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SURVEY OF SPREAD OF COMMON RAGWEED (*AMBROSIA ARTEMISIIFOLIA* L.) ON ŽITNÝ OSTROV (SLOVAKIA) AND ON SZIGETKÖZ (HUNGARY) REGIONS

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1. INTRODUCTION AND OBJECTIVES

The control of weeds can only be successful through the rational and integrated application of different weed control procedures. The condition for this is knowing the weed flora. The neophyte weeds with a very good adaptability are the main source of danger for our days. Therefore, it is of a major importance to know and research the flora and fauna (invasive species) which appear and spread in agricultural areas.

The common ragweed (*Ambrosia artemisiifolia* L.), with its strong temporal and spatial spread, is one of the most dangerous weeds in Europe, the first weed in Hungary. By virtue of its ability to compete, it causes large losses of produce and other direct or indirect damage to producers.

In addition to its agricultural consequence, it is necessary to protect against it because of human health reasons: one of the most serious consequences of its spread is the pollen-caused allergy and the resulting economic damage to the country.

Its adverse effect on biodiversity of invasive species is also known. In the case of ragweed, can be observed its appearance nature in nearby natural areas, which is the result of human activities.

While in Hungary since the spread of ragweed there have appeared numerous studies on the weeds caused by the species as well as the contamination of non-agricultural areas, in Slovakia so far there have been only references to the occurrence of this dangerous weed.

The **primary** and **principal** objective of our research is therefore the common ragweed (*A. artemisiifolia* L.) and the

a) mapping of its occurrence and spread in Žitný ostrov and Szigetköz,

(b) examination of the quantity and frequency of the species on the basis of the surveys and

(c) the determination of the accompanying weed species in the two regions.

Furthermore, our aim was

d) Using ArcGIS to display 2D map results.

Within our research separately

e) We analyzed the spread of ragweed and the presence of accompanying weeds in the priority bird protection area of the NATURA 2000 network in Ostrovné lúky region (Slovakia).

d) Our aim was to investigate whether the ragweed infestation values of the Žitný ostrov (Slovakia) and Szigetköz (Hungary) were different from each other.

The collected and systematized data could be a valuable addition to the grouping of the accompanying species by flora elements, or the W-indicator value, R-ecological rating for each year or the cultures examined, and can be analyzed the diversity in the examined areas.

From the data of 3 years, we can get an overview of the frequency of ragweed and the accompanying species, by distribution of plants per lifestyle.

In the future it is possible to compare the species spectrum analysis and the information in the database of the Slovak Academy of Sciences, which allows to mark the dangerous invasive species and their occurrences in the examined areas, and to contribute with this data to the formation of control strategies of the Žitný ostrov, including Ostrovné lúky from the ecological, nature conservation and farm-weed aspects.

2. MATERIALS AND METHODS

2.1. Terrains weed survey

Our research was carried out in 2014, 2015 and 2016, in a total of 762 places in the Žitný ostrov (Slovakia) and in Szigetköz (Hungary) in a total of 180 locations. In order to determine the level of infection, we counted the ragweed individuals. The sampling sites were usually (if it was possible) located where weed vegetation was well developed and *A. artemisiifolia* L. and associated vegetation were recorded and counted. Because weed survey methods are different in two countries to determine the occurrence of ragweed, we have chosen the exact counting method. Before the weed survey was started, a 5 km * 5 km grating grid (GRID) was constructed on the map of Žitný ostrov and Szigetköz so that the planned locations of the surveys would be similarly distributed in the two regions. In each of the cadastre, on randomly selected locations was marked out 10 m^2 sample field (quadrats). The size of the sample quatrats was 3.17m * 3.17m. In the selection, it was a that the sample quadrat should provide the most and the most reliable information from the table around it.

Recording points were identified by a unit (GPS Garmin Oregon 650 navigation software version 4.50) and we recorded latitude and longitude coordinates. At the recruitment points, 8-10 photos were taken per location for documentation purposes. To determine the degree of infestation, we counted the ragweed stems within the sample quatrats. Next, the accompanying weed species within the quadrat were recorded by name. The surveys were carried out on late summer field arable vegetation: grain-, rape-, pea-, silage corn-, sunflower-, soybean stubbles, sugar beet, alfalfa and on fallowed lands.

