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# RESULTS FROM SUNFLOWER BREEDING DIRECTED TO OBTAINING GENE MATERIALS OF HIGH PROTEIN CONTENT IN THE KERNEL

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## Summary

Protein quantity has been fixed in 408 inbred lines. 27 out of them have shown a kernel protein content over 30% as against 23.6% for cultivar Peredovik and at a high percentage of the kernel too.

Some single heads of cultivar Peredovik's seed production with lowest oil content have been analyzed too. A self-pollination of these with highest protein content was performed in 1976 since the formation of the level of oil and protein are controlled by the genome of the mother plant. In 1977 six of the self-pollinated heads were decomposed again. In this way a gene-bank of 12 heads were formed with a protein content in the kernel coming to 31.0-36.0% and a kernel percentage of 71.0-82.8%.

In 1978 our experimental work will contain through self-pollination and a isolation in free pollination conditions.

Selection work till now has been directed to receiving higher yields of oil per hectare. But besides oil specialists pay attention to the high quality protein too. The high and stable sunflower yields obtained in the climatic conditions of East Europe put very tempting a task to receiving a second sunflower cultivar or hybrid type with a protein content in the kernel close to that of soybean whose cultivation in the cited conditions without any irrigation is rather ventured. This will be a new utilization of the ecological and genetical sunflower potentials for satisfying human and animal necessities of protein.

At the 7th International Sunflower Conference held in 1976 in the town of Krasnodar, SU, we related facts and proved the reality of conducting a breeding work directed to obtaining gene materials with high protein content (38-40%) in the kernel (Ivanov and Stoyanova, 1976). The results below supported our viewpoint:

1. Correlation between kernel yield/ha and the quantity of protein in the kernel is negative but low (about 0.2).

2. The analysis made on 200 self-pollinated lines has noted such lines whose protein content in the kernel comes to more than 30% that is eight absolute percent higher than the standard cultivar Peredovik.

3. Among the plants of lowest oil content selected from the superelit of cultivar Peredovik we have found samples that exceed the standard with up to 13 absolute percent.

## Material and Method

Protein was determined in petroleum ether defatted kernel by Kjeldahl method using 6.25 as a coefficient for calculating nitrogen content in protein.

## Results and Discussion

As an extension of the research work planned we enlarged the circle of the analyzed self-pollinated lines with another 408 new numbers. The values of protein in the kernel that were obtained varied from 16.9 to 36.0%. Distribution of the results according to the quantity of protein is given in Figure 1. The maximum of the curved line as it can be seen from the diagram is at the interval of 23-25% of protein against 23.6% for the standard cultivar Peredovik. Explanation to this can give the fact that the majority of the tested lines originate from modern cultivar sunflower cultivars and hybrids.

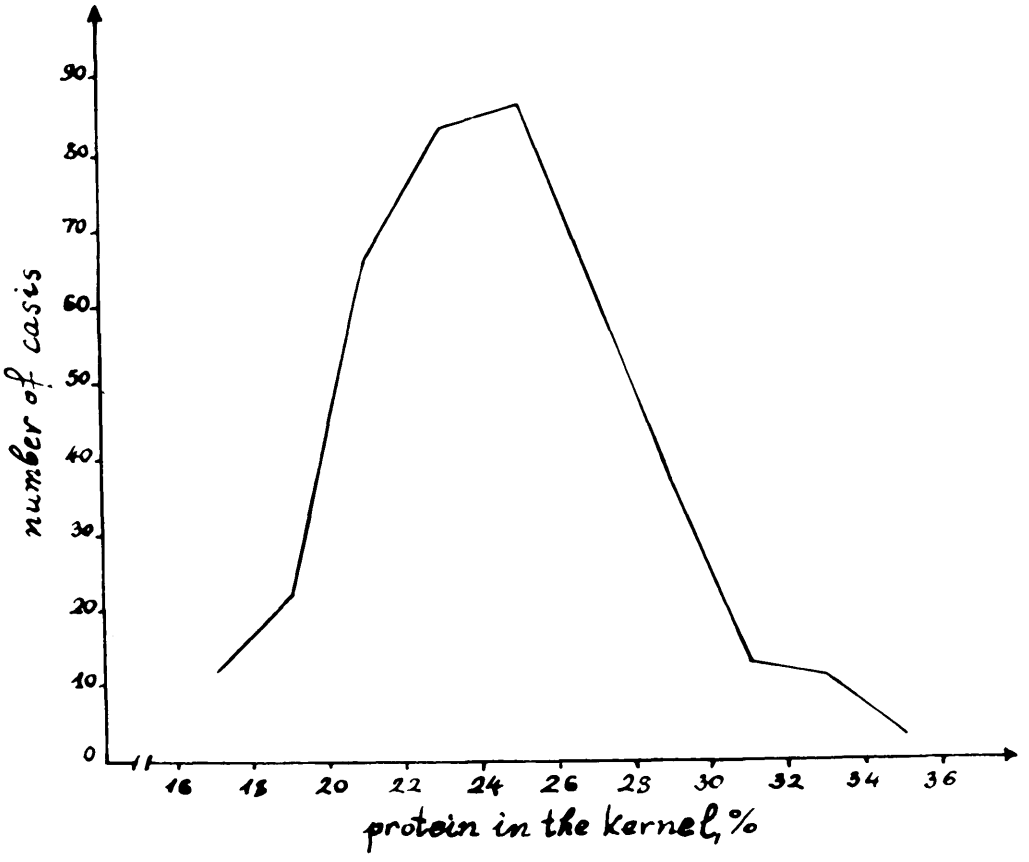
Table 1 gives data for the most interesting lines where the protein content in the kernel is over 31% and the share of the kernel out of the whole seed is over 70%. These materials present a promising start for a future breeding work based on decomposition and selection of even higher protein seeds.

