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VARIABILITY IN THE COMPOSITION OF HIGHER FATTY ACIDS IN OIL OF SUNFLOWER INBREDS WITH DIFFERENT OIL CONTENTS IN SEED.

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ABSTRACT

When developing sunflower hybrids, oil quality is as important as high oil content in seed. To develop hybrids with different compositions of higher fatty acids (HFAs) in oil, we examined a number of inbreds which varied in the oil content in seed from 22 to 57%. The following conclusions were drawn. The examined inbreds varied significantly in the composition of HFAs. Environmental factors caused variations in the expression of HFAs among the inbreds and within them. A limited number of the inbreds remained virtually unaffected by the environment. The contents of the most important HFAs, linoleic (18:2) and oleic (18:1), displayed the variability necessary for the development of hybrids with different oil quality. Stearic acid (18:0) displayed the largest variability. Myristoleic acid (14:1) was found in a small number of the inbreds only in 1978. The oil content in seed was significantly correlated only with linoleic (positive) and oleic acid (negative). Some correlations were found between the contents of certain HFAs. The correlations were mostly negative.

INTRODUCTION

When developing sunflower hybrids on the basis of male sterility, one should breed for both, high oil content in seed and certain oil quality. The biological value of oil is estimated by the contents of HFAs and liposoluble vitamins paying special attention to the contents of essential fatty acids (EFA) and alpha-tocopherol, i.e., vitamin E. Oleic (18:1) and linoleic acid (18:2) are the most important HFAs.

Ivanov (1974), Konstantinov *et al.*, (1974) and other authors found differences in the composition of HFAs in various sunflower genotypes and perceived the effect of environmental factors on their expression. Fernandez-Martinez and Knowles (1976) found large variability in the composition of HFAs in wild sunflowers. According to Skoric *et al.*, (1978), the inheritance of oleic and linoleic acid in F1 is controlled by the nonadditive component of genetic variability.

Although linoleic acid commonly prevails over oleic acid in sunflower oil, the market frequently demands oil with a high content of oleic acid. Soldatov (1976) pointed at the possibility of using mutagenic chemicals to develop a high oleic sunflower variety. His variety Pervenec, which has a high content of oleic acid in oil, could be used in breeding to change FA composition in future sunflower hybrids.

MATERIALS AND METHODS

The subject-matter of this paper is a study conducted during 1978 — 1980 to determine the variability in the composition of HFAs in oil of different inbreds and the effect of environmental factors on the expression of HFAs. We analysed 86 inbreds beyond S7, of different genetic origins, with known GCA for the important agronomic characters, which were grown in field in 1978 and 1979 under uniform cultural practices. Average seed samples were analysed for oil content in seed by the method of NMR and for the content of HFAs in oil by the method of gas chromatography. The graphs enclosed show the contents of several HFAs; the other will only be discussed.

In 1980 we examined 16 inbreds varying in their oil contents and composition of HFAs. The data were processed by the regression analysis and correlation coefficients were calculated between oil content in seed and contents of HFAs and between contents of individual HFAs.

RESULTS AND DISCUSSION

The oil contents in seed ranged from 22 to 57%. Environmental factors affected largely the final oil content as well as the processes of oil formation and the accumulation of individual HFAs in oil.

The examined inbreds differed in the content of oil and the composition of HFAs in oil. The variability in linoleic acid (18:2) depended on genotype and environmental factors. The latter were less favorable in 1978 than in 1979; consequently, the contents of linoleic acid ranged from 60 to 67% in 1978 and from 66 to 70% in 1979 (Figure 1).

As there was a highly significant negative correlation between the contents of linoleic (18:2) and oleic acid (18:1) ($r = -94$), environmental factors had the contrary effect on the expression of oleic acid (Figure 2). Most of the inbreds had a higher content of oleic acid in 1979 than in 1978.

Figure 1. Distribution of linoleic acid (18:2) in oil of different sunflower inbreds.

