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Ecological and agronomical factors influencing the abundance of ragweed (*Ambrosia artemisiifolia* L.) along the Austrian-Hungarian border

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1. Introduction, goals

The author was seeking the answers for the following questions during the research:

(1) Are there any differences in the amount of ragweed infectation between the two countries' borderzone?

(2) Which land-use and environmental variables are responsible for the possible differences in the abundance of ragweed between the two countries?

(3) Which land-use and environmental variables are influencing the spread of ragweed in the entire research area (regardless of country)?

(4) Are there any differences in the species composition and abundance of summer arable weeds between the two countries' borderzone?

2. Materials and methods

We set the scope of our investigations to the strip of land extending approximately 30 km from the Austrian-Hungarian border into both countries. As the 355 km long borderline follows an irregular zigzag shape, this resulted in a region of ~150 km N-S and 105 km E-W extent. The northern part of the study area belongs to the Western Pannonian Plain consisting of the south-eastern part of the Vienna Basin in Austria and the western part of the Little Hungarian Plain in Hungary. Towards the south plains are increasingly replaced with the foothills of the Eastern-Alps extending well into Hungary with slightly decreasing altitudes.

We focussed at fields of four major regional crop species, which were known to be sensitive to ragweed infestations: sunflower (*Helianthus annuus* L.), soyabean (*Glycine max* (L.) Merr.), maize (*Zea mays* L.) and oil pumpkin (*Cucurbita pepo* L.). Altogether, 200 fields were sampled (25 fields from each crop per country). Weed data were recorded between the years 2015 and 2018 at the seasonal peak of Ambrosia artemisiifolia in the months of July and August each year. Sampling was done in four 50 m^2 (5 x 10 m rectangle shaped) plots within each field. One plot was located on the field edge (inside the outermost seed drill line), whereas the remaining three plots were located inside the fields at different distances (between 10 and 200m) from the edge.

Management variables, including the fertilization, tillage, and weed control activities applied (which directly targeted the culture surveyed), as well as factors describing site history (preceding crop) and ownership structure (field size, farmhold size) were queried directly from the farmers in brief targeted interviews.

3. Results

The binomial generalized linear models (GLM) revealed that A. artemisiifolia occurred (Th0) significantly more frequently in Hungary both in the field edges and the field cores. In field cores even the exceedance of the relatively low (1%, Th1) ragweed cover threshold was significantly more frequent in Hungary than in Austria. Nevertheless, there were no significant differences in the proportion of larger cover values between the countries, and actually, cover values (Th10) were even slightly more common in the Austrian field edges and cores.

Model-based recursive partitioning could only identify significant differences between the two countries in 2 of the studied 8 cases, both of them in the field cores. Preceding crop turned out to be an important factor for Th5 (ragweed cover >5%), whereas for Th10 (ragweed >10%) both farming type and preceding crop seem to be relevant factors. For Th5 if the previous crop was maize, soyabean, or oilseed rape, a high ragweed cover was significantly more frequent in Austria (23% in AT vs. 7.5% in HU), but in the case of cereal or oil pumpkin as a preceding crop there was an opposite trend (2.9% in AT and 18.3% in HU). As for Th10, the highly infested fields seem to be connected to organic farms in Hungary (40% in HU vs. 5.2% in AT) whereas to conventional farms with specific preceding crops (maize, soyabean, oil pumpkin) in Austria (18.1 in AT vs. 2.7% in HU).

The decision trees revealed significant patterns in all of the eight cases studied. Country indicated separation only once, though at first position regarding presence/absence values in the field edges. For Austria, subsequent splits were determined by N fertiliser showing less frequent ragweed presence in case of its greater amounts. In Hungary, the subsequent splitting variable was soil Na content associating negatively with ragweed occurrences. In the other seven cases, the most influential variable was definitely crop cover, which determined the highest number of splits in the tree models (six times in the seven models, almost in the first position), with lower crop cover values indicating larger ragweed abundances. Annual precipitation sum was also an important splitting variable; it appeared three times in the models showing larger ragweed infestations with higher annual precipitation. Three further variables emerged as important factors in the models: mean annual temperature and phosphorous fertiliser negatively, while soil phosphorous concentration positively associated with ragweed's abundance. The calculation of R-squared values and variation partitioning revealed that land-use variables accounted for multiple more variance than environmental variables in the abundance patterns of ragweed.

