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# THE INTERACTIVE EXAMINATION OF ENVIRONMENTAL AND BIOLOGICAL FACTORS IN THE SUNFLOWER YIELDS

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## 1. Introduction, Aims

In recent years different natural resources have gained importance. It is crucial that they can be maintained and the circumstances of their reproducibility broadened. Biological resources are renewable. Substances of biological origin cannot be substituted with anything else in the food supply, they function as raw materials for the industry and also have a role as regional energy resources. To satisfy these requirements crop cultivation has an important role. On the other hand, in order to improve both the quantity and the quality of yields, we must acquire a complex ecological attitude and a more rational use of natural resources. All this requires favourable material, technical and social circumstances. The exploitation of genetic resources – as a form of renewable resource – is a fundamental method to increase yields. To do this we have to harmonize the biological needs of the given variety, its ecological attributes and the circumstances of its cultivation.

The national level of average yield equals the useful quantity of crop that can be produced with the required agricultural engineering and the types of crop (hybrids). In the shaping of yields, the primary factors are the right choice of the variety (hybrid), and the application of the most suitable, hybrid-specific methods of production.

Beside the quantitative parameters the security and the quality of yields is also important and forms an integral part of genetic resources, especially in the case of field crops with high energy and protein content.

Nowadays, sunflower is one of the most important industrial plants with vegetable fats, in the past decade the crop area has increased to almost half a million hectares, in 1995 it was 491 thousand hectares. By the end of the ’80s, yields were excellent on a world scale as well. The 2-2.2 tons/hectares average yields of those years have dropped markedly in recent times, the main reason of which was the deterioration of the quality of production. Beside this the stability of production also decreased, both in national and in operating statistics. In the northern-plains district we can find the third of the sowing area for sunflower in Hungary, which highlights even more the importance of this region. The present economical environment somewhat narrows the possibilities for developing production methods. As a consequence we have to turn towards new resources, among which the exploitation of the genetic potency is fundamental. The first step in this direction is to choose those varieties and hybrids, which are most effective in land farming.

Similar to other strains the tendency according to which graded hybrids are more likely to be enlisted as state registered varieties also prevails. The agro-ecological and agricultural engineering necessity of different genotypes, furthermore their resistance to stress shows significant differences.

In my Ph.D. thesis I overview and summarize the research conducted at the Látókép research site of Debrecen University in 1998-2001 supervised by Dr. Péter Pepó.

The objective of my research was to determine, via the examination of yields in different years, the biotic and non-biotic stress-factors that effect sunflower yields with special attention to the Hajdúság region and the specific varieties of sunflower hybrids, which favour the loess soil. In the vegetation periods of the observed years I surveyed the standing crop and by comparing the obtained parameters with the yields using a correlational function I explored their relationships. Relying on the results gained at the time of the harvest I determined the cropping capacity of hybrids in specific agro ecological environments. The analyses of the samples of achene were carried out in the laboratory of the research site of the OMMI at Tordas. I determined the quality of variety in different years on the basis of the obtained parameters.

In order to analyse the stability of the yields I evaluated the data using a linear regression function. To evaluate the complexity of factors effecting yields I applied a special statistical method using multifactorial analysis.

The results of our observations have great practical consequences, as they can improve the effectiveness of the cultivation of sunflower – our principal industrial plant – by the right selection of the most appropriate biological circumstances and genetic resources.

## 2. Materials and Methods

### 2.1 The location of the research site

The observations were carried out at the Látókép Plant Cultivation Research Site of Debrecen University. The site is about 15 km from Debrecen on Route 33.

The soil of the research site is calciferous chernozem, with sediments of around 50% and somewhat lower values in the lower layers. Its physical characteristics are that of semi-compacted clay category.

## 2.2 The weather in the examined years

Beside soil conditions the profitable cultivation of sunflower depends on temperature, the amount of rain and sunshine. In Hungary, the environmental conditions for sunflower are good with special attention to the vegetation period and the occurrence of frosty days in autumn and spring. The only exceptions are the mountain regions and the cold basins surrounded by mountain rigs.

The years, in which I conducted my research, 1998 had the worst weather for sunflower. The distribution and quantity of annual rainfall caused unfavourable nosological circumstances and obstructed harvesting as well. In the summer months of 1999 there were more rain than in average, but the yield that year was still worse than in previous years. In 2000 there was a long draughty period, but despite this, it was an excellent year for sunflower yields – it was the best in the period of observation. The influence of the weather in 2001 was more hostile than in 2000, there were significant rainfalls at the beginning of summer and just before harvesting. In general, yields were higher than average.

## 2.3 The circumstances of the research

Agrotechnological conditions:

The research area:

Random block arrangements with four replications: 3,04 x 9,2 = 27,968 $m^2$

| | | |
|---|---|---|
| Number of plants: | very early: | 60 000 /ha |
| | early and medium | 47 000/ha |
| | confectionary | 35 000/ha |

The sowing-of the plants took place in every year at the middle of April, with soil temperature of 10 $C^0$. The sowing was carried out manually. In the research we have applied an unified agrotechnology and an integrated and harmonious nutrients supply (table 1). To determine the natural resistance of genotypes were not applied pesticides in the vegetation period.

**Table 1 Nutrient-supply and green crop in the years**

| Year | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| **Green crop** | mays | winter wheat | pea | mays |
| **Nutrient-supply (N kg/ha)** | 120 | 90 | 60 | 75 |

In the vegetation period I surveyed the standing crop and determined its biological and agronomical characteristics (phenological parameters, haulm strengths, phytosanitary traits) of the hybrids. On the basis of the yields/parcel and the dampness of the achene, we determined the yields/hectare for the genotypes. During the analysis of the samples of achene we determined the oil and protein content for the sunflower varieties.

