares	191 e	0.82 c	786 d	68.5 a	19.7 b	2.96 d	46.9 d	72.3 d	1.25 d
Cisa	209 b	0.61 c	1046 a	60.7 d	19.5 b	3.40 b	47.8 c	80.5 c	1.46 b
Gloriasol	202 c	0.70 c	1051 a	59.4 e	20.5 a	3.38 b	49.2 b	42.1 f	1.49 b
Granada	197 d	1.45 ab	1082 a	56.9 f	20.8 a	3.26 c	47.2 d	83.5 b	1.38 c
Oleica	214 a	1.57 a	935 c	62.6 c	20.0 ab	3.20 c	47.4 cd	87.8 a	1.36 c
Select	206 bc	1.21 b	984 b	65.1 b	17.6 c	3.53 a	52.2 a	47.1 e	1.67 a

Means followed by the same letters do not differ significantly at the 5% probability level according to Duncan's multiple range test.
HD = head diameter in mm; HAS = sterile area in the head in %; SN = seed number per head. SW = 1000 seed weight in g; MHE = mechanical hull extraction in %; GYH = achene yield in t/ha; OIL = oil content in the achene in %; OAC = oleic acid content in the oil in %; OYH = oil yield in t/ha

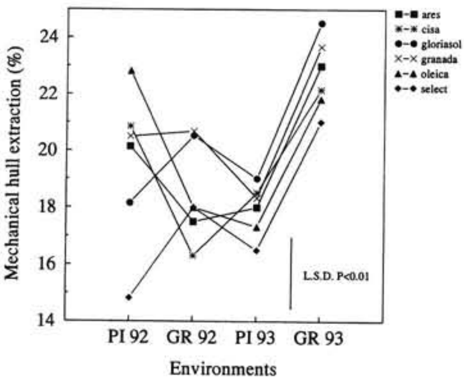

Figure 1: Effect of environment x hybrid interaction on mechanical hull extraction

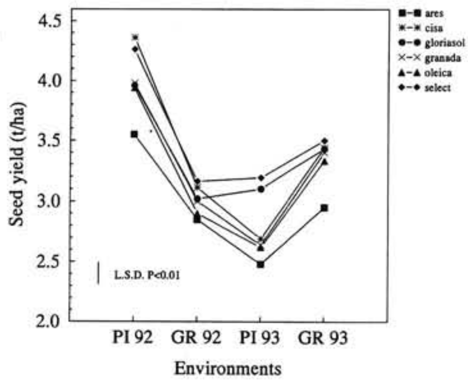

Figure 2: Effect of environment x hybrid interaction on achene yield.