The most important weeds were *Echinochloa crus-galli*, *Panicum dichotomiflorum*, *Chenopodium album*, *Ambrosia artemisiifoli*, *Setaria pumila*, *Convolvulus arvensis*, *Datura stramonium*, *Amaranthus powellii*, *Panicum miliaceum spp*. *ruderale*, *Persicaria lapathifolia*, *Calystegia sepium*, *Cirsium arvense and Equisetum arvense*. The most important families were *Poaceae*, *Asteraceae* and *Chenopodiaceae*. The most significant life forms were summer annuals and geophytes.

4. Discussion

Regarding the presence/absence status of ragweed in the two countries (Th0), it is highly remarkable from our results that *A. artemisiifolia* occurred significantly more frequently in Hungary, both in field edges and field cores. This suggests a longer infection history of ragweed in Hungary, with more stable soil seed bank and local populations. One possible explanation behind this is the Hungarian version of the storyline with high local infestation rates in the collective agriculture in all Transdanubia, including the regions adjacent to Austria. This high infestation rate might have been sharply cut at the country border by the iron curtain, which thus can have functioned as an efficient barrier in the spreading and saturation process of common ragweed.

Worth mentioning that fields with cover values >10% (Th10) are even slightly more common in Austria. This suggests that once ragweed established in a field, it can reach similar abundances on both sides of the country border.

As our results also suggested, the saturation phase of *A. artemisiifolia* invasion might still be in progress in the Austrian borderland. we can say that there is a ‘saturation lag’ between the two countries, which can be on the magnitude of 20-30 years. The current differences in ragweed occurrences might be seen as legacies of this saturation lag, originally created by the ‘iron curtain’.

Our search for any country-dependent factors causing different ragweed infestation patterns found that the effects of preceding crop could be relevant. Regarding this variable in both models maize and soyabean as previous crops were responsible for higher infestations in the Austrian field cores. Interestingly, compared the mean cover values of common ragweed by the four actual crops studied between the countries, they were larger in Austria. The soil cultivation following the harvest of these crops and before the seedbed preparation for the next ones, might contain some specific elements, which can better stimulate the germination of common ragweed. Similar hidden intrinsic factors might be the reason why previous crop turned out to be a stronger explanatory variable than the actual crop. The probability of ragweed cover values >5% (Th5) was greater after cereals in the Hungarian field cores. This might be explained by the common practice of performing stubble ploughing with a long delay after the cereal fields had been harvested, and thus the re-growing ragweed populations can replenish its weed seedbanks.

Farming type (conventional vs organic) also revealed an important country-specific pattern: in organic fields common ragweed occurred significantly more frequently in Hungary with high cover values (Th10). In Austria, organic farming has a rich tradition. This attitude is most likely associated with greater expertise and more appropriate non-chemical weed management technologies. The application of modern approaches to non-chemical weed control operation techniques can thus explain the lower ragweed abundances in Austrian organic fields compared to Hungarian ones. However, also suggests that conventional management in combination with certain previous crops resulted in just an opposite tendency: the proportion of highly infested fields became slightly larger in Austria. Although, the model shows preceding crop as the most influential subsequent variable here, it might be assumed that chemical weed management is implemented with higher efficiency by the Hungarian farmers in the conventional systems.

In our study, crop cover proved to be the most important variable influencing the abundance of *A. artemisiifolia* in the whole area studied. The models showed higher infestations of common ragweed if crop cover was lower than 35-65%. These results suggest that high crop cover can create unfavourable conditions for *A. artemisiifolia*, because it would grow best in full sunlight and the lack of adequate light intensity leads to a decrease in its performance. Crop cover can be regarded as an indirect cultural variable, which definitely depends on many direct cultural practices, like seeding rate, row spacing, cultivar type and fertilisers. The management of these parameters targets the development of a dense crop canopy as early as possible, which can be able to overcome the emerging weed populations.

