SZENT ISTVÁN EGYETEM

LOW ENVIRONMENTAL BURDEN RISK WEED CONTROL SOLUTIONS IN MAIZE

THESIS OF PH.D. DISSERTATION

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1 Research antecedents and the defined objectives

It is no exaggeration to say that maize, which leads the list of cultivated row crops, is one of the most definitive plants of both the world economy and the world in general since, besides it being a source of human food, it is also a staple in the kitchens and foods of developing countries. In addition, it is fundamentally essential and important in the feed of practically all livestock, meaning it is of strategic importance in the production of raw meat meant for human consumption. It also plays a leading role in the research and development of production technologies and all involved players; furthermore, maize is the most elemental motivator of agricultural market trends.

An enormous change started taking place in the 1950's that is still under way in the production of food raw materials and feed as well as in the market demand for those. However, this process is far from over, since agricultural developments, changes in the industry, and structural changes are becoming increasingly precise and are increasingly meeting all aspects of demand.

We have a responsibility to conscientiously develop a type of plant production and plant protection that is sustainable (or at least produces suitable quantities and meets the requirements of the consumer side) and to help these two areas cooperate. The challenge is also given, since we are required to produce increasing quantities under changing environmental, cultural, and legislative conditions, also taking care to not deteriorate quality indices.

However, globalization and the continuous growth of the global population pose ever newer quantitative challenges to the people involved in maize production. Besides the countries that show visible economic expansion (such as Brazil, Russia, India, and China) behind the increased demand, the second wave of developing countries (Algeria, Egypt, Indonesia) are also responsible for economic success, as the increasingly widespread change in their dietary habits has led to a transition from the consumption of plant-based foods to meats, in addition to the fact that meat has become a regular and important component of the everyday kitchen of an ever wider layer of society. However, in the case of developing Asian countries, the explosive increase in demand caused by the changes that occurred in the quality of life and in dietary habits has not been accompanied by the in-depth intensification of agriculture that would be able to supply the above demand, as a result of which the production of the necessary greater quantities has to be provided from the areas of developed countries, which in turn leads to the continued intensification of the production in those countries and the inclusion of new arable areas in production. Simultaneously, both the areas in which maize can be utilized and its markets have continued to expand as

bioethanol plants start their operations and oil prices increase; these have led to a market characterized by shortage.
Hungary has been a leading maize producer ever since the 1960s and has maintained its position for decades. The centuries old traditions and technological know-how of production have been passed on from the small farms worked by peasants through to Hungarian twin row planting and down to today, and they have developed along the way. We, as a leading producer, thus have a place and continue to play an important role in continuing the development of production technologies and increasing the efficiency of the entirety of production with the knowledge and skills we have at our disposal. As time passes, the ranking of national production data seems to rearrange, as Ukraine, Romania, and Serbia from Europe and Brazil, Mexico, and Argentina from other parts of the world are playing increasingly important roles in providing a solution to the quantitative questions of maize production.
The task is thus to maximize production with the smallest possible losses and to attain this production potential through technological intensification, of course with production posing the requirement of effectiveness and environmental factors requiring sustainability and the minimization of loads.
Of these, the most important aspect is the effect weeds and weed coverage have on potential yields. In addition to the continued intensification of production technologies, there is also a need for a change in the views of both producers and consultants, since it is decisions and solutions that are based on the knowledge of individual fields which are capable of taking us into a world that is past the qualitative and quantitative limits we encounter today.

Since the fourth national weed field survey (1996-1997), significant changes have taken place in our arable lands. The past one and a half decades have seen a rearranging of the ownership structure of Hungary's lands and those can now considered to be permanent, with the number of people farming small areas of land having increased together with the sizes of the lands they farm. Partly because of farming methods and partly due to the simplification of crop rotation, this has also led to substantial changes in the dominance relationships of field crop weeds, which in turn has increased the spreading of several weed species. In addition to all the above, a change in herbicide use is one of the other important, if not the most important, factors that plays a role in weed flora changes. In recent years, the European Union has revoked and is also currently in the process of revoking the licenses of numerous herbicide active ingredients, with which it allowed certain species that were previously not present or were only rare in farmed areas to appear or to proliferate, respectively. The new and the hard-to-eradicate species can cause production safety risks or can require substantial additional costs in case of a poor selection in treatment. However, it must be made clear that the right decision on protection, which focuses on only the occurring species, can suitably repress their presence, and can halt future spreading in the given crop, can only be made with suitable knowledge of our arable lands and the weeds that infect those. For these reasons, it is important to track, be familiar with, and document the dominance relationships of the present field crop weed flora for both herbicide development and herbicide use.

After identifying the weed species that play the greatest part in the production of row crops in Hungary, the goal is to develop, test, and fine tune an optimized herbicide formula that is capable of effectively repressing weeds with prevalent coverage values in maize, both in Hungary and in the similarly weeded areas in neighbouring countries; and all this is to be attained with a smaller environmental burden. This allows us to come one step closer to utilizing a higher yield potential, since a product developed explicitly for the dominant weeds that occur in Hungary can allow us to start the fight against the most important weeds in good time. I was basically looking to identify a solution that would help weed control in maize and provide production technology with a more sustainable and environmentally friendly framework.

Taking the above into account, my objectives were as follows:

- My objective was to perform individual weed surveys in 4 settlements in Pest County, to determine trends on the basis of the weed survey results, and to rank the important weeds occurring in maize cultures.

- To analyse the weed infestation of maize on the basis of my own surveys. During the course of the study, to highlight the most dangerous weeds on both a national and international level. To identify the species that most influence the success of weed control.

- To conduct studies to determine the optimal time of weed control as the intervention that most affects yield amounts in the future, as well.

- To develop a product that is tailored to the weed flora and environmental conditions of Hungary, its important neighbouring maize producing countries, and the most prominent weed species; the product is to aid the sustainable and knowledgeable utilization of areas by local farmers.

- To test herbicide combinations in greenhouse production conditions, to identify the various ratios of active ingredients, to select the suitable product based on herbicide efficacy, and to continue development of the latter in field tests.

- To use field tests to present the range of efficacy of the product developed for the more important weeds occurring in Hungarian maize production.

2 Materials and methods

2.1 Weed surveys in the field

As part of the fifth national weed field survey, which is of increased importance for the future, I performed weed surveying two times (early summer and late summer) each in two subsequent years (2007-2008) from 4×4 metre quadrates in maize fields located at the edges of the settlements Káva, Ráckeve, Dömsöd, and Tahitótfalu; the quadrates numbered ten per each settlement in order to ascertain that my results could be compared with the national survey results to thus provide a true picture of the developments in weed flora.

