FATTY ACID COMPOSITION AND RELATION TO OIL CONTENT IN SUNFLOWER CULTIVARS TESTED IN INTERNATIONAL F. A. O. TRIALS (1978—1979)

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INTRODUCTION

This paper presents a review of the results obtained on fatty acid composition study with different sunflower genotypes experimented in the second cycle (1978—1979), its variability as influenced by the environment and an estimation of the ecostability regarding the linoleic acid content of sunflower oil. At the same time, because some data on linoleic acid content suggest a possible direct relationship with oil content, a linear correlation coefficient was estimated among these characteristics. In this respect, the actual literature is rather diverging, some authors informing on a direct relationship (Filipescu, Stoenescu et al., 1977; Afzalpurkar and Lakshminarayana, 1980), others on a lack of it (Schuster, Marquard et al., 1972; Borodulina, Popov et al., 1974).

MATERIALS AND METHODS

The participating institutions and countries which provided seed samples for analyses are indicated in Table 2 (Trial No. 1) and Table 5 (Trial No. 2). Seed and oil yield capacity and morpho-physiological characteristics of these genotypes are found in HELIA No. 2 and No. 3 (Vrânceanu, Stoenescu et al., 1979, 1980). The oil for analyses was prepared by cold extraction from dehulled kernels. Fatty acid composition was performed by gas-liquid chromatography, as described earlier (Filipescu and Stoenescu, 1978). Data on oil content (% dry matter in the whole seed) were obtained from each member country. The ecostability of the linoleic acid content was estimated in terms of regression coefficient and deviation from regression (Eberhart and Russell, 1966). The interaction "cultivar × location" was considered as error, because in most cases only seed samples from one replication and one year were received. The simple linear coefficient of correlation was computed according to the usual method.

RESULTS AND DISCUSSION

FATTY ACID COMPOSITION

Trial No. 1. This trial comprised 11 open pollinated varieties and a single hybrid (Romsun 59), as check. The experimentation was performed in 11 locations, strongly differentiated as climatic conditions and latitude (Iran-Karaj, 30°N; Turkey-Edirne, Luleburgaz and Yeşilköy, 40°N; Romania-Fundulea, and U.S.A.-North Dakota Casselton, and Hungary-Szeged and Iregszemcse, 45—47°; F. Rep. Germany- Gross Gerau, The Netherland-Wageningen and Poland-Poznań, 51—53°N).

Table 1 presents the mean and extreme values for each genotype in all locations. The saturated fatty acids varied much less than the unsaturated ones. The oleic and linoleic content, as well as the iodine value, varied in large limits, of 20—25 percent or more. We notice that all genotypes expressed the lowest oleic in Wageningen (The Netherlands) and the highest in Yeşilköy (Turkey). A reverse situation was encountered for linoleic content, since oleic and linoleic acid are in an indirect relationship in sunflower oil. As a consequence, the linoleic/oleic ratio exhibits also a large variation. Iregi Csikós was the most affected by Yeşilköy environment, in which the oleic acid became slightly predominant.

* Trials were carried out and seed samples sent by: D. Wolffhardt (Austria); M. Rollier and P. Leclercq (France); W. Schuster (F. R. Germany); E. Kurnik and J. Frank (Hungary); Seed and Plant Improvement Institute, Karaj-Teheran (Iran); E. Alba (Italy); D. Dantuma (The Netherlands); Z. Kloczowski (Poland); T. Cirit, K. Ilisulu and E. Idelen (Turkey), W. W. Roath (U.S.A.); D. Šcorić (Yugoslavia).

Table 1

Trial No. 1 with open pollinated varieties. Fatty acid composition of oil. Average values and variation range for 11 locations * (1979)

Entry No.	Variety	Genetic type	Percentage of total acids				Iodine value	Linoleic/ oleic ratio
			palmitic	stearic	oleic	linoleic		
1	Peredovik	OPV	6.0 5.6—7.1	5.4 4.3—6.8	22.8 13.8—34.8	65.7 54.6—75.6	133 125—143	2.9 1.6—5.5
2	Hemus	OPV	6.1 5.5—7.2	5.3 4.1—6.2	23.6 13.7—37.7	65.0 52.0—75.6	133 123—143	2.7 1.4—5.5
3	IH-10	OPV	6.1 5.5—7.9	5.6 4.4—7.1	23.7 14.2—35.5	64.6 54.2—75.6	132 124—143	2.7 1.5—5.3
4	Iregi 816 B	OPV	6.6 5.8—7.7	5.4 3.9—7.7	23.2 15.9—39.5	64.8 49.6—73.3	132 120—141	2.8 1.3—4.6
5	Iregi Csikos	OPV	5.9 5.2—7.0	6.0 4.7—7.1	24.5 15.3—47.8	63.5 40.8—73.2	131 112—140	2.6 0.8—4.8
6	Argentario	OPV	6.0 5.2—7.2	5.5 4.3—6.9	23.3 13.5—39.4	65.2 50.7—76.0	133 122—143	2.8 1.3—5.6
7	Record	OPV	6.2 5.2—7.4	4.8 3.4—5.9	22.1 13.3—40.8	66.8 49.8—76.7	135 121—144	3.0 1.2—5.8
8	Romsun 59	SH	6.0 5.1—7.0	6.3 5.4—7.5	21.0 13.1—37.4	66.7 51.8—75.1	134 122—141	3.2 1.4—5.7
9	Sepasol	OPV	6.2 5.6—7.3	5.4 4.0—6.6	22.9 12.9—41.1	65.6 49.0—76.5	133 120—144	2.9 1.2—5.9
10	Novi Sad 20	OPV	6.1 5.5—7.2	5.5 4.2—7.4	22.0 13.4—37.6	66.4 52.0—76.1	134 122—145	3.0 1.4—5.7
11	Novi Sad 61	OPV	6.1 5.3—7.3	5.7 4.5—7.2	22.7 14.3—40.3	65.5 49.0—74.8	133 120—142	2.9 1.2—5.2
12	VNIIMK 8931	OPV	6.1 5.3—7.4	5.4 4.2—6.8	22.7 12.9—39.2	65.7 50.4—76.6	133 121—144	2.9 1.3—5.9

* F. Rep. Germany (Gross-Gerau) ; Hungary (Iregszemcse) ; Hungary (Szeged) ; Iran (Karaj) ; The Netherlands (Wageningen) ; Poland (Poznań) ; Romania (Fundulea) ; Turkey (Edirne) ; Turkey (Yesilköy) ; Turkey (Luleburgaz) and U.S.A. (Casselton, North Dakota).