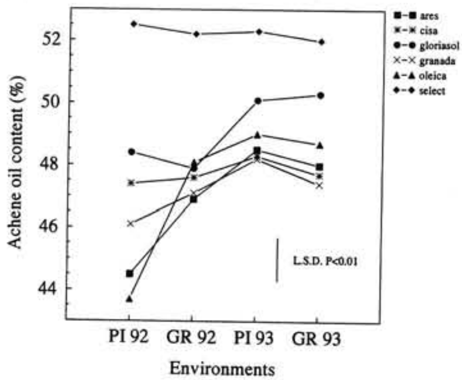

Figure 3: Effect of environment x hybrid interaction on achene oil content

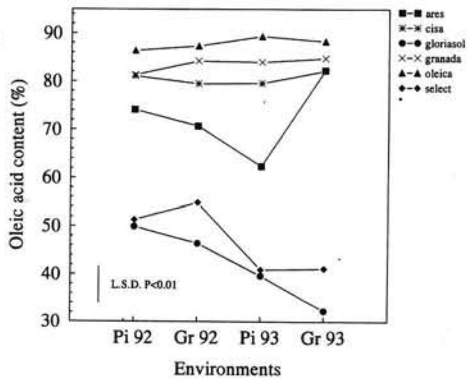

Figure 4: Effect of environment x hybrid interaction on oleic acid content

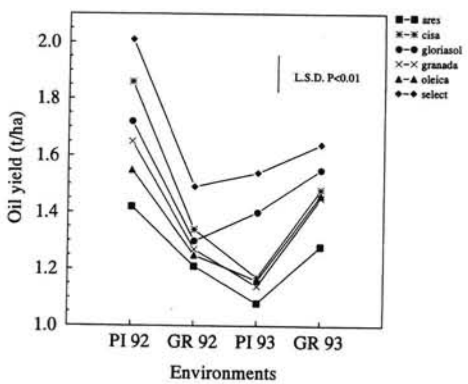

Figure 5: Effect of environment x hybrid interaction on oil yield

same relationship was made, for each environment, separately, the significative correlations disappear, with the exception of GR92 (-0.59**). Both this result and genotype x environment effect (Figure 1) could explain the very complicated expression of the dehullability character. In fact dehullability is related to many seed characteristics and in particular hull content, hull anatomy and seed density (all strictly related to seed weight) may explain differences in dehullability (Beauguillaume and Cadeac, 1992), corresponding to a genotypic effect. But the environment, both climatic conditions (mainly temperature) and crop management practices (water, nitrogen, date of harvest...) may have considerable effect of the expression of the above seed characteristics during the period of seed filling and maturation (Merrien *et al.*, 1992).

Seed yield per hectare (SYH) was very elevated at Pisa 1992, for both rainfed and irrigated crops (Table 3). But in the other environments, irrigation determined a significant increment in yield. The SYH obtained at Pisa 1993 (following the late sowing time) and at Grosseto 1992 under rainfed conditions was found to be the lowest of the trial. Generally all hybrids showed the highest SYH at Pisa 1992 (Figure 2) (mean 4.01 t/ha), a reduction at Grosseto 1992 (3.01 t/ha), a further reduction at Pisa 1993 (2.79 t/ha) and finally an increase at Grosseto 1993 (3.34 t/ha). An exception to this general behaviour was observed for Select and Gloriasol: these hybrids showed no decrease in SYH at Pisa 1993, and exhibited a higher SYH than the other hybrids in this environment (3.19 and 3.10 t/ha for Select and Gloriasol respectively). Of the high oleic hybrids, Cisa doesn't show differences in SYH as compared to Select, with the exception of Pisa 1993 (2.69 t/ha). In Ares, SYH was significantly lower than in the other genotypes in the environments of Pisa 1992 and Grosseto 1993.

Table 3: Effect of "environment x water management" interaction on same yield characters in sunflower hybrids

Environment		SW		GYH		OIL		OYH	
		R	I	R	I	R	I	R	I
Pisa	1992	64.9 b	62.2 c	4.09 a	3.92 b	46.4 c	47.8 b	1.71 a	1.69 ab
Grosseto	1992	51.1 e	57.7 d	2.76 f	3.26 d	47.2 c	49.4 a	1.17 f	1.45 c
Pisa	1992	75.4 a	75.6 a	2.72 f	2.85 e	49.2 a	49.6 a	1.22 ef	1.28 de
Grosseto	1993	52.3 e	58.4 d	3.00 e	3.68 c	48.9 a	49.1 a	1.32 d	1.63 b

Values followed by the same letter do not differ significantly at the 5% probability level according to Duncan's multiple range test.
R = rainfed crop; I = irrigated crop. SW= 1000 seed weight in g; GYH= achene yield in t/ha; OIL= oil content in the achene in %; OYH= oil yield in t/ha

Achene oil content (OIL) showed lower values at Pisa 1992 than in the other environments (Table 2). Irrigation treatments determined an increase in OIL in both trials of the 1992 and no effects in 1993 (Table 3).

Ares and Oleica presented significantly lower values (44.5% and 43.7% respectively) than the other hybrids in Pisa 1992, while Select showed constant and higher

OIL as compared to the other genotypes under all environments examined (mean value 52.2%), (Figure 3). The other conventional hybrid, Gloriasol, consistently showed higher OIL (50.2%) than the other high oleic hybrids at Grosseto 1993.