2.2 Maize trough and pot studies in greenhouse conditions

In the greenhouse tests, I studied the herbicide candidates on 34 various weed species at 6 different dose levels and with 2 repetitions, applying the herbicides both in the preemergent and the postemergent phase within the same study. Similarly to the field studies, the evaluations took place on the 7^{th}, 14^{th}, and 21^{st} days. The greenhouse tests were used to test various combinations and formulas of mesotrione and terbuthylazine.
In the interest of ascertaining the time at which weeds start discernibly "disturbing" maize in the case of the control plants, which enjoyed ideal conditions in all other respects, I also completed a similar greenhouse trough and pot study with a suitable number of repetitions but without the use of herbicides, in addition to the chemical tests described above.

2.3 Weed control experiments in field maize cultures for the purposes of development and registration

The field studies were primarily set up in accordance with EPPO Guidelines. In addition, I also planned and set the studies, used evaluation methods, analysed the results, and defined the formal requirements of the reports as set forth in the EPPO Guidelines. I conducted the small plot trials on 15 m^2 sized parcels per each treatment.
On the one hand, I used box and whisker plots to analyse the data, which summarize the noted results and graphically depict their distribution. On the other hand, I also used star charts (radar charts or cobweb charts) to display the data comprising the results of the entire test series, which unequivocally indicate the weed spectrums of the various doses pertaining to several target organizations.

3 Results

3.1 Weed survey results

I established that the degree of early on-set weeds had significantly increased since the data recorded in the 1960's and weed coverage has practically doubled. It must be noted that the greatest increase took place in the last decade, which experienced a rate of growth of 15% between 1997 and 2007 compared to previous values of 3-4% for similar periods.

Based on early and late summer data, barnyard grass and common ragweed intermittently occupy first place, depending on the timing of the survey. In the past 40 years, *Echinochloa* has consistently finished in first place in all early summer surveys and has only been pushed further down the list in the late summer surveys in the past two decades, even though its coverage appears uniform in its percentage values. Contrary to the above, *Ambrosia* has exhibited aggressive spreading and strong yet generally widespread prevalence.

The "Top 10" list of weeds set up on the basis of the weed coverage values determined by the early summer weed surveys is as follows: common ragweed, common lambsquarters, barnyard grass, Bermuda grass, millet, Johnson grass, redroot pigweed, quackgrass, field bindweed, and common knotgrass. In the late summer weeds infecting maize in the vicinity of Káva, Ráckeve, Dömsöd, and Tahitótfalu, the top 10 list was made up of common ragweed, common lambsquarters, barnyard grass, millet, redroot pigweed, smooth pigweed, quackgrass, green foxtail, Jimson weed, and hairy crabgrass.

3.1.1 Data for early summer

70% of the national top 20 list consists of T_4 plants, with the remaining 30% made up of species belonging to the physiology groups G_1 and G_3. The list in Pest County shows a similar distribution with a breakdown of 75% to 25%, with my areas showing a T_4 dominance of 60%, G_1 and G_3 values of 30%, and T_2 and H physiologies with 5% each. In any case, the top 20 lists are good at showing that, based on numbers, the monocotyledons and dicotyledons that germinate from seeds are present in 60-75% in both small plots and in the national overview, compared to perennial plants, which show a value of 25-30%.

With its en masse germination and its omnipresence in agricultural fields, barnyard grass is at the head of the national list and it also showed a distinct increase in its coverage rate compared to ten years prior (26%). The increased prevalence of AMBEL and CHEAL has resulted in the amaranth species being forced back, for example, redroot pigweed coverage values

have fallen to the levels experienced 40 years ago at 2.1% in the national values and 1.1% in my surveys.
As a result of the spreading of dicotyledons and the appearance of millet species, the values of barnyard grass are less than the national average in 3 out of 4 of the studies settlements. Its competitiveness lags behind that of millet and ragweed under more extreme soil and weather conditions and in areas with sandy soil, areas that warm up quickly, and that contain lower values of organic matter. However, it is easy to see that these five species are the most determinate in coverage; naturally, all settlements have their own dominant individual species, but the whole of these five species determine the early summer weed flora. Taking the average of the four settlements into account, none of the dicotyledons presented herein exceeded the national coverage values, and I encountered lower total coverage values as well.

3.1.2 Data for late summer

In the case of the late summer data, the relations in mass pertaining to physiology are similar to those recorded for the early summer, though the dominance of T_4 species is stronger: T_4 values both nationally and in Pest County are 75%, with 25% values for both $G_1$and G_3. In the 4 studied settlements, this distribution was only upset a little by the greater dominance of common wormwood: T_4 accounted for 70%, G_1-G_3 accounted for 25%, with ARTVU, as a member of the H group, valued at 5% in the top 20 list. However, if we only examine the top 10 weeds, T_4 accounts for 90% of weeds in the individually surveyed areas; quackgrass was the only perennial species that was indicative of the fact that stubble had not been properly treated for several years in the grain previous crop. In the areas I surveyed, common ragweed (10.2%) not only strengthened its position, its coverage value was more than twice that of the runner-up, common lambsquarters (4.98%), which was closely followed by barnyard grass (4.15%). It is undeniable that these three plants play the predominant role in our maize cultures both nationally and in a regional breakdown; depending on soil types and other factors, they are followed by redroot pigweed, millet, and yellow foxtail, or even green foxtail. The number of species with coverage values over 1% is 14, with the same number equalling 16 in Pest County and 14 in the four settlements in question. In the past 10 years, SETPU and CYNDA have achieved the greatest advances, with coverage increases exceeding 300%. However, DATST, PANMI, SORHA, ABUTH, XANST, and HELAN, germinating via volunteer seeds, showed the greatest advances if we take the past 4-5 decades into account. The majority of these weeds managed to proliferate due to the products used at the time (i.e. the ineffectiveness of aminotriazines) and due to technological deficiencies, and the seed production and biological suitability were enough for them to fill the available niches and become widespread.

3.2 Greenhouse trough and pot studies results

After seeing the results of both the greenhouse trough and pot studies and the small plot trials, I can factually state that maize plants are capable of detecting the presence of weeds almost immediately after germination. The greatest damages resulting from the presence of weeds and weed proliferation, the loss of yield, takes place at a significantly earlier stage of maize plant development than previously assumed. Weeds that sprout together with the crop cause such significant and lasting losses in maize crop yield that the process can unfortunately neither be reversed nor can the yield be recovered with postemergent treatments carried out subsequently, even if those are impeccable.