The effect of the environmental conditions on fatty acid composition is clearly pointed out in Table 2 where the average values and variation range of all genotypes are computed for each location. It is evident that more favourable conditions for linoleic synthesis are found at Wageningen (The Netherlands), Gross-Gerau (F. Rep. Germany), Poznań (Poland) and Iregszemcse (Hungary), while less favourable at Yeşilköy (Turkey), Luleburgaz (Turkey) and Karaj (Iran). Between these two groups, the locations Fundulea (Romania), Szeged (Hungary) and Casselton USA, N. Dakota) occupy an intermediate position. The difference among genotypes, concerning the linoleic or oleic content is generally of 4—7 percent in each location, which is far less than the range of variation determined by the environmental conditions to the same genotype. Data from Table 3 express also this finding. Considering the mean values for each genotype, two distinct groups are evident : IH-10, Iregi 816 B and Iregi Csikós present significant lower values in comparison with all the others. These three genotypes coming from the same breeding centre and perhaps having a common initial material, are the earliest entries of this trial (Vrânceanu, Stoenescu et al., 1979). Their earliness could be considered one of the main factors responsible for this trait (Anand and Chandra, 1979). For early genotypes seed ripeness and linoleic synthesis are, generally, falling in a sesonal period characterized by more high daily temperature. It is already established that linoleic synthesis is in an indirect relationship with temperature (Williams, Harris et al., 1976 ; Popov, 1973 ; Pereira, 1978). Nevertheless, it is considered that in this case temperature is an indirect factor only, the oxygen playing the main role. Lower temperature reduces respiration and larger quantity of molecular oxygen is available for the desaturation reaction in linoleic synthesis (Dompert and Beringuer, 1970).

High significant differences among locations are also found in Table 3.

Trial No. 2 comprised 16 single hybrids, 3 three-way hybrids and 1 open pollinated variety. Seed samples for analyses were received from 15 locations. The mean and extreme values concerning their fatty acid composition (Table 4) are not too different from those found at the open pollinated varieties. The

Table 2

Trial No. 1 with open pollinated varieties. Location effect on fatty acid composition. Average values and variation range for 12 varieties * (1979)

Entry No	Country and location	Percentage of total acids				Iodine value	Linoleic/ oleic ratio
		palmitic	stearic	oleic	linoleic		
1	F. Rep. Germany — Gross-Gerau	6.1 5.7—6.5	5.7 4.7—6.9	17.7 15.1—20.6	70.5 68.0—73.0	137 134—139	4.0 3.5—4.8
2	Hungary — Iregszemcse	5.6 5.1—6.3	4.9 3.9—5.9	18.0 16.3—20.1	71.5 69.5—73.6	139 138—142	4.0 3.5—4.5
3	Hungary — Szeged	6.1 5.7—6.5	4.9 3.8—6.4	21.2 18.1—26.6	67.8 62.7—70.6	136 131—138	3.2 2.4—3.9
4	Iran — Karaj	6.9 6.3—7.4	6.0 5.4—6.4	26.2 24.2—29.1	60.9 58.5—63.5	128 126—130	2.3 2.0—2.6
5	The Netherlands — Wageningen	6.3 5.8—6.6	4.5 3.4—5.7	13.8 12.9—15.9	75.4 73.2—76.7	143 140—144	5.5 4.6—5.9
6	Poland — Poznań	5.7 5.2—6.1	5.5 4.4—6.3	18.4 16.1—22.2	70.5 66.4—73.4	138 134—141	3.8 3.0—4.6
7	Romania — Fundulea	7.3 7.0—7.9	5.4 4.8—6.8	21.2 19.0—22.2	66.0 62.1—68.6	133 128—135	3.1 2.6—3.6
8	Turkey — Yesilköy	5.4 5.1—5.8	5.0 4.2—5.9	39.3 34.8—47.8	50.3 40.8—54.6	121 112—125	1.3 0.8—1.6
9	Turkey — Luleburgaz	6.5 6.1—7.1	5.9 5.3—6.8	27.0 22.2—31.0	60.6 57.2—64.5	128 126—131	2.2 1.8—2.9
10	Turkey — Edîrne	6.0 5.8—6.5	5.3 4.7—6.7	25.5 22.0—27.0	63.2 61.3—65.1	131 130—133	2.5 2.3—3.0
11	U.S.A. — Fargo, North Dakota	5.8 5.4—6.5	6.9 5.9—7.7	22.2 20.5—24.1	65.1 61.7—66.6	132 128—134	2.9 2.6—3.2

* Varieties as in Table 1.

Table 3

Trial No. 1 — Linoleic content (%) in 11 different locations * (1979)

Entry No.	Variety	1 N.	2 H.I.	3 P.	4 G.	5 H.S.	6 R.F.	7 U.	8 T.E.	9 I	10 T.L.	11 T.Y.	Mean	$s_{\bar{x}}$	s%
1	Peredovik	75.6	73.6	70.0	71.1	66.2	65.4	63.4	63.7	61.7	58.7	54.6	65.8	1.92	9.7
2	Hemus	75.6	71.8	70.5	69.5	68.7	66.8	65.5	62.0	61.7	55.6	52.0	65.4	2.13	10.8
3	IH-10	75.6	69.8	70.1	70.2	62.7	64.9	64.0	61.3	58.7	59.1	54.2	64.6	1.90	9.8
4	Iregi 816 B	73.3	72.5	68.9	70.2	64.5	64.7	61.7	62.7	58.5	62.9	49.6	64.5	2.06	10.6
5	Iregi Csikos	73.2	69.5	66.4	68.7	63.3	62.1	63.5	62.8	60.1	63.6	40.8	63.1	2.51	13.2
6	Argentario	76.0	71.2	70.6	70.5	67.0	67.6	64.7	62.3	61.9	56.9	50.7	65.4	2.17	11.0
7	Record	76.7	72.7	73.4	70.5	70.5	68.6	66.6	63.3	63.5	61.4	49.8	67.0	2.23	11.0
8	Romsun 59	75.1	72.1	70.9	71.1	70.5	66.3	65.8	65.1	61.4	63.3	51.8	66.7	1.94	9.7
9	Sepasol	76.5	70.9	71.6	69.9	70.0	66.4	66.4	62.5	60.4	59.4	49.0	65.7	2.28	11.5
10	Novi Sad 20	76.1	71.8	72.0	70.6	69.4	66.2	66.5	65.0	59.7	61.3	52.0	66.4	2.05	10.2
11	Novi Sad 61	74.8	70.5	71.2	68.5	70.6	67.1	65.9	64.6	61.0	59.6	49.0	65.7	2.15	10.9
12	VNIIMK 8931	76.6	71.4	69.9	70.4	69.3	66.1	66.5	63.0	62.1	58.8	50.4	65.9	2.14	10.8
	Mean	75.4	71.5	70.5	70.1	67.7	66.0	65.0	63.2	60.9	60.0	50.3	65.5		

