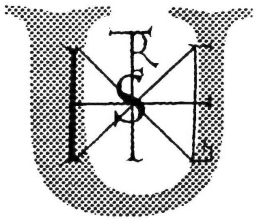

SZENT ISTVÁN UNIVERSITY

WEED FLORA ANALYSIS OF ORGANIC FARMING IN THE FEHÉR-KÖRÖS REGION

Abstract of the PhD. thesis

MIHÁLY ZALAI

GÖDÖLLŐ

2011

Name of PhD school: **Crop Science PhD School**

Field of science: **Crop and Horticulture Sciences**

Head of PhD school: **Dr. László Heszky**
Professor, member of the Hungarian Academy of Science
SZIU, Faculty of Agricultural and Environmental Sciences
Institute of Genetics and Biotechnology

Supervisor: **Dr. Zita Dorner**
Assistant professor
SZIU, Faculty of Agricultural and Environmental Sciences
Plant Protection Institute

.....	.....
Dr. László Heszky	Dr. Zita Dorner
Head of PhD School	Supervisor

Antecedents and aims of work

The development of numerous well-known types of organic farming based on an environmental systems approach in the last century. Hereby the organic farming has become an factor to support the maintenance of the environment to produce healthy food to carry out agricultural structure reform to use environment friendly producing methods and to help the social acceptance of the agriculture (BEDŐ, 2006).

The organic approach differs from conventional farming in many ways. An idealistic industrial approach has appeared in the agriculture connected to the intensive agricultural producing. The aim of this system is to get independent of the environment, the absolute human control and to change natural resources for artificial (ÁNGYÁN and LŐRINCZI, 2003).

The organic farming system does not aim at high yields. Its aim is only an environmentally optimal yield level. In production it uses as few as possible artificial inputs and it refuses the use of Genetically Modified Organism (GMO) both in the plant production and animal breeding.

The controlled organic farming has been present in Hungary since 1986. It became a dynamically developing part of the Hungarian agriculture during the last twenty years. The total controlled area has reached more than 120 thousand hectares by now. In addition to grassland areas the proportion of cereals is the highest.

One of the most cardinal parts of the crop protection of the organic fields is the weed control. Weeds are major factors in yield losses. They use water and nutrient reserve of the soil, suppress crop plants, could be reservoirs of crop diseases and could serve as hiding places of pests. They can increase the production cost, can cause yield loss and can decrease the value of the product (RADICS et al. 2004). According to the organic approach the aim is not to remove weeds totally but to reduce their cover below a damaging threshold level without use of herbicides. Several methods of weed control have to be used efficiently with special knowledge to obtain a low weed cover level.

The utilizing of some useful property of weeds is needed to maintain the unity of the environment. For example they can decrease the wind and water deflation can be used as ingredients of pesticides and well-condition agents can be used as green manure and weeds can help to keep the biodiversity (RADICS et al. 2004).

The organic farming is also practicable in large scale. It needs particular attention in application of high level technologies with respect of the environment and knowledge of the local conditions. Beside the many small organic farms numerous large (many-hundred hectare), long standing farms are in Hungary, for example the “Körös-Maros Biofarm” the “Ecological Modell Farm of Kishantos” or the “Galgafarm Co-operative”.

The aim of my research was to characterize the weed flora of organic farming at the Fehér-Körös River area on the territory of an above 2500 hectare organic farm and to find differences between the different approaches based organic and conventional farms in weed flora. I tried to answer the following questions during my work on the fields of both farming systems:

- Which are the most typical weed species of the organic maize and cereal (spelt) fields, and what is the extent of their cover?
- Does the weed flora of the previously conventionally managed organic fields differ from the weed flora of the neighbouring conventional fields?
- Does any interesting, rare or protected species turn up at the herbicide-free fields?
- Can weed control without herbicides keep the weeds at an acceptable level in different crops?
- Which are the dangerous and problematic weed species of organic farming?
- Are there any differences between the organic and conventional systems in the weed cover in the number of weed species or in the weed diversity?
- Which factors are suitable for the comparison of the organic and conventional fields?

Material and methods

Research circumstances

My research study was made at twenty corn and spelt fields of Körös-Maros Biofarm Ltd in the Fehér-Körös River region between 2007 and 2009. Besides this I surveyed corn and winter wheat fields for a comparison at the neighbouring conventional farm in each year. During my research I identified and classified the present weed species and I surveyed the weed cover and the number of weed species for the description of the weed flora at different crops in organic and conventional farming.

