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FATTY ACID COMPOSITION OF SUNFLOWER (*HELIANTHUS ANNUUS* L.) VARIETIES AND F_1 PLANTS

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In recent years there has been considerable interest in the high linoleic acid content in vegetable oils. Plant breeding for the improvement of oil quality and increase in nutritive value is becoming very important. The available of fast and/or non-destructive screening thechniques, for both oil content and quality has made breeding work easier and more effective.

Due to high content of linoleic acid in sunflower oil it seems to be of interest to the plant breeder to know the overall varability in fatty acid composition of sunflower seeds. Because the fatty acid composition in sunflower is largely determined by the genotype of the seed (1) selection for fatty acid composition can be initiated on the individual seeds of an F_1 plant rather than in latter generations on individual plant basis.

This study was initiated to determine 1, the variation of fatty acid composition of the oil in the seeds located in different positions within an invidual sunflower head ; 2, correlation between content of oil and its fatty acid composition and 3, effect of the seed genotype on the fatty acid composition of sunflower oil.

MATERIALS AND METHODS

All biological material was obtained from the Institute of Agricultural Research in Novi Sad.

Mature heads (botanically, the capitulum) were selected at random from three open-pollinated varieties (Peredovik, VNIIMK 8931 and Cherneanka). Each head was divided into three concentric, about five cm ring-shaped zones and two randomized bulk samples from each ring were taken. Content of oil was determined for single seeds by the Spin-Echo NMR techniques (3) or oil was extracted in a classical way using petroleum ether. Composition of oil was determined by gas-liquid chromatography utilizing standard method of the esterification (4).

In order to investigate the effect of the seed genotype on the fatty acid composition, segregating F_2 seeds were analyzed within the heads of F_1 plants. Fatty acid composition was also analyzed in five inbred lines used as pollinators and one inbred line used as common mother strain for five F_1 plants.

RESULTS AND DISCUSSION

Due to high quality of plant oil for human food in general, it is very important to develop a breeding programme with the aim of developing varieties or hybrids with increased content of oil of satisfactory quality. The great increase of the efficiency of breeding programmes based on selection from non-destructivelly analyzed single seeds is a function of the heritability of the variation between seeds produced by one and the same plant. This was shown erlier (6,7) for oil content in maize. Results reported before (5) show that oil content in sunflower seeds also follows such a pattern of inheritance. In a sunflower variety VNIIMK 8931 with mean oil content 45.7% the C.V. in oil content was found to be 12.4%, the variation following the normal distribution. Then, it was concluded that if the seeds contribute equaly to the volume of a sample, the size of a representative sample was computed to about 100 g, at the limit 0.5% permissible relative error in 95% of analyses. In the cited study (5) the heritability of oil content as determined by the genotype of single seed, was studied. Part of the inter-seed within-head variation was indicated to be heritable, as judged from data obtained in the second generation after measurement ($r = 0.53$ P 0.001). In the first generation this heritability was obscured, however, by large influence of the pollinator and by environmental factors ($r = 0.23$ non-significant).

In recent experiments concerning fatty acid composition extensive variability in four major fatty acids (palmitic, stearic, oleic and linoleic) was found in maize (8) (table 1). A very high negative correlation

Table 1

The range of variability in fatty acid composition of corn oil (8)

Fatty acid	Mean value	Range
Palmitic	13.95	7.64—18.70
Stearic	1.76	0.83—3.47
Oleic	29.18	16.36—43.45
Linoleic	55.06	41.35—68.26

of oleic with linoleic acid was observed ($r = 0.95$) (table 2). Also with change in oil level a considerable change in fatty acid composition is observed. The rate of increase of oleic acid is much the same as the rate of decrease of linoleic acid resulting in a constant value for their sum at all oil levels. This finding and the fact that there is a broad variation of oleic (18—35%) and linoleic (54—72%) acids (9) in sunflower are promising and it seemed reasonable to start a programme for breeding sunflower for high content and good quality of oil. Since

Table 2

Correlation coefficients among fatty acids of corn oil (195 inbred lines) (8)

	Stearic	Oleic	Linoleic
Palmitic	—0.11	—0.10	—0.15***
Stearic		0.27*	—0.30***
Oleic			—0.95***

The significance levels * ***
Significant at 5 and 0.1% levels, respectively

the initiation of the flowering begins at the outer perimeter of the head and progresses toward the center over a 14—16 day period, individual achenes are developing and maturing under different environmental conditions. Genotype will also be different due to biology of flowering and pollination.

In VNIIMK 8931 the oil content was determined in single seeds (10 seeds per each circle of the head) and the following results were obtained for oil content and for weight of the seeds (table 3). As indi-

Table 3

Content of oil and weight of single seeds of sunflower open pollinated variety VNIIMK 8931

Circle	% of oil	Weight (mg)
1 outer	36.84	85.14
2 middle	38.18	77.02
3 central	39.46	56.94

Table 4

Estimates of variance components for oil content in different positions on 20 heads (30 single seeds analysed per head) of VNIIMK 8931 variety

Cause of variation	d.f.	square sum	mean square	F
Between circles within plants	40	2,038.01	50.95	6.31**
Within circles	540	4,361.90	8.078	= 2 rest
Total	580	6,399.91		

** *Significant at 1%*

cated by the estimation of the variance components for oil content (table 4) and weight of the seeds (table 5) position effect for both oil content and seed weight is strong.