L.S.D. For varieties 5% = 1.4 ; 1% = 1.8 ; 0.1% = 2.4
For locations : = 1.5 = 1.9 = 2.5

* The Netherlands-Wageningen ; 2. Hungary-Iregszemcse ; 3. Poland-Poznań ; 4. F. Rep. Germany-Gross-Gerau ; 5. Hungary-Szeged ; 6. Romania-Fundulea ; 7. U.S.A.-Casselton, N. Dakota ; 8. Turkey-Edirne ; 9. Iran-Karaj ; 10. Turkey-Luleburgaz ; 11. Turkey-Yesilköy.

Table 4

Trial No. 2 with hybrids. Fatty acid composition of oil.
Average values and variation range for 15 locations * (1979)

Entry No.	Variety	Percentage of total acids				Iodine value	Linoleic/oleic ratio
		palmitic	stearic	oleic	linoleic		
1	HB-451	6.5 5.6—8.0	5.3 3.9—6.5	23.0 14.3—30.9	65.2 59.2—73.9	133 128—140	2.8 1.9—5.2
2	Remil **	5.8 5.0—7.4	6.1 4.8—7.8	27.4 15.7—43.8	60.7 45.6—72.0	129 116—140	2.2 1.0—4.6
3	Luciole **	6.3 5.6—7.3	5.7 4.6—8.1	23.1 13.4—32.2	64.8 56.6—74.7	132 126—141	2.8 1.7—5.6
4	INRA 7702 **	6,0 5.2—6.8	6.0 4.7—7.8	25.1 15.0—36.6	62.8 51.2—72.4	131 121—138	2.5 1.4—4.8
5	Sorex	5.9 5.2—7.1	5.2 4.5—6.3	22.8 13.4—37.5	66.0 52.6—76.1	134 123—143	2.9 1.4—5.7
6	Olga II	6.0 5.2—7.4	5.8 4.7—7.4	24.1 15.1—36.9	64.1 52.3—73.3	132 122—140	2.7 1.4—4.8
7	Sorem HT-111	6.0 5.1—7.2	5.7 4.5—6.9	22.2 12.9—34.5	66.1 54.9—75.6	134 125—142	3.0 1.6—5.9
8	Sorem HT-116	5.7 4.9—6.4	6.6 5.1—8.7	21.8 12.5—33.6	65.9 55.5—76.0	133 125—142	3.0 1.7—6.1
9	Sorem HT-117	6.2 5.3—7.0	5.4 4.7—6.8	22.3 13.7—34.9	66.1 53.5—75.3	134 122—142	3.0 1.5—5.5
10	Romsun 90	6.0 5.1—7.8	5.4 4.5—7.2	22.1 13.6—36.3	66.5 53.5—75.2	133 124—143	3.0 1.5—5.5
11	HS-1161	6.6 5.5—7.8	5.6 4.0—7.6	23.4 15.3—39.6	64.4 49.7—73.0	132 120—140	2.7 1.3—4.7
12	HS-72 M	6.4 5.3—8.1	5.5 3.6—7.5	22.7 14.0—37.3	65.4 52.5—74.3	133 123—140	2.9 1.4—5.3
13	P.O.I. 301 A **	6.2 5.5—7.6	5.0 3.9—6.7	22.6 12.9—34.3	66.2 55.6—76.3	134 126—143	2.9 1.8—5.9
14	Hybrid 894	6.5 5.4—7.4	5.0 4.2—6.5	22.7 12.3—41.2	65.8 48.9—75.3	134 120—141	2.9 1.2—6.1
15	Hybrid 241	6.2 5.2—7.2	4.7 3.9—6.5	23.1 13.0—38.7	66.0 51.9—76.1	134 123—143	2.9 1.3—5.8
16	Sungro 380 A	6.1 5.1—7.3	5.0 3.7—6.7	22.7 12.6—39.4	66.1 50.7—76.5	134 122—143	2.9 1.3—6.1
17	NS-H-27 RM	6.3 5.2—7.2	5.9 4.8—7.5	23.1 11.6—41.3	64.7 48.7—76.7	132 119—143	2.8 1.2—6.6
18	NS-H-34 RM	6.3 5.1—7.3	5.1 4.3—6.3	23.0 11.9—43.3	65.5 47.1—76.1	133 119—142	2..8 1.1—6.4
19	NS-H-63 RM	6.7 5.1—7.6	5.2 4.5—6.6	21.5 12.0—41.0	66.6 48.8—76.0	134 120—142	3.1 1.2—6.3
20	Peredovik	6.2 5.4—7.2	5.2 4.0—6.9	22.8 13.8—34.9	65.7 54.5—75.6	133 124—143	2.9 1.6—5.5

* Austria (Vienna) ; France (Aude) ; France (Clermont Ferrand) ; F. Rep. Germany (Gross-Gerau) ; Hungary (Szeged) ; Hungary (Iregszemcse) ; Iran (Karaj) ; Italy (Bari) ; The Netherlands (Wageningen) ; Poland (Poznań) ; Turkey (Yesilköy) ; Turkey (Luleburgaz) ; Turkey (Edirne) ; U.S.A. (Casselton, N. Dakota) ; Yugoslavia (Novi Sad).
** absent in Yugoslavia, Novi Sad.