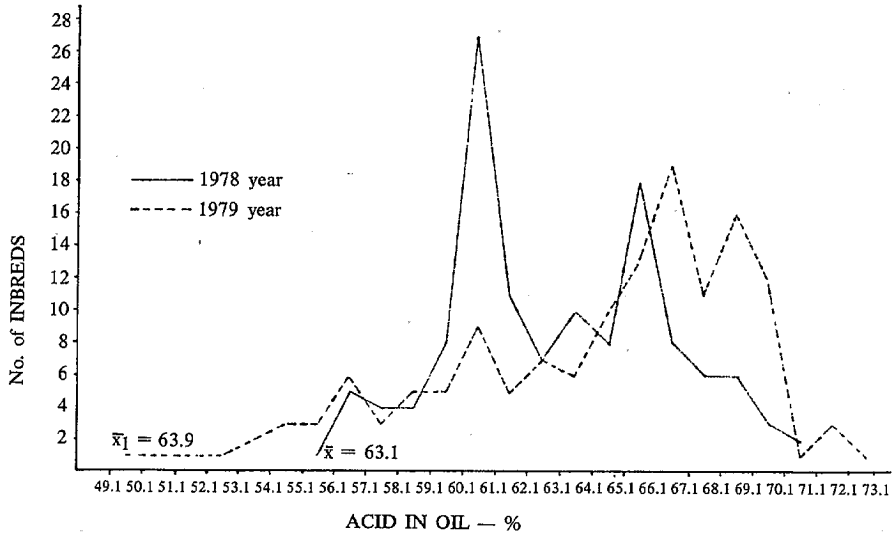
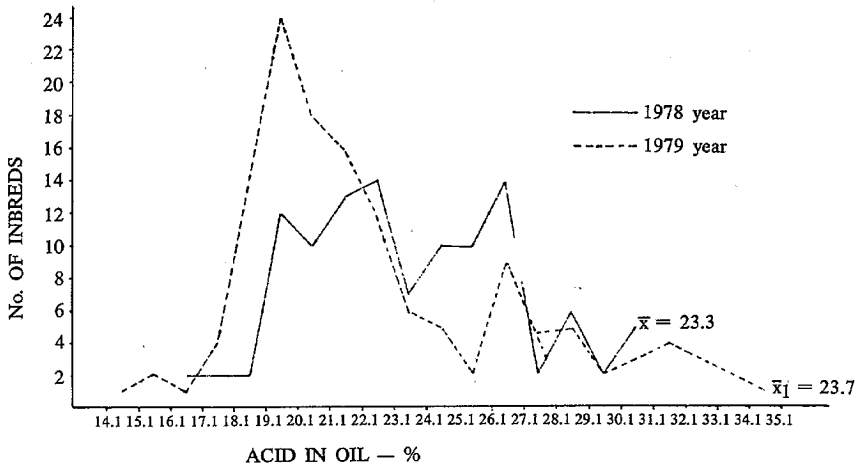


Figure 2. Distribution of oleic acid (18:1) in oil of different sunflower inbreds.



Only a small number of the inbreds had similar contents of linoleic and oleic acid in both years indicating differences in heritability for the above acids in the inbreds. The lines with higher heritability should be used for breeding. The average contents of oleic and linoleic acid were quite close in the test years (Figures 1 and 2) in spite of large differences in environmental factors and genetic differences.

Regression analysis and correlation coefficients found significance only for linoleic and oleic acid: a positive correlation between oil content and linoleic acid and a negative correlation between oil content and oleic acid. It is thus not feasible to make high-oil hybrids rich in oleic acid. The problem may be overcome by including Soldatov's (1976) variety Pervenec into a program of breeding of inbred lines in order to break the negative correlation by mutagenic chemicals.

Figure 3. Distribution of stearic acid (18:0) in oil of different sunflower inbreds.

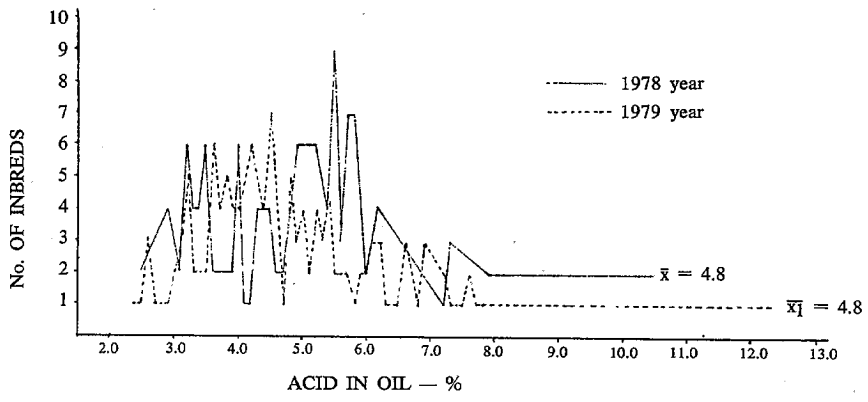
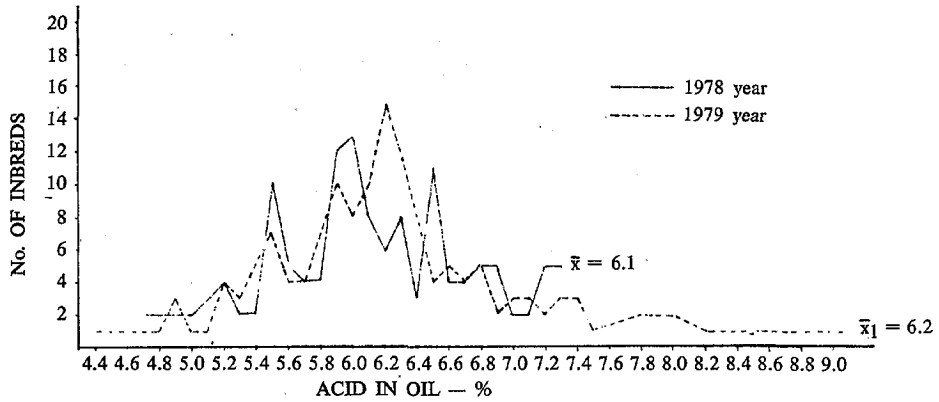


Figure 4. Distribution of palmitic acid (16:0) in oil of different sunflower inbreds.