3.2.1 Competition trough and pot study results

As part of the change that was brought about by competition, maize plants developing in a weed infested environment become elongated and end up being taller than their ideal development state with changed habitus.

Contrary to previous theories and findings, as well as in expansion of those, it can be established that weeds already influence maize development from the very start of their appearance - or rather as soon as they develop foliage - even if suitable amounts of space, light, nutrients, and water are available and no competition is necessary. Together with the above, we place the start of competition (and its results) in a framework that is much closer to factual events.

When examining the surface, length, and diameter of nodal roots, I experienced significantly differing results among the individual maize plants grown in a weed-free environment, which shows the development stage from which the presence of weeds become determinant and how this is manifest in carbon allocation to above-ground plant parts.

3.2.2 Chemical trough and pot study results

When developing the formula, I first used various types of mixtures with different mounts of each active ingredient in greenhouse tests to combat the target organisms in order to determine the degree the individual active ingredients are able to "help each other," that is to see whether the possible technological gaps in the given doses of a product can be bridged by the other active ingredient or not. I started to consistently experience a practically 100% effect on the selected dicotyledons species when applying a mixture containing between 75 and 100 g/ha of mesotrione and 300 g/ha of terbuthylazine. In addition, monocotyledons also displayed heightened sensitivity in the case of this combination. After seeing and experiencing the positive synergy between mesotrione and terbuthylazine, I conducted additional tests to thus arrive at the final formula (50 g/l mesotrione and 326 g/l terbuthylazine), which exhibited good - very good - excellent effects (species specifically) on the more prominent monocotyledons when applied to the culture. Before starting the field tests, I also conducted several dose studies, on the basis of which it could be seen that when applying a total active ingredient amount of 400 g/ha, I achieved significantly beneficial results in the case of certain weed species, but the spectrum of the products was still quite limited. However, the application of a total active ingredient amount of 800 g/ha resulted in a suitably robust product regarding both the weed spectrum and its duration, to which the grown crop displays excellent tolerance and which also exhibited very good technological flexibility in addition to its excellent herbicidal effect.

3.3 Results of chemical tests on field maize cultures

Fitotoxicity tests practically failed to discern any damages to the culture crop, meaning that farmers do not have to fear that the maize crop will be exterminated eve in case of overlaps.

3.3.1 Results of preemergent treatments

The 2.3 l/ha dose of Calaris Pro, applied in the preemergent phase, provided the best and the reliably most uniform herbicidal effect in the entirety of the studies. Concurrently to the increasing dose amounts, I experienced an increase in the amount of exterminated weeds, meaning an unequivocal rate response was experienced, which can be clearly seen in the case of the various weed species.

In the case of dicotyledons, the differences in doses is made apparent by the species classified as difficult to control. Low doses were entirely incapable of controlling the en masse and yet prolonged ragweed sprouting. In general, it can be established that the 2.0-2.3 l/ha dose provided a good preemergent herbicidal effect on weeds that germinate from seeds; however, regarding duration, the maximum dose will provide suitable protection against the late germinators.

3.3.2 Results of early postemergent treatments

In the case of more sensitive species, the products' effects via the leaves provided to be suitable at even the smaller doses, since the product can directly come into contact with the target organisms, absorption is easier through the leaves, and absorbed active ingredient amounts are greater due to the larger surface areas, allowing us to achieve greater flexibility and weed spectrum with smaller doses. Nonetheless, the duration of treatments applied to the soil naturally starts at the time of application, meaning we can calculate with 4-6 weeks, depending on the given dose. The advantage of early postemergent treatments is that a part of the weeds has already sprouted and is still before root establishment, with the majority still germinating, meaning that all stages show a high level of herbicide sensitivity.

In the interest of achieving a guaranteed affect, the recommended early postemergent dose of Calaris Pro is 2.0-2.3 litres per hectare, which provides us with suitable flexibility even with variable environmental factors. In addition, the duration effect acting through the soil ensures the crop will remain weed-free for weeks.

3.3.3 *Results of postemergent treatments*

Because of the phenological state of the weeds (which assumes a much more advanced level of development compared to the early postemergent stage), the herbicide droplets sprayed during the postemergent treatment provide much better cover and allow for the application of more active ingredients - naturally a greater amount of active ingredients might be necessary to control the greater biomass load.

Common lambsquarters was practically eradicated by the 1 litre dose of Calaris Pro and received a qualification of excellent because of its very good results in the other higher dose categories. Similar results were achieved in the evaluation of parcels contaminated with cockleburr, as well. The effects were 97.5-100% in the case of all four doses, with a deviation that was slightly greater than that of common lambsquarters, but still negligible. In the case of millet, the two highest doses proved to be suitably effective even against individuals that attained above average levels of development.

<u>Calaris Pro weed spectrum</u>

The weed spectrum that can be assigned to the given dose of a given product applied at a given time can be clearly seen from the rate response displayed by the star charts and the summary of the evaluation data, both for monocotyledons and dicotyledons. It is unequivocally shown that when preemergent treatment is applied (Figure 1), the higher dose range provides the consistently high herbicidal effect, which is attributable to the high active ingredient concentration, since that is the only possible means to allow the lethal doses to be absorbed by the seeds that have a very small surface (for absorption) when they absorb the tiny amounts of water they require, which is orders of magnitude smaller than that of developed plants. Also taking into account the other two times of application, the development stage of the weed in question and its inherent sensitivity (before/after root establishment, biomass, foliage area and surface changes, trichomes, waxiness, and the strength of the epidermis) plays the decisive role in establishing the spectrum. In the case of postemergent treatments, the plants have only reached a stage when one or two leaves have unfurled, meaning they have not yet undergone root establishment, their tissues are soft and pliable, and they are capable of quick surface absorption and therefore exhibit greater vulnerability than in later stages. This explains the better effects achieved in EPOST treatments (Figure 2) compared to POST treatments in even the smaller doses.

