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WEED VEGETATION OF PHACELIA FIELDS IN THE LITTLE HUNGARIAN PLAIN, CONDUCTING FIELD AND QUESTIONNAIRE SURVEYS

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1. Introduction and Objective

Common phacelia (*Phacelia tanacetifolia* Benth.), also known as lacy phacelia, is a versatile crop belonging to the beeflower (Hydrophyllaceae), and is now cultivated worldwide.

The weed conditions greatly influence the success of phacelia crop production in the fields. However, national arable weed surveys do not cover this culture. To increase the effectiveness of weed management strategies and seed cleaning procedures, it would be essential to have up-to-date knowledge of the weed status of crops, especially as weed-free stands are expected in seed production. One of the objectives of this dissertation was to provide a comprehensive picture of the weed vegetation of the phacelia fields in the Little Hungarian Plain.

The species composition of weed communities is influenced by several environmental and cultural factors acting simultaneously. The unique diversity of accompanying circumstances in Hungarian phacelia cultivation offers an excellent opportunity for studying the connections between background variables and weed species composition. The current situation also provides an excellent opportunity to study the weeding impact of tine harrow on phacelia crops within real, multidimensional farming circumstances. Accordingly, the main goal of this research was twofold. Firstly, to assess the effect of environmental variables and herbicides on the weed flora of phacelia; and secondly, to explore the impact of alternative weed management technologies, particularly the tine harrow, on the abundance and biomass of the most burdensome weed species.

Nowadays, the technology for seed production of phacelia is available in several textbooks, but no survey has been carried out on the actual management methods used in practice. My thesis aims to fill a gap by presenting the farming practices used in phacelia cultivation in the region where more than half of seed production still occurs today.

The weed surveys conducted between 2017 and 2021 made it possible to determine the actual and current quantitative composition of the weed flora in phacelia fields in the Little Hungarian Plain region. At the same time, this raises an important question: which weed species do the growers consider the most significant? Are the most abundant and frequent weeds the most problematic for them? In my research, I set out to explore which weed species are perceived as the most important by farmers, comparing these perceptions with the ranked significance of weeds based on survey data; furthermore, the available options for weed control.

In my research, I also examined the knowledge of phacelia growers about weed identification in the Little Hungarian Plain region. Seed-producing phacelia farmers must have a thorough understanding of the weed composition in their fields to implement more precise weed control strategies and seed cleaning procedures. My study aimed to explore how factors such as age, (relevant) educational background, and professional experience influence farmers' knowledge of weed species and to identify which weeds they most commonly recognise.

2. Materials and Methods

The research was carried out in north-western Hungary, in the Little Hungarian Plain. We identified 92 farmers and 205 arable fields throughout the region. In these fields, we conducted two different types of weed surveys: a broad-scale survey in all the 205 phacelia fields and a more detailed fine-scale survey in a smaller subset of these areas, in 22 fields.

For the broad-scale surveys weed data were recorded once during the flowering peak of phacelia (between the end of May and the end of June) in the 2017–2021 period in all 205 phacelia fields. In each field, the weed vegetation was sampled in a single randomly selected rectangular plot of 200 m^2, located at least 10 m far from the field edges, and the percentage ground cover of all plant species was estimated visually. A soil sample of 1000 cm^3 was also collected from the top 10 cm layer in each of the the broad-scale field surveys.

The data were used to calculate the average cover and abundance of weed species and then ranked them according to these criteria.

For the fine-scale studies we selected a subset of 22 fields from the two last years of the surveys (2020–2021), in which a more intensive measurement of crop and weed biomass was performed. To examine deeply the effects of mechanical and chemical weed control, half of the selected fields received a treatment with tine harrow, and the other half received either clopyralid herbicide or no weed control at all. We restricted this selection to three major farm holdings in the vicinity of Mosonmagyaróvár, all of which were located within a circle with a radius of about 3 km, thus ensuring relatively similar management and

environmental conditions. In these fields, six microplots of 0.25 m^2 (50 cm × 50 cm) were randomly selected within the 200 m^2 plots of the broad-scale survey. Then, the above-ground parts of the crops and weedswerecutineachmicroplot in the first week of June each year.

Weeds were separated by species, and for each of the species found, the number of individuals (cuttings) was first counted, and then the samples were oven-dried at 75 °C for 72 h to obtain their dry weights,

A soil sample of 1000 cm^3 from the top 10 cm layer was also collected from each microplot. Soil samples were analyzed in the laboratory of Széchenyi University using an Agro cares scanner, with near-infrared spectroscopy (NIRS).