In 1998 we observed 4 very early varieties, 23 early ones, 18 medium maturation ones and 4 confectionary varieties. In 1999, 4 very early, 24 early, 12 medium maturation varieties and 6 confectionary varieties were observed. In 2000 we observed 49 hybrids in the comparison of strains, 6 of these were from the very early, 25 from the early, 12 from the medium maturation groups and 6 confectionary varieties. In 2001 we observed 7 very early, 27 early, 15 medium maturation hybrids and 6 confectionary varieties.

### 2.4 The method of evaluation

I processed the data using an IBM compatible PC, with Windows 98 operational system. The table wizard and statistical softwares used were MS EXCEL 2000 and SPSS 9.0 for Windows.

For the evaluation of data we applied a multivariation analysis, linear regression analysis, correlation calculus. I determined the correlation using the Pearson method. I used the F-trial to compare the standard variations. To analyse the ecological effects of each vintage I determined the PET and TET values and their differences. I calculated the evapotranspiration by taking into account each day, using Gábor Szász's method. The actual evapotranspiration was also calculated on a daily basis using the formula of Emánuel Antal. In the stability-analyses I used the KANF method (1993). To reveal the different factors effecting crops I applied Principal Component Analysis.

## 3. The result of the research and their evaluation

### 3.1 The effect of the different years on the yields of the varieties

The results of the observations have revealed that the ecological factors of the habitat fundamentally influence the yields of sunflower. The rainfall in the vegetation period has a primary role in the strengthening of diseases in the shaping of yields. Favourable soil conditions however enables sunflower yields to utilize the rainfall before the vegetation period, so that high yields could be achieved even in a dryer vegetation period.

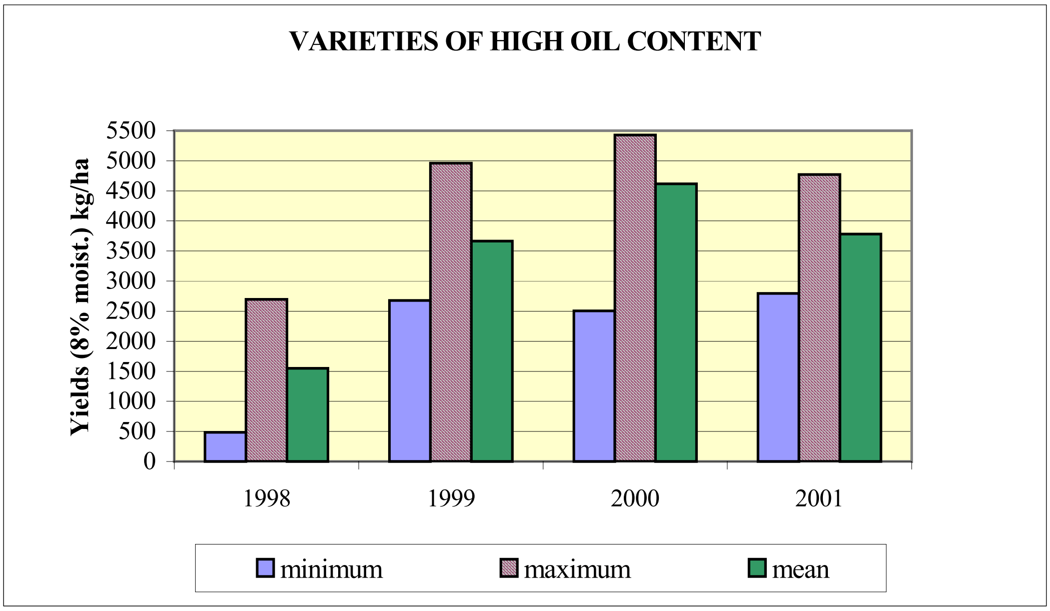
In the period of observation we analysed the weather conditions, the potential and actual transpiration and relying on these we can state that there were significant differences. We observed the greatest divergence in 2000 when the vegetation period was more draughty than average. At the same time the worst year was not 1999, when the divergence was the smallest, but in 1998. This means that the weather conditions and the changes occurring in the vegetation period must be analysed in a differentiated, sensitive manner (table 2).

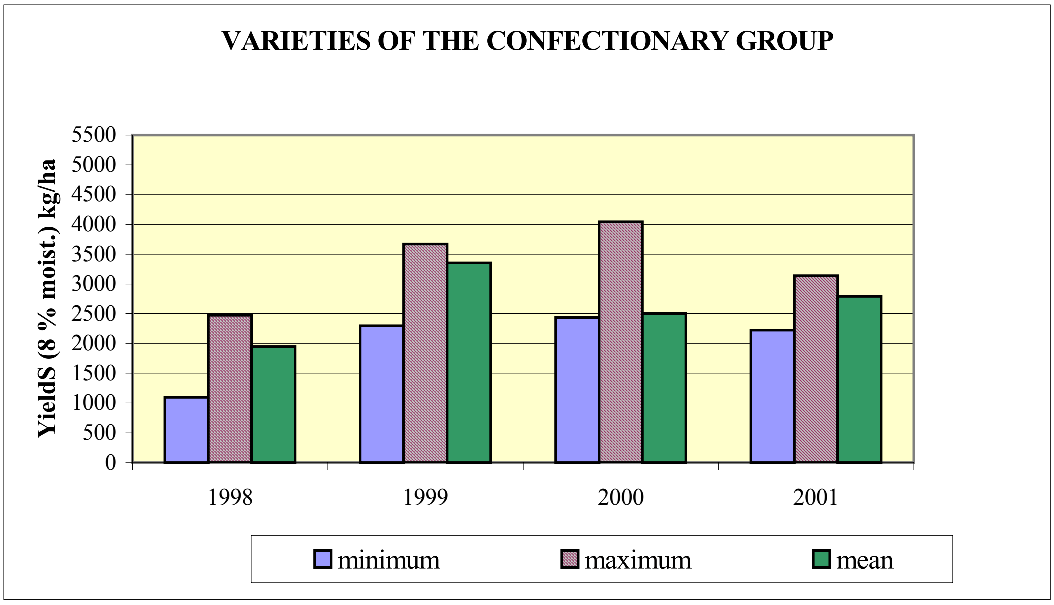
**Table 2 The results and differences of PET and TET. (Debrecen 1998-2001)**