Stearic acid (18:0) was most variable (Figure 3 and Table 1). With this acid too the effect of environmental factors varied dependent on the genotype but the average reaction of the inbreds was similar. Stearic acid was in negative correlation with the acids 18:3, 18:2, 16:1, and 16:2, in positive correlation only with 20:0.

The inbreds also varied in the contents of palmitic (16:0) acid (Figure 4 and Table 1). Environmental factors affected the formation of this acid in dependence of the genotype. Palmitic acid was positively correlated with the acids 16:1 and 16:2.

The contents of margaric acid (17:0) varied in the inbreds as well as the effect of environmental factors on the expression of this acid (Figure 5). No significant correlations were found between this and the other acids.

Environmental factors had a very high effect on the content of arachidic acid (20:0) in the test years (Figure 6). This acid was positively correlated with the acid 18:0, negatively with 16:1 and 16:2.

Figure 5. Distribution of margaric acid (17:0) in oil of different sunflower inbreds.

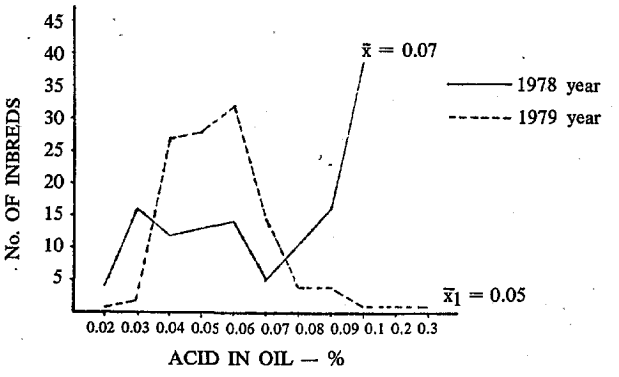
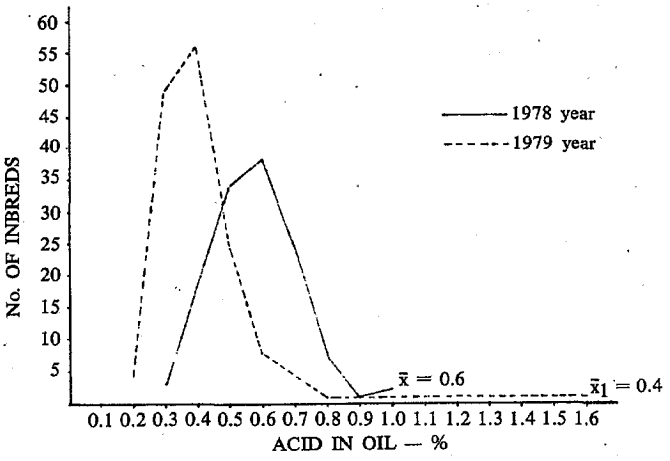


Figure 6. Distribution of arachidic acid (20:0) in oil of different sunflower inbreds.



The contents of myristic acid (14:0) varied from 01 to 1.01%. This acid was positively correlated with the acid 18:2 ($r = 0.76$), negatively with 18:1 ($r = -0.75$).

The contents of pentadecaonic acid (15:0) varied from 0.01 to 0.6%. The expression of this acid was heavily affected by environmental factors. It was not significantly correlated with the other HFAs.

The contents of 16:1 and 16:2 varied from 0.07 to 0.3% and from 0.01 to 0.1%, respectively, in dependence of the line and year. The acids were mutually positively correlated. Positive correlation also existed between 16:1 and 18:2 as well as negative correlation between the two acids on one side and the acids 18:0 and 20:0 on the other.

Linolenic acid (18:3) showed the lowest variability, its contents ranging from 0.16 to 0.39%. It was negatively correlated with the acid 18:0.

The contents of behenic (22:0) acid varied from 0.43 to 1.18% in dependence of the line and year.

In 1978, myristoleic acid (14:1) was found in oil of several inbreds only. The variability discussed hitherto enables the development of hybrids which would differ in oil content as well as in oil quality.

Table 1. Oil content in seed and composition of HFAs in oil of different sunflower inbreds (1980).