TABLE 1. Self-pollinated lines with the best combinated characteristics of the kernel (Harvest 1975).

| Line | Kernel | Oil in the kernel, % | Protein in the defatted kernel, % | Protein in the kernel, % | Total, oil and protein % |
|---|---|---|---|---|---|
| Peredovik | 79.0 | 60.5 | 59.8 | 23.6 | 84.2 |
| 1418 | 77.6 | 54.1 | 67.7 | 31.1 | 85.4 |
| 1451/2 | 75.7 | 49.6 | 64.0 | 32.3 | 81.9 |
| 1495/1 | 73.4 | 50.1 | 67.6 | 33.7 | 83.8 |
| 1495/3 | 72.9 | 49.8 | 65.1 | 32.7 | 82.5 |
| 1642 | 82.8 | 49.2 | 63.4 | 32.2 | 81.4 |
| 1642/1 | 82.8 | 49.2 | 65.1 | 33.1 | 82.3 |
| 2319/2 | 74.7 | 44.1 | 64.4 | 36.0 | 80.1 |
| 2324/1 | 71.0 | 46.7 | 64.3 | 34.3 | 81.0 |
| 2438/1 | 79.7 | 52.8 | 65.7 | 31.0 | 83.8 |
| 2527/2 | 71.3 | 53.0 | 68.1 | 32.0 | 85.0 |
| 2575/3 | 76.7 | 47.9 | 62.8 | 32.7 | 80.6 |
| 2786/2 | 75.8 | 48.5 | 61.9 | 31.9 | 80.4 |

The juxtaposition made of the results from seeds obtained through a free flowering of the head as it is with the standard cultivar Peredovik and data concerning lines where pollination and development of seeds have passed under semi-transparent paper isolators is not quite satisfactory. That is due to the fact that under the influence of isolator the share of the kernel and its oil content decrease while the quantity of protein in the kernel increases. The inaccuracy pointed out above cannot be avoided but it has to be borne in mind when evaluating results from self-pollinated materials (Stoyanova and Ivanov, 1974).

FIGURE 1. Distribution of Self-pollinated lines according to the protein quantity in their kernel.



Another problem to solve directed to creating high protein gene materials is the work with selected single heads from the superelite of cultivar Peredovik harvest 1974 and 1975 where the high percent kernel is combined with low oil content and high protein content. As the oil content is controlled by the genome of the mother plant (Stoyanova and Ivanov, 1974) and the selected single heads are flowering free to stabliize the given character it is necessary to carry out a decomposition by means of self-pollination of the plants grown from each separate head and to select those of them that happen to be with highest protein content in the kernel. For that purpose in 1976 were decomposed in the same way 20 heads out of which six heads have been chosen for decomposition in 1977. Distribution of the results in intervals concerning materials that have been grown last year from each line is given in Table 2. It can be seen that as a result of double self-pollination a gene bank of 48 heads is created with a protein content in the defatted kernel of over 66%. The effectiveness of self-pollination can be illustrated with data in Table 3. As a result of the second self-pollination of plants grown from the primary head PH74/125 with a protein content of 62.4% the new plant grown in 1977 (PH 74/1254/14/6) is with protein level of 68.9%. Thus an increase of 6.5 absolute percent is achieved. The absolute percent represents the difference between the two relative values. An increase of 8 absolute percent is achieved in head PH74/1959 and such is the increase in PH75/684 too. Best is the level of protein content in head PH75/1906 -- 12.2%. A certain decrease of results is observed only in the generations of PH75/1712. Table 4 includes data of the best self-pollinated heads available now, materials with well combined level of the kernel and its protein quantity, that surpass the standard with more than 10 absolute percent. Research work on these materials will be continued through self-pollination and selection of plants with still higher protein content. Moreover they will be used for producing a synthetic population by a compulsory pollination with mixed pollen under isolator and free flowering in an isolated plot.