| Year | PET | TET | PET-TET |
|---|---|---|---|
| | mm | | |
| **1998** | 624,4 | 477,3 | 147,1 |
| **1999** | 538,4 | 437,4 | 101,1 |
| **2000** | 607,4 | 304,1 | 303,3 |
| **2001** | 623,8 | 456,1 | 167,7 |

The different years may influence yields decisively, however they influence specific varieties in different manner. The worst year for both the varieties with high oil-content and those in the confectionary group was 1998, while the highest yields were observed in 2000. Through the comparison of the yields of the most prominent genotypes we recognized a divergence of almost 50%. In the year of the best yield, 2000, there were also significant differences between specific varieties (figure 1).

**Figure 1 The yields of sunflower varieties (Debrecen, 1998-2001)**




## 3.2 Examination of the phenological stages of sunflower varieties

The interactions of the x genotypes, the phenological stages of specific varieties and the duration of the phenological stages can be observed at the time of their occurrence. By analysing the average values of the specific varieties (very early, early, medium maturation and confectionary groups) gathered in the period of observation we can see that the different years influences both the vegetative and generative stages. It also effects the speed of the sprouting, the beginning and duration of blooming, and the length of the maturation period. The period between sowing and coming up is in negative correlation with the yields (r= -0.5698). The period between sowing and coming up is in a tight positive correlation with the number of days between the sowing and the flowering (r= 0.8504). There is also a negative correlation between the days from sowing to the flowering and the yield for parcels (r= -0.4982). There is a negative correlation between the period from the beginning to the end of the blooming and the yield for parcels (r= -0.4404).

We observed the most favourable yields when the shooting period was between 12-14 days, and the 13-14 day long flowering period took place 65-70 days after the time of the sowing.

### 3.3 The influence of pathological parameters of sunflower varieties on the yields

In the observation period the most vigorous pathogen was Diaporthe helianthi, which weakened yields through epidemic infections.

The degree of the epidemic was the worst in 1998-9, which was due to the ecological factors that occurred in the different years. Figure 2. shows the values of infection for the high oil content and the confectionary varieties.

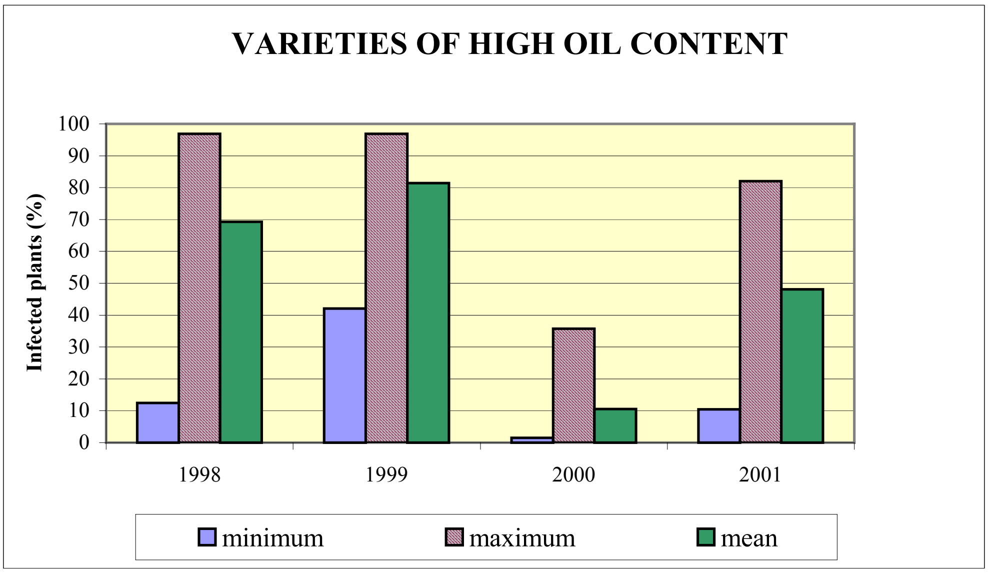
In each of the years we conducted the observations, the varieties Rondo, Hysun 421, Sonrisa and Lympil were more resistant to pathogens, both in regard to infection-dynamics and to the contamination ratio expressed in percentages. Ex 399, Viki, Dogo and Largo in the confectionary group were more resistant to infections.

