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# A STUDY OF COMBINING ABILITY FOR OIL AND PROTEIN CONTENTS IN SEED OF DIFFERENT SUNFLOWER INBREDS

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## Abstract

The following conclusions were drawn on the basis of diallel crossing of 11 lines which differed in genetic origin and the contents of oil and proteins in seed.

The examined lines had different GCA and SCA values for the contents of oil and proteins. The additive genic action governed the inheritance of oil content and the non-additive genic action governed the inheritance of protein content.

The lines with protein content above 2o% (L-6, L-1o, and L-11) had highest GCA values for that character.

Also, the lines with highest oil contents had highest GCA values for oil content in seed.

The lines with high GCA for oil had invaribiably low GCA for proteins. The only exception was L-11 which combined high GCA values for both characters.

The hybrid combinations with high heterotic effect for oil content usually had negative heterotic effect for protein content. It is an indication that the processes of oil synthesis were dominant over the poecesses of protein synthesis in seed as well as that the two characters were negatively correlated.

Highest heterotic effects were observed in some hybrid combinations which featured low oil contents in seed. Hower, their absolute oil contents were too low to be of any practical value.

Regarding SCA for protein content in seed, intermediacy was most frequent in F1 while superdominance practically did not exist.

## Introduction

The sunflower is not only an oil crop but also an important protein crop. It is grown for oil and proteins whose yields per area unit are the result of seed yield and their contents in seed.

Oil percent in seed is highly variable within and between varietal populations. It also depends on environmental factors (Morozov, 1947). Since hybrids replaced varieties in commercial production, it became important to gain knowledge of the mode of inheritance of oil percent in $F_1$. Results of Putt (1966) and Škorić (1976) show that the positive component of genetic variability determines the expression of oil content in $F_1$. According to Schuster (1964), the effect of heterosis for oil content in seed was manifested in 18% of the tested hybrid combinations and its highest reach was only 13% in relation to better parent.

The majority of commercially used varieties and hybrids have between 16 and 22% of proteins in seed. According to Pustavoit and Diakov (1971 and 1972), the increase in oil yield per area unit achieved in the process of breeding does not decrease protein yield but only protein content in seed. These authors also maintain that the main target in sunflower breeding for proteins should not be the breeding for increased protein content in seed but rather for increased protein yield per unit area, although it is followed by an increase in oil content.

A large number of authors reported of significant differences in protein content in seed among sunflower genotypes as well as of the role of environmental factor on the expression of protein content. However, there are only scant data on the mode of inheritance of protein content in F1 seed.

Significant negative correlations between the contents of oil and proteins in sunflower seed were found by many authors. That finding should be kept in mind when simultaneously breeding for high yields of oil and proteins.

The objectives of this study were to examine the mode of inheritance of oil and protein yields in F1 diallels and to determine combining ability for these characters in sunflower inbreds.

## Material and Methods

We examined 11 sunflower inbreds (above $S_{10}$) which differed in oil and protein contents as well as in origin. The lines were labeled L-1 to L-11.

Experiments were conducted in 1982 and 1983 at the experimental field of the Institute of Field and Vegetable Crops at Rimski Šančevi. In 1982, the 11 lines were crossed to produce F1 hybrid combinations. The lines were crossed diallelly, including reciprocals. Mother plants were manually castrated each morning, before the anthers opened, to obtain male sterile plants. The castrated plants and father plants were crossed at two-day intervals throughout the stage of flower. The instruments for crossing were sterilized with $CH_2Cl_2$ after each crossing.

In 1983 we conducted a comparative trial which included all lines and their hybrid combinations. The trial was conducted after the system of random blocks in three replications. The basic plot included 40 plants. Experimental plants were treated against Phomopsis two times during the season, at the stage of 7-8 pairs of leaves and at the stage of budding. The spraying was done with a portable "Honda" sprayer using 2 kg of Benlate plus 3 kg of Cineb with 250 l of water per hectare each time.

