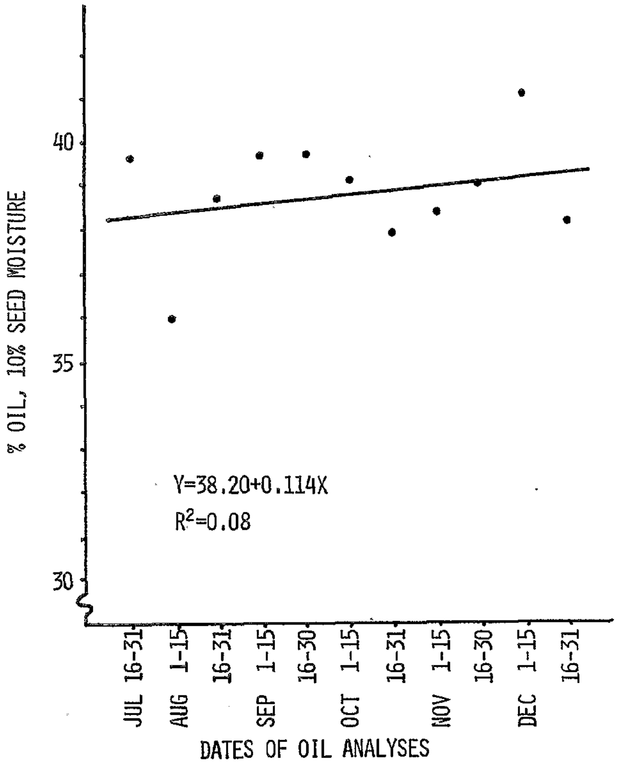
Figure 2. Relationship of oil content of seed produced from hybrid sunflower in Texas, 1980, and dates of oil analyses (analyzed immediately after harvest).



DISCUSSION

Rainfall was above average and temperatures were near normal at Lubbock in 1979, and early delivered seed from early plantings was significantly higher in oil content than that from later plantings. In contrast, temperatures during the summer of 1980 were above normal and rainfall was below normal, and oil content of the early planted and late planted hybrids was very similar. The higher temperatures appeared to favorably influence oil content of the later plantings in 1980. From these data, it appears that a grower or processor can get an indication of the expected oil content of seed produced by hybrid sunflower from weather conditions during the crop growing season.

LITERATURE CITED

ANONYMOUS. 1975. Official and tentative methods of the American Oil Chemists' Society. Method Ai 3 — 75. The American Oil Chemists Society, Champaign, Illinois.

EFFECT OF THE PLANTING DATE OF SUNFLOWERS ON THE AGRONOMIC CHARACTERISTICS AND ON THE QUANTITY AND QUALITY OF OIL.

H.S. AZPIROZ, A. ORTEGON, A. IRUEGAS and E. VAZQUEZ
Instituto Nacional de Investigaciones Agricolas, Apdo. Post. 6 — 882, Mexico 6, D.F.

ABSTRACT

Five sunflower cultivars were sown at fifteen different planting dates at Rio Bravo, Tamps., and these showed a significant variation in: days to the flowering stage and to physiological maturity; plant height; head diameter; viability of the seeds; seed yield; oil content; and instearic, palmitic, oleic, and linoleic acid contents due to the effects of diverse genotypes and planting dates.

Oil contents showed a direct correlation with number of days to physiological maturity. In addition, oleic acid content was positively correlated with seed yield; with the reverse effect in linoleic acid content. Temperature expressed as heat unit and cumulative light-hours from the end of blooming to physiological maturity, was negatively correlated with the linoleic acid content, which varied from 30.9 to 72.9%.

The performance of the different genotypes and the best conventional balance between seed yield, seed oil content and oleic — linoleic ratio, suggested that March 16th is the best planting date for the Rio Bravo, Tamps., region in Mexico.

INTRODUCTION

High grain yield and an oil content above 40% in the sunflower seed, is important for the farmer and deep frying oil industry. The adequate proportion of oleic and linoleic acid is also important for human metabolism and from the viewpoint of nutritional value (Owen, 1977).

The fatty acid composition of sunflower oil is known to vary depending on genetical and environmental factors (Knowles, 1970; Robertson, 1979). Putt (1969) found high genetic variability in stearic, oleic and linoleic acid contents of sunflowers, but palmitic acid was relatively constant. Robertson (1980) studied the effect of planting date on yield and on oil quantity and quality, and found differences in the mean oil content between planting dates, but these differences did not appear to be related to temperature. Variation in oleic and linoleic acid contents was found to be related to temperature, with increasing oleic acid contents at higher temperatures.