2.2. Method of processing data

The data recorded during the field survey was sorted and organized into tables for which the Microsoft Excel program (2010) was used, and then we detected the level of infection by scaling 0-10. If we did not find ragweed in a sample quatrat, it received 0 value. At the value between 1 and 10 pieces of ragweed stems we wrote 1, and so on. Sample quatrats in which the number of ragweed stems exceeds 90 were commonly labeled with 10. For this scale, we assigned a subjective rating that provided a clear map representation. Each quadrat can be classified as no infestation (0), weak infestation (1,2,3), medium infestation (4,5,6) strong infestation (7,8), and heavy infestation (9,10).

2.3. Geospatial analysis

For the geospatial analysis the ESRI (Environmental Systems Research Institute, 380 New York Street, Redlands, CA 92373-8100, USA), ArcGIS ArcView 10.1, ArcGIS Spatial Analyst, and the ArcGIS 2D Analyst were applied. The natural status was modelled by using Spatial Analyst software additions, field measurements corresponding data series, as well as digitized table borders. Additional information about the status field from the scale models and the models produced by different sets of data produced by juxtaposition were obtained. For the model production the IDW (Inverse Distance Weighted) interpolation method was used. An attention was paid to the 5 categories of infestation, and other five points were included in the interpolation, the grid size is determined by 3 m. In the interest of informative representation unique gradient keys were made for data signal lines, which were used in the 2D graphing

2.4. The frequency of accompanying weeds, their classification according to botanical families and their lifestyle

From the data obtained from the survey, the frequency of the accompanying weed species was calculated. In addition, we systemized the accompanying weed species on the basis of botanical families and the occurrence frequency of life forms. We used Microsoft Office Excel program (2010) for table counting and chart presentation of the data. Nomenclature and family classification of recorded weed species were based on Hunyadi et al., (2000) and the Király, (2009). Their classification according to their life-style was based on Ujvárosi (1973).

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2.5. Statistical analysis

Statistical analysis were performed using Statistica (version 12.3; StatSoft) software. Hypothesis was performed to determine whether the ragweed infestation values in the area of the Žitný ostrov and Szigetköz differed (F test for the variables and then t-test for averages) (Berzsenyi, 2015, Rencher, 2002, Sváb, 1973). This study was carried out in pairs for each of the two quality categories for the two examined regions. In addition, we investigated how the total number (or biomass) of the companion weed species of ragweed is evenly distributed among the species.

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3. RESULTS

3.1. Evaluation of the 3 year results of the recording on Žitný ostrov

From the results of the investigation made in the Žitný ostrov we can coclude that the proportion of ragweed-infected and ragweed-free areas is almost equally distributed in the years under survey. The most frequently infected categories were the sample quadrats with heavy infestation. They were followed by quadrats with weak infestation, then medium and with strong infestation. In the year 2014 were 13, 42, 70, 156, in 2015 were 12, 50, 74 and 146, and in 2016 were 12, 50, 75 and 121 average number of ragweed individuals according to the categories of contamination.

During the 3 years survey we recorded the common ragweed's accompanying weeds as well. The most commonly occurring accompanying weeds were *Chenopodium album* (10.58%), *Mercurialis annua* (7.78%), *Datura stramonium* (5.87%), *Polygonum aviculare* (5.71%), *Setaria viridis* (5.41%), *Echinochloa crus-galli* (4.90%), *Chenopodium hybridum* (3.80%), *Cirsium arvense* (3.77%), *Amaranthus retroflexus* (3.55%), *Setaria pumila* (2.91%), *Abutilon theophrasti* (2.61%), *Solanum nigrum* (2.45%), *Capsella bursa-pastoris* (2.26%), *Panicum miliaceum* (2.26%) és *Convolvulus arvensis* (2.21%). The 74 accompanying weeds recorded in the Žitný ostrov region belong to 29 plant families. The most commonly occurring accompanying weeds of ragweed belong to the *Poaceae f*amily (18.06%). They were followed by weeds of *Chenopodiaceae* (14.51%), *Asteraceae* (14.08%), *Solanaceae* (8.32%), *Euphorbiaceae* (8.32%) families in the prevalence rate. In the three-year summary of the Žitný ostrov study, we analyzed the incidence rates of the accompanying weeds according to the life form groups. Based on the distribution of life-form groups, late summer T_4 dominated by 75.29%, G_3 (6.86%) and T_1 (5.25%) weeds were present in a smaller proportion.