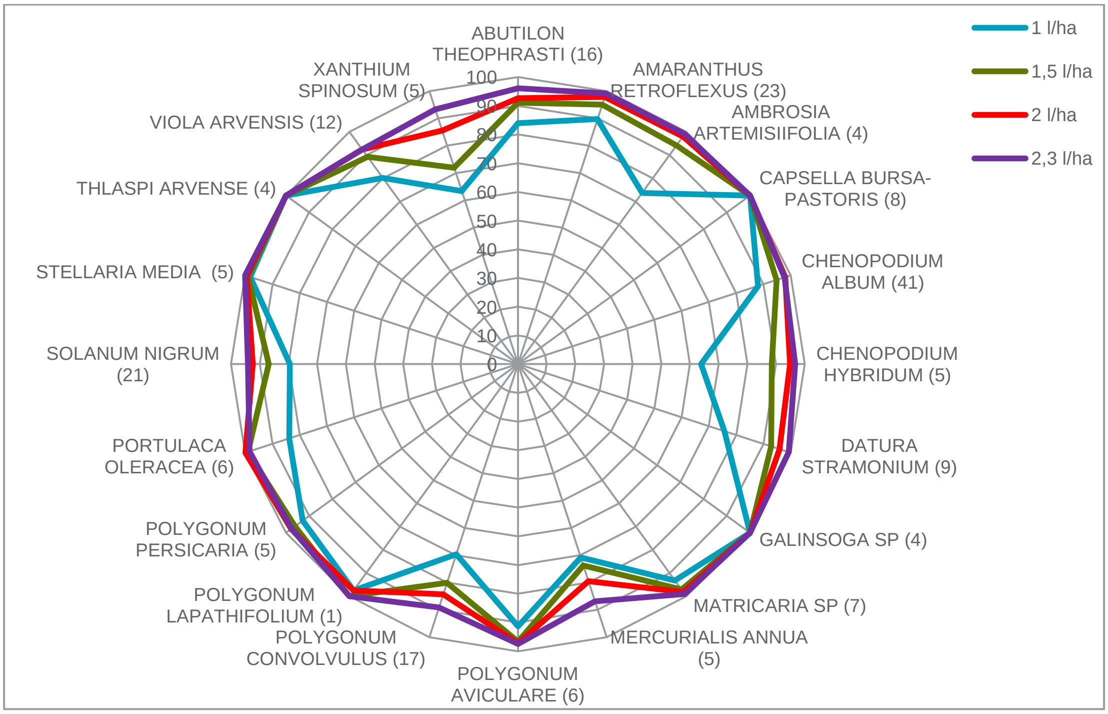

Figure 1: Weed spectrum of Calaris Pro preemergent (PRE) treatments against dicotyledons when applied in different doses, at the time of the final evaluation

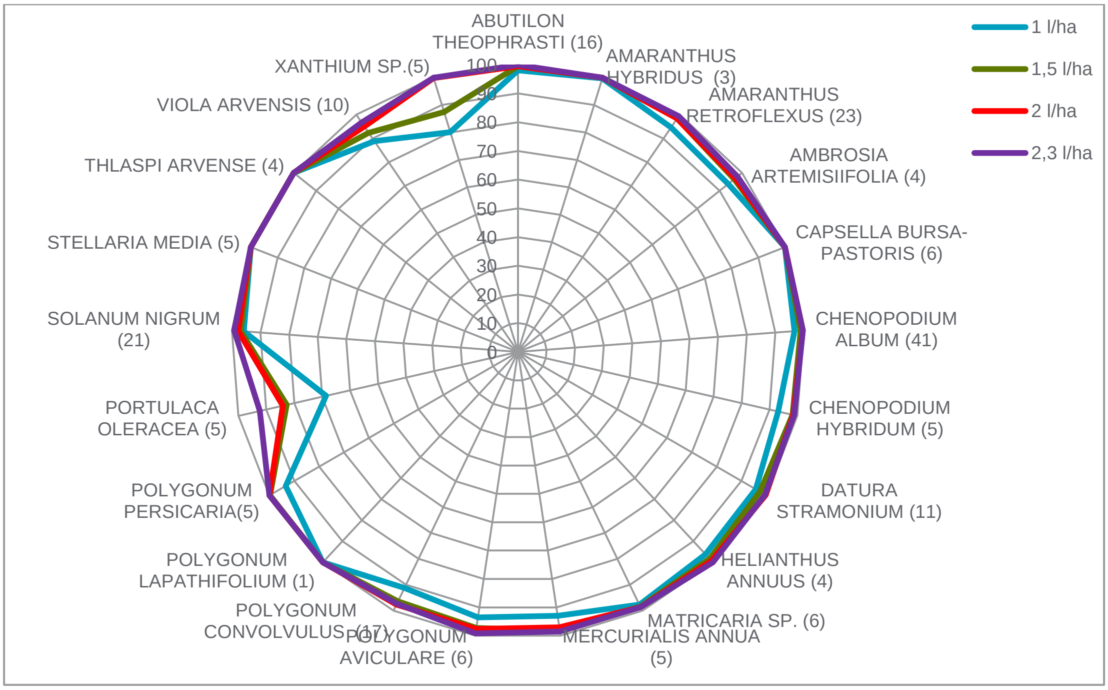

Figure 2: Weed spectrum of Calaris Pro early postemergent (EPOST) treatments against dicotyledons when applied in different doses, at the time of the final evaluation

3.4 New scientific results

In two subsequent years, I surveyed the weed conditions of maize cultures near four settlements in Pest County in early and late summer, the data of which are being handled together with the Fifth National Weed Survey data.

After comparing the data of the weed surveys conducted in Pest County maize fields (in the vicinity of the settlements Káva, Ráckeve, Dömsöd, and Tahitótfalu) with the national results, I can unequivocally declare that the 3 most important weeds in maize fields are common ragweed, common lambsquarters, and barnyard grass, which are responsible for the difficulties encountered in the weed control of row crops, and thus maize.
The data of my individual early summer surveys (also coinciding with the data of Pest County) show that common ragweed and common lambsquarters are ahead of barnyard grass, which was listed first on the national survey's list, since the former weeds, thanks also to their competitive properties, physiologies, strategies, and better resistance to herbicides, were able to refill the soil with their seeds and thus become widespread in all locations.
In the areas I surveyed, common ragweed (10.2%) not only strengthened its position by the end of summer, its coverage value was more than twice that of the runner-up, common lambsquarters (4.98%), which was closely followed by barnyard grass (4.15%). I thus found that these three plants play the predominant role in our maize cultures from the start of sowing the seeds all the way until the end of summer both nationally and in a regional breakdown; depending on soil types and other factors, they are followed by redroot pigweed, millet (generally in Pest County and in some regions with looser types of soil), and yellow foxtail, or even green foxtail (on dense soils). Based on my analyses, in the past 10 years, SETPU and CYNDA have achieved the greatest advances, with coverage increases exceeding 300%. However, DATST, PANMI, SORHA, ABUTH, XANST, and HELAN, germinating via volunteer seeds, showed the greatest advances if we take the past 4-5 decades into account.