The seeds of the six heads selected from harvest 1976 besides for decomposition in 1977 have been used in equal parts to form two synthetic populations by the methods mentioned above. Plants grown under paper isolators possess known characters of the mother plant and after analyzing each of them, data obtained are distributed in intervals according to the values of protein in the defatted kernel (Table 5). That resulted in obtaining 14 heads with a protein content in the defatted kernel over 66%. This figure represents 35% of the whole number of all analyzed plants. The parents of the free flowering isolated plants are not known. All data distributed in intervals are presented in Table 5. Fifteen plants here surpass the accepted limit of 66%, that comes to 19% of the total number of analyzed plants. The best heads obtained by pollination with combined (mixed pollen) are presented in Table 6. Obviously, a great number of plants are available.

Data concerning the best heads, obtained through isolation with free flowering, given in Table 7, surpass with 8.8 absolute percent averagely the protein in the kernel of the standard cultivar Peredovik. It makes an impression that the results for protein level in these materials are lower when compared to those seeds grown under isolation that are discussed in Table 6. Most briefly that can be explained with the influence of the isolator, mentioned before, because of which results increase with respect to protein. But from the other hand these data are quite juxtaposable with the characteristics of cultivar Peredovik.

Research work will continue in 1978 too dealing with the creating of synthetic populations including the available hybrid seeds and the best self-pollinated materials.

## References

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TABLE 2. Distribution of values for protein content in the defatted kernel of materials obtained by self-pollination of some lines (Harvest 1977)

| Intervals | PH74/ 1254/14 | PH74/ 1959/4 | PH75/ 684/5 | PH75/ 1712/4 | PH75/ 1712/6 | PH75/ 1906/2 |
|---|---|---|---|---|---|---|
| 58.1 - 60.0 | | 1 | | | | |
| 60.0 - 62.0 | | 1 | | | | |
| 62.1 - 64.0 | 2 | 1 | | 1 | 2 | |
| 64.1 - 66.0 | 1 | 7 | 2 | 1 | 6 | 4 |
| 66.1 - 68.0 | 3 | 6 | 7 | 4 | 6 | 2 |
| 68.1 - 70.0 | 4 | 3 | 8 | 2 | 1 | |
| 70.1 - 72.0 | | | 1 | | | 1 |

TABLE 3. Heads with highest protein content in the defatted kernel consecutively for years of decomposition

| Lines | 1974 | 1975 | 1976 | 1977 |
|---|---|---|---|---|
| Peredovik | 58.1 | 56.1 | 51.1 | 58.8 |
| PH74/1254 | 62.4 | | | |
| PH74/1254/14 | | | 66.9 | |
| PH74/1254/14/16 | | | | 68.9 |
| PH74/1959 | 61.3 | | | |
| PH74/1959/4 | | | 67.3 | |
| PH74/1959/4/20 | | | | 69.3 |
| PH75/684 | | 62.0 | | |
| PH75/684/5 | | | 67.4 | |
| PH75/684/5/10 | | | | 70.4 |
| PH75/1712 | | 69.9 | | |
| PH75/1712/4 | | | 68.3 | |
| PH75/1712/4/4 | | | | 68.8 |
| PH75/1712/6 | | | 67.0 | |
| PH75/1712/6/8 | | | | 67.8 |
| PH75/1906 | | 58.4 | | |
| PH75/1906/2 | | | 66.6 | |
| PH75/1906/2/2 | | | | 70.6 |