3.1. Evaluation of the 3 year results of the recording on Szigetköz

The results of the Szigetköz study show that the distribution of groups of infectious categories differs from the results of the Žitný ostrov study. In the Szigetköz area, the proportion of sample quadrats infected with ragweed and ragweed-free areas is not equally distributed in the years under review (38,5-61,5). The most commonly infected categories were sample quadrats with weak infestation. They were followed by with medium infestation, then by strong and heavy infestation sample quadrats in prevalence rates. The sum of the sample quadrats infected with ragweed exceeded the amount of infection-free quadrats. In year 2014 were 8, 36, 0, 0, in year 2015 were 12, 46, 66 and 127 and in the year 2016 were 11, 40, 68, and 96 the average number according to the categories of contamination.

The most commonly occurring accompanying weeds were *Chenopodium album* (5.39%), *Mercurialis annua* (4.25%), *Cirsium arvense* (2.67%), *Setaria viridis* (2.67%), *Chenopodium hybridum* (2.05%), *Panicum miliaceum* (1.96%), *Setaria pumila* (1.96%), *Datura stramonium* (1.86%), *Amaranthus chlorostachys* (1.81%), *Polygonum aviculare* (1.81%), *Amaranthus retroflexus* (1.38%), *Echinochloa crus-galli* (1.34%), *Stachys annua* (1.34%), *Capsella bursa-pastoris* (1.24%) és *Convolvulus arvensis* (1.24%). In the Szigetköz, the 70 recorded weed species can be classified into 23 plant families. The study found that the most frequently occurring accompanying weeds belong to the *Poaceae* family (20.32%). These are followed by *Chenopodiaceae* and *Asteraceae* (15.08%), then by *Euphorbiaceae* (9.54%) families at the prevalence rate. In the three-year summary of the Szigetköz survey, the frequency of accompanying weeds according to life form groups was also analyzed. Based on the distribution of life-forms by groups, one-year-olds (T4) dominated in 71.53%, G3 (8.83%) and T1 (5.89%) weeds were present in a smaller proportion.

3.3. Evaluation of statistical results

During the analysis, the number of ragweed counted in the two regions was considered as the basis for the elements of the samples, taking in consideration just the ragweed infected sample areas. The Žitný ostrov contained 376 and Szigetköz 110 samples. By comparing the sample averages of these we concluded the equivalence or difference between the averages of the two populations. First, as a null hypothesis we argued that the variance of the two variables is equal, and as counter-hypothesis, they are different with the 95% probability (confidence level), F test. The result of the test was that the deviation of the samples differed ($p < 0.05$). Subsequently, a two-sample t test was performed to examine the deviation of the sample averages. As a null hypothesis, we told that the population averages are equal, and as counter-hypotheses, they are different with a 5% error. Since $p < 0.05$, therefore, the result of the t test was that the deviation of the sample averages is different and can be statistically justified. The hypothesis is true and with 95% probability can be said that the population averages are not equal in the two examined areas. The statistical results support the fact that the Žitný ostrov is more contaminated with ragweed than Szigetköz.

The above mentioned analysis was performed on all samples, including both infected and non-infected quadrants. A similar result was obtained as before, since p values were less than 0.05%. In both cases, the deviations and averages of samples of the two regions differ from 95% probability and the extent of the ragweed infection in the two regions is statistically different.

3.4. Geoinformation maps

With the help of the GIS software, we created the exploration maps of ragweed in the examined regions. On the maps it can be clearly seen in which part of the hinterland and island regions can be found ragweed. From the results obtained, it can be stated that its incidence is not homogeneous and the degree of infection is regional heterogeneity. The highest incidence of ragweed in the examined years was recorded in the eastern and central parts of the area at Žiný ostrov. During the survey, it was noted that in these parts, small-scale sunflower cultivation is more common, which may promote the growth of weeds.