Management information was received directly from the farmers, who filled in pre-prepared agrotechnical data sheets to provide information on the farming methods used in their fields. In each field, the abiotic factors were soil and climatic characteristics. Climatic conditions were represented by annual mean temperature and the precipitation sum of 1970–2000 taken from the WorldClim 2.0 database.

Altogether, 34 predictor variables (11 *environmental*: 2 climate, 9 soil; 19 *non-chemical management*: 14 cultural, 5 mechanical management; and 4 *chemical weed control factors*) were recorded during the surveys.

The statistical analysis of the broad-scale surveys followed the same lines as the analysis described in Pinke et al. (2012), as previously done in the summer annual weed vegetation surveys. In analysing the fine-scale data, we focused on the effectiveness of mechanical (by tine harrow) and chemical weed management.

Data processing and statistical analyses were conducted in the R statistical software using its packages ‘abind’, ‘car’, ‘DHARMa’, ‘glmmTMB’, ‘multcomp’, ‘raster’, ‘sf’, ‘vegan’ and ‘VennDiagram’.

Following the field-based weed surveys, an online questionnaire survey was also conducted. Most of the farmers who completed the study were the same individuals on whose farms the field surveys had been carried out. The farmers were contacted by phone and invited to complete the questionnaire. The survey was launched on September 21, 2022, and concluded on December 29, 2022. It consisted of a questionnaire we designed. During this period, 50 phacelia growers from the Little Hungarian Plain region completed the questionnaire online using a Google Form.

The first section of the structured questionnaire included general questions related to crop production and cultural practices, covering three years (2020–2022). This section gathered information on the following elements: farm-related data; general information about cultivation; the name of the phacelia variety; sowing date; row spacing; seed rate; preceding and subsequent crops; quantity of applied fertilisers; herbicides used; number of mechanical weed control operations; harvesting method; and average yields. The survey also included questions related to weed control practices to provide a comprehensive overview of the weed management technologies applied in phacelia cultivation. Furthermore, the questionnaire aimed to assess how open farmers are to mechanical weed control methods, as there is an increasing expectation for reduced-pesticide or pesticide-free production technologies.

During the survey, the responses to the following two questionnaire items addressed to farmers were analysed separately:

(1) Which weed causes you the most problems during phacelia cultivation?

(2) To what extent do weed seeds cause problems in your phacelia seed lots?

In the second part of the structured questionnaire, we included images of 34 weed species, randomly selected by us. Farmers were asked to provide short written responses identifying the weed shown in each picture. During the evaluation of the tests, 1 point was awarded for correctly identified names (either the Hungarian common name, the scientific name, or a well-known local name was all accepted). Thus, the maximum possible score was 34 points. In cases where the identification was not entirely accurate – for example, if only the genus were correctly named – the respondent received 0.5 points. The responses were evaluated manually, form by form.

3. Results

3.1. Results of broad-scale and fine-scale weed surveys

3.1.1. Results based on comparisons of mean coverages and frequencies in broad-scale weed surveys

During the broad-scale surveys, altogether, 159 weed species were found. The most frequent were *Chenopodium album* (94.63%), *Polygonum aviculare* (84.88%), *Chenopodium hybridum* (75.61%), *Fallopia convolvulus* (74.15%), *Stachys annua* (70.24%), *Convolvulus arvensis* (67.32%), *Mercurialis annua* (60.98%), *Ambrosia artemisiifolia* (59.02%), *Anagallis arvensis* (57.07%) and *Reseda lutea* (53.17%).

Chenopodium album (4.5580%), *Ambrosia artemisiifolia* (2.7376%), *Polygonum aviculare* (2.5117%), *Convolvulus arvensis* (2.2054%), *Stachys annua* (1.9556%), *Sinapis arvensis* (1.9220%), *Fallopia convolvulus* (1.8488%), *Reseda lutea* (1.4029%), *Anagallis arvensis* (1.1610%) és *Euphorbia falcata* (1.0390%) had the highest mean cover.

The 159 weed species recorded during the survey belong to a total of 31 plant families, among which the following four families had the highest coverage share: *Chenopodiaceae* (16.8%), *Polygonaceae* (13.6%), *Asteraceae* (12.1%) and *Poaceae* (10.9%). In the frequency-based ranking of coverage share, the same four families ranked at the top, but in reverse order: *Poaceae* (13.4%), *Asteraceae* (11.2%), *Polygonaceae* (9.9%) and *Chenopodiaceae* (9.5%).