Agronomical and mechanical methods were used in order to decreasing the weed density at the organic farm. The crop rotation and the cultivation have been found important from the aspect of weed control. On conventional fields the weed control was based on "traditional" herbicide treatments.

The number of surveyed fields in the organic farm were seven (four spelt and three maize) in 2007, nine (four spelt and five maize) in 2008 and ten (four spelt and six maize) in 2009. The number of surveyed fields in the conventional farm were two (one winter wheat and one maize) both in 2007 and in 2008 and four (two winter wheat and two maize) in 2009. During the survey field-margins – which meant the area within 2m distance from the sides of the field – and the inner area were also investigated. Two repeats were done in the margins and four in the inner area of each field. The examination areas were 1 m^2 square and were selected randomly. The weed cover and the number of weed species were surveyed during the study.

The weed cover of each field was estimated based on the mean values of four replicates. Species founded only out of sampling areas registered with 0.1 percent cover value. Covering rate of the single weed species was recorded by direct covering percentage (NÉMETH and SÁRFALVI, 1998). Life forms of weed species were determined according to NÉMETH (1996) and *Helianthus annuus* was recorded as T4 species.

Maize fields were sampled three times in 2007 and four times in 2008 and 2009. The dates of surveys were similar in all years adjusted to the phenology of the maize. Cereals were surveyed four times in each year. The first surveys were done before the weed harrowing of the organic fields and the last were done before harvest.

Statistical methods

Conventional and organic maize and cereal fields were compared by statistical analysis. Analysis was based on the number of weed species in each fields, on the total weed cover, and on the Rényi's diversity calculated according to the weed coverage of the fields at $\alpha=2$ value (in what follows diversity). In case of weed cover statistical test were done used the natural base logarithm values.

In case of cereals the result of all survey times (from the first to the fourth) were used for the analyses. In case of the maize only the times from the second to the fourth were used because the first survey was missed in 2007. Statistical analysis was done in three steps with the exception of extreme values in case of all parameters (number of species, weed cover, diversity). Data of maize and cereals was analyzed separately.

First Two Samples T Test was run. The normality and the homogeneity of the variances were controlled by the Kolmogorov-Smirnov and Levene tests. Second Multifactor Univariate Analysis of Variance was run with the farming system and the year-effect and with the farming system and the sampling date when farming systems differed according to Two Samples T Test (with the exception of one case). The homogeneity of variance was controlled by the Levene Test.

Third Logistic Regression was run used values of the number of weed species of each field values of the weed cover and values of the diversity on the same time. Logistic Regression demonstrates how effective the used factors for the modelling of the farming systems are. All of analyses were made on 95 percent confidence level by SPSS programs.

Diversity methods

In addition the statistical test the farming systems were compared by the Rényi's diversity profile, too. The calculation of diversity values were bases on the distribution of cover of weed species. The weed coverage of each conventional and organic field was used for the comparison. ÖKO 05 and KONV 02 cereal fields were compared in 2007, ÖKO 04 and KONV 04 in 2008, ÖKO 18 and KONV 06 in 2009. Comparison of maize fields was based on values of ÖKO 04 and KONV 01 fields in 2007, OKÖ 11 and KONV 03 in 2008, ÖKO 12 and KONV 01 in 2009. Comparisons were done according to second third and fourth times. Exceptions are cereal fields in 2007 when comparison was based not on second time but on value of first time.

Results

Weed flora of organic maize fields

A high level weed presence was experienced during the whole three survey years on the organic maize fields. The weed flora was different from year to year but the most important species as *Cirsium arvense*, *Echinochloa crus-galli*, *Convolvulus arvensis*, *Hibiscus trionum*, *Amaranthus retroflexus* and *Setaria pumila* were significant in the weed flora of maize in all years.

Considering the total weed flora of whole three years the cover and the number of Therophyta (T) species was the highest and the T4 species were the most dominant. The presence of Geophyta (G) species was limited to the presence of *Cirsium arvense* and *Convolvulus arvensis* on the most fields. The rarely present Hemitherophyta (HT) and Hemikryptophyta (H) species were not important.

T4 and G3 species were the most important on the maize fields in the first year. The cover of two monocotyledon annual species (*Echinochloa crus-galli* and *Setaria pumila*) were the highest according the mean of the surveys. The total weed cover was the highest in June.