French hybrids Remil and INRA 7702 are characterized by a lower linoleic content and iodine value comparing with all the others.

The variation limits for linoleic content are, generally, of 21—25 percent, excepting the genotype HB-451 on one side, and the genotypes NS-H-27 RM and NS-H-34 RM on the other side which presented a restricted (15 percent) and, respectively a larger (28—29 percent) variation.

Table 5 presents the mean and extreme values of all genotypes experimented in each location. At Wageningen (The Netherlands) all genotypes possess more than 72% linoleic, with small differences among them (around 4 percent). On the countrary, at Yesilköy

Table 5

Trial No. 2 with hybrids. Location effects on fatty acid composition. Average values and variation range for 20 varieties * (1979)

	Country and location	Percentage of total acids				Iodine value	Linoleic/ oleic ratio
		palmitic	stearic	oleic	linoleic		
1	Austria — Viena	5.5 5.0—6.1	5.8 4.9—7.5	20.1 16.8—25.3	68.6 63.3—72.3	136 131—140	3.4 2.5—4.3
2	France — Aude	5.9 5.4—6.6	4.7 3.7—5.5	27.0 24.2—32.4	62.4 56.8—65.8	131 126—136	2.3 1.7—2.7
3	France — Clermont Ferrand	6.3 5.6—6.7	5.1 4.4—6.6	18.8 16.6—22.1	69.8 65.8—71.7	137 133—139	3.7 3.0—4.3
4	F. Rep. Germany Gross-Gerau	6.1 5.5—6.8	5.2 4.4—7.2	17.2 14.3—20.2	71.4 68.4—75.2	139 136—143	4.2 3.4—5.2
5	Hungary — Szeged	6.8 5.9—7.4	5.5 4.6—6.7	20.6 16.5—25.3	67.1 61.7—70.7	134 128—137	3.3 2.4—4.3
6	Hungary — Iregszemcse	5.5 5.0—6.0	5.1 4.1—6.7	19.4 16.8—22,8	70.0 66.5—73.0	138 135—141	3.6 2.9—4.3
7	Italy — Bari	7.1 6.1—8.1	5.0 3.6—6.3	29.8 23.7—37.7	58.1 49.6—64.6	125 118—132	2.0 1.3—2.7
8	Iran — Karaj	7.2 6.4—7.8	6.8 5.6—8.7	23.3 20.1—27.1	62.6 57.5—65.7	129 123—131	2.7 2.1—3.3
9	The Netherlands Wageningen	6.4 5.9—7.1	5.1 4.3—6.2	13.5 11.6—15.7	75.0 72.8—76.7	141 138—143	5.6 4.6—6.6
10	Poland — Poznań	5.8 5.1—6.2	5.6 4.8—7.0	18.9 16.7—24.5	69.7 64.6—72.3	137 133—140	3.7 2.6—4.3
11	Turkey — Yesilköy	5.4 4.9—6.4	5.0 3.9—6.4	37.4 30.9—43.3	52.2 45.6—59.2	123 116—129	1.4 1.1—1.9
12	Turkey — Luleburgaz	6.5 5.9—7.2	6.3 5.1—7.6	27.0 23.7—31.8	60.2 55.7—64.5	127 123—132	2.2 1.8—2.7
13	Turkey — Edîrne	6.2 5.8—6.9	4.9 4.1—6.8	24.9 20.6—30.8	64.0 57.6—67.8	132 126—136	2.6 1.9—3.3
14	U.S.A. Casselton N.D.	6.3 5.9—6.8	6.7 5.8—8.1	22.9 19.5—27.6	64.0 58.6—67.7	131 125—134	2.8 2.1—3.5
15	Yugoslavia Novi Sad **	6.2 5.4—7.4	5.3 4.5—6.3	25.2 21.4—28.0	63.3 60.7—66.5	131 129—134	2.5 2.2—3.1

* varieties, as in Table 4.
** absent : Remil, Luciole, INRA 7702 and P.O.I. 301 A.

(Turkey) the linoleic synthesis is repressed up to 45% and the divergence among genotypes is extended to around 13 percent.

Taking into account the linoleic mean values at 1% probability level (Table 6), only the genotypes Remil, Luciole, INRA 7702, Olga II and HS-1161 are significantly inferior to all the other 15 genotypes which are statistically similar. Considering the assertion coming out from Trial No. 1 earlyness could be the cause for the lower values only in the case of the genotype Luciole (V r â n c e a n u, S t o e n e s c u et al., 1979). The low values of genotypes Remil, INRA 7702, Olga II and HS-1161 are most likely determined by other genetic factors. It may be remarked that in the former cycle (1976—1977), Remil expressed also the lowest linoleic content among 16 half-late genotypes experimented (F i l i p e s c u and S t o e n e s c u, 1978).

As in Trial No. 1, location effects are much greater than the genetic ones. Wageningen (The Netherlands) and Yesilköy (Turkey) are also the two extremes which differ highly significantly from all the other locations. Gross Gerau (F. Rep. Germany), Iregszemcse (Hungary), Clermont Ferrand (France), Poznań (Poland) and Vienna (Austria) seem to be characterized by similar climatic conditions for linoleic synthesis (70—67% linoleic mean). Another group is formed by the following locations : Edîrne (Turkey), Casselton (U.S.A., North Dakota), Karaj (Iran) and, unexpected, Aude (France) with 62—64% linoleic as a mean. Bari (Italy) and Luleburgaz (Turkey) proved to have similar environments for linoleic synthesis (58—60% linoleic mean).