Analysis of the fatty acid composition of the two conventional hybrids showed that the oleic acid content (OAC) (Figure 4) decreased significantly, in particular in Select, from 1992 to 1993 in each environment (51.3% at Pisa in 1992 and 40.9 % in 1993; 54.8% at Grosseto in 1992 and 41.2% in 1993). Oleic acid accumulation, in conventional hybrids, was favored by elevated temperature that occurred during oil accumulation (grain-filling period) as reported by many authors (Harris *et al.*, 1978; Goyne *et al.*, 1979; Trémolieres *et al.*, 1982; Silver *et al.*, 1984), due to the effect of temperature on the activity of the desaturase enzymes which are responsible for the conversion of oleic to linoleic acid (Harris *et al.*, 1978). Among the high oleic hybrids, which present more stability in OAC with respect to conventional hybrids by the presence of specific genes, Oleica presented the most constant and elevated OAC in each environment (mean value 87.8%) and showed no significant differences from Granada (mean 83.5%). Cisa showed a lower OAC than Oleica, except at Pisa 1992. The OAC of Ares in the 1993 Grosseto environment (82%) was similar to that observed in the other hybrids, but in all other environments, the OAC of Ares was found to be significantly lower, with an elevated range of variability (about 14%) (Figure 4) by its OAC mean (72.3%) calculated across environments and water managements (Table 2).

Table 4: Phenotypic correlations between mechanical hull extraction (MHE) and 1000 seed weight (SW) in four environments

Variable	PISA92	GROSSETO92	PISA93	GROSSETO93	Pooled data
MHE - SW	-0.02 n.s.	-0.59**	-0.22 n.s.	-0.14 n.s.	-0.41**

Data are means across genotypes and treatments.
**, significant at $P < 0.01$ probability level; n.s., non-significant

Oil yield per hectare (OYH) showed the same behaviour as seed yield, discussed earlier, with the exception of Pisa 1993 (Table 3), where no significant difference in yield between rainfed and irrigated crops was observed.

The environment x hybrid interaction, shown in Figure 5, showed a significantly higher OYH in Select than the other hybrids in all environments (mean 1.67 t/ha), with the exception of Grosseto 1993, where yield in Gloriasol (1.55 t/ha) was similar to Select (1.65 t/ha). In these two hybrids used as controls, OYH was unaffected in Pisa 1993, where all other hybrids showed a significant yield reduction.

CONCLUSIONS

The greatest head diameter, lowest sterile area of the head, highest number of full seeds per plant and the greatest seed and oil yield were recorded under the environment with greatest water availability, Pisa 1992, as consequence of an elevated water use during the total crop cycle and as already reported by Salera and Baldini (1998). On the contrary the lowest seed and oil yield was found at Pisa 1993 (Table 2) where, due to a delayed sowing time, the flowering time and the grain-filling period occurred during high daily temperature and limited water availability (Salera and Baldini, 1998) and it caused a high degree of flower sterility and consequently a very limited full seed number per plant (Table 2).

Both the conventional hybrids showed greater seed yield potential and oil yield than the other genotypes at Pisa 1993 (Figure 2 and Figure 5), confirming the same considerations for the seed yield per plant made in note 1. At the same time the seed yield potential of Cisa, Granada and Oleica could be considered generally satisfactory in the other environments. Ares showed the lowest yield potential, due probably also to an inappropriate crop management practices adopted, especially in plant density, regarding to its semidwarf size with respect to the other genotypes (Salera and Baldini, 1988). Select exhibited constant and very high achene oil content in all environments, on the contrary this character has to be improved in all high oleic hybrids; especially in Ares and Oleica that exhibited a significantly low achene oil content in Pisa 1992 (Figure 3).

Oleic acid content of the conventional hybrids, used as controls, was found to be strongly affected by different environments, especially by temperatures in the various environments during the flowering-maturity period (Steer *et al.*, 1984). The hybrids Oleica, Granada and Cisa, as high oleic genotypes, confirmed a high and constant oleic acid level in the oil (respectively 87.8% , 83.5% and 80.5% as means) and were unaffected by the environment (Figure 4). In contrast, the oleic content of Ares was strongly influenced by the environment and showed a lower level than the minimum limits required by the current rules of the national varieties register, at Pisa 1993 (Figure 4). In this case, genetic control of high oleic is probably due to a major gene, which needs particular environmental conditions, above all as regards temperature, to give high oleic acid content (Alonso, 1988; Tatini, 1995). These results indicate that the high oleic gene(s) present in genotypes traded today may also vary (Miller and Vick, 1995).