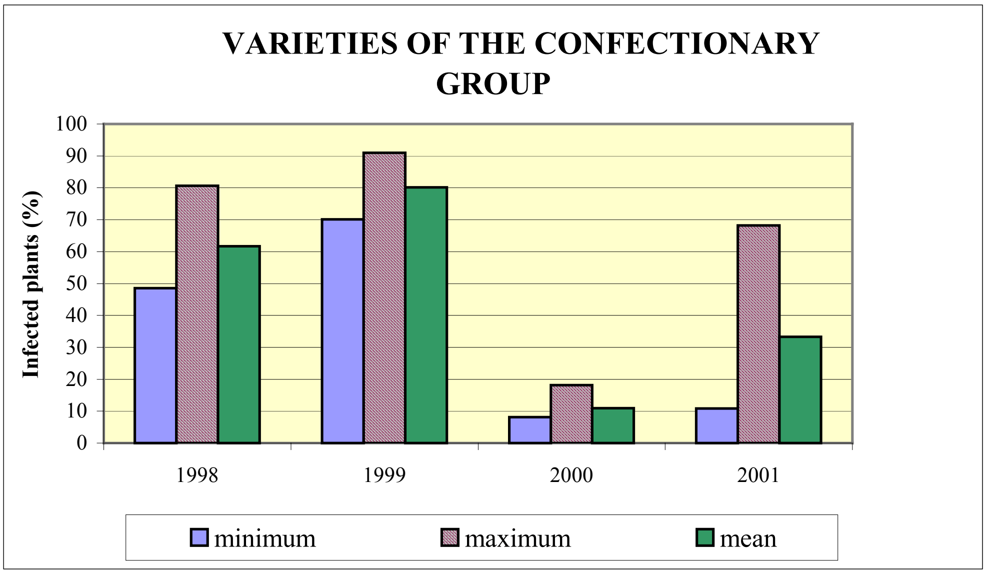
On the basis of the data we gathered the following correlations were observed between Diaporthe helianthi infection and yields:

- there is negative correlation (r= -0.5441) between yields and the contamination ratio expressed in percentages (based on 4 years of observation)
- there is negative correlation (r= -0.5124) between oil content and the contamination ratio expressed in percentages (based on 2 years of observation)

It can be argued that infections influence both the quantity and the quality of yields in a negative way.

**Figure 2 The Diaporthe helianthi contamination of sunflower varieties (Debrecen, 1998-2001)**




The occurrence of Sclerotinia sclerotirorum was more intense in 2001 than in 1999 and 2000. The contamination ratio was however under that for Diaporthe helianthi. The contamination ratio expressed in percentages stayed under 10% for all the 15 varieties observed during the four years. The ratios were the lowest for Fantasol, Sonrisa and Iregi szürke csíkos variety from the confectionary group.

### 3.4 The effects haulm strength parameters of sunflower varieties on yields.

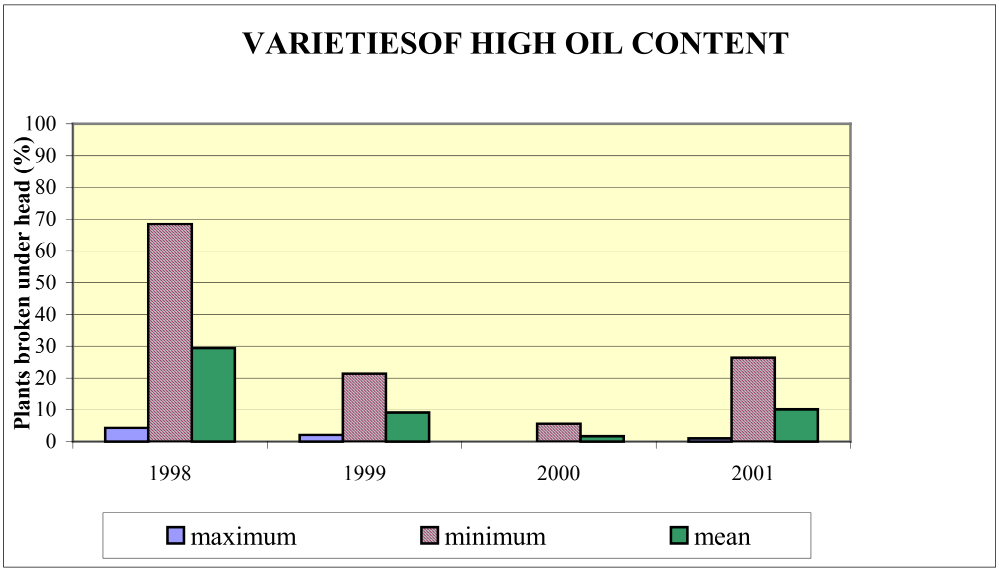
The observed hybrids showed great deviations in relation to haulm strength parameters. The most favourable year was 2000. When the number of stem breaks was low. At the same time the occurrence of wet periods, especially in the second half of the maturation period increased the number of plants, which broke under the head and consequently worsened haulm strength parameters. In 1998 the number of was over 20% with notable differences in the case of specific varieties.

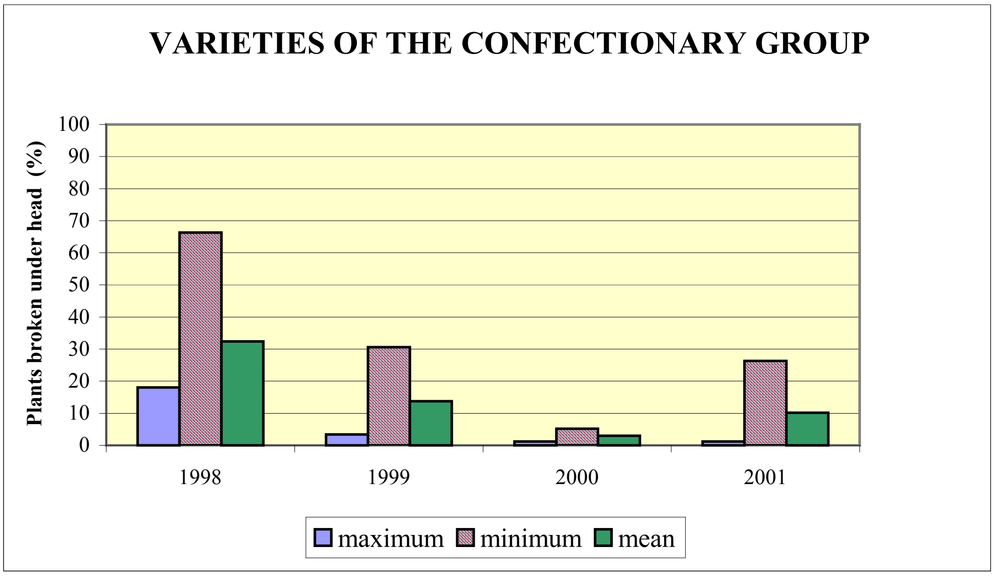
Figure 3. reveals on a yearly basis the parameter of plants, which broke under the head and its distribution among different varieties. In the worst years (as 1998) the maximum figure for the hybrids with high oil content was as high as 70%, whereas the minimum figures were only 5%.