In the present study, the oil quantity and quality of three sunflower hybrids and two open pollinated varieties were determined for fifteen planting dates at Rio Bravo, Tamps., Mexico, for the purpose of selecting the planting date on which the seed yield, oil content and oleic-linoleic acid ratio was most suitable in relation to production, processing and oil-consumption.

MATERIALS AND METHODS

The sunflower hybrids, Sunhi 301A, Big-top, Sunhi 338 and the open-pollinated varieties Peredovik and Rib 77 were seeded on February 16th, and at fifteen-day intervals until

September 17th, at the Experimental Station of the National Institute of Agricultural Research (INIA, at Rio Bravo, Tamps., Mexico.

The experiment was established on a la luz clay loam soil. Each planting was made under dry soil conditions and immediately afterwards irrigation was applied. When the plants reached 15 — 20 cm height, roguing was carried out in order to have a plant population of 4 to 5 plants per meter of each row. The experimental plots were irrigated twice after the planting with irrigation, at 30 and 55 days after emergence of the plants. In order to control an attack of Sunflower Moth (*Agrotis sp.*), during seed formation, 50% methyl-parathion was applied at a rate of 2.5 liters ha^{-1}.

The experimental plots were four 5 meter rows 80 centimeters apart. The two central rows, less 50 centimeters at each end, were used to evaluate the number of days required to reach the initial flowering stage and the 50 and 100% flowering stages, plant height, head diameter and the number of days to physiological maturity (when browning of the bracts was observed).

The harvest was carried out in the plot described above, when the heads reached complete maturity, and yields were calculated on a 10% moisture basis.

The oil content was measured in a 15 gram sample taken from each of the five replications, and determined on dry weight basis using a Newport MK III wide-line Nuclear Magnetic Resonance Analyzer. The fatty acids present in the sunflower seed oil were also determined on methylated samples by the A.O.A.C. method (1975), by means of gas liquid chromotography, using a Varian Model 3700 apparatus with a 2.5 m stainless steel column, packed with 20% DGS on 80/100 mesh chromosorb W A W DMCS.

The climatic factors studied were temperature, expressed as heat units (Fisher, 1961) and length of daylight period expressed as cumulative light-hours from the end of flowering to physiological maturity. These parameters were calculated from meteorological data obtained at the Rio Bravo Experimental Station.

The experimental design used was a randomized block with five replications for each planting date. Simple correlations among the variables were established. Stability analyses, according to Eberhart and Russel (1966), were calculated for seed yield, seed oil content, and oleic and linoleic acid percentages of total fatty acid contents of oil.

RESULTS AND DISCUSSION

The analysis of variance showed highly significant differences for flowering stages, plant height, physiological maturity, head diameter and seed yield, among the five genotypes studied and the planting dates used ($P < 0.0001$). The seed length was the only trait which did not show significant differences between different planting dates.

The analysis of variance also showed highly significant differences in oleic and linoleic acid contents and total oil content, due to genotypes and environmental factors ($P < 0.0001$). Oil content was a positively correlated ($r = 0.48^{**}$) with both physiological maturity, and seed yield ($r = 0.58^{**}$). Figure 1 shows the negative relationship found between oleic and linoleic acid contents.

Figure 1. Relationship between the linoleic and oleic acid contents of five sunflower genotypes.

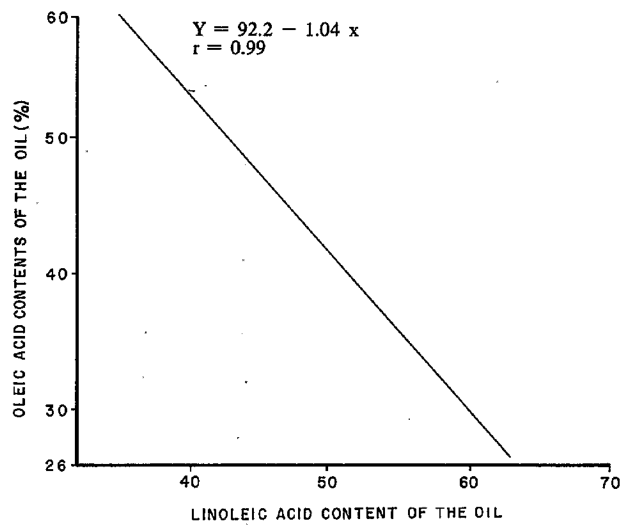


Table 1. Performance of five sunflower genotypes in relation to oleic and linoleic acid contents and oil content on three planting dates. Means of light-hours and cumulative heat units from end of flowering to maturity are shown for each planting date.