In 2008 the weed cover of fields was lower than in 2007. The highest cover was found in June (on average 26.35%) but this value was also lower in the same period of 2007. The number of recorded species was similar at the different times. It was between 41 and 48 species.

The weed flora of organic maize was similar in 2009 to 2007 and 2008. The ratio of summer annuals (T4) and perennials with root-stolon (G3) was the highest. The cover of *Cirsium arvense* and *Echinochloa crus-galli* was the highest. The presence of weeds was differ in this year because the weed cover was the highest (nearly 30%) at the last survey time in August. The number of weed species was different, too. Its value was lower than in the previous years.

Weed flora of organic cereals

The weed flora of organic cereals changed due to the distribution of annual rainfall. The degree of the weed density was the highest in April 2007 and in June 2008 following a heavy rainfall period in the surveyed area. Except these times the weed cover was on an acceptable level. Annual and perennial weed species were also present on the fields only few life forms (T2, T4 and G3) had a high value of coverage and high number of species.

As a consequence of the high level of spring rainfall the weed community had increased until the end of April in 2007. The weed cover decreased until May because the most frequent species of cereals finished they life cycle early because of the dry weather.

In 2008 the weed cover was the highest in June. Until June the cover of annual and G3 perennial had increased in the highest degree. The Hemikryptophyta perennials and biennials were less

important during the whole year. The number of weed species changed during the vegetation. The highest value was surveyed at the second time, at 29th of April.

The measure of the weed cover of cereal fields was commonly low in 2009. The degree of weed cover was increasing during the vegetation but its degree was low at the survey before the harvest, too. It was because of the dry spring weather. Therophyta and Geophyta weeds were the most frequent while the cover and number of Hemikryptophyta (H3, H5) and Hemitherophyta weeds was low.

Weed flora of conventional maize fields

The weed flora of conventional maize fields differed in a high degree from the organic maize fields. The weed cover and the number of weed species were lower, too. Beside this mainly T4 species were present on conventional fields while more species from other annual and perennial life forms were present on organic fields.

The results of conventional maize fields were average according the number of species and weed cover, too, in the first year. The weed cover was the highest at the end of June but its measure did not change to a high degree during the vegetation. It was evenly low (2-4%). The number of species was the highest in May and it decreased from this time.

In 2008 the weed cover was lower than in the previous year on the conventional fields. Then the cover changed between 0.60 and 2.18 per cent. The most species were present in April. Its number decreased from the end of May.

In 2009 the weed cover of conventional fields was higher (0.94-8.64%) than in the previous years mainly in July and in August. The number of species was similar like in the previous years but it increased during the vegetation, too.

Weed flora of conventional cereals

The weed cover of conventional cereals was similarly low (0.24-5.20%) as cover of conventional maize. Its value was not extremely high in any survey years. The weed flora included mainly by perennials but numerous annuals mainly T4 species were present, too. The ratio of common cereal weeds (T1, T2) was lower than on organic fields.

The weed cover was low in 2007. Its value was the highest at the first survey and it decreased after that.

In 2008 the measure of the weed cover was low (less than 2 per cent) similarly to the previous year but the number of weed species was higher than in 2007. Annuals were present on the fields at every survey time. The weed flora included annual species expect *Cardaria draba* in March.The measure of the weed cover of conventional cereals was low in the third survey year, too. The cover

was extremely low (less than 1 per cent) in the first part of the vegetation but it increased up to 3.17 per cent until harvest. In March only two species were present and the *Veronica hederifolia* was the most frequent on the surveyed fields.

Comparison of organic and conventional fields by statistics

In case of maize the number of weed species of organic fields was higher than in conventional fields. The organic and the conventional fields were very different according to the weed cover, too. The coverage of the organic fields had a higher degree. The Rényi's diversity (α=2) of organic and conventional fields was different only in a slight degree. In case of maize the chance of the right determination of the farming system is 80.4 per cent without use of Logistic Regression because 80.4 per cent of the samples come from organic farming. The chance of right determination is 98.2 per cent with the use of the model so the Logistic Regression is suitable to model farming systems.

A high difference appeared between organic and conventional cereal fields, too. The measure of the difference of weed cover and the number of species was similarly high between the farming systems and the organic and the conventional fields were also different according to the Rényi's diversity (α=2).