Besides the assessment of importan characters during the season, we took average seed samples per basic plot for chemical analyses.

Oil content in seed was determined by an NMR analyser, protein content by Kjöldahl's method. The characters were analysed separately in each of the three replications. The results were processed by the analysis of variance. Combining ability was analysed after Griffing, mathematical model I.

## Results and Discussion

The examined inbreds differed in the contents of oil and proteins in seed. The oil contents ranged from 27.07 to 50.57%, in L-4 and L-11, respectively. The variability in protein content was also considerable, from 13.26 to 21.89%, in L-1 and L-10, respectively. While L-11 combined the highest oil content with a relatively high protein content, L-1, L-3, and L-4 had low contents of both, oil and proteins. Finally, L-6, L-9, and L-10 had high protein contents and low oil contents (Table 1).

The examined lines also differed in combining ability for oil and protein contents in seed. The analysis of variance showed highly significant differences in GCA and SCA for oil and protein contents in seed.

| LINE | L-1 | L-2 | L-3 | L-4 | L-5 | L-6 | L-7 | L-8 | L-9 | L-10 | L-11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| L-1 | 13.26<br>25.55 | 10.92 | 11.12 | 11.58 | 17.14 | 11.04 | 10.49 | 9.17 | 9.25 | 11.38 | 10.46 |
| L-2 | 44.85 | 13.69<br>41.05 | 14.60 | 12.66 | 18.11 | 12.81 | 10.44 | 16.59 | 13.25 | 11.74 | 19.89 |
| L-3 | 44.42 | 44.25 | 16.05<br>34.65 | 10.65 | 13.38 | 11.39 | 18.16 | 10.72 | 18.23 | 19.42 | 20.17 |
| L-4 | 38.71 | 35.56 | 36.63 | 16.53<br>27.07 | 16.94 | 18.80 | 16.97 | 13.99 | 12.94 | 18.29 | 19.78 |
| L-5 | 47.51 | 49.92 | 47.04 | 39.80 | 18.22<br>45.89 | 16.24 | 15.59 | 15.82 | 12.25 | 11.94 | 15.80 |
| L-6 | 38.77 | 38.40 | 39.44 | 31.26 | 43.93 | 20.65<br>29.16 | 18.44 | 16.46 | 17.79 | 20.44 | 17.38 |
| L-7 | 38.25 | 40.85 | 40.96 | 36.27 | 44.75 | 31.08 | 18.46<br>29.89 | 16.66 | 17.84 | 17.91 | 18.19 |
| L-8 | 46.42 | 45.08 | 39.40 | 37.01 | 42.56 | 36.19 | 40.64 | 19.89<br>43.52 | 16.01 | 17.24 | 18.29 |
| L-9 | 43.37 | 42.03 | 42.07 | 35.98 | 47.96 | 39.34 | 37.03 | 45.04 | 20.99<br>37.02 | 22.22 | 18.98 |
| L-10 | 40.51 | 41.45 | 39.51 | 35.34 | 39.93 | 34.66 | 35.03 | 44.91 | 37.46 | 21.89<br>30.31 | 20.46 |
| L-11 | 46.37 | 48.17 | 46.17 | 37.07 | 49.32 | 40.09 | 39.04 | 48.10 | 46.09 | 42.70 | 19.57<br>50.57 |

Column heading: PROTEIN CONTENT, %; row heading: OIL CONTENT, %

For oil content
LSD 5% 1,41%
LSD 1% 87%

For protein content
LSD 5% 0,87%
LSD 1% 1,15%

For the content of oil in seed, the ratio GCA/SCA = 19.09 indicated that the additive genic action governed the inheritance of that character in F1. These results are in good agreement with the results of other authors who studied that character. The non-additive genic action, i.e., dominance and epistasis, governed the inheritance of protein content in seed since the ratio GCA/SCA was 0.68 (Table 2).