According to the analysis of life form types, the following categories had the highest coverage and frequency shares: T_4 (72.3%, 65.5%); G_3 (8.9%, 6.4%); T_3 (8.4%, 6.7%); T_2 (4.9%, 10.3%) and T_1 (2.7%, 5.0%).

Regarding the flora elements, the following types showed the most dominant share: Cosmopolitan (49.9%, 36.7%), Eurasian (27.8%, 35.8%) and Mediterranean (15.1%, 17.6%).

3.1.2. Results obtained by multivariate data analysis in broad-scale weed surveys

The full RDA model (comprising 24 explanatory variables) explained 27.32% of the variance, while the reduced model (comprising 11 explanatory variables) still explained 20.93% of the total variation in species data. According to the pRDA, all of the 11 remaining variables have significant net effects, with two soil parameters (pH and clay content) being the most influential. In addition, the effects of three further environmental parameters (precipitation, temperature and soil K), four non-chemical management variables (crop cover, preceding crop, irrigation and tillage system) and two herbicides (linuron and clopyralid) were significant.

The variation partitioning of the RDA model revealed that environmental variables altogether accounted for 1.2 times the variance of non-chemical management variables and were 2.9 times that of herbicides, while non-chemical management practices had 2.4 times more variance than herbicides. The relative impact of cultural variables was more than 24 times larger than that of mechanical treatments; the relevance of

chemical weed control is 9.5 times larger than that of mechanical treatments; and cultural variables altogether had 2.5 times more variance than the chemical weed control variables.

3.1.3. Results of fine-scale weed surveys

During the fine-scale weed surveys, 37 weed species were found. *Chenopodium album*, *Setaria viridis*, *Chenopodium hybridum*, *Mercurialis annua*, *Fallopia convolvulus* and *Stachys annua* were the top six species in terms of having the largest number of individuals. Besides these six species, *Polygonum aviculare* occurred also in more than 15 fields. Due to the wide confidence intervals, there was no significant difference in weed biomass and abundances between fields treated by clopyralid and left without weed control. However, there is a tendency toward a lower abundance of *Chenopodium album*, *Setaria viridis*, *Chenopodium hybridum* and *Polygonum aviculare*, and total weed abundance and biomass were also slightly lower in fields treated with clopyralid. On the other hand, *Mercurialis annua*, *Fallopia convolvulus* and *Stachys annua* are slightly more abundant in these fields.

Applying tine harrow significantly decreased the total weed biomass and abundance, as well as the abundance of *Mercurialis annua*, *Fallopia convolvulus* and *Stachys annua*, while there were non-significant changes in *Chenopodium album*, *Chenopodium hybridum* and *Polygonum aviculare* (decrease), as well as *Setaria viridis* (increase). The abundance of *Mercurialis annua*, *Fallopia convolvulus* and *Stachys annua* was significantly lower in fields where tine harrow was applied than where clopyralid was. Total weed biomass and abundance, as well as the

abundance of *Chenopodium hybridum* and *Polygonum aviculare*, were also lower if tine harrow was applied, but this difference was not significant. *Setaria viridis* was the only species whose abundance was considerably, but not significantly, higher if tine harrow was applied than in fields with chemical weed control.

3.2. Results of the questionnaire survey

Our study revealed that phacelia was a popular element of the crop rotation in most surveyed farms. It was mainly sown after cereals between 10 and 20 March, at a seeding rate of 8-10 kg/ha, in crop rows spaced at 12 cm. The most prominent cultivars were *Lilla* and *Angelia*. NPK fertilisers and foliar fertilisation with boron were most general in plant nutrition. A two-pass harvesting system characterised all farms. Harvesting was done in two stages in every farm that completed the questionnaire. Under average conditions, the harvestable yield ranged from 300 to 800 kg/ha. Based on the results of our study, this range expanded in both positive and negative directions, correcting to an interval of 200 to 910 kg/ha. About 60% of the farms applied chemical weed management, but only 35% were satisfied with the efficiency of the licensed herbicides. Over the three years, various plant protection products were used. In all three years, the herbicide containing the active ingredient clopyralid (Cliophar 300/600 SL) ranked first, while the second most used was quizalofop-P-ethyl (Targa Super). Herbicide use visibly declined over the years. According to the majority of the interviewed farmers (~70%), the recent withdrawal of linuron herbicide has been a great challenge in crop protection. Nevertheless, about the same

proportion of farmers assumed that the tine harrow could overtake chemical weed management. Our results suggest that most farmers are open to introducing pesticide-free cropping technology in phacelia seed production.