3.5. Analysis of Ostrovné lúky area

From the Žitný ostrovs ragweed survey we highlighted the results obtained in Ostrovné lúky (Slovakia), which were analyzed separately. The survey was analyzed in 12 samples in 2014, in 24 in 2015 and 33 in 2016 of sample quatrats. Average species of ragweed in the Ostrovné lúky (Slovakia) area according to the categories of infectivity in 2014 were 6, 35, 71, 215 at 10 m^2 each. In the 2015 survey, the average number of ragweed was 8, 45, 65, 110 and 2016, 15, 38, 68, and 159 respectively. It can be seen from the results of the Ostrovné lúky series of analysis that the proportion of ragweed-infected and ragweed-free areas is not equally distributed in the years under review. The most frequently infected categories were sample quatrats with heavy infestation. They were followed by weak, then medium and strong infestations sample quatrats at the prevalence rate. In three years we found sample quatrats that did not have ragweed. In 2014, the ragweed stems of 10 m^2 will have a maximum of 400, 154 in 2015 and 201 in 2016.

The 36 weed species recorded in the Ostrovné lúky area can be classified into 17 plant families. The study found that the most frequent accompanying weeds belong to the *Poaceae* family (17.77%). They are followed by *Asteraceae* (14.88%) and *Polygonaceae* (9.92%) weeds at the prevalence rate.

During the statistical analysis, the number of ragweed measured in the Natura 2000 areas was considered as the basis for all the elements of the samples, all of the ragweed and non-infected samples. We compared the sample averages of each pair by comparison to the equivalence or variation of the average of the multitude. As a null hypothesis we argued that the variance of the two variables is equal in pairs, and as a hypothesis, the 95% probability (confidence level) is different. As a result of the F test, it can be stated that only the deviation of the samples from 2014 and 2016 does not differ ($p > 0.05$). Subsequently, a two-sample t test was performed to examine the deviation of the sample averages. Our null hypothesis here is that the population averages are equal and the hypothesis is different with a 5% error. Since in all three cases $p > 0.05$, as a result of the t test, we found that the sample deviation is not differed, the random work can not be statistically justified. With 95% probability, it can be stated that the population averages are equal in the three years studied. The above analysis has been performed for all the survey areas. The p values were greater than 0.05, and the three-year infestation averages did not differ in 95% probability, which means that the ragweed infection of the examined years is considered to be of the same degree.

4. NEW SCIENTIFIC RESULTS (THESIS)

1. In Žitný ostrov (Slovakia) region, we were the first who conducted a scientific research on the spread of ragweed in summer vegetation, on 762 sites identified with GPS coordinates and photo documentation.

2. The spread, frequency and dominance of ragweed on the examined Žitný ostrov (762) and Szigetköz (180) sites has been demonstrated, and based on the data we can say that the spread of ragweed is likely to occur. We have shown that in the average of 3 years in Szigetköz (Hungary) is more common the ragweed than in Žitný ostrov, but the average contamination of the area is smaller.

3. The spread of ragweed and the degree of infection was illustrated for both regions with 2D maps using GIS software. For the illustration, it was used the subsystem - rating scale we created. Based on our data and maps, the detected points in 2014 in Žitný ostrov were: Ekel, Mad, Bogya, Medve, Balázsfa and in Szigetköz: Kisbajcs, Dunaszeg. In 2015 in Žitný ostrov: Pódafa, Bogyarét, Madérrét, Megyercs, Kisbudafa and in Szigetköz: Gyulamajor, Kimle, Dunaszeg, Ásványráró. In 2016 in Žitný ostrov: Violín, Štúrová, Mad, Nemesócsa, Ógele and in Szigetköz: Feketeerdő, Halászi, Novákpuszta cadaster of settlements. The most polluted areas of Žitný ostrov were in the central and eastern part of the region.

4. The recording of the ragweed accompanying weeds will allow further analysis later. Based on the frequency of the three years' cumulative data we found that the most commonly occurring weeds are *Poaceae, Chenopodeceae, Solanaceae*.

5. The data from weed surveys with accurate positioning (GPS) can provide a basis for the development of precision plant protection strategies and may serve as a basis for further studies and analysis (seedbank studies and soil-weed interactions).

6. We have statistically shown that the averages and dispersions of the samples from the two examined regions differ by 95%, that is to say, the contamination of Žitný ostrov and Szigetköz is different, and Žitný ostrov is more contaminated with ragweed.

7. The first scientific ragweed infestation survey was carried out in the bird protection area of Ostrovné lúky - NATURA 2000 (Slovakia), involving 69 sample sites. Based on the averages of 3 years we have shown that Ostrovné lúky is highly infected with ragweed, the infection can be considered identical in 3 years of the study. We also statistically demonstrated that average weeds increased year by year in this region.

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