Table 6

Trial No. 2 — Linoleic content (%) in 14 different locations * (1979)

Entry No.	Variety	1 N.	2 G.	3 H.I.	4 F.G.	5 P.	6 A.	7 H.S.	8 T.E.	9 U.	10 I.	11 F.A.	12 T.L.	13 I.T.	14 T.Y.	Mean	$s_{\bar{x}}$	s %
1	HB-451	73.9	69.7	68.4	65.8	68.2	68.8	67.5	64.8	64.1	61.8	59.2	61.9	62.0	59.2	65.4	1.15	6.6
2	Remil	72.8	67.4	66.5	67.0	64.6	64.0	61.7	57.6	58.6	57.5	56.8	54.8	54.8	45.6	60.7	1.86	11.5
3	Luciole	74.7	69.2	71.2	67.9	68.3	67.4	63.9	63.7	61.0	63.2	61.0	60.5	58.5	56.8	64.8	1.37	7.9
4	INRA-7702	72.4	68.5	68.2	68.1	68.3	65.7	63.9	61.8	60.0	59.1	61.9	55.6	51.1	51.6	62.6	1.75	10.5
5	Sorex	76.1	71.4	70.7	71.6	71.1	70.4	67.5	63.0	65.8	65.2	63.3	60.7	56.5	52.6	66.1	1.73	9.8
6	Olga II	73.3	69.9	69.7	68.4	68.0	67.4	65.6	62.8	64.6	61.5	60.5	58.4	57.9	52.3	64.3	1.53	8.9
7	Sorem HT-111	75.6	69.7	71.4	71.7	70.2	70.0	69.2	65.2	63.8	62.3	60.6	62.2	59.8	54.9	66.2	1.55	8.7
8	Sorem HT-116	76.0	70.4	70.2	70.9	70.4	69.5	70.7	65.1	64.1	61.8	64.0	59.4	55.6	55.5	66.0	1.66	9.4
9	Sorem HT-117	75.3	71.0	71.6	71.0	72.3	70.2	69.9	65.4	62.8	62.8	63.3	60.1	54.1	53.5	66.1	1.80	10.2
10	Romsun 90	75.1	72.6	73.0	71.6	71.2	70.8	66.3	64.8	65.7	64.0	63.1	63.6	55.2	53.4	66.5	1.74	9.8
11	HS-1161	72.5	71.2	68.9	67.1	68.8	66.9	64.7	64.1	63.2	61.0	59.8	60.3	61.4	49.7	64.3	1.56	9.1
12	HS-72 M	74.1	70.5	69.3	68.3	68.6	68.8	66.9	65.6	64.9	62.8	60.0	60.6	64.6	52.5	65.5	1.44	8.2
13	P.O.I. 301 A	76.3	69.6	70.0	70.9	70.2	68.0	66.4	64.7	63.4	65.1	64.2	57.1	64.0	55.6	66.1	1.45	8.2
14	Hybrid 894	75.3	70.1	69.9	70.7	71.2	69.4	68.8	65.1	65.2	62.2	61.3	61.9	61.1	48.9	65.8	1.75	9.9
15	Hybrid 241	76.1	71.1	70.5	71.6	69.9	69.1	69.0	64.2	63.9	64.1	65.8	61.4	61.5	51.9	66.4	1.59	9.0
16	Sungro 380 A	76.5	69.7	70.6	71.7	70.0	69.0	68.4	63.6	63.4	64.1	66.0	64.1	60.7	50.7	66.3	1.64	9.2
17	NS-H-27	76.7	70.3	69.4	71.1	71.5	68.6	69.3	62.3	63.3	62.5	64.3	58.5	49.6	48.7	64.7	2.17	12.5
18	NS-H-34 RM	76.1	71.2	70.5	70.9	70.5	68.5	68.4	67.7	65.7	63.7	63.6	58.7	55.5	47.1	65.6	2.01	11.5
19	NS-H-63 RM	76.0	71.0	67.8	69.6	71.6	69.3	67.8	67.8	67.7	65.7	64.4	62.1	56.2	48.8	66.1	1.82	10.3
20	Peredovik	75.6	70.2	72.5	70.3	69.7	69.4	67.3	62.4	64.0	62.0	64.6	57.9	62.1	54.5	65.9	1.56	8.9
	Mean	75.0	70.2	70.0	69.8	69.7	68.5	67.2	64.1	63.8	62.6	62.4	60.0	58.1	52.2	65.3		

L.S.D. For varieties : 5% = 1.1 ; 1% = 1.5 0.1% = 1.9.
For locations : 5% = 1.4 ; 1% = 1.8 0.1% = 2.4

* 1. The Netherlands-Wageningen ; 2. F. Rep. Germany Gross-Gerau ; 3. Hungary-Iregszemcse ; 4. France-Clermont Ferrand; 5. Poland-Poznań ; 6. Austria-Vienna ; 7. Hungary-Szeged ; 8. Turkey-Edirne ; 9. U.S.A.-Caselton, N.D. ; 10. Iran-Karaj ; 11. France-Aude ; 12. Turkey-Luleburgaz ; 13. Italy-Bari ; 14. Turkey-Yesilköy.

ECOSTABILITY OF GENOTYPES CONCERNING LINOLEIC CONTENT

According to Eberhart and Russel's model (1966), a stable genotype is one which has the highest mean over a broad range of environments, a regression coefficient ($b_{x,y}$) near the unit and a deviation from regression (s^2_b) closed to zero.

The stability parameters, both for open pollinated varieties (Trial No. 1) and hybrids (Trial No. 2) are presented in Table 7.

All open pollinated varieties, excepting Iregi Csikós, have a regression coefficient of about 0.9—1.0, suggesting that their response was almost the same from location to location. Peredovik, IH-10, Iregi 816 B and Iregi Csikós are the genotypes which deviate the most from regression. It is of interest that these open pollinated varieties were noticed as presenting the greater coefficients of variation for oil yield (Vrânceanu, Stoenescu et al., 1979). This suggests that instability (or stability) characterizes more than one plant trait in one genotype.

The single hybrid Romsun 59 proved to be as stable as the most stable open pollinated varieties. In this respect there is also a coincindence with the low coefficient of variation for oil yield (Vrânceanu, Stoenescu et al., 1979).

In Trial No. 2, regression coefficients of 0.9—1.0 and relatively small deviations (< 2.0) were recorded to the following genotypes : Sorex, Olga II, Sorem HT-111, Sorem HT-116, Hybird 894 and Hybrid 241. The regression coefficient value suggests that HB-451 realizes performances over the mean in unfavourable conditions, while INRA 7702, Remil, NS-H-27, NS-H-34 and NS-H-63 give particular poor responses in such environments. Most of these hybrids exhibited a similar stability for linoleic content and for oil yield (Vrânceanu, Stoenescu et al., 1979).