We can state that during the four years of observation from the group the 15 hybrids Resia, Florix, Dogo, and from the confectionary variety, Largo exhibited the least favourable figures, while Hysun 321, Lympil, and Iregi szürke csíkos variety from the confectionary group had the best haulm strength parameters.
We identified the following correlations between the observed hybrids and their haulm strength parameters:

- there was a negative correlation (r= -0.7539) between yields and the percentage of plants, which broke under the head (based on four years of observation).
- there was a positive correlation (r= 6614) between Diaporthe helianthi infections and the number of plants which broke under the head
- there was no statistically demonstratable correlation between oil content and the number of plants which broke under the head (based on the results of two years)

**Figure 3 The haulm strength parameters of sunflower varieties (Debrecen, 1998-2001)**



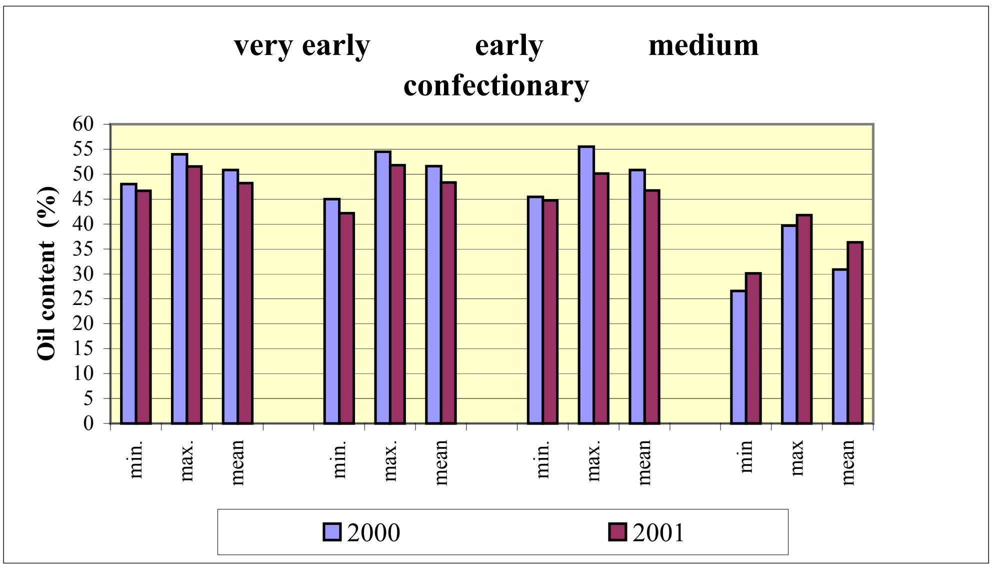

## 3.5 The quality parameters and correlations of sunflower varieties

In relation to the quality parameters, I analysed the oil contents and the protein contents of the confectionary group in 2000 and 2001. In 2001 besides calculating the quantitative indexes for oil content I also determined qualitative parameters, primarily in relation to the composition of fatty acids. In 2000 most of the observed varieties had oil contents higher than 50%. Moreover the figures for Nova, Florix, Alexandra and Dogo exceed 55%. On the other hand the same figure for Rigasol RP and Zoltán were below 45%. From the confectionary group Marica-2 and Hattyú stood at 40% and Largo at 30%. In 2001 only a few hybrids' oil content exceeded 50% (Nova, LGV5385/LHA 147/01, Samantha, Hysun 321, Astor, Fleuret, LG 5645/LHA 347/02). The oil content of some of the hybrids remained below 45% (Rigasol PR, Allstar RM, Altess RM, XF 475/PR63A90). The oil content of the confectionary group – except for Marica-2 and Hattyú – was under 30%.

The observations of the protein contents of confectionary groups showed differences in relation to different years. In 2000 there were only two varieties that reached or exceeded 18% (Marica and the Iregi szürke csíkos), while in 2001 all the observe genotypes. The free withering Iregi had the highest protein content in both years. The confectionary group had better protein content levels in 2001.

In 2000 the average oil content of high oil content hybrids was 51.16%, in 2001 it was less, 47.75%. In relation to separate maturation groups, we observed that high oil content hybrids had outstanding results in 2000, and in 2001 they again exceeded the oil content of hybrids from the confectionary group. Although the yields of the very early maturation group decreased their oil content remained the same and we observed modest differences between the oil content of varieties (Figure 4).

**Figure 4 The oil content of sunflower varieties (Debrecen 2000-2001)**



The correlations between the yield quantity and oil content/protein content were determined by a correlation calculus on the basis of data gathered in 2000 and 2001.

- In the case of hybrids with high oil content and the quantity of yields there is positive correlation (r= 0.5224)
- There was a positive correlation (r=0.5436) in the case of all the 24 hybrids examined in both years.

These data prove that the positive correlations published by OMMI in relation to the yields and the oil content of registered varieties are correct, while for hybrids that were registered earlier, there was no significant correlation between the two parameters.