The chance of the right determination of the farming system is 73.1 per cent without use of Logistic Regression because 73.1 per cent of the samples come from organic farming. The chance of right determination is 94.2 per cent with the use of the model because variables of the model explain 94.1 per cent of total variance of farming system. The Logistic Regression is suitable to model farming systems in case of cereals, too.

Comparison of organic and conventional fields by diversity

The Rényi's diversity profiles of maize fields according to the weed cover in May had a similar range of change expect the profile of the conventional field in 2008. The functions of organic fields had a higher degree at every value than functions of conventional fields. In spite of different range of change of functions of conventional field in 2008 the organic fields were more diverse than conventionals according the weed cover in May.

In case of cereals diversity profiles of organic and conventional fields are significantly different according to weed cover also in May. The functions of organic fields had a higher value at zero α value because of the higher number of weed species. The range of change of functions of organic fields was higher than the range of change of functions of conventional fields but the values of organic functions were higher at any α values. In this way organic fields were more diverse than conventional fields in May according to the weed cover of all surveyed years.

New scientific results

1. Weed species of T4 and G3 life forms are present to the highest degree both in organic and conventional maize fields in the Fehér-Körös Region. The cover of species of both life forms decrease during the vegetation. The measure of increasing is higher in case of T4 weeds than in case of G3 species.
2. The cover of T1 T2 T4 and G3 weed species in the more frequent in organic cereals in the Fehér-Körös Region. T1 species are present until the end of April. The appearance of T4 species is continuously during the whole vegetation and it is to be expected they get the most important life form of the weed flora till June. T2 and G3 species are present also continuously and their cover is unchanging.
3. I established by reasons of surveys of organic and conventional maize and cereal fields and by reasons of statistic analyses that fields of different farming systems are different in number of weed species in weed cover and in case of cereals in diversity, too. The number of weed species the weed cover and the diversity had also a higher value on organic fields than on conventionals.
4. I established by reasons of models of Logistic Regression of data from organic and conventional maize as well as cereal fields that all of "number of species" "weed cover" and in case of cereals "diversity" variables make the estimation of the model better but no variables have significant effect on the model. These models are suitable for differing farming systems in case of both crops.
5. I established by reasons of comparison of Rényi's diversity profiles of neighbouring organic and conventional maize as well as cereal fields that diversities of fields of different farming systems are different only in May in case of both crops. Organic fields were more diverse at May surveys than conventional fields.
6. Some rare (uncommon on arable area) weed species appeared on organic maize and cereal fields as *Brassica rapa*, *Caucalis platycarpos*, *Cerastium dubium*, *Chenopodium urbicum*, *Lythrum virgatum*, *Myagrum perfoliatum*, *Potentilla anserina* in the Fehér-Körös Region.

Conclusions and suggestions

Organic and conventional areas are different by reasons of surveys between 2007 and 2009 according to more parameters.

In maize T4 and G3 weeds were the more frequent in both farming systems. From the summer annual monocotyledons *Echinochloa crus-galli* and *Setaria* species were common. Other monocot annuals were present rarely. Organic and conventional fields were different in the highest degree by reason of dicotyledonous weeds. *Amaranthus retroflexus* and *Hibiscus trionum* had a high cover on organic fields in all three years. The presence of *Helianthus annuus* was common on conventional fields because of the differences between crop rotations. In addition these species *Chenopodium* and *Persicaria* species as well as *Abutilon theophrasti* were frequent in both farming systems. Some rare (uncommon on arable area) species were present in organic maize at more times as *Chenopodium urbicum Lythrum virgatum* and *Pastinaca sativa*. For information *Ambrosia artemisiifolia* was not frequent neither on organic nor on conventional maize fields. The most common G3 perennials were *Cirsium arvense* and *Convolvulus arvensis* in both farming systems.

The measure of difference between weed floras of farming systems was higher in case of cereals than in case of maize. While few common weed species of cereals were present on conventional fields after the herbicide treatment, T1 and T2 weeds as *Stellaria media Lamium purpureum Capsella bursa-pastoris Veronica* species *Galium aparine* and *Thlaspi* species were the more frequent on organic fields in March and in April. In addition to annuals *Cirsium arvense* and *Convolvulus arvensis* were present then. These G3 species kept their importance until the May and June surveys before harvest but T4 species became the most frequent. The emergence of summer annual weeds (*Chenopodium album*, *Xanthium strumarium*, *Persicaria* species) was common on fields of both farming systems but a high degree of coverage was experienced only in case of *Tripleurospermum inodorum* on more organic fields.