A comparison between open pollinated varieties and hybrids do not clearly reveals better stability of the former ones.

THE RELATIONSHIP BETWEEN OIL AND LINOLEIC ACID CONTENT

1. All correlation coefficients between oil and linoleic content, established for each genotype, are positive, and almost half of them

Table 7

Mean values of linoleic acid content and stability parameters for 12 sunflower open pollinated varieties and 20 hybrids, grown in 11 and 14 locations, respectively

Entry No.	Cultivar	Linoleic content % Mean	Regression coefficient $b_{x,y}$	Deviation mean square s^2_b
	Trial No. 1 (OPV)			
1	Peredovik	65.8	1.00	3.1
2	Hemus	65.4	0.89	3.4
3	IH-10	64.6	1.00	5.7
4	Iregi 816 B	64.5	0.97	4.5
5	Iregi Csikös	63.1	0.77	8.9
6	Argentario	65.4	0.89	2.1
7	Record	67.0	0.93	1.1
8	Romsun 59 (SH)	66.7	1.06	1.9
9	Sepasol	65.7	0.91	0.7
10	Novi Sad 20	66.4	1.01	1.1
11	Novi Sad 61	65.7	0.96	1.9
12	VNIIMK 8931	65.9	0.94	1.1
	Mean	65.5	0.94	2.9
	Trial No. 2 (Hybrids)			
1	HB-451	65.4	1.21	5.9
2	Remil	60.7	0.85	0.9
3	Luciole	64.8	1.08	3.7
4	INRA 7702	72.6	0.87	2.6
5	Sorex	66.1	0.90	1.1
6	Olga II	64.3	1.00	0.5
7	Sorem HT-111	66.2	1.01	1.6
8	Sorem HT-116	66.0	0.93	1.8
9	Sorem HT-117	66.1	0.87	1.6
10	Romsun 90	66.5	0.89	2.4
11	HS-1161	64.3	0.96	3.1
12	HS-72 M	65.5	1.04	3.7
13	P.O.I. 301 A	66.1	0.97	5.0
14	Hybrid 894	65.8	0.91	1.9
15	Hybrid 241	66.4	0.98	1.3
16	Sungro 380 A	66.3	0.96	3.4
17	NS-H-27 RM	64.7	0.73	2.4
18	NS-H-34 RM	65.6	0.78	1.6
19	NS-H-63 RM	66.1	0.82	4.5
20	Peredovik (OPV)	65.9	0.92	2.9
	Mean	65.3	0.93	2.6

are significant (Table 8). It is known that some contributing factors are the same for oil, as well as for linoleic content in the kernel. In all publications, oil content determined in the whole dry seed does not appear closely related to linoleic content. One cause could be the kernel/husk ratio, which is generally different among genotypes (Filipescu, Vrânceanu et al., 1977).

Table 8

Sunflower trial No. 1 and No. 2. Linear correlation coefficients between oil and linoleic content

For an entry in n locations

Entry	n	r
Trial No. 2 (Hybrids)		
IH-10	9	.90***
Peredovik	9	.88***
Hemus	9	.72**
Argentario	9	.70**
Novi Sad 20	9	.66*
Sepasol	9	.65*
Novi Sad 61	9	.53
Romsun 59 (SH)	9	.53
Iregi Csikós	9	.49
Record	9	.43
Iregi 816	9	.40
VNIIMK 8931	9	.32
Trial No. 2 (Hybrids)		
Remil	13	.73**
P.O.I. 301 A	13	.70**
INRA 7702	12	.66**
Hybrid 894	14	.63**
Hybrid 241	14	.61**
Sungro 380 A	14	.60**
HS-1161	14	.55*
Romsun 90	14	.52*
Sorem HT-116	14	.52*
Sorem HT-117	14	.48*
NS-H-27 RM	14	.47*
NS-H-63 RM	14	.43
Peredovik (OPV)	14	.43
NS-H-34 RM	14	.41
Luciole	13	.38
Sorem HT-111	14	.37
HB-451	14	.27
Sorex	14	.16
Olga II	14	.10
HS-72 M	14	.06

For a location with n entries

Country and location	n	r
Trial No. 1 (OPV)		
Turkey, Yeşilköy	12	.82***
Poland, Poznań	12	.69**
România, Fundulea	12	.61*
Hungary, Iregszemcse	12	.52*
U.S.A., Casselton, N.D.	12	.49*
Iran, Karaj	12	.25
Turkey, Edîrne	12	.23
F. Rep. Germany, Gross-Gerau	12	.07
Turkey, Luleburgaz 1978	12	.58*
1979	12	.61*
Trial No. 2 (Hybrids)		
France, Clermont Ferrand	20	.51*
Turkey, Yeşilköy	20	.46*
Poland, Poznań	20	.40*
Yugoslavia, Novi Sad	16	.39*
France, Aude	20	.37*
Hungary, Iregszemcse	20	.37*
Turkey, Luleburgaz	20	.33
Turkey, Edîrne	20	.26
Italy, Bari	20	.17
Austria, Vienna	20	.15
Iran, Karaj	20	.11
U.S.A. Casselton	20	.09
F. Rep. Germany, Gross-Gerau	20	.01

*, **, *** — significant at the 5%, 1% and 0.1% level, respectively

Figure 1 illustrates the linear expression of correlations and the corresponding equations for those genotypes which presented significant coefficients of correlation. It is evident that the open pollinated varieties possess different slopes of regression than the hybrids. For an oil content unit, the rate of linoleic increase is greater for open pollinated varieties than for hybrids. In spite of this, for the same oil content value, the hybrids seem to possess some greater linoleic content than the open pollinated varieties, at least below 45% oil content. Beyond this value, the two groups are superposed, with the tendency that, over 50% oil, a richer linoleic content might characterize the open pollinated varieties. Stoyanova and Ivanov (1974) stated that seed oil from free-pollinated plants shows a slight linoleic increase over the oil from controlled pollinated plants.