Weed management is the most crucial element of phacelia seed production. Farmers nominated 15 taxa (species, genera and families) as important weeds in their phacelia fields. Based on the farmers' vote, *Cirsium arvense* turned out to be the most troublesome weed, despite this species reaching only the 12th position in the previous weed surveys. Farmers likely consider this the most significant weed because, where it establishes itself in large numbers, its damage is perhaps the most visibly noticeable, and efforts to control it are likely associated with the most significant struggles across multiple generations of farmers in most crops. *Chenopodium album* was ranked second by the farmers, and it was the most dominant and frequent weed species in the weed surveys. Our research also suggested that 14% of the farmers had significant problems with weed seeds in the phacelia seed item.

After correcting the weed identification tests, the total scores showed that the farmers achieved an average of 17.25 points, representing 50.73% of the maximum possible points. Nearly half of the respondents scored below 50% on the weed identification test. Farmers are most familiar with *Ambrosia artemisiifolia* and *Papaver rhoeas*. In second place is *Avena fatua*, followed by *Convolvulus arvensis* and *Datura stramonium*. The most common weed in phacelia fields, *Chenopodium album*, only ranked sixth. Despite being considered the most problematic weed by farmers in the Little Hungarian Plain region, *Cirsium arvense* ranked only

eighth. Identifying *Persicaria* and *Setaria* species was also a great challenge for most of the farmers. Unsurprisingly, the rare, red-listed *Misopates orontium* and *Ajuga chamaepitys* took the last positions. Farmers with a higher level of education and a larger farm holding size performed better. Age and farming experience seemingly did not influence the farmers' performance.

4. Conclusions, recommendations

4.1. Weed conditions in domestic phacelia fields

I assessed the weed vegetation of the crops in the centre of phacelia cultivation in the Little Plain. I found that, both in terms of coverage and frequency ranking, *Chenopodium album* occupied the first place, which can be attributed to its initial rapid growth, wide tolerance range, significant seed yield, and vigorous habitus.

Based on the taxonomic analysis of the data, the *Chenopodiaceae, Polygonaceae, Asteraceae*, and *Poaceae* had the highest coverage and frequency shares. These families are also ordinary in other crops, while the combined high share of the *Brassicaceae, Euphorbiaceae, Lamiaceae,* and *Resedaceae* is a uniquely distinctive feature of the examined phacelia fields.

The research proved that, among the weeds that germinate in large numbers during different periods in phacelia, the T_4 species, which germinate intensively from early April, cause the real weed problem.

Among the floristic elements, the Cosmopolitan, Eurasian, and Mediterranean elements were dominant. The higher proportion of the latter is likely partly due to the chemical-free cultivation technology.

There were declining weed species (for example, *Stachys annua*) and red-listed species in the diverse weed flora, resulting from extensive and organic farming. To maintain biodiversity and certain rare species, consider introducing chemical-free cultivation technologies, and I recommend this to farmers.

4.2. Effect of abiotic and agrotechnical factors

Our research highlighted that environmental and cultural variables are responsible for most of the variance in the weed species composition of phacelia fields in Hungary. The most critical abiotic variables were soil pH and clay content, but soil potassium (K) content also had an influence. In areas without herbicide treatment, sensitive soil indicator species were present. Climatic conditions (precipitation, temperature) also influenced the composition of the weed species here, as in other crops.

The most important cultural variable influencing the composition of the weed flora was the crop cover, which integrates the effects of several other, more direct cultural practices and variables, such as seeding rate, plant density, cultivar type and fertilizer use, all of which affect the weed suppression capacity of the crop.

Crop cover was the primary agrotechnical factor influencing weed infestation, so it is advisable to minimise the presence of weeds through effective weed control. I recommend creating an appropriate, fine-crumb seedbed and selecting the correct sowing time to ensure the rapid and uniform germination of the crops. I recommend choosing the proper variety and adjusting the seed quantity to suit the conditions. I would also draw attention to optimal nutrient supply, as this can promote healthy plant development and ensure crop security. Furthermore, I consider it essential to choose the right field and implement a rational crop rotation, as these factors can significantly influence weed infestation. The effect of the preceding crop was also remarkable in our study. The timing of the final soil cultivation related to sowing determines the composition of the developing weed vegetation. The weed flora after cereals and phacelia