Genotype	Feb. 16			Mar. 16			Sept. 17		
	%18:1[a]	%18:2[b]	Oil (%)	%18:1[a]	%18:2[b]	Oil (%)	%18:1[a]	%18:2[b]	Oil (%)
Rib 77	46.5	42.9	41.3	42.7	47.7	41.7	14.7	73.1	40.4
Peredovik	44.5	45.2	44.4	42.9	47.1	42.2	14.5	74.3	39.4
Sunhi 301A	65.7	22.3	46.4	48.0	42.9	47.4	16.9	72.5	43.9
Sunhi 338	56.2	33.3	46.6	36.1	54.4	47.4	17.8	71.5	43.5
Big-top	41.3	48.2	42.8	50.4	42.3	43.8	15.6	73.3	43.9
Mean of sowing	50.8	38.4	44.3	44.1	46.9	46.5	15.9	72.9	42.2
LSD (0.05)	0.5	0.9	3.3	0.5	0.9	3.3	0.5	0.9	3.3
Mean of light-hours	288.7			326.8			184.9		
Mean of heat units	648.7			326.8			369.0		

(a) — oleic acid
(b) — linoleic acid.

The mean linoleic acid content for the September 17th planting date, was greater than the mean linoleic acid content at the other fourteen planting dates (Table 1). The differences apparently are related to the lower number of heat units and lower number of light hours cumulated from the end of flowering to physiological maturity, on this planting date. The data also indicate that, at Rio Bravo, sunflowers planted on May 16th, that is; maturing with 705 heat units and 275 cumulative light hours, which can be regarded as relatively high values, will have high oleic acid contents (>60%) and low linoleic acid contents (<35%) (Figure 2). Table 2 shows that the environmental factors, such as cumulative heat units and light hours from the end of flowering to physiological maturity, had a positive correlation with seed yield, seed oil content, oil yield (kg ha^{-1}) and oleic acid content.

Yields were highest for the March 16th planting date and lowest for the July 17th date (865 kg ha^{-1}). A similar trend was reported by Graves, *et al.,* (1972) for sunflowers grown in Tennessee, U.S.A. They reported decreasing yields with later plantings. Our data show that after July 16th the yield increased to 1523 kg ha^{-1} for the genotypes planted in August 17th and decreased at the last two planting dates. Seed yield had a positive correlation ($r = 0.42^{**}$) with oleic acid content and a negative correlation with linoleic acid content ($r = -0.40^{**}$).

Table 2. Significative correlations observed between some selected characteristics of five sunflower genotypes.

	Correlation		
Characteristics	Heat units	Light hours	Oleic acid
Linoleic acid	−0.70**	−0.50**	−0.99**
Oleic acid	0.71**	0.51**	1.00
Yield	0.63**	0.71**	0.42**
Oil content	0.56**	0.54**	0.33**
Oil yield	0.67**	0.73**	0.44**

** Significant at 0.01 level.

The open pollinated varieties of sunflowers generally responded well under all environmental conditions and were equal to or exceeded the average performance under unfavorable conditions. The hybrids performed well only under the better environments (Table 3). The hybrids Big-top and Sunhi 338 showed a significant deviation from regression (difference from zero) for seed yield indicating that their responses were not consistent (Figure 2). The oil content of the three hybrids also had a significant deviation from regression (difference from zero), indicating an inconsistency in their response. The hybrid Sunhi 301A had a regression coefficient that was significantly greater than 1.0, indicating a better performance in good environments than the other genotypes studied.

Table 3. Stability parameters of five sunflower genotypes on yield, oil content, oleic and linoleic acid contents sowed, planted on fifteen dates.

	YIELD			OIL CONTENT		
	x̄ kg ha⁻¹	Regression coefficient (b)	Regression deviation s^2	(%)	Regression coefficient (b)	Regression deviation S^2
Rib 77	1624	0.86	4917.3	39.2	0.79	0.17
Peredovik	1594	0.87	8257.1	40.2	0.91	0.03
Sunhi 301A	1815	1.11	2873.4	44.2	1.19*	0.52*
Sunhi 338	1672	1.09	36036.7**	43.7	1.05	1.38**
Big-Top	1667	1.06	4876.3**	41.8	1.05	0.67**
	OLEIC ACID			**LINOLEIC ACID**		
	x̄ (%)	Regression coefficient (b)	Regression deviation S^2	(%)	Regression coefficient (b)	Regression deviation S^2
Rib 77	45.3	0.79	65.11**	44.9	0.76	40.63**
Peredovik	42.6	0.96	52.29**	47.5	0.96	55.53**
Sunhi 301A	43.6	1.06	31.70**	46.8	1.09	41.24**
Sunhi 338	43.7	1.15	39.40**	46.8	1.16	82.81**
Big-Top	43.7	1.04	43.26**	46.9	1.02	57.89**

S^2* Significative at 0.05 probability.
S^2** Significative at 0.01 probability.
(b)* Significative at 0.05 probability.