Tab. 2 - GCA values for oil and protein contents in seed

| LINE | GCA for protein content | LSD 5% | LSD 1% | GCA for oil content | LSD 5% | LSD 1% |
|---|---|---|---|---|---|---|
| L-1 | -3,89 | | | +0,89++ | | |
| L-2 | -1,63 | | | +2,15++ | | |
| L-3 | -0,75 | | | +0,04 | | |
| L-4 | -1,10 | | | -5,14 | | |
| L-5 | -0,007 | | | +4,60++ | | |
| L-6 | +0,94++ | 0,37 | 0,49 | -4,08 | 0,63 | 0,83 |
| L-7 | +0,06 | | | -3,14 | | |
| L-8 | +0,07 | | | +2,13++ | | |
| L-9 | +0,84++ | | | +0,44 | | |
| L-10 | +1,92++ | | | -2,49 | | |
| L-11 | +2,21++ | | | +4,58++ | | |
| | GCA/SCA = 0,68 | | | GCA/SCA = 19,09 | | |

L-6, L-11, L-10, and L-9 had highest GCA values for the content of proteins in seed (Table 2). These lines had the protein contents above 20%. The other lines, which had the contents below 20%, had low combining ability for that character. It indicates that high-protein hybrids may be developed only if both parent lines have the protein content above 20%. There are only a few sunflower genotypes with 30% of proteins in seed. Our results indicated that the heterotic effect for protein content is rare, and as a rule low when it occurs. It ensues that the most efficient way of increasing the yield of proteins per area unit is to increase the yield of seed per hectare. Highest GCA values for oil content in seed were found in L-11 and L-5, the lines with highest oil contents (Table 2). Besides these two, high GCA values were also found in L-8, L-2, and L-1, the lines with a low oil content. The other lines had low GCA values for oil content in seed.

When we compared the GCA values for oil content and protein content, certain regularities were observed for all lines save L-11.

Namely, high GCA for oil content was as a rule combined with low GCA for protein content and vice versa. Only L-11 combined high GCA values for both characters which makes it valuable for breeding sunflower hybrids.

Certain regularities were found when we considered SCA values for oil and protein contents in seed (Tables 3 and 4). Negative heterosis for protein content was frequent in the hybrid combinations. Also, the F1 combinations had lower protein contents than their parents. The highest values of negative heterosis were found in some combinations of L-1 and L-5. The majority of hybrid combinations with negative heterosis for proteins had significantly high positive heterosis for oil. It means that the processes of oil synthesis in seed are dominant over the processes of protein synthesis. It explains the observed negative correlations.

Tab. 3 - SCA values for protein content in seed

| Line | L-2 | L-3 | L-4 | L-5 | L-6 | L-7 | L-8 | L-9 | L-10 | L-11 |
|---|---|---|---|---|---|---|---|---|---|---|
| L-1 | -0,65 | -0,03 | -0,78 | +5,24 | -1,82 | -2,02 | -2,81 | -3,50 | -2,46 | -3,67 |
| L-2 | | +1,18 | -0,40 | +3,95 | -2,31 | -4,34 | +2.35 | -1,77 | -4,36 | +3.59 |
| L-3 | | | -3.29 | -1,67 | -4.61 | +2,50 | -4,41 | +2.33 | +2.44 | +2.90 |
| L-4 | | | | +2.28 | +3.15 | +1.67 | -0.78 | -2.60 | +1.66 | +2.86 |
| L-5 | | | | | -0.05 | -0.31 | -0.05 | -4.40 | -5.79 | -2.22 |
| L-6 | | | | | | +1.08 | -0.37 | +0.19 | +1.75 | -1.60 |
| L-7 | | | | | | | +0.18 | +0.58 | -0.43 | -0.44 |
| L-8 | | | | | | | | -0,75 | -0.57 | +0.15 |
| L-9 | | | | | | | | | +2.73 | +0.11 |
| L-10 | | | | | | | | | | +0.51 |