formed a joint fraction against maize, sunflower and rape. This can be explained by the fact that the weed vegetation of phacelia is reminiscent of that of cereals, because these crops are ordinarily not mechanically disturbed after sowing, and they have a similar stature and the same midsummer harvesting season. In contrast, maize and sunflower are often hoed after sowing, they are much taller with broader row spacings, with peculiar conditions for the light competition, and they also have a long growing season until autumn. Rape has a similar growing season as cereals, but it usually forms very dense stands in the area studied. The weed flora after preceding crops sown in spring (phacelia, maize and sunflower) was also separated from autumn-sown preceding crops (cereal and rape). This result also confirms the importance of the sowing time and the timing of the final soil tillage. Different sowing dates induce the development of distinct weed communities, whose impact can be traced also in the subsequently grown crops. Consequently, alternating crops with distinct life cycles can break the development of crop–weed associations; thus, the proper selection of the preceding crop can be one of the most efficient tools of cultural weed management.

Irrigation and tillage systems were also significant during our investigation. As is well known, irrigation water can transport weed seeds to the fields. The increased water supply is not only beneficial for the crop but can also benefit certain weeds, which is reflected in our results. Therefore, it is essential to pay attention to irrigation, and only in absolute necessity should we apply water appropriately.

This indicates a significant abundance of some perennials in fields without ploughing. Some studies have shown an increase in perennial

weeds with reduced tillage compared to ploughing. Based on our results, I recommend ploughing as a control method against perennial weeds.

We found significant effects on weeds in the case of linuron and clopyralid. *Chenopodium album,* which was by far the most prevalent weed in our study, seems particularly sensitive to linuron. This herbicide was withdrawn in the third year of our research. Clopyralid can also reduce some other weeds, even *Chenopodium album*, but it could not significantly decrease the total weed number and biomass. Treatment with tine harrow proved to be more effective on its own than clopyralid for non-*Astreraceae* weeds, and our results also suggest that tine harrow can efficiently decrease the total number and biomass of weeds, even if its efficiency might be affected by soil properties. Accordingly, tine harrow is a promising tool in the weed management of phacelia for non-perennial weeds, which should be inserted into the integrated management of this challenging crop species.

4.3. Applied agrotechnology

The results regarding the cultural practices farmers apply (crop rotation, preceding and succeeding crops, sowing time, seed quantity, row spacing, nutrient supply, harvesting) are largely in line with the recommendations found in the literature, and growers generally follow the guidelines provided. The technical books published so far can continue to assist farmers in planning the cultivation technology in the future, and they can supplement the practices they have applied so far with the technological suggestions mentioned above. It is also important to note that farmers should not neglect field surveys. I recommend continuous

monitoring of their crops to ensure they can take appropriate action against weeds at the right time.

4.4. Weeds that pose a problem in practice, weed knowledge.

Among the significant weeds in the domestic context that also appear in phacelia crops, farmers have correctly identified only a few. This area is where improvement is significant, as up-to-date knowledge of the weed conditions in seed-producing phacelia fields is essential for increasing the effectiveness of weed control strategies and seed cleaning procedures. It would be beneficial for farmers to familiarise themselves with the weeds present in their crops, conduct more frequent field surveys, and practice weed identification with the help of textbooks, training, specialists, or even applications. This is important because many weed control issues can be traced back to a lack of weed knowledge or an insufficient understanding of the weed flora at the field level.

5. Theses

1. In my field botanical work over several years in broad-scale and fine-scale weed surveys in the phacelia fields in the Little Hungarian Plain, I have identified 159 weed species, demonstrating the dominance of *Chenopodium album*.

2. The uniqueness of the surveyed fields was reflected in the fact that among the most significant weeds, not only late summer species typical of tillage crops were present, but also characteristic stubble plants, as well as the typical weeds of spring and autumn cereals.

3. I found that in the phacelia fields of the Little Hungarian Plain region, among the life form types, late summer annuals dominated, while among the flora elements, the Cosmopolitan, Eurasian, and Mediterranean elements were the most significant.

4. Regarding plant families, the *Chenopodiaceae, Polygonaceae, Asteraceae*, and *Poaceae* families had the highest cover and frequency shares in the phacelia fields of the Little Hungarian Plain region.

5. I identified declining species in extensively cultivated and organic phacelia fields, including red-listed species, which suggests the necessity of pesticide-free phacelia cultivation to preserve biodiversity.

6. In the redundancy analysis, I found that crop coverage was the most critical agronomic variable influencing the weed flora composition. In contrast, soil ph and clay content were the most important abiotic variables.