In light of the results of my weed surveys, I can say that the weed flora of farming areas continuous to constantly change; continuing previous trends of soil disturbance, the number of species is decreasing, diversity is being reduced, and species with a wide range of tolerance, thus individuals that tolerate stress well and show good adaptability (euryoecious species), are becoming increasingly prevalent. It was also established that the unbalanced use of herbicides for decades had an enormous selective effect on weed flora, which can be felt today, as well. On the one hand, this can be experienced in both the proliferation of monocotyledons and in the increasing presence of large seeded dicotyledons that are difficult to exterminate (DATST, ABUTH, XANST). In regard to mass, 70-75% of maize plots were ruled by T_4 plants with 25% by the G physiological group; furthermore, the number of weed species that are present in almost all regions in Hungary and that fundamentally define maize weed flora and weed control can be narrowed down to 5 or 6. In addition to the above, if we add certain region-specific weed species (CYNDA, SORHA) to these, we can cover the species relevant from the aspect of weed control with a high level of certainty in individual counties and regions. The species that are most deterministic regarding the maize weed flora are as follows: common ragweed, common lambsquarters, and barnyard grass, followed by redroot pigweed.

I recognized and presented the fact that ridding our maize plots of weeds before they influence maize root growth is probably the most prominent step from the aspect of maximizing yield results. Using trough and pot studies, I proved the changes in carbon allocation that I experienced in maize plants developing in weedy circumstances, namely equal to greater vegetative area growth and smaller root mass increases. Contrary to previous theories and findings, as well as in expansion of those, it can be established that weeds already influence maize development from the very start of their appearance - or rather as soon as they develop foliage - even if suitable amounts of space, light, nutrients, and water are available and no competition is necessary. With this, I managed to prove the viability of preemergent and durable early postemergent treatments as opposed to previously accepted targeted postemergent treatments in the case of single application, post-germination POST and late POST products.

Taking into account the weed conditions characteristic of Hungary and mentioned above, I studied the various mixtures of mesotrione and terbuthylazine combinations in greenhouse tests. As the end result of these tests, I selected and developed a herbicide product - Calaris Pro - which provides an answer to the above questions of weed infections and challenges.

Finally, based on the results of my surveys and the several year-long greenhouse and field chemical tests conducted on the basis of the weed infection conditions characteristic of Hungary, I developed a herbicide that is not detrimental to the environment and solves the weed infestation problem referred to. Regarding its use, the herbicide product can be considered to be suitably flexible, as it can be applied in both preemergent, early postemergent, and postemergent stages thanks to its suitably optimized active ingredient ratios. The product has been licensed. The recommended amount of Calaris Pro product to be applied is 2.3 l/ha when applied in the preemergent stage or 1.8 - 2.0 - 2.3 l/ha when applied in the early postemergent or postemergent stage with the use of a wetting agent; the product should be applied when seed germinating dicotyledons are in their 2 or 2-4 leaf stage, respectively, or monocotyledons are in their 1-2 or 3-5 leaf stage, respectively. In addition, I recommend early postemergent treatments, since the results of my research show that is when the product has the widest weed spectrum.

4 Conclusions and recommendations

Besides the role played by the suitability of the various species and by other agricultural technology deficiencies, unsuitable or unbalanced herbicide use (atrazine and auxins, followed by sulfonylurea) and the switch from preemergent application times to postemergent treatments plays a strong role in the spread of weeds that are difficult to control. The changes that took place in field weed flora in the past twenty years also reflects the transition from large scale farming to a smaller scale and to private farms, which, in addition to the proliferation of seed germinating dicotyledons, were unable to limit all cases of the spread of perennials.
According to the results I achieved, it is thus undeniable that common ragweed, common lambsquarters, and barnyard grass play the predominant role in our maize cultures both nationally and in a regional breakdown from the start of sowing the seeds all the way until the end of summer; depending on soil types and other factors, they are followed by redroot pigweed, millet (generally in Pest County and in some regions with looser types of soil), and yellow foxtail, or even green foxtail (on dense soils). These weeds are capable of growing and ripening seeds even in the shadows between maize rows. It is thus very important to select a product for their control that also has durable effects, since the weeds, sprouting in several waves and in large numbers, are capable of infiltrating maize rows and posing strong competition for the maize crop, resulting in drastic decreases to potential yield amounts.
Based on the additional results I arrived at as well as on the national coverage data, I have established that Hungary's weed flora has changed in the past decades. Numerous weed species that were previously prominent have lost their significance and in many cases have been replaced by plant species that are difficult to control or can only be controlled with numerous treatments, and these have transformed and now define weed control technologies, posing quite a formidable planning and labour organization task for farmers. Unfortunately, the extremes in climate conditions and the limited amount of springtime "infiltrating" rain have pushed weed control measures in the direction of controlling weed flora that has already sprouted (postemergent and late postemergent treatments) - and I must note that this is undeserving.

Taking into account the characteristic Hungarian weed infection conditions referred to, I developed a herbicide product - Calaris Pro - which provides an answer to the above questions of weed infections and challenges, based first on greenhouse tests and then continued in field tests.
Mesotrione is still the latest organically developed herbicide molecule on the herbicide market, allowing it to shine as a primary partner for combinations from the aspect of environmental protection and, thanks to its positive

synergic effect with terbuthylazine, the Calaris Pro product allows for professional weed control in an environmentally aware fashion and with the application of small amounts of active ingredients.
In addition to traditional maize weed species such as lambsquarters species, pigweed species, or field mustard, its affects are excellent against difficult to control dicotyledons, for example Jimson weed, velvetleaf, volunteer seed sunflower, knotweed species, annual mercury, hemp, black nightshade, bladder weed, and wild buckwheat, meaning its effects on dicotyledons sprouting from seeds is complete.
The effects of Calaris Pro's two active ingredients, mesotrione and terbuthylazine, are proven; and their combined beneficial results ensure an excellent herbicidal effect even on areas with strong ragweed infestations against even well-developed ragweed plants without any chance of the plant re-sprouting. And let's not forget it is impossible to overemphasize the importance of products that control ragweed. Based on the results of my individual weed surveys, ragweed is the primary weed and has the greatest range in the weed flora of the settlements Káva, Ráckeve Dömsöd, and Tahitótfalu.
The recommended amount of Calaris Pro product to be applied is 2.3 l/ha when applied in the preemergent stage or 1.8 - 2.0 - 2.3 l/ha when applied in the early postemergent or postemergent stage with the use of a wetting agent; The product should be applied when seed germinating dicotyledons are in their 2 or 2-4 leaf stage, respectively, or monocotyledons are in their 1-2 or 3-5 leaf stage, respectively. I personally recommend postemergent treatments. When applied on the maize culture level, 2-3 kg of active nitrogen / ha should be applied in the form of some sort of nitrogen fertilizer by adding it to the herbicide mixture to provide for better absorption and thus a more perfect effect.
Calaris Pro can be used without restrictions in the agricultural-environment management programme.