Table 5

Estimates of variance components for seed weight in different positions on 20 heads (30 single seeds analysed per head) of VNIIMK 8931 variety

Cause of variation	d.f.	square sum	mean square	F
Between circles within plants	40	102,572.0	2,564.3	55.62**
Within circles	540	24,878.8	46.1	= 2 rest
Total	580	127,450.8	219.7	

** Significant at 1% level

In order to see if there is any relation between oil level and fatty acid composition inside the same head and circle, five random selected heads from each of three varieties (VNIIMK 8931, Peredovik and Chernanka) were analyzed for oil content and fatty acid composition. Position effect on oil content was as mentioned above, for all of the three analyzed varieties. The same sample was used for determination of the oil content (extracted by petroleum ether) and fatty acid composition. From the table 6 it is obvious that there is a strong

Table 6

Correlation coefficients among seed position inside the head and fatty acids in sunflower (R = head diameter)

Seed position in variety	R/Palmitic	R/Oleic	R/Linoleic
Peredovik	—0.65	—0.97	+0.99
VNIIMK 8931	—0.98	—0.58	+0.89
Cherneanka	—0.95	—0.98	+0.98

All values significant at 0.1% level.

correlation between seed position and the content of palmitic, oleic and linoleic acids. Stearic acid situation will be discussed in another paper.

As it was reported for maize (8,10) and for sunflower (1,11) there is large negative correlation between oleic and linoleic acid and this is evident from table 7 for all of the three analysed varieties and for different positions inside the heads. Such strong correlation is also evident for single sunflower seeds (table 8). In the same table are presented the results about differences in the correlation coefficients among fatty acids in the oil from maize and sunflower. These results will be discussed in later reports.

Table 7

Correlation coefficients among oleic and linoleic acids in different positions on the heads of sunflower varieties

Variety	Circle	Oleic/Linoleic
VNIIMK 8931	outer middle central	—0.99 —0.96 —1.00
Peredovik	outer middle central	—1.00 —0.95 —0.91
Cherneanka	outer middle central	—0.98 —0.94 —0.98

Table 8

Correlation coefficients among fatty acids of sunflower and maize single seeds

Fatty acid	Maize	Sunflower	Maize	Sunflower
1. C_{160}/C_{180}	—0.11	—0.27	—0.03	—0.35
2. C_{160}/C_{181}	—0.10	—0.53	—0.35	—0.29
3. C_{160}/C_{182}	—0.15	+0.41	—0.54	+0.23
4. C_{180}/C_{181}	+0.27	+0.29	+0.32	+0.12
5. C_{180}/C_{182}	—0.30	—0.47	—0.37	—0.20
6. C_{181}/C_{182}	—0.95	—0.97	—0.97	—0.97

Table 9

Fatty acid composition (%) in the inbreds used as parental components and content of fatty acids of segreagting F_2 seeds in F_1 plants

	Palmitic	Stearic	Oleic	Linoleic
Inbred line I	5.65	4.52	20,14	68.70
Mother line	5.39	3.62	25.26	64.82
F_2 seeds/F_1 plant	5.38	3.74	23.60	66.42
Inbred line II	6.83	3.25	16.28	72.73
Mother line	5.39	3.62	25.26	64.82
F_2 seeds/F_1 plant	5.49	2.86	25.21	65.61
Inbred line IV	5.67	4.70	22.01	66.57
Mother line	5.39	3.62	25.26	64.82
F_2 seeds/F_1 plant	5.44	4.16	24.03	65.50
Inbred line V	6.31	4.15	14.81	73.85
Mother line	5.39	3.62	25.26	64.82
F_2 seeds/F_1 plant	5.63	3.78	20.86	68.97

The validity of the suggestion, that the oil composition of a seed is determined by the genotype of that seed, is being tested by selection from segregation F_2 seeds in F_1 plants. Fatty acid composition was analysed in the seeds of five inbred lines used as pollinators and one inbred line utilized as mother strain. Fatty acid composition was determined in the seeds within F_1 (table 9). From the data obtained so far we can summarize that oil content as well as oil composition in single seeds within the head of a heterozigous plant, as indicated in preliminary experiments, is partly dependent on the seed genotype. As a guidance to breeding work and development of analytical techniques permitting also a non-destructive determination of oil quality in single seeds, the strength of this heritability has to be determined in model experiments.

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REFERENCES

1. Putt, E. D., Craig, B. M., Carson, R. B., 1969, JAOCS *46*, 126.
2. Zimmerman, D. C. and Fick, G. N., 1973, JAOCS *50*, 273.
3. Zupačić, I., Vrščaj, S., Porok, J., Levstek, I., Eržen, V., Blinc, R., Paušak, S., Ehrenberg, L. and Dumanović, J., 1967, Acta Chem. Scand., *21, 6*, 1664.
4. Jellum, M. D. and Wortmington, R. E., 1966, Crop Sci., *6*, 251.
5. Blinc, R., Eržen, V., Levestek, I., Porok, J., Zupančić, I., Ehrenberg, L., Dumanović, J., Konstantinov, Kosana and Ratković, S., 1969, AOCS Meeting.
6. Bauman, L. F., Conway, T. F. and Watson, S. A., 1963, Science *139*, 498.
7. Dumanović, J. and Trifunović, V., 1964, Savremena Poljoprivreda, *7—8*, 521.
8. Dumanović, J., Kapor S., Mišović, M., Popović, S., Ratković, S. and Trifunović, V., 1973, Genetika, *5*, 301.
9. Solomon, B., 1972, 5 Conf. Inter. Tournesol, 429—433.
10. Jellum, M. D., 1970, J. Agr. Food Chem., *18* (3) 365.
11. Zimmerman, D. C. and Fick, G. N., 1973, JAOCS, *50*, 273.