Achene mechanical dehullability was affected by genetic x environmental interaction as reported by many authors (Merrien, *et al.*, 1992; Baldini *et al.*, 1994; Baldini and Vannozzi, 1996; Beguillaume and Cadeac, 1992; Denis *et al.*, 1994) and in particular seems to be of higher magnitude in some cultivars as Select, Gloriasol and Granada (Figure 1). The strong reduction of phenological periods (especially flowering-maturity period) at GR93, due to the combination of limited water supply and high temperature (Salera and Baldini, 1998), could be responsible of the elevated MHE (Table 2), as already reported by Merrien, (1992) that found that drought stress tended to result in higher dehullability.

REFERENCES

Alonso, L.C., 1988. Estudio genetico del caracter alto oleico en el girasol (*Helianthus annuus L.*) y su comportamiento a distintas temperaturas. Proc. 12th Int. Sunf. Conf., Novi Sad, vol.II, 454-462.

Baldini, M., Vannozzi, G.P., Cecconi, F., Macchia, M., Bonari, E. and Benvenuti, A., 1994. Genetic analysis of hullability in sunflower. Industrial Crops and Products, 3, 29-35.

Baldini, M. and Vannozzi, G.P., 1996. Crop management practices and environmental effects on hullability in sunflower hybrids. Helia, 19, 25, 47-62.

Beauguillaume, A. and Caceac, F., 1992. Elements of explication of the dehulling ability in sunflower. Proc. 13th Int. Sunf.Conf., Pisa, vol.2, 993-999.

Benvenuti, A. and Vannozzi, G.P., 1988. Obiettivi e risultati del miglioramento genetico del girasole. Proc. of "Stato attuale e prospettive delle colture oleaginose erbacee in Italia", Pisa, 24-26 febbraio, 49-68.

Bossio, B. and Tronchi, M., 1990. L'utilizzazione degli olii vegetali come combustibili per l'alimentazione dei motori diesel. Energie Alternative HTE, pp. 1-67.

Burghart, P., 1992. Tourneasol: le decorticage. Perspect. Agricoles, 169, 146-150.

Carre', P., Evrard, J., Burghart, P., Champolivier, L. and Merrien, A., 1994. Ameliorer l'aptitude des graines. CETIOM- Oleoscope n° 22, 16-21.

Conte, L.S., Leoni, S., Palmieri, S., Capella, P. and Lercker, G., 1989. Half-seed analysis: rapid chromatographic determination of the main fatty acids of sunflower seed. Plant Breeding, 102,158-165.

Denis, L., Dominguez, J., Baldini, M. and Vear, F., 1994 a. Genetical studies of hullability in comparison with other sunflower seed characteristics. Euphitica 79, 29-38.

Denis, L., Dominguez, J. and Vear F.a 1994 b. Inheritance of hullability in sunflowers (*Helianthus annuus* L.). Plant Breeding, 113, 27-35.

Fernandez-Martinez, J.A., Jimenez, A., Dominguez, J., Garcia, J.M. Garces, R. and Mancha, M., 1989. Genetic analysis of the high oleic content in cultivated sunflower (*Helianthus annuus* L.). Euphytica, 41,39-51.

Fernandez-Martinez, J.A., Munoz, J. and Gomez-Arnau, J., 1993. Performance of near-isogenic high and low oleic acid hybrids of sunflower. Crop Sci., 33, 1158-1163.

Fick G.N., 1984. Inheritance of high oleic acid in the seed oil of sunflower. Proc. Sunflower Research Workshop, Bismark. N.D., 9.

Fuller, M., Diamond, J. and Applewhite, T., 1967. High oleic safflower oil. Stability and chemical modification. J.Am.Oil Chem. Soc., 44, 264-267.

George, D.L., Mcleod, C.M. and Simson, B.W., 1988. Effect of seed position on fatty acid content in sunflower (*Helianthus annuus* L.) Australian Journal of Experimental Agriculture, 28, 629-633.

Goyne, P.J., Simpson, B.W., Woodruff, D.R. and Churchett, J.D., 1979. Environmental influence on sunflower achene growth, oil content and oil quality. Aust. J. Exp. Agric. Anim. Husb., 19, 82-88.