According to the analysis of behavior of the genotypes and best conventional balance between seed yield, oleic and linoleic acid ratio and total oil content, the best planting date for Rio Bravo, Tamps., in Mexico was March 16th. On this planting date, all genotypes had the highest seed yield, an oil content of over 40% and a oleic/linoleic acid ratio of 0.9, which are satisfactory for the oil industry, the farmer, and the consumer.

ACKNOWLEDGEMENTS

Dr. Rodolfo Moreno Dahme and Dr. Jorge Galindo for assistance in the English translation of this manuscript. E. Sevilla, E. Muro and M. Posadas who provided technical assistance in the analytical work, and M. Lopez Reyna for his assistance in the statistical analyses.

LITERATURE CITED

ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTS. 1975. *Official Methods of Analysis.* Ed. William Horwitz Twelfth Ed. p. 1093.

EDERHART, S.A. and RUSSELL, W.A. 1966. Stability parameters for comparing varieties. *Crop Science* 6: 36 — 40.

FISHER, D.V. 1961. Heat units and number of days required to mature some pome and stone fruits in various areas of Norteamerica. Canada Dpt. Agriculture, *Journal of the American Society for Horticultural Science* 8:44 — 124.

GRAVES, C.R., OVERTON, J.R., McCUTCHEN, T., DUCK B.N. and CONNEL, J. 1972. Production of sunflower in Tennessee, Bulletin 494, University of Tennessee Agricultural Experimental Station Knoxville, Tenn. April 1972.

KNOWLES, P.F., TEMPLE, S.R. and STOLP, F. 1970. Variability in the fatty acid composition of sunflower seed oil in, *Proceedings of the Fourth International Sunflower Conference* — June 23 — 25. Memphis, Tennessee, USA.

OWEN, D. 1977. Aspectos nutricionales de las grasas y aceites de Sudamerica. en Seminario: "Alternativas para aumentar las disponibilidades de grasas y aceites comestibles en America La tina. Instituto de Investigaciones Tecnologicas Industriales y de Normas Tecnicas": 26 — 30 Sept. Lima, Peru.

PUTT, E.D., CRAIG, B.M. and CARSON, R.B. 1969. Variation in composition of sunflower oil from composite samples and single seeds of varieties and inbred lines. *Journal of the American Oil Chemists' Society* 46:126 — 129.

ROBERTSON, J.A., MORRISON, W.H. and WILSON, R.L. 1979. Effects of planting location and temperature on the oil content and fatty acid composition of sunflower seeds USDA. SEA. Agricultural Research Results. ARR-S-S/October.

ROBERTSON, J.A. and GREEN, V.E. Jr. 1981. Effect of planting date on sunflower seed oil content, fatty acid composition and yield in Florida, *Journal of the American Oil Chemists' Society* 58:698 — 701.

Figure 2. Effect of accumultated heat units on the average linoleic and oleic acid contents of five sunflower genotypes.