2. When the correlation coefficients were computed for a location with 12 (Trial No. 1)

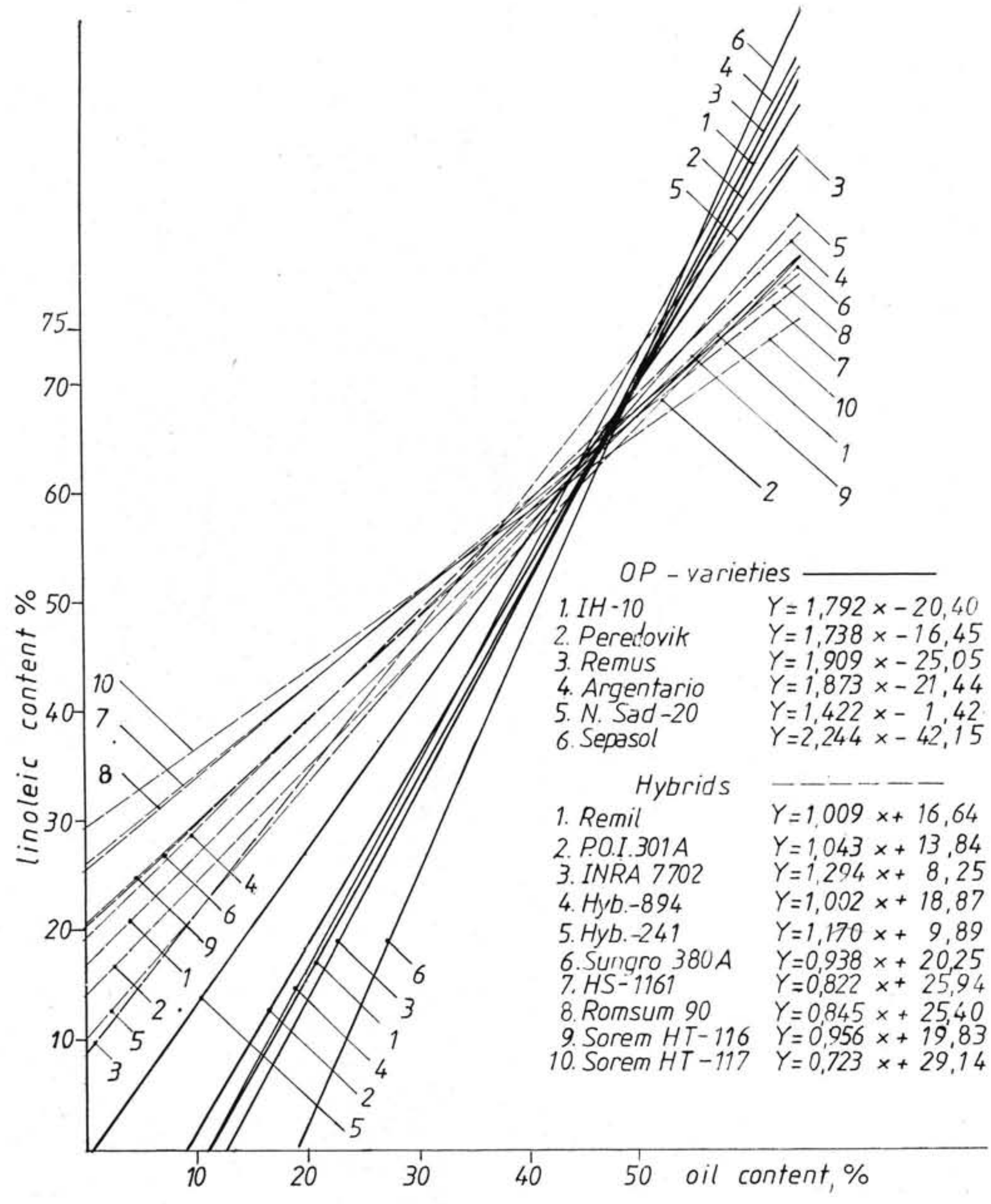

Fig. 1 — Relation between oil content *(x)* and linoleic content *(y)* for open pollinated varieties and hybrids.

or 20 (Trial No. 2) genotypes (Table 8), positive and significant correlations between the two traits were recorded generally in zones known as favourable for sunflower. In extreme environmental conditions, as for exemple at Gross-Gerau (F. Rep. Germany), where the climatic conditions were extremely favourable for linoleic synthesis so that all genotypes are almost identical for linoleic acid but not for oil content, lack of correlations were found.

The graphs illustrated in Figure 2 for those localities characterized by positive and significant correlation coefficients, show that the regression slopes are similar in almost all localities, excepting Yesilköy (Turkey), where the linoleic synthesis was the most depressed (see Table 3 and Table 6), probably due to the arid climate.

CONCLUSIONS

The unsaturated fatty acids of sunflower oil are usually much more affected by genotype and environment than the saturated ones. Cooler and shorter summers of the North European climate favour the linoleic acid synthesis. Earlier genotypes generally exhibit significant lower linoleic acid content and iodine values.

Both hybrids and open pollinated varieties show a similar ecostability for linoleic content. All correlation coefficients between oil and linoleic content are positive and significant for almost half of genotypes, suggesting that a part of the contributing factors are the same for oil and linoleic acid accumulation.