### 3.6 The evaluation of the fertility of sunflower varieties in the years of observation

We consider favourable the fertility of those varieties, which produce higher than average yields in consecutive years. Table 2. contains the absolute and relative yields of those varieties, which we observed during the full, four years period. Among these, Hysun 321 from the early group had the best yield (the absolute, average yield for the four years: 3922 kg/ha, relative yield: 112.1%) and the other variety above 110% relative average yield was Lympil with 3871kg/ha.

From the confectionary group Marica-2 and the IS 8004 had a 110% relative yield and IS 8004 also exhibited balanced yields.

**Table 3 Absolute and relative yield of sunflower varieties in different years (Debrecen, 1998-2001)**

| Varieties | Yield | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1998 | | 1999 | | 2000 | | 2001 | | Mean | |
| | kg/ha | % | kg/ha | % | kg/ha | % | kg/ha | % | kg/ha | % |
| ***High oil content*** | | | | | | | | | | |
| Ex. 399 | 486 | 28,2 | 3126 | 84,9 | 3927 | 81,5 | 3836 | 101,9 | 2844 | 81,3 |
| Viki | 1426 | 82,7 | 3200 | 86,9 | 4755 | 98,7 | 3423 | 90,9 | 3201 | 91,5 |
| U 55 E | 1654 | 95,9 | 3015 | 81,8 | 4962 | 102,9 | 3665 | 97,4 | 3324 | 95 |
| Sonrisa | 1566 | 90,8 | 4047 | 109,9 | 4789 | 99,4 | 4107 | 109,1 | 3627 | 103,7 |
| Rondo | 1540 | 89,3 | 3673 | 99,7 | 4736 | 98,3 | 3521 | 93,5 | 3367 | 96,3 |
| Resia | 2168 | 125,7 | 4070 | 110,5 | 4360 | 90,5 | 3834 | 101,9 | 3608 | 103,1 |
| Florix | 1721 | 99,8 | 3753 | 101,9 | 4964 | 103,0 | 3675 | 97,6 | 3528 | 100,9 |
| Hysun 321 | 2565 | 148,7 | 4251 | 115,4 | 5207 | 108,0 | 3666 | 97,4 | 3922 | 112,1 |
| Fantasol | 2062 | 119,5 | 4387 | 119,1 | 5045 | 104,7 | 3616 | 96,1 | 3777 | 108 |
| Lympil | 2140 | 124,1 | 3813 | 103,5 | 5427 | 112,6 | 4105 | 109,1 | 3871 | 110,7 |
| Dogo | 1646 | 95,4 | 3187 | 86,5 | 4847 | 100,6 | 3958 | 105,2 | 3409 | 97,5 |
| **Mean** | **1725** | **100** | **3684** | **100** | **4820** | **100** | **3764** | **100** | **3498** | **100** |
| ***Confectionary*** | | | | | | | | | | |
| Marica-2 | 2477 | 127,3 | 3645 | 111,9 | 3643 | 109,6 | 2528 | 94,4 | 3073 | 109,7 |
| Iregi szürke csíkos | 2182 | 112,1 | 3413 | 104,8 | 3693 | 111,1 | 2899 | 108,2 | 3047 | 108,4 |
| Largo | 1093 | 56,2 | 2295 | 70,5 | 2434 | 73,2 | 2224 | 83,0 | 2012 | 71,8 |
| IS 8004 | 2030 | 104,3 | 3672 | 112,8 | 3526 | 106,1 | 3064 | 114,4 | 3073 | 109,7 |
| **Mean** | **1946** | **100** | **3256** | **100** | **3324** | **100** | **2679** | **100** | **2801** | **100** |

### 3.7 The statistical evaluation of yield stability for sunflower varieties

With the help of linear regression analysis we analysed the correspondence of the environment (in this case the different yields) and the group of genotypes which were observed every year. We calculated the lowest dispersions in the case of the Largo hybrid from the confectionary group, which altogether had lower dispersion values. The highest dispersion values were observed in the case of Ex. 399, a representative of the very early group. With the help of the SPSS 9.0 for Windows software we calculated the linear regression function of the varieties. After analysing the regression coefficients we put the genotypes into an order that reflected the yield stability of the maturation groups. The most productive genotypes are those where there are both high yields and a good stability.

Varieties with the best yield stability:

Varieties with high oil content:

- Resia (average yield: 3608 kg/ha, 103.1%)
- Hysun 321 (average yield: 3922 kg/ha, 112.1%)
- Viki (average yield: 320 kg/ha, 91.5%)

Varieties from the confectionary group:

- Largo (average yield:2012 kg/ha, 71.8%)
- Marica-2 (average yield: 3073 kg/ha, 109.7%)

By comparing the different varieties we reached the following conclusions:

- In the period of observation Hysun 321, Lympil and Fantasol had the best yields in the great oil content group.
- In favourable years, specific varieties may reach the yields of the hybrids with high cropping capacity, however the worsening of environmental circumstances effects them in a negative way and results in a decrease of yields.
- Overall, those varieties proved to have greater fertility which are capable of high yields and furthermore have a greater yield stability with a given habitat and cultivation technique in consecutive years. Such varieties with insignificant fluctuation of yields were Hysun 321 and Marica-2.

### 3.8 The statistical analysis and evaluation of the factors influencing yields with the help of Principal Component Analysis.

In order to evaluate the complex role of ecological and biological influences determining yields we used Principal Component Analysis on the parameters gathered during the four years of observation. From among the methods related we decided to apply the Principal Component Analysis and carried out the calculation by the SPSS software. We compared 14 factors in our calculations.