It was established by comparison of maize fields of two farming systems that organic and conventional farming were different by reason of number of weed species and weed cover. It was also demonstrated by analyses used year-effect and sampling date at the same time. In addition to the number of weed species and weed cover cereals from different farming systems were different in case of diversity, too. Neither the year-effect nor the sampling date had effect on the results of analyses. According the statistic analyses the organic fields had a higher number of weed species and weed cover and in case of cereals they were more diverse. The weed flora of conventional maize and cereals reduced after the herbicide treatment and it appeared in case of weed cover in case of number of species and in case of diversity, too.

I established by the Logistic Regression that any used variables (number of weed species, weed cover, diversity) had not significant effect into the model in case of neither crop. In case of maize number of weed species and weed cover variables, in case of cereals number of weed species weed cover and diversity variables can better the estimation of the model. Models are suitable by reasons of both crops because the chance of right determination of fields is 98.2 per cent in maize and 90.4 per cent in cereals. The chance of right determination is 80.4 and 73.2 per cent without the model. The estimation is more correct on organic fields with the model both in maze and in cereals. Because the weed cover, the number of species and the diversity are also suitable for a comparison of farming systems due to the results of Logistic Regression thus all are suggestible for research of differences of farming systems.

Differentiation of diversity profiles of neighbouring organic and conventional maize fields is able according to the second (May) surveys. In this case functions of all three organic fields had a higher value at any α value so organic maize fields were more diverse than conventionals. The herbicide treatment at the end of April and at the beginning of May had a high effect on the diversity profiles of conventional fields. These treatments kept maize field right weed-free until May. After that the difference between diversities of organic and conventional fields decreased because of the decreasing of the herbicide effect. The differentiation is not able according to results of third and fourth surveys.

Differentiation of Rényi's diversity profiles of neighbouring organic and conventional cereals is able according to the third (May) surveys. Than the values of functions of organic fields was higher so organic fields were more diverse. Herbicides had an effect on diversity on conventional cereals similarly conventional maize. The comparison of cereals is not effective according to results of second and fourth surveys.

In case of organic maize and organic cereals was found rare species in all three surveyed years which are not common in the weed flora of arable area.

Publication list:

Articles in English:

ZALAI, M. – JUHÁSZ, L.T. – RABOCZKI, É. – DORNER, Z. (2009): Differences between ecological farms in weed flora and diversity in Hungary, *Herbologia*, 10: 49-58.

DORNER, Z. – **ZALAI, M.** (2009): Influence of different farming systems on the weed flora in maize in Hungary. *Herbologia*, 10: 29-39.

ZALAI, M. – DORNER, Z. (2010): Weed flora of cereals in different farming systems. *Plant Breeding and Seed Science*, 61: 15-23.

Articles in Hungarian:

DORNER, Z. – BUJDOSÓ, J. – **ZALAI, M.** (2010): Ökológiai és konvencionális gazdálkodásban termesztett kalászos kultúrák gyomviszonyainak elemzése Gyula térségében. *Növényvédelem*, 46: 59-66.

Proceedings in English:

ZALAI, M. – DORNER, Z. (2010): Analysis of weed flora of cereals at the organic farm in Gyula, Hungary. Proceedings. 15th EWRS Symposium, Kaposvár, pp. 143.

DORNER, Z. – **ZALAI, M.** (2010): Effect of ecological farming on weed composition in maize in Hungary. Proceedings. 15th EWRS Symposium, Kaposvár, pp. 278.

Abstracts of presentations and posters in English:

ZALAI, M. – DORNER, Z. (2008): Effect of ecological farming on weed flora in cereals in Hungary. Intractable Weeds and Plant Invaders, 2nd International Symposium, Osijek, Croatia, pp. 77.

ZALAI, M. – DORNER, Z. (2009): The influence of farming system on the development of weed flora in cereals. 1st International Conference „Conserving Arable Weed Diversity" The role of weeds as an ecological resource and indicators of agro-ecosystem function, Radzików, Poland, pp. 28-29.