5 Bibliography

Articles in periodicals

Articles in IF periodicals

Kiss, T., Lévai, P., Ferencz, Á., Szentes, Sz., Hufnagel, L., Nagy, A., Balogh, Á., Pintér, O., Saláta, D., Házi, J., Tóth, A., Wichmann, B., Penksza, K. (2011): Change of composition and diversity of species and grassland management between different grazing intensity - in Pannonian dry and wet grasslands. *Applied Ecology and Environmental Research* 9(3): 197-230. (IF: 0,379)

C., Accinelli, M., Mencarell, A., Balogh, B. J., Ulmer, C., Screpanti (2015): Evaluation of field application of fungi-inoculated bioplastic granules for reducing herbicide carry over risk, *Crop Protection*, 67, pp. 243 – 250 (IF: 1,539)

IF conference publications

Pottyondy, Á., Centeri, Cs., Bodnár, Á., Balogh, Á., Penksza, K. (2007): Comparison of erosion, soil and vegetation of extensive meadows under Mediterranean and submediterranean effects. – Cereal Research Communications 35: 949-952. (IF: 1,12)

T., Kiss, Á., Balogh, E., Herczeg, I., Pándi, A., Nagy (2008): Examination of soil-plant interrelations on pastures of the great hungarian plain. Cereal Research Communications 36 (Suppl.): 1671-1675. (IF: 1,12)

Non-IF articles

Balogh, Á., Nagy, A., Vona, M., Pottyondy, Á., Herczeg, E., Malatinszky, Á., Penksza, K. (2006): Data to the weed composition of the Southern Trans–Tisza area. – *Tájökológiai Lapok* 4: 139–148.

Herczeg, E., Malatinszky, Á., Kiss, T., Balogh, Á., Penksza, K. (2006): Biomonitoring studies on salty pastures and meadows in south–east Hungary. – *Tájökológiai Lapok* 4: 211–220.

Balogh, Á., Penksza, K., Benécsné, Bárdi G. (2006): Kísérletek a selyemkóróval fertőzött természetközeli gyepek mentesítésére. – *Tájökológiai Lapok* 4: 385–394.

Penksza, K., Center, Cs., Vona, M., Malatinszky, Á., Szentes, Sz., Balogh, Á., Pottyondy, Á., Szemán, L. (2007): The effects and environmental aspects of grasslands use change on plant–soil–erosion relations in Hungary. *Lucrări Ştitinţifice* 9(1): 375–380. ISSN 1453-1410

Penksza, K., Balogh, Á., Benécsné, Bárdi G. (2007): Experiments to eliminate milkweed (*Asclepias syriaca*) infection on natural grasslands. *Lucrări Ştitinţifice* 9(1): 381–389. ISSN 1453-1410.

Kiss, T., Nagy, A., Malatinszky, Á., Balogh, Á., Penksza, K. (2008): habitat mapping and map presentation of characteristic habitats in the Körös-Maros National Park, Kis-Sárrét territory. *Lucrări Ştitinţifice* 10(2): 357-364. ISSN 1453-1410

Tóth, A., Balogh, Á., Wichmann, B., Berke, J., Gyulai, F., Penksza, P., Dancza, I., Kenéz, Á., Schellenberger, J., Penksza, K. (2011)**:** Gyomvizsgálatok Pest megyei homoki mezőgazdasági területeken (lucernaföldek gyomvizsgálatai) I. *Tájökológiai Lapok* 9(2): 449-462.

A., Tóth, Á., Balogh, B., Wichman, I., Dancza, Cs., Szalkay., K., Penksza (2011): Seasonal changes in weed vegetation on arable Pannonian sand and loses lands in Hungary. *Hungarian Journal of Industrial Chemistry* 39: 313-315.

Conference publications

Full Hungarian articles

Nagy, A., Balogh, Á., Penksza, K. (2005): Összehasonlító élőhely vizsgálatok dél–tiszántúli és veresegyházi területeken a természetességi állapotok alapján. – IV. Kárpát–medencei Biológiai Szimpózium kiadványkötete. pp. 307–311. ISBN 963 219 3334

Balogh, Á., Nagy, A., Penksza, K. (2005): Dél–tiszántúli védett területek gyomviszonyai I. – IV. Kárpát–medencei Biológiai Szimpózium kiadványkötete. pp. 237–243. ISBN 963 219 3334

Balogh, Á., Benécsné, Bárdi G., Penksza, K. (2006): Kísérletek az *Asclepias syriaca* terjedésének visszaszorítására. XXVI. Vándorgyűlés, Budapest, 2006. 11. 9–10. pp. 33–42. ISBN-13: 978-963-87343-0-3

Balogh, Á., Tasi, J., Szentesi, Sz., Penksza, K. (2006): Dél–tiszántúli természetvédelmi terület gyepjeinek természetvédelmi és gyepgazdálkodási értékelése. XXVI. Vándorgyűlés, Budapest, 2006. 11. 9–10. pp. 205–212. ISBN-13: 978-963-87343-0-3

Balogh, Á., Benécsné, Bárdi G., Csontos, P., Penksza, K. (2007): Az *Asclepias syriaca* terjedésének visszaszorítása, növényvédelmi vonatkozásai. Budapest, – V. Kárpát–medencei Biológiai Szimpózium kiadványkötete. pp. 205–212. ISBN:–13: 978–963–87343–1–0