After calculations – relying on the observed factors – were carried out, we found that four factors alone were responsible for 83.3% of all the variations, thus the renewed observations were concentrated only on these four, most determinant factors (Table 4).
During the calculations these factors were transformed into complex factors which are although distinct were grouped according to their correlations. (Table 5).

**Table 4 Variance explained**

| Component | Total | % of Variance | Cumulative % |
|---|---|---|---|
| 1 | 6,421 | 45,866 | 45,866 |
| 2 | 2,862 | 20,441 | 66,307 |
| 3 | 1,902 | 13,583 | 79,890 |
| 4 | 1,037 | 7,407 | 87,297 |

**Table 5 The Principal Component Analysis-matrix**

| | Component | | | |
|---|---|---|---|---|
| **Factor** | **1** | **2** | **3** | **4** |
| Yield | -0,685 | 0,004 | 0,596 | 0,007 |
| Sowing–Flowering | 0,840 | 0,001 | 0,410 | 0,280 |
| Sowing – 50 % flowering | 0,840 | -0,007 | 0,437 | 0,234 |
| Sowing – End of flowering | 0,914 | -0,115 | 0,204 | 0,228 |
| Sowing – technical maturing | 0,198 | 0,864 | -0,007 | 0,404 |
| Lodged plants | 0,207 | 0,721 | 0,484 | -0,292 |
| Broken plants | 0,202 | 0,610 | 0,388 | -0,588 |
| Broken under head | 0,673 | 0,001 | -0,592 | 0,160 |
| Diaporthe h. contamination | 0,800 | 0,291 | -0,138 | -0,285 |
| Sclerotinia s. contamination | 0,576 | 0,480 | -0,119 | -0,146 |
| Infection of the head | 0,740 | 0,007 | -0,393 | -0,170 |
| Difference of PET-TET | -0,835 | 0,439 | -0,234 | 0,005 |
| TET | 0,953 | -0,005 | -0,005 | 0,008 |
| PET | 0,007 | -0,829 | -0,399 | 0,290 |

The first group of factors, closely related to the parameters on the biology of flowering revealed close correlations between the number of days to the time of flowering and the yields. Calculations revealed that the shortness of the period between sowing and flowering effects yield in a positive way. This effect is more emphatic if the flowering itself is brief, that is, the process of flowering is fast and is not effected negatively by any factors. The length of maturation did not reveal similar effects on yields. From the group of haulm strength related parameters it was the number of plants broken under the head that effected yields in a negative way. In the case of pathological parameters Diaporthe helianthi had the worst effect on yields, but in the case of other infections we observed a negative correlation between infections and yields. TET and the differences in the value of TET-PET revealed the importance of ecological factors on yields. These correlations proved that in case the factual figures of evapotranspiration (TET) are high, or the weather is rainy, yields will be smaller. The other factor revealed correlation between lower evapotranspirational values and the period of maturity. The third factor showed the negative correlation between the number of plants broken under the head and yields, while the fourth factor signalled slight negative correlations between the period of maturity and the lodged plants.

## 4. Summary


In my thesis I analysed the productivity, quality parameters, agricultural characteristics of high oil content and confectionary varieties of sunflower in relation to different years. My aim was to reveal the critical stress-factors influencing yields within the specific ecological environment of our habitat by observing the correlations between the different years and genotypes. The comparison of specific genotypes was also useful in determining those hybrids, which have better agricultural characteristics and are more resistant to given stress factors. This way I hope to have helped farmers choose those varieties which are suitable to the region and enable more effective production.

By taking into account the information gathered in the years of observation we can state that the different years influence the yields of genotypes even in favourable soil conditions and by applying the necessary agricultural technologies. We can also conclude that in the years of observation the occurrence and duration of the phenological phase is not only effected by the maturation period, but by environmental factors as well. We also observed that future yields are effected by the stages of maturation, especially by the period of flowering. In case the flowering took place at an earlier date and lasted for a shorter period yields were better.

Among diseases Diaporthe helianthi was the most destructive. The appearance and the dynamics of infections showed significant differences in succeeding years. In 1998 the average of contamination was 70%, in 1999 – 80%, in 2000 – 10 % and in 2001 it stood at 50%. Although yearly differences primarily effected the degree of contamination and the damage caused, there are significant dissimilarities between varieties in relation to their resistance to serious infections. In 1998 the figures of contamination stood between 14 and 90% for specific varieties, while in the most favourable year, which was 2000, it was only between 2 and 38%. The negative effect of diseases on yields was evident (r= -0.5441). The resistance against Diaporthe helianthi was most obvious in the cases of Aréna, Util, Zoltán, Zsuzsa which all had better parameters than the average of their group. In relation to those hybrids we observed during the full four years Rondo, Hysun 321, Sonrisa and Lympil had the best results. Among the parameters of haulm strength the figures describing the under head breaking was the highest, which is in close correlation with degree of contamination by infections. The ratios were different for different yields and specific genotypes and also had a negative effect on yields (r= -0.7539). At the same time, the weather conditions in the period prior to harvesting also influence haulm strength. In favourable, dry weather there were no problems with haulm strength in the case of the observed hybrids. In 2000 the ratio of broken

plants was 0-5%, whereas in 1998 – because of the rainy weather – and the Diaporthe helianthi infections, the ratio of plants which broke under the head was 70%. In this year, (which was the worst from the point of view of haulm strength) Pixel, U-55-E and Util had the lowest number of breaks under the head. In the case of those hybrids we observed during the full four years Hysun 321, Lympil and in the confectionary group the Iregi szürke csíkos had the best haulm strength parameters.