Abstract of presentations and posters in Hungarian:

ZALAI, M. – DORNER, Z. (2008): Ökológiai gazdálkodásban termesztett napraforgó gyomviszonyainak elemzése. 54. Növényvédelmi Tudományos Napok, Budapest, pp. 51.

DORNER, Z. – **ZALAI, M.** (2008): Az ökológiai és a konvencionális gazdálkodás összehasonlítása diszkriminancia-analízissel. 54. Növényvédelmi Tudományos Napok, Budapest, pp. 58.

ZALAI, M. –DORNER, Z. (2008): Az ökológiai gazdálkodásban termesztett kalászos kultúrák gyomviszonyainak elemzése. 18. Keszthelyi Növényvédelmi Fórum, Keszthely, pp. 118.

BUJDOSÓ J. – **ZALAI, M.** – DORNER, Z. (2009): Ökológiai és konvencionális gazdálkodásban termesztett kalászos kultúrák gyomviszonyainak összehasonlító elemzése. 55. Növényvédelmi Tudományos Napok, Budapest, pp. 52.

JUHÁSZ, L.T. – **ZALAI, M.** – DORNER, Z. (2009): Az ökológiai gazdálkodás hatása a kukorica gyomflórájára a konvencionális gazdálkodás tükrében. 55. Növényvédelmi Tudományos Napok, Budapest, pp. 53.

DORNER, Z. – **ZALAI, M.** (2009): Ökológiai gazdálkodásban termesztett kalászosok gyomviszonyainak összehasonlító elemzése. Dr. Ujvárosi Miklós Gyomismereti Társaság 26. találkozója és a Magyar Gyomkutató Társaság Konferenciája, Salgóbánya, *Press in Magyar Gyomkutatás és Technológia, (10) 1. 61*

ZALAI, M. – DORNER, Z. (2010): Tönkölybúza táblák jelentős gyomnövényei a gyulai Körös-Maros Biofarmon. 56. Növényvédelmi Tudományos Napok, Budapest, pp. 43.

Other publications:

KISS, G. – **ZALAI, M.** (2006): Mezei acat (Cirsium arvense L.) ellen alkalmazható herbicidek tartamhatásának vizsgálata. 52. Növényvédelmi Tudományos Napok, Budapest, pp. 74.

PATAKI, J. – **ZALAI, M.** – DORNER, Z. (2007): Gyomszabályozási kísérletek fekete bodza ültetvényben. 53. Növényvédelmi Tudományos Napok, Budapest, pp. 54.

ZALAI, M. – PATAKI, J. – NÉMETH, I. (2007): A parlagi rézgyom (Iva xanthiifolia Nutt.) térhódításának újabb eredményei Békés megyéből. 53. Növényvédelmi Tudományos Napok, Budapest, pp. 60.

DORNER, Z. – **ZALAI, M.** (2008): Szántóföldi kultúrák gyomviszonyainak elemzése a Kishantosi Ökológiai Mintagazdaság területén. 18. Keszthelyi Növényvédelmi Fórum, Keszthely, pp. 108.

DORNER, Z. – **ZALAI, M.** (2008): Analysis of weed flora of ecological farming system at the ecological model farm of Kishantos. Hungary. Intractable Weeds and Plant Invaders, 2nd International Symposium, Osijek, Croatia, pp. 78.

DORNER, Z. – **ZALAI, M.** – SZEKERES, D. – PÁLINKÁS, Z. – SZÉNÁSI, Á. (2010): Glyphosate-toleráns (DAS-1507 x NK603, DAS-59122 x NK603) kukorica: csökkenhet vagy növekedhet-e a biodiverzitás? 56. Növényvédelmi Tudományos Napok, Budapest, pp. 65.

ZALAI, M. – NÉMETH, I. (2007): A parlagi rézgyom (*Iva xanthiifolia* Nutt.) bemutatása és jelenléte Békés megyében. *Növényvédelem*, 43: 539-542.

ZALAI, M. – PATAKI, J. – DORNER, Z. (2008): A fekete bodza (*Sambucus nigra* L.) vegyszeres gyomszabályozása. *Növényvédelem*, 44: 159-164.

VIKÁR, D – SZIRMAI, O. – CZÓBEL, SZ. – DORNER, Z. – **ZALAI, M.** (2010): Fiatal szántóparlagok szekunder szukcessziójának vizsgálata, különös tekintettel azok gyomviszonyaira. *Növényvédelem*, 46: 109-116