Nagy, A., Laborczi, A., Balogh, Á., Penksza, K. (2007): Élőhely csoportok létrehozása különböző területek táj szintű összehasonlításához. – V. Kárpát–medencei Biológiai Szimpózium kiadványkötete. pp. 247–252. ISBN:–13: 978–963–87343–1–0

Pottyondy, Á., Hortobágyi, T. C., Vona, M., Falusi, E., Balogh, Á., Penksza, K. (2007): Az apátsági gazdálkodás hatása napjaink élőhelyeire Pannonhalmán. – V. Kárpát–medencei Biológiai Szimpózium kiadványkötete. pp. 259–266. ISBN:–13: 978–963–87343–1–0

Kiss, T., Herczeg, E., Szerdahelyi, T., Balogh, Á., Nagy, A., Malatinszky, Á., Penksza, K. (2008): Botanikai vizsgálatok dél-tiszántúli löszgyepekben. XXVII. Vándorgyűlés, Budapest, 2008. 09. 25-26. pp. 179–184. ISBN: 978-963-87343-2-7

Tóth, A., Balogh, Á., Gyulai, F., Berke, J., Penksza, P., Wichmann, B., Dancza, I., Penksza, K. (2011): Homok és lösz gyomflóra szezonális változása Pest megyei mezőgazdasági területeken. – VI. Kárpát–medencei Biológiai Szimpózium kiadványkötete. pp. 127-132.

Hungarian abstracts

Penksza, K., Herczeg, E., Balogh, Á., Malatinszky, Á., Vona, M. (2006): Összehasonlító botanikai és talajtani vizsgálatok a Biharugrai Tájvédelmi Körzetben. Kitaibelia 11(1): 72. ISSN 1219-9672

Herczeg, E., Balogh, Á., Kiss, T., Nagy, A., Malatinszky, Á., Penksza, K. (2006): A legeltetés, mint antropogén környezeti tényező hatása és a természetes gyepek fenntartásának lehetőségére az alföldi régióban. Napjaink környezeti problémái – globálistól lokálisig. Sérülékenység és alkalmazkodás. Keszthely, Nemzetközi Konferencia, 2006. november 30. – december 1.

Full foreign language articles

Non-IF publications

Balogh, A., Nagy, A., Penksza, K. (2005): Data to the weed–composition of the Southern–Trans–Tisza protected area. 13th International Poster Day, Bratislava pp. 13–19. ISBN 80-857554-13-4

Herczeg, E., Balogh, Á., Kiss, T., Nagy, A., Malatinszky, Á., Penksza, K. (2006): Effects of grazing as anthropogenic environmental factor and possibilities for the maintenance of natural grasslands in the Hungarian Great Plain Napjaink környezeti problémái – globálistól lokálisig. Sérülékenység és alkalmazkodás. Keszthely, Nemzetközi Konferencia, 2006. november 30. – december 1. ISBN: 978-963-9639-14-0

Nagy, A., Herczeg, E., Balogh, Á., Vona, M., Penksza, K. (2007): The use experiences of habitat mapping int he naturalness valuation. 15h International Poster Day, Transport of Water, Chemicals and Energy in the System Soil–Crop Canopy–Atmosphere, Bratislava, 15.11.2007. pp. 425–432. ISBN 978–80–89139–13–2

Balogh, Á, Nagy, A., Penksza, K., Vona, M., Pottyondy, Á., Herczeg, E. (2008): Data to the weed–composition of the Southern–Trans–Tisza protected area. Implementation of landscape ecology in new and changing conditions, Proceedings of the 14th International Symposium on Problems of Landscape Ecology Research, 4–7 October 2006, Stará Lesná, Slovakia ISBN 978–80–89325–03–0, pp. 29–34.

Foreign language abstracts

K., Penksza, V., Gronas, A., Barczi, Cs., Centeri, A., Balogh (2006): Classification (FCC) System for Intensive Rice Possible Reasons of Giving up Arable Farming in the Western Hungarian Region. 18th World Congress of Soil Science Philadelphia p 234.

Balogh, A., Vona, M., Pottyondy, Á., Herczeg, E., Penksza, K. (2006): Data to the weed composition of the Southern Trans–Tisza area. 14th International Symposium on Landscape Ecology Research – Implementation of landscape ecology in new and changing condozions, Stara Lesna, Slovakia, 2006. 4–7 October p. 13.

A., Tóth, Á., Balogh, B., Wichmann, I., Dancza, K., Penksza (2011): Seasonal changes in weed vegetation on arable Pannonian sand and loess lands in Hungary. Weed management in arid and semi-arid climate and,

Weed management systems in vegetables, 4-8 September 2011. Huesca, Spain p. 33.

Á., Balogh, A., Tóth, K., Penksza, B., Wichmann, I., Dancza (2011): Weed-composition on arable lands and on pastures as a special subset of invasive plants in Hungary. Weed management in arid and semi-arid climate and, Weed management systems in vegetables, 4-8 September 2011. Huesca, Spain p. 34.

Presentations (E), posters (P)

Nagy, A., Balogh, Á., Penksza, K. (2005): Összehasonlító élőhely vizsgálatok dél–tiszántúli és veresegyházi területeken a természetességi állapotok alapján. – IV. Kárpát–medencei Biológiai Szimpózium, Budapest, 2005. október 17–19. **(E)**

Balogh, Á., Nagy, A., Penksza, K. (2005): Dél–tiszántúli védett területek gyomviszonyai I. – IV. Kárpát–medencei Biológiai Szimpózium, 2005. október 17–19. **(E)**

Balogh, Á., Nagy, A., Bíró, I., Penksza, K. (2005): Dél–tiszántúli védett területek legelőinek gyomviszonyai. – Botanikai Szakosztály. 2005. november 7. **(E)**

Balogh, A., Nagy, A., Penksza, K. (2005): Data to the weed–composition of the Southern–Trans–Tisza protected area. 13th International Poster Day, Bratislava Bratislava 10. 11. 2005. **(P)**

Penksza, K., Herczeg, E., Balogh, Á., Malatinszky, Á., Vona, M. (2006): Összehasonlító botanikai és talajtani vizsgálatok a Biharugrai Tájvédelmi Körzetben. Aktuális Flóra– és Vegetációkutatás a Kárpát–medencében VII. Debrecen, február. 26–27. **(P)**

Nagy, A., Balogh, Á., Penksza, K. (2006): Élőhely értékelések dél–tiszántúli és veresegyházi területeken természetességi mutatók alapján. – Botanikai Szakosztály. április 24. **(E)**