TABLE 4. Self-pollinated heads with best combined characteristics of the kernel (Harvest 1977)

| Lines | Kernel | Oil in the kernel, % | Protein in the defatted kernel, % | Protein in the kernel, % | Total, oil and protein % |
|---|---|---|---|---|---|
| Peredovik | 78.3 | 61.3 | 58.8 | 22.8 | 84.1 |
| PH74/1254/14/5 | 74.5 | 49.9 | 68.8 | 34.5 | 84.4 |
| PH74/1254/14/13 | 75.1 | 49.1 | 68.7 | 35.0 | 84.1 |
| PH74/1254/14/14 | 76.9 | 50.0 | 68.5 | 34.3 | 84.3 |
| PH74/1959/4/16 | 73.1 | 50.0 | 66.4 | 33.2 | 83.2 |
| PH75/684/5/10 | 73.3 | 49.9 | 70.4 | 35.3 | 85.2 |
| PH75/684/5/20 | 72.0 | 48.7 | 68.8 | 35.3 | 84.0 |
| PH75/1712/4/4 | 72.6 | 48.8 | 68.8 | 35.3 | 84.0 |
| PH75/1712/4/7 | 75.7 | 45.7 | 66.6 | 36.2 | 84.9 |
| PH75/1712/4/12 | 73.5 | 49.6 | 66.3 | 33.4 | 83.0 |
| PH75/1712/4/14 | 78.1 | 49.7 | 66.6 | 33.5 | 83.2 |
| PH75/1712/6/12 | 71.0 | 49.8 | 68.6 | 34.5 | 84.3 |
| PH75/1906/2/7 | 72.0 | 47.1 | 67.7 | 35.8 | 82.9 |

TABLE 5. Distribution of the values for protein content in the defatted kernel of the materials from synthetic and the isolation (Harvest 1977)

| Intervals | PH74/ 1254/ 14 | PH74/ 1959/ 4 | PH75/ 1712/ 4 | PH75/ 1712/ 6 | PH75/ 1906/ 2 | PH75/ 684/ 5 | Isolation |
|---|---|---|---|---|---|---|---|
| 54.1 - 56.0 | | | | | | | 5 |
| 56.1 - 58.0 | | 1 | | | | 1 | 8 |
| 58.1 - 60.0 | | | | | | | 8 |
| 60.1 - 62.0 | 1 | 1 | 2 | 1 | 1 | 1 | 10 |
| 62.1 - 64.0 | 2 | 2 | 1 | 4 | | 4 | 17 |
| 64.1 - 66.0 | 2 | 2 | 2 | 1 | 1 | 2 | 14 |
| 66.1 - 68.0 | 2 | 1 | 1 | 2 | 3 | 3 | 10 |
| 68.1 - 70.0 | | | | | | 1 | 4 |
| 70.1 - 72.0 | | | | | 1 | | 1 |

TABLE 6. Heads pollinated by a mixed pollen that have shown best combination of the kernel's characteristics (Harvest 1977)

| Line | Kernel | Oil in the kernel,% | Protein in the defatted kernel, % | Protein in the kernel, % | Total, oil and protein % |
|---|---|---|---|---|---|
| Peredovik | 78.3 | 61.3 | 58.8 | 22.8 | 84.1 |
| PH74/1254/14/7 | 72.8 | 48.5 | 67.8 | 34.9 | 83.4 |
| PH74/1959/4/8 | 73.7 | 49.2 | 66.1 | 33.6 | 82.8 |
| PH75/784/5/7 | 75.3 | 48.5 | 68.9 | 35.5 | 84.0 |
| PH75/1712/4/1 | 76.1 | 45.7 | 66.4 | 36.1 | 81.8 |
| PH75/1712/4/3 | 76.5 | 49.4 | 65.5 | 33.1 | 82.5 |
| PH75/1712/4/6 | 72.4 | 49.5 | 64.9 | 32.8 | 82.3 |
| PH75/1712/6/6 | 72.6 | 51.3 | 68.0 | 33.1 | 84.4 |
| PH75/1906/2/4 | 74.6 | 49.4 | 66.7 | 33.8 | 83.2 |
| PH75/1906/2/6 | 81.3 | 52.0 | 71.8 | 34.5 | 86.5 |

TABLE 7. Heads from the isolation displayed best combination of the characteristics of the kernel (Harvest 1977)

| Head | Kernel | Oil in the Kernel,% | Protein in the defatted kernel, % | Protein in the kernel, % | Total, oil and protein % |
|---|---|---|---|---|---|
| Peredovik | 78.3 | 61.3 | 58.8 | 22.8 | 84.1 |
| 9 | 74.0 | 51.7 | 62.9 | 30.4 | 82.1 |
| 11 | 72.3 | 54.0 | 67.1 | 30.9 | 84.9 |
| 22 | 81.8 | 48.1 | 67.4 | 35.0 | 83.1 |
| 57 | 73.2 | 51.8 | 63.1 | 30.4 | 82.2 |
| 92 | 73.9 | 52.7 | 66.1 | 31.3 | 84.0 |