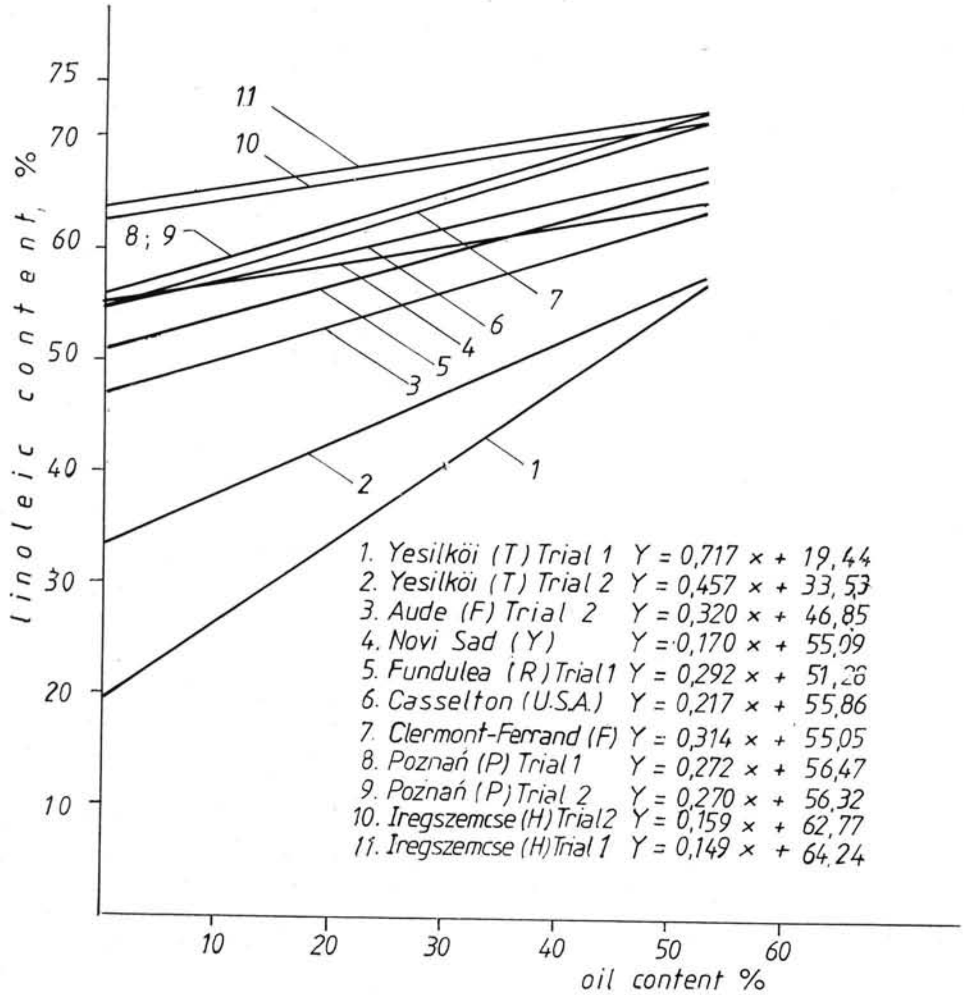

Fig. 2 — Relation between oil content *(x)* and linoleic content *(y)* for a location with 12 (Trial I) or 20 (Trial II) entries.

The rate of linoleic increase for an unit of oil content appeared to be greater in open pollinated varieties than in hybrids. On the other hand, the hybrids presented a higher linoleic percent for the same oil content value, especially under the level of 45% oil content.

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COMPOSITION EN ACIDES GRAS ET LA RELATION AVEC LA TENEUR EN HUILE CHEZ LES CULTIVARS DE TOURNESOL EXPÉRIMENTÉS DANS LES ESSAIS INTERNATIONAUX F.A.O. (1978—1979)

Résumé

Les valeurs moyennes et les extrêmes de la variation de la teneur en acides gras : palmitique, stéarique, oléique et linoléique sont présentées pour 12 variétés-populations et 20 hybrides de tournesol, soumis aux essais dans 11 et respectivement 15 sites à conditions climatiques différentes (30° et 50° latitude Nord). Pour la tensur en acide linoléique, des différences significatives ont été mises en évidence, dues à l'influence du génotype et aux conditions de culture. Les génotypes IH-10, Iregi 816 B et Iregi Csikos (63—64% acide linoléique) — des variétés — populations et les génotypes des hybrides Remil, Luciole, INRA 7702, Olga II et HS 1161 (61—64% acide linoléique) ont été significativement inférieurs aux autres génotypes (65—67% acide linoléique en moyenne). Pour toutes les variantes, la plus faible teneur en acide linoléique (51% en moyenne) a été trouvée à Yesilköi (Turquie) et la plus forte (75%) à Wageningen aux Pays Bas. La stabilité écologique de la teneur en acide linoléique, appréciée à l'aide de l'analyse des regressions, est une preuve que la réaction de la plupart des génotypes est similaire ($b_{x,y}$ =0,9—1,1) même si certains de ces génotypes — IH-10, Iregi 816, Iregi Csikos, HB-451, NS-H-63, Luciole — présentent un écart considérable.

Le coefficient de corrélation linéaire entre la teneur en acide linoléique et la teneur en huile, calculé pour le même génotype, a toujours été positif et significatif pour près de la moitié des génotypes. Calculé pour chaque site pour le même groupe de génotypes, le coefficient de corrélation a montré que dans les zones à climat extrême, l'intensité des corrélations baisse.

COMPOSICION EN ÁCIDES GRASOS Y LA RELACIÓN CON EL CONTENIDO EN ACEITE DE LAS VARIEDADES E HÍBRIDOS DE GIRASOL EXPERIMENTADOS EN LA RED INTERNACIONAL F.A.O. (1978—1979)

Resúmen

Se presentan los valores medios y los extremos de la variación de la composición en ácidos (palmítico, esteárico, oléico, y linoléico) para 12 variedades-poblaciones y 20 híbridos de girasol experimentados en 11 y respectivamente 15 localidades de condiciones climáticas diferentes, entre las latitudes 30 y 50° Norte. Se han puesto en evidencia diferencias significativas con respecto al contenido en ácido linoléico, debidas al efecto del genotipo y las condiciones de cultura. Los genotipos IH-10, Iregi 816 B e Iregi Csikos (63—64% linoleico) variedades poblaciones y Remil, Luciole, INRA 7702, Olga II y HS-1161 (61—64 por ciento linoléico)-híbridos resultaron significativamente inferiores en comparacion a los demás genotipos (65—67 por ciento linoléico, en media).

Todas las variantes han presentado el más reducido contenido en ácido linoléico (en media 51 por ciento) en Yesilköi (Turkia) y el más elevado (75 por ciento) en Wageningen (Holanda).

La ecoestabilidad del contenido en ácido linoléico, estimada por el análisis de la regresión, mostró que la respuesta de la mayoría de los genotipos presenta gran similitud ($b_{x,y}$ =0,9—1,1) pero durante algunos días ha deviado considerablemente IH-16, Iregi 816, Iregi Csikos, HB-451, SH-55, Luciole).

El coeficiente de correlación lineária entre el contenido en ácido linoléico y el de aceite, calculado en el interior del mismo genotipo resultó siempre positivo y significativo para casi la mitad de los genotipos. El coeficiente de correlación calculado para cada localidad on el mismo set de genotipos, ha puesto de relieve el hecho de que en zonas de condiciones climáticas extremas, la intensidad de la correladón disminuye.