LSD 5% = 0.75%
1% = 0.99%

Tab. 4 - SCA values for oil content in seed

| Line | L-2 | L-3 | L-4 | L-5 | L-6 | L-7 | L-8 | L-9 | L-10 | L-11 |
|---|---|---|---|---|---|---|---|---|---|---|
| L-1 | +1.41 | -0.90 | +2.57 | +1.62 | +1.58 | +0.12 | +3.00 | +1.95 | +1.75 | +0.50 |
| L-2 | | +1.67 | -1.84 | +2.77 | -0.05 | +1.46 | +0.40 | -0.95 | +1.41 | +1.04 |
| L-3 | | | +1.35 | +2.01 | +3.10 | +3.68 | -3.16 | +1.20 | +1.58 | +1.16 |
| L-4 | | | | -0.05 | +0.11 | +4.18 | -0.37 | +0,29 | +2.60 | -2.76 |
| L-5 | | | | | +3.03 | -0.53 | -4.56 | +2.53 | -2.56 | -0.26 |
| L-6 | | | | | | -2,07 | -2,24 | +2,60 | +0,87 | -0.79 |
| L-7 | | | | | | | +1.27 | -0.65 | +0.30 | -2.78 |
| L-8 | | | | | | | | +2,08 | +4.89 | +0.99 |
| L-9 | | | | | | | | | -0.87 | +0.67 |
| L-10 | | | | | | | | | | +0.23 |

LSD 5% = 1.26%
1% = 1.67%

Besides negative heterosis, protein content in F1 was most frequently inherited intermediately. Dominance was found seldom while superdominance practically did not exist.

The line L-11, which had the highest oil content (50.57%) and high GCA for oil, did not bring significant heterotic effects when crossed with the other lines. Highest heterotic effects were found between the lines with low oil contents (L-1, L-10, and L-4). Unfortunately, all hybrid combinations had too low absolute oil contents to be of any practical value. When we considered the values of SCA for oil content, highly significant heterosis was found in 15 hybrid combinations and significant heterosis was found in 8 combinations. Negative heterosis for oil content was not observed, but some combinations had extremely low values of SCA for oil content in seed (Table 4).

The majority of hybrid combinations with high SCA for oil content had one parent with high and another with low GCA for that character. It means that a certain line, although with a low GCA value for a certain character, does not have to be a poor combiner for that character.

To acquire better insight into the effect of genes on the expression of oil and protein contents in the hybrid combinations, it is necessary to calculate the components of genetic variability and regression.

## References


BEDOV, S. and ŠKORIĆ, D. 1981. Possibilities of increasing protein content in sunflower. Eucarpia Symposium: Sunflower -Breeding, 267-278, Praque.

GRIFFING, B.: 1954.: Concept of general and specific combining ability in relation to diallel corssing systems. Aust.J.Biol. Sci. 9: 463-493.

MOROZOV, B.K.:1497: Selekcija podsolnečnika v. SSSR. Piščepro mizdat, 1947. Podsolnečnik. Saratovenoe knižnoe izdateljstvo, 1959.

PUTT, E.D. : 1966: Heterosis, combining ability, and predicted synthetics from a diallel cross in sunflowers. Can. J. Plant Sci. Vol. 46.

PUSTAVOJT,V.S.Djakov, A.B., 1971: Urožajnost podsolnečnika i puti jejo povišenija i v procese selekcij. Selekcija i semenovodstvo No 1: 25-29 Moskva.

PUSTAVNOJT,V.S., Djakov, A.B. 1972: O selekcii podsolnečnika na saderžanije belka v semenah. Rastenivodstvo i selekcija No 7: 11-15, Moskva.

SCHUSTER, W. 1964: Inzucht und Heterozis bei der Sounenblume (H. Annus), Habilitationschrift, 1964. Giessen.

ŠKORIĆ, D., 1976: Karakter nasledovanija saderžanija masla v semenah pervova pokolenija i komponenti podsolnečnikaka. Materijali VII Meždunarodnoj konferencii po podsolnečniku (191-195). Kranodar, 1976.