Among the climatic variables mean annual precipitation appeared to be also highly relevant, its decisive values ranged between around 600-680 mm indicating higher ragweed's infestations above. In the present study, mean annual temperature turned to be also influential, though to a lesser extent, showing greater ragweed abundances under 9.9 °C. It can be concluded that regarding the Carpathian basin as a whole, as well as in its western periphery *A. artemisiifolia* correlated with larger precipitations and cooler temperatures.

It may seem contradictorily that phosphorous fertiliser was negatively, while soil phosphorous concentration (P_2O_5 – which refers to the P content available for the plants) was positively associated with ragweed abundances. The greater amounts of P fertilisers in the whole area (and also N fertilisers in Austria) probably affect ragweed cover negatively via its stimulating impact on crop cover, which enhances the crop's weed suppressive ability. Although in many previous studies there were correlations between soil charactristics and the abundance of ragweed, the potential P preference emerged as a new finding in this study. Checking our dataset showed that soil P content correlated with none of the other factors.

Variation partitioning revealed that land-use factors are much more powerful predictors to ragweed infestations than environmental variables in the area studied. While the proportion of differences between the two groups of factors are roughly the same by the four threshold limits in the edges, the greater cover values associated with the larger impact of land-use in the field cores. Our results also highlighted that the build-up of ragweed populations in the field cores could be the consequence of improper land-use management, rather than of abiotic constraints. Our results seem to suggests that common ragweed exhibits a “generalist” ecological strategy, as its expansion in crop fields is largely unaffected by environmental variables, but is largely susceptible to land-use operations.

According to our results the most common summer annual weeds dominated each crop regardless of the countries. The most important families were *Poaceae* and *Asteraceae* families regardless of the countries. The same tendency could be observed in sunflower, soyabean and oil pumpkin, since three families provide at least the 80% of the average cover of weeds. Except for maize the first three place in the abundance occupied by *Asteraceae*, *Chenopodiaceae* and *Poaceae* families. These results indicate that the weed flora of the spring sown crops is rather uniform, which is presumably due to the very similar agronomy and usage of herbicides.

Studying the mass ratio of the life forms highlights that the 70-80% of the mean cover values derive from the summer annuals in every crop, regardless of the country. In addition, the geophytes are also significant. Due to the fact that mostly the last tillage conected to the sowing determines the composition of arable weed flora. There were more geophytes in Austria which indicate that might be ploughing fades into the background there. The examined fields had 32% usage of no tillage in Austria, while in Hungary had only 22%.

5. New scientific results (Theses)

1. I proved during the research, that the presence of *A. artemisiifolia* was more significant in Hungary. This phenomenon indicates, that compared to Austria in Hungary the presence of ragweed is more older with more stable local populations and seed bank in the soil.
2. According to our research the farming type (conventional and ecological) shows a country-specific pattern: in organic fields common ragweed occurred significantly more frequently in Hungary with high cover values. However, also suggests that conventional management in combination with certain previous crops resulted in just an opposite tendency: the proportion of highly infested fields became slightly larger in Austria.
3. In our study, crop cover proved to be the most important variable influencing the abundance of *A. artemisiifolia* in the whole area studied.
4. Variation partitioning proved that land-use factors are much more powerful predictors to ragweed infestations than environmental variables in the area studied. This information could be important for the more precise prediction of the future spread of common ragweed (as the predicitons largely based on climatic data).

6. Publications

PUBLICATIONS RELATED TO THE SUBJECT OF THE PRESENT DISSERTATION

ARTICLES

Kolejanisz, Tamás ; Nagy, Katalin ; Bede-Fazekas, Ákos ; Vér, András ; Pinke, Gyula: *Nyárutói gyomnövényzet összetétele az osztrák–magyar határ térségének szántóföldjein*. MAGYAR GYOMKUTATÁS ÉS TECHNOLÓGIA 21: 2 pp. 3-17., 15 p. (2020)

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Pinke, Gyula ; **Kolejanisz, Tamás** ; Czúcz, Bálint ; Botta-Dukát, Zoltán: *Weed species composition of oil pumpkin fields in Hungary*. In: Schumacher, M; Westermann, P (editors): Proceedings 7th meeting of the EWRS working group "Weeds and biodiversity" (2019) pp. 15-15., 1 p.

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