In relation to oil content, the most favourable varieties were Nova, Florix, Alexandra and Dogo, the oil content of which was over 55% in 2000. The oil content of LG 5385/LHA 147/01, Samantha, Hysun 321, Astor, Fleuret, LG 5645/LHA 347/02 hybrids were over 50% in 2001. In the confectionary group the oil content of Marica-2 and Hattyú was higher than the group average.

Oil content was also effected by infections, which was proved by the negative correlation (r= -0.5124) between oil content and Diaporthe helianthi contamination. Relying on the data gathered we argue that the protein content varied in relation to the different years and genotypes. In 2000 we observed ratios between 15.8% and 18.9 %, whereas in 2001 every genotype exceeded 18%. The highest values were tested in the Iregi szürke csíkos strain.

We also determined the varieties that are capable of the highest yields. In 2000, which was the most favourable year, Hysun 321, Fantasol, Lucil, Torero had yields over 5 t/ha with Lympil being the best hybrid capable of 5.4 t/ha yields. In the group of hybrids – we observed for the full four years – Hysun 321, Lympil and from the confectionary group Marica-2 and IS 8004 surpassed the group average by 10%. In the period of observation Hysun 321 and in the confectionary group Marica-2 had the best yield stability.

The overall effects influencing plants were investigated through Principal Component Analysis. Our observations proved those correlations, which we established in relation to individual factors. There is positive correlation between yields and the extent of PET-TET differences, and the flowering which occurred in the beginning of the biological optimum. There are further correlations between yields and the degree of Diaporthe helianthi contamination/ the number of plants, which broke under the head.

## 5. New scientific results

- During the observation carried out in the Hajdúság region we confirmed that there are significant ecological differences between specific sunflower varieties. The effect of the different yields is well reflected in the average yields of the 15 varieties (1998: 1780 kg/ha, 1999: 3570 kg/ha, 2000: 4420 kg/ha, 2001: 3204 kg/ha), which shows a 2640 kg/ha interval of yield fluctuation in the period observed.
- Apart from the ecological factors of the Hajdúság loess soil we determined those hybrids capable of outstanding yields (Hysun 321, Fantasol, Lucil, Torero, Lympil, Alexandra, Cergold, Aréna, Util, Zoltán, Zsuzsa, Magog, Nova, Astor, Florix, Sonrisa, Opera PR, Marica-2, Birdy, Hattyú)
- During the phenological tests of 98 hybrids we determined a negative correlation between the yields and the days from sowing to shooting (r=-0.5698), sowing to flowering (r=-0.4982), and the beginning to the end of flowering (r=-0.4404). We observed the most favourable yields when the shooting period was between 12-14 days, and the 13-14 day long flowering period took place 65-70 days after the time of the sowing.
- The results of experiments carried out on four different yields revealed that there is negative correlation between Diaporthe helianthi contamination and the yields (r=-0.5441) and the contamination and the oil contents (r=-0.5124). In 1999 with a contamination rate of 80% the yield was 3600 kg/ha, in 2000 with a 10% contamination rate the yield was 4600kg/ha for all the observed hybrids. We determined those varieties that have good resistance against infections (Rondo, Hysun 321, Sonrisa, Lympil, Resia).
- During the examination of the haulm strength parameters of the observed hybrids we found that there is a negative correlation between the number of plants broken under head and the yields (r=-0.7539), and there is a positive correlation between the number of plants broken under head and the Diaporthe helianthi contamination (r=0.6614). In 1998 with a Diaporthe contamination rate of 70% the average of broken plants was 30%. In 2000 with a contamination rate of 10% the average of plants broken under head was around 4%. We determined those varieties that have good haulm strength parameters (Hysun321, Lympil, Fantasol, Sonrisa, U-55-E).

- There was a positive correlation between yields and oil-content (r=0.5524) for the high oil-content hybrids in 2000 and 2001. The average data for all the varieties observed in the two years showed a similar positive correlation (r=0.5438).
- The yields we observed proved hat for in evaluation of productivity both the amount of yields and yield stability have to be taken into account. The varieties with the best yield levels and yield stability are Hysun 321, Lympil, Fantasol, Sonrisa and Resia.

## 6. Suggestions for practical use

- We determined those varieties that have good resistance against Diaporthe helianthi infections ((Rondo, Hysun 321, Sonrisa, Lympil, Pixel, Florix, Cersol, Cergold, Master, Iregi HNK 173, Util, Aréna, Zoltán, Zsuzsa, Nova, Alexandra PR, Torero, Abigél, Arena PR, Opera, Mazurka, Agatha, NSH 484, Manade, LG5645/LHA 347/02)
- We determined those varieties that have good haulm strength parameters (Pixel, Hysun 321, U-55-E, Lympil, Util, Fantasol, Sonrisa, Alexandra PR, Fleuret, Opera PR, Iregi szürke csíkos). We determined those varieties with outstanding oil-contents ((Nova, Florix, Alexandra, Dogo, LG5358/LHA 147/01, Samantha, Hysun 321, Astor, Fleuret). From the confectionary group Hattyú has the highest oil-content levels, while Iregi szürke csíkos has the highest protein-content level.
- Relying on our observations the varieties recommended for growing in the Hajdúság region are:
- Varieties with excellent yields: Hysun 321, Fantasol, Lucil, Torero, Lympil, Alexandra, Cergold, Aréna, Util, Zoltán, Zsuzsa, Magog, Nova, Astor, Florix, Sonrisa, U-55-E, Resia, Rondo, Opera PR, Marica-2, a Birdy
- Varieties with excellent productivity and yield stability: Hysun 321, Lympil, Fantasol, Sonrisa, Resia, U-55-E, Florix, Rondo
- Varieties with excellent productivity, yield stability and oil-content: Hysun 321, U-55-E, Florix, Lympil

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