Grundy, S.M., 1986. Comparison of monounsaturated fatty acids and carbohydrates for lowering plasma cholesterol. The New England Journal of Medicine, vol. 314, 12, 745-748.

Grundy, S.M., 1989. Monounsatured fatty acids and cholesterol metabolism: implications for dietary recommendations. The Journal of Nutrition, 119,4, 529-533.

Harris, H.C., Mcwilliam, J.R. and Mason, W.K., 1978. Influence of temperature on oil content and composition of sunflower seed. Aust. J. Agric. Res., 29, 1203-1212.

Merrien, A., Blanchet, R. and Gelfi, N. 1981. Relationship between water supply, leaf area development and survival and production in sunflower. Agronomie, I, 917-922.

Merrien, A., 1986. Cahier tecnique tournesol. Phisiologie. CETIOM, Paris, pp. 1-47.

Merrien, A., Dominguez, J., Vannozzi, G.P., Baldini, M., Champolivier, L. and Carre', P., 1992. Factors affecting the dehulling ability in sunflower. Proc. 13th Int. Sunf. Conf., Pisa, vol.1, 260-267.

Merrien, A., Champolivier, L., Raimbault, J. and Evrard, J., 1993. Tournesol oleique: premiers facteurs de variation de la composition. Oleoscope, Bulletin CETIOM, 15, 17-19.

Miller, J.F., Zimmerman, D.C. and Vick, B.A., 1987. Genetic control of high oleic acid content in sunflower oil . Crop Sci., 27, 923-926.

Miller, J.F. and Vick, B.A., 1995. Effect of isolated vs. nonisolated on oleic acid content in hybrid sunflower. 17th Sunflower research workshop. Ed. NSA, 1-4.

Monotti, M., Bianchi, A.A., Bressan, M., Conti, D., Pirani, V., Del Pino, A.M., Cardone, A.M., Pino, S., Capitanio, R., Valoti, P. and Tanzi F., 1995. Adattamento, produttività e contenuto d'olio di varietà di girasole saggiate nel 1994 in ambienti dell'Italia centrale e settentrionale. L'Informatore Agrario, LI, 7, 33-46.

Piva, G., 1992. Nutritional value of sunflower seed and sunflower meal for livestock animal. Proc. 13th Int. Sunf. Conf., Pisa, vol. 2, 1611-1625.

Riva, G., 1992. Impiego energetico delle oleaginose: una soluzione fattibile?. L'Informatore Agrario, XLVIII, 42, 27-35.

Salera, E. 1991. Selective chemical weed control in sunflower crop. Results of three years of experimental period. Helia, 14, Nr.15, 87-100.

Salera, E. and Baldini, M. 1988. Performance of high and low oleic acid hybrids of sunflower under different environmental conditions. Note I. Helia, in press.

Silver, J.G., Rochester, C.P., Bishop, D.G. and Harris, H.C., 1984. Unsatured fatty acid synthesis during development of isolated sunflower (*Heliantus annuus* L.) seed. J. Exp. Bot., 35, 1507-1514.

Simić, D., Pantelić, Z.and Milovanović, M., 1992. Industrial testing of centrifugal decorticator. Proc. 13th Int. Sunf. Conf., vol. 2, 1600-1607.

Steer, B.T., Hocking, P.J., Kortt, A.A. and Roxburgh, C.M. 1984. Nitrogen nutrition of sunflower (*Helianthus annuus* L.): yield components, the time of their establishment and seed characteristics in response to nitrogen supply. Field Crop Res., 9, 219-236.

Tatini, W., 1995. Girasole alto oleico: influenza del genotipo e della temperatura sul contenuto in acido oleico. Sementi Elette, III/IV, 31-32.

Tremolieres, A., Dubacq, J.P. and Drapier, D., 1982. Unsaturated fatty acids in maturing seeds of sunflower and rape: regulation by temperature and light intensity. Phytochemistry, 21, 41-45.

Urie, A.L., 1984. Inheritance of very high oleic acid content in sunflower. Crop Sci., 25, 986-989.

Vannozzi, G.P., Salera, E. and Baldini, M., 1990. Risultati delle prove di confronto tra varietà di girasole eseguite in Toscana nel 1989. L'Informatore agrario, XLVI, 6-12.