7. My studies confirmed the fact that no-till and reduced tillage practices promote the spread of perennial weed species.

8. The farmers' questionnaire-based weed knowledge survey results revealed that those with higher education and larger farm holding areas have a better understanding of the weed conditions in their fields.

6. List of publications

Scientific article in the international journal

Pinke Gyula; Giczi Zsolt; Vona Viktória; **Dunai Éva**; Vámos Ottília; Kulmány István; Koltai Gábor; Varga Zoltán; Kalocsai Renátó; Botta-Dukát Zoltán; Czúcz Bálint; Bede-Fazekas Ákos (2022): Weed Composition in Hungarian Phacelia (*Phacelia tanacetifolia* Benth.) Seed Production: Could Tine Harrow Take Over Chemical Management? AGRONOMY 12: (4) p. 891. 20 p. (IF: 3.949; Q1)

Scientific articles in national journals

Pinke Gyula; Papp Veronika; Majdán Tünde; **Dunai Éva**; Kukorelli Gábor (2021): Vetőmag-előállító facéliavetések gyomviszonyai a Kisalföldön. NÖVÉNYVÉDELEM 82: (57) 11 pp 475-482.

Dunai Éva; Pinke Gyula (2023): A közönséges mézontófű (*Phacelia tanacetifolia* Benth.) termesztésének magyar vonatkozású történeti áttekintése. BOTANIKAI KÖZLEMÉNYEK 110: (1) pp 43-60. (Q2)

Dunai Éva; Kukorelli Gábor; Pinke Gyula (2023): A kisalföldi facéliavetésekben alkalmazott gazdálkodási módszerek felmérése. ACTA AGRONOMICA ÓVÁRIENSIS 64: (1) pp 57-80.

Dunai Éva; Kukorelli Gábor; Pinke Gyula (2023): A kisalföldi facéliavetések legfontosabb gyomnövényei – a gazdálkodók szemszögéből. MAGYAR GYOMKUTATÁS ÉS TECHNOLÓGIA 24: (1) pp 15-25.

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Popular magazines

Dunai Éva; Szűcs Zoltán; Pinke Gyula (2022): Gyomfésű alkalmazása a facéliatermesztésben. MEZŐHÍR 26: (10) pp 86-87.

Pinke Gyula; **Dunai Éva**; Majdán Tünde; Papp Veronika; Vasas Dávid; Giczi Zsolt; Varga Zoltán (2022): A gyomnövényzet tömegviszonyai gyomfésűvel kezelt és gyomirtásban nem részesült facéliavetésekben. BIOKULTÚRA 33: (2-3) pp 42-45.

Abstracts

Pinke Gyula; **Dunai Éva**; Czúcz Bálint; Botta-Dukát Zoltán; Bede-Fazekas Ákos (2024): A kisalföldi mézontófűvetések gyomnövényzetét befolyásoló tényezők: Factors influencing weed species composition in phacelia fields in the Little Hungarian Plain. XIV. Aktuális Flóra- és Vegetációkutatás a Kárpát-medencében nemzetközi konferencia, Gödöllő, pp 66-66.

Pinke Gyula; **Dunai Éva**; Czúcz Bálint; Botta-Dukát Zoltán; Bede-Fazekas Ákos (2023): Factors influencing weed species composition in Hungarian phacelia fields. Workshop of the EWRS Working Group 'Weed Vegetation and Biodiversity', Prága, p. 25. 1 p.

Other publications

Pinke Gyula; **Dunai Éva**; Czúcz Bálint (2021): Rise and fall of Stachys annua (L.) L. in the Carpathian Basin: a historical review and prospects for its revival. GENETIC RESOURCES AND CROP EVOLUTION 68: (7) pp 3039-3053. (IF: 1.876; Q2).

Pinke Gyula; **Dunai Éva**; Vona Viktória; Varga Tamás Imre; Zsuppán László (2020): Tisztesfüves facéliatarló megőrzése méhlegelőnek. MÉHÉSZ ÚJSÁG 7: (11) pp 16-18.

Pinke Gyula; **Dunai Éva** (2020): Elődeink nyomdokain: Tarlóvirág termesztése méhes közelében. BIOKULTÚRA 31: (4-5) pp 30-34.

Dunai Éva Zsuzsanna; Pinke Gyula; Magyar László; Kulmány István Mihály; ifj. Szűcs György Zoltán; Roszík Péter (2020): Tarlóvirágmag begyűjtése és tisztítása méhlegelők vetéséhez. BIOKULTÚRA 31: (6) pp 18-21.