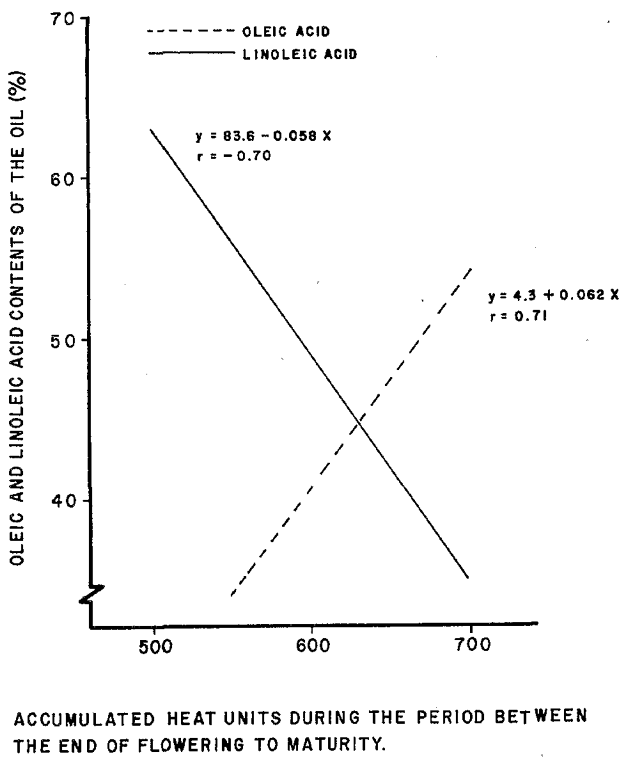
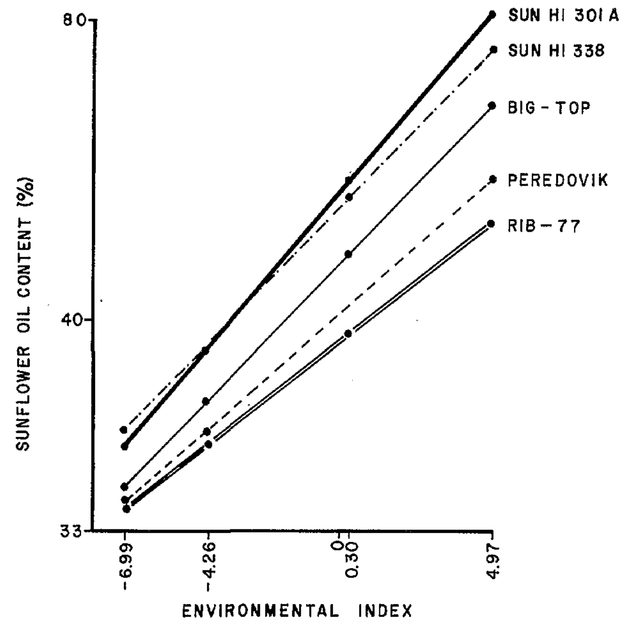


Figure 3. Performance of five sunflower genotypes in oil content.



T1982AGR22

A TECHNIQUE FOR SELECTING SUNFLOWER GENOTYPES WITH TEMPERATURE-STABLE LINOLEIC ACID SYNTHESIS.

JENNY G. SILVER, J.R. McWILLIAM and HAZEL C. HARRIS
Department of Agronomy and Soil Science, University of New England, Armidale, N.S.W. 2351. Australia.

ABSTRACT

High temperatures during seed development reduce the linoleic acid content of sunflower oil. An approach to this problem has been made using a new technique to investigate the effect of temperature on the *in vivo* synthesis of linoleic acid in sunflower cypselae (seeds). The technique involves growing developing seeds in agar medium containing nutrients and hormones. Seeds were taken from sunflower heads fourteen days after pollination and grown in the agar medium. After five days the oil content and dry weight of the embryos had doubled. The oil and storage tissue produced by embryos grown under these conditions appeared completely normal. The oil from these embryos was identical in composition to that from embryos taken from intact inflorescences. This technique is being used to screen sunflower genotypes for the capacity to synthesise high levels of linoleic acid over the range of temperatures experienced in sunflower-growing areas of Australia.

INTRODUCTION

Much of the sunflower oil produced in Australia is low in linoleic acid and does not meet the statutory level of 62% required for use in polyunsaturated products. The cause of this reduced level appears to be high temperature during seed development which depresses linoleic acid synthesis. Evidence from controlled temperature experiments indicates an inverse relationship between temperature during seed development and the degree of unsaturation of the fatty acids (Canvin, 1965; Harris *et al.,* 1978). This relationship has also been demonstrated in the field (Keefer *et al.,* 1976; Harris *et al.,* 1978; Goyne *et al.,* 1979).

In sunflowers, oil composition is under genetic control although there is also a strong environmental component (Putt *et al.,* 1969; Downey and McGregor, 1975). Selection has produced genotypes with the potential for higher linoleic acid levels, but these are thought to be no more stable to high temperature than standard genotypes. To guarantee the production high levels of linoleic acid in sunflower oil it will be necessary to select genotypes that are capable of high linoleic production at high temperature and thus will require an efficient screening technique. Because it is difficult to screen plants under uncontrolled temperature conditions in the field, a more reliable system involving the control of temperatures during seed development will be required. This is necessary because most of the synthesis of oil in developing sunflower seeds occurs over a 10 — 12 day period commencing about ten days after anthesis (Harris *et al.,* 1978). Also, virtually all the oil is contained in the axis and cotyledons of the developing embryo. If cypsellae (seeds) or naked embryos could be successfully grown *in vitro* during this phase of active oil aynthesis it should be possible to grow large numbers of embryos, representing individual genotypes, at an elevated temperature and, using a rapid oil assay, select those