Vona, M., Barczi, A, Balogh, Á., Malatinszky, Á., Centeri, Cs., Pintér, B., Penksza, K. (2006): Changes in water regime due to melioration and anthropogenization effects reflecting on vegetation in the fen meadows near Galgahévíz. VI. International Conference Anthropization and Environment of Rural Settlements Flora and Vegetation. Tarcal, June 28–30, 2006. **(P)**

Malatinszky, Á., Vona, M., Centeri, Cs., Balogh, Á., Kiss, T., Penksza, K. (2006): Vegetation, erosion and pedology observations on extensively cultivated and abandoned agricultural areas in the Putnok Hills. VI. International Conference Anthropization and Environment of Rural Settlements Flora and Vegetation. Tarcal, June 28–30, 2006. **(P)**

Balogh, Á., Nagy, A., Herczeg, E., Vona, M., Kiss, T., Penksza, K. (2006): Weedyness tendencies in grasslands near Biharugra (ES Hungary), VI. International Conference Anthropization and Environment of Rural Settlements Flora and Vegetation. Tarcal, June 28–30, 2006. **(P)**

Herczeg, E., Balogh, Á., Kiss, T., Vona, M., Penksza, K. (2006): Comparative coenological study of pastures and meadows of the Great Plain. VI. International Conference Anthropization and Environment of Rural Settlements Flora and Vegetation. Tarcal. June 28–30, 2006. **(P)**

K., Penksza, V., Gronas, A., Barczi, Cs., Centeri, A., Balogh (2006): Classification (FCC) System for Intensive Rice Possible Reasons of Giving up Arable Farming in the Western Hungarian Region. 18th World Kongress of Soil Science Philadelphia 9–14 July 2006. **(P)**

Balogh, A., Vona, M., Pottyondy, Á., Herczeg, E., Penksza, K. (2006): Data to the weed composition of the Southern Trans–Tisza area. 14th International Symposium on Landscape Ecology Research – Implementation of landscape ecology in new and changing condozions, Stara Lesna, Slovakia, 2006. 4–7 October p. 13. **(E)**

Balogh, Á., Benécsné, Bárdi, G., Penksza, K. (2006): Kísérletek az *Asclepias syriaca* terjedésének visszaszorítására. XXVI. Vándorgyűlés, Budapest, 2006. 11. 9–10. **(E)**

Balogh, Á., Tasi, J., Szentes, Sz., Penksza, K. (2006): Dél–tiszántúli természetvédelmi terület gyepjeinek természetvédelmi és gyepgazdálkodási értékelése. XXVI. Vándorgyűlés, Budapest, 2006. 11. 9–10.

Herczeg, E., Balogh, Á., Kiss, T., Nagy, A., Malatinszky, Á., Penksza, K. (2006): A legeltetés, mint antropogén környezeti tényező hatása és a természetes gyepek fenntartásának lehetőségére az alföldi régióban. Napjaink környezeti problémái – globálistól lokálisig. Sérülékenység és alkalmazkodás. Keszthely, Nemzetközi Konferencia, 2006. november 30. – december 1. **(P)**

Penksza, K., Kiss, T., Nagy, A., Herczeg, E., Szentes, Sz., Balogh, Á., Tasi, J. (2006): Legeltetett–kaszált természetes gyepek gyepgazdálkodási és

természetvédelmi szempontú vizsgálata – Botanikai Szakosztály, 2006. december 4. **(E)**

Pottyondy, Á., Centeri, Cs., Bodnár, Á., Balogh, Á., Penksza, K. (2007): Comparison of erosion, soil and vegetation of extensive meadows under Mediterranean and submediterranean effects. – VI Alps–Adria Scientific Workshop, Obervellach, Austria 29–30 April 2007 **(P)**

Penksza, K., Center, Cs., Vona, M., Malatinszky, Á., Szentes, Sz., Balogh, Á., Pottyondy, Á., Szemán, L. (2007): The effects and environmental aspects of grasslands use change on plant–soil–erosion relations in Hungary. International Scientific Symposium Management of durable rural develeopment, Temeşoara, May 24–25, 2007 **(P) (P)**

Penksza, K., Balogh, Á., Benécsné, Bárdi G. (2007): Experiments to eliminate milkweed (Asclepias siriaca) infection on natural grasslands. International Scientific Symposium Management of durable rural develeopment, Temeşoara, May 24–25, 2007 **(P)**

Nagy, A., Herczeg, E., Balogh, Á., Vona, M., Penksza, K. (2007): The use experiences of habitat mapping int he naturalness valuation. 15th International Poster Day, Transport of Water, Chemicals and Energy in the System Soil–Crop Canopy–Atmosphere, Bratislava, 15.11.2007. **(P)**

Kiss, T., Herczeg, E., Szerdahelyi, T., Balogh, Á., Nagy, A., Malatinszky, Á., Penksza, K. (2008): Botanikai vizsgálatok dél-tiszántúli löszgyepekben. XXVII. Vándorgyűlés, Budapest, 2008. 09. 25-26. **(P)**

Penksza, K., Falusi, E., Kiss, T., Szentes, Sz., Pintér, O., Wichmann, B., Nagy, A., Balogh, Á., Tóth, A. (2011): A fajdiverzitás fenntarthatóságának kérdései gyepekben. MTA Gyepgazdálkodási Bizottság erdélyi tanulmányútja, "A fenntarhatóság aktualitásai gyepekeben" Marosvásárhely, 2011. 07. 11-16. (**E**)

A., Tóth, Á., Balogh, B., Wichmann, I., Dancza, K., Penksza (2011): Seasonal changes in weed vegetation on arable Pannonian sand and loess lands in Hungary. Weed management in arid and semi-arid climate and, Weed management systems in vegetables, 4-8 September 2011. Huesca, Spain **(P)**

Á., Balogh, A., Tóth, K., Penksza, B., Wichmann, I., Dancza (2011): Weed-composition on arable lands and on pastures as a special subset of invasive plants in Hungary. Weed management in arid and semi-arid climate and,

Weed management systems in vegetables, 4-8 September 2011. Huesca, Spain **(P)**

Tóth, A., Balogh, Á., Gyulai, F., Berke, J., Penksza, P., Wichmann, B., Dancza, I., Penksza, K. (2011): Homok és lösz gyomflóra szezonális változása Pest megyei mezőgazdasági területeken. – VI. Kárpát–medencei Biológiai Szimpózium. Budapest, 2011. okt. 13-14. **(E)**