Inbred no.	Oil content %	16:0	18:0	18:1	18:2
1	33.82	5.40	12.35	26.63	52.91
2	43.96	8.01	3.22	14.84	71.88
3	22.42	6.38	6.13	35.79	49.45
4	23.68	7.86	4.46	31.16	53.75
5	42.52	5.27	6.50	31.14	54.89
6	40.29	7.88	4.71	15.21	70.09
7	36.73	7.05	6.28	28.20	55.91
8	22.52	6.37	3.17	30.06	58.36
9	47.63	6.92	7.69	20.34	62.99
10	44.50	6.09	4.88	17.19	69.59
11	30.77	5.55	5.08	27.15	60.11
12	34.70	6.00	6.86	26.70	58.38
13	26.43	6.27	2.65	22.11	66.52
14	25.94	5.73	4.37	29.73	58.02
15	50.06	7.06	4.11	22.82	63.94
16	56.31	5.52	4.04	20.16	68.28
$\bar{x}$	36.39	6.46	5.40	24.95	60.94

CONCLUSIONS

The examined inbreds differed not only in the content of oil but also in the composition of HFAs in oil.

Environmental factors caused variations in the expression of HFAs among the inbreds and within them.

A limited number of the inbreds remained virtually unaffected by the environment.

The contents of the most important HFAs, linoleic (18:2) and oleic acid (18:1), displayed the variability necessary for the development of hybrids with different oil quality.

Stearic acid (18:0) displayed the largest variability.

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VARIABILITY IN PROTEIN AND AMINOACID CONTENTS IN DIFFERENT SUNFLOWER INBREDS.

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ABSTRACT

A two-year study on the variability in protein and amino acid contents showed:— The examined cms lines differed in their contents of protein in seed. Also, significant differences among lines were observed during the experimental years. The majority of the lines had higher protein contents in 1980 and only a small number of lines had same or similar contents in both years.

The examined restorers differed in their protein contents in seed.

The restorers differed considerably in the composition of amino acids. The contents of all amino-acids save methionine increased with the increases in protein content in seed.

INTRODUCTION

Protein content in seed is a qualitative character which is largely dependent on genotype and environment. The presently grown varieties and hybrids have protein contents of 16 — 22%.

Plant proteins are increasingly gaining importance in human nutrition. Attempts to extract protein concentrates after oil extraction place sunflower among important sources of proteins. Concurrent breeding for oil and proteins should turn out hybrids with seed which should be larger and more easily dehulled. Such protein-oil hybrids could be used directly in the industrial production of ready-to-serve meals and pastries.

Pustavoit and Diakov (1971, 1972) found variability in protein content in seed of different sunflower varieties and recommended methods of breeding for increased protein yield per area unit. Diakov (1972, 1974) offered a model of protein behaviour in the process of seed forming and oil synthesis.

The objectives of this study were (1) to examine variability in protein content in seed of cms lines with high values of GCA, (2) to examine variability in protein and aminoacid contents in a group of restorers, and (3) to determine correlations between protein and aminoacid contents as well as between individual aminoacids in the restorers.

MATERIALS AND METHODS

Experiments were conducted in 1979 and 1980 in field conditions applying the same cultural practices in both years.

We examined 37 cms lines (A lines) with high values of GCA for seed yield and other important agronomic characters, of different genetic origins, in S12 generation of selfing. They were analysed for protein content in seed and the obtained results were statistically processed.

Fourteen restorers of different genetic origins, used for the development of hybrids, were analysed for protein and amino acid contents. Correlation coefficients r were calculated between protein and aminoacid contents as well as between individual aminoacids.

Kjeldahl's method was used to determine protein content in seed, aminoanalyser to determine the composition of aminoacids.

VNIIMK 8931 and NS-H-26-RM were used as controls.

RESULTS AND DISCUSSION

The examined 37 cms lines showed a large variability in protein content in seed which depended on the genotype and environmental factors. The line cms 2 had the lowest two-year average protein content (19.3%), cms 40 the highest (26.3%): the difference was 7%. A large number of the examined cms lines had significantly different protein contents in the two years.

In 1980, environmental factors were more favorable for protein synthesis than in 1979. In the latter year, cms 40 alone had an outstandingly high protein content. In 1980, cms 40 and 56 had much higher protein contents than in 1979. Some lines, as cms 18, had similar yields in both years. These results show specific genotypic reactions in protein synthesis to the changes in environmental conditions. The lines which were less sensitive to these changes should be used for breeding purposes. However, two-year results are insufficient to draw reliable conclusions on the real value of the examined lines.

The examined restorers displayed significant differences in protein content in seed (Table 2). The minimum content was 18.1%, the maximum 32.9%. The average content of 26.03% was quite high, indicating that the majority of them could be used in certain combinations for breeding hybrids with increased protein content.

Numerous authors have found a negative correlation