COMPORTAMIENTO DE HÍBRIDOS DE GIRASOL CON ALTO Y BAJO CONTENIDO DE ÁCIDO OLÉICO EN DIFERENTES CONDICIONES AMBIENTALES. NOTA II

RESUMEN

Se realizaron ensayos a lo largo de dos años (1992. y 1993.) y en dos ubicaciones distintas en el centro de Italia (Pisa y Grosseto) y el principal objetivo fue evaluar la influencia de cuatro condiciones ambientales diferentes (Pisa, 1992.; Grosseto, 1993.) y los efectos de dos disponibilidades de agua distintas (con o sin riego) en seis híbridos de girasol: Ares, Cisa, Granada y Oleica, con un alto contenido oléico, y Gloriasol y Select, híbridos convencionales (alto contenido linoléico) utilizados como controles. Se adoptó un esquema experimental de bloques divididos, con 5 replicaciones. Se analizaron las principales características: producción de semillas y aceite, la extracción mecánica de la cáscara y el perfil de ácidos grasos en el aceite.

No se observó ninguna diferencia significativa en la posible producción de aquenios entre los híbridos analizados en todos los ambientes, salvo en Pisa 1993., donde, con altas temperaturas durante el período de floración y una disponibilidad de agua limitada, los híbridos convencionales mostraron un potencial de producción más elevado que los híbridos alto oléico. Los híbridos con alto contenido en oléico exhibieron un contenido de este ácido significativamente más bajo que el del Select. De entre los híbridos de alto contenido oléico presentes en el registro italiano de variedades nacionales, sólo se encontró la influencia de los distintos ambientes en la composición de ácidos grasos en Ares, que presentaba un contenido de ácido oléico más bajo y mas inestable que los otros genotipos, con una escala elevada de variabilidad (alrededor de 14%) por su media de contenido en oléico (72,3%) calculada a través de los ambientes y las gestiones del agua. Esto confirma que el control genético del alto contenido oléico podría ser distinto entre los genotipos analizados. La capacidad para retirar las cáscaras de forma mecánica se vió afectada tanto por las características genéticas como las condiciones ambientales.

PERFORMANCE D'HYBRIDES DE TOURNESOL À FAIBLE OU À FORTE TENEUR EN ACIDE OLÉIQUE SOUS DIFFÉRENTES CONDITIONS DE MILIEU. NOTE II

RÉSUMÉ

L'experimentation a été réalisée sur deux années (1992. et 1993.) en deux lieux, au centre de l'Italie (Pise et Grosseto), l'objectif principal étant d'évaluer l'influence de 4 conditions de milieu (Pise et Grosseto, 1992.; Pise, 1993. et Grosseto, 1993.) ainsi que les effets de deux régimes de disponibilité en eau (avec et sans irrigation) sur six hybrides de tournesol: Ares, Cisa, Granada et Oleica à teneur élevée en acide oléique et sur Gloriasol et Select, hybrides classiques (riches en acide linoléique), utilisés comme témoins. Le dispositif expérimental utilisé consiste en un split-plot à 5 répétitions. Ont été analysées, les principales caractéristiques de production, le rendement en grains et en huile, le décorticage mécanique, et la qualité de l'huile.

Il n'a pas été observé de différences significatives dans le potentiel de rendement en akénes parmi le hybrides testés dans les différents milieux à l'exception de Pise 1993, où, sous de fortes températures et disponibilités hydriques réduites durant la phase de floraison, les hybrides conventionnels ont montré un potentiel de rendement supérieur aux hybrides oléiques. Les hybrides oléiques ont présenté une teneur en huile significativemnt plus faible que Select. Parmi les hybrides à teneur élevée en acide oléique présents au catalogue national Italien des variétés un effet des milieux sur la composition en acides gras est décelée seulement chez Ares qui présente une teneur en acide oléique plus faible et plus instable que les autres génotypes; avec une plage de variabilité plus élevée (de l'ordre de 14%) par rapport à la teneur moyenne en acide oléique (72%) calculée à partir des différents régimes hydriques. Ceci confirme que le contrôle génétique de la teneur élevée en acide oléique pourrait être différent selon les génotypes analysés. Le décorticage mécanique est affecté à la fois par les caractéristiques génétiques et les conditions de milieu.