Distribution of Invasive Weed *Ambrosia artemisiifolia* L. in Croatia

Natalija GALZINA (✉)
Klara BARIĆ
Maja ŠĆEPANOVIĆ
Matija GORŠIĆ
Zvonimir OSTOJIĆ

Summary

Ambrosia artemisiifolia L., is an invasive alien plant in Europe that has been the subject of research of many scientific disciplines, particularly in last twenty years. In addition to being known as a noxious weed, it came into the public interest as a source of very strong allergenic pollen that causes allergic responses in 10% of the Croatian population, a figure similar to that of other European countries. The genus *Ambrosia* consists of about 40 species but in Europe just five of them are present. The most widespread is *Ambrosia artemisiifolia* L. It is present normally in row crops, particularly in sunflower (*Helianthus annuus* L.) fields. Furthermore, its presence is noticed along communication lines, in urban, industrial and building areas, and other non-agricultural areas. Distribution monitoring of *Ambrosia artemisiifolia* L. was conducted during three years, from 2004 to 2006, by recording its presence or absence in settlements of districts in the 21 counties of Croatia. Inland parts of Croatia are highly infested with *Ambrosia artemisiifolia* L. while in the coastal area it is mainly concentrated on bands along communication lines. In this area we observed individual (solitary) plants. Systematic and well organized monitoring of the *Ambrosia artemisiifolia* L. spread and distribution in the coastal parts of Croatia would reduce its progression to the more southern parts and the Croatian islands.

Key words

Ambrosia artemisiifolia L., distribution, Croatia

[1] University of Zagreb, Faculty of Agriculture, Weed Science Department, Svetošimunska 25, 10000 Zagreb, Croatia
✉ e-mail: ngalzina@agr.hr

Received: December 4, 2007 | Accepted: September 20, 2008

ACKNOWLEDGEMENTS
This paper is result of the project "Common ragweed (*Ambrosia artemisiifolia* L.) spread, biology, ecology, damages and control measures" financed by the Ministry of Agriculture, Forestry and Water Management. The project was conducted over three years by the Weed Science Department, Faculty of Agriculture, Zagreb and the Institute for Plant Protection in Agriculture and Forestry of the Republic of Croatia.

Introduction

In the last twenty years invasive alien plants have been of interest to researchers from different scientific fields as it is known that they are a serious threat to ecosystems and biodiversity. The European and Mediterranean Plant Protection Organization (EPPO) lists plant species considered to pose a threat to plant health, the environment and biodiversity in the EPPO region and therefore recommends control measures to prevent their further introduction, spread and the management of unwanted populations. *Ambrosia artemisiifolia* L. is on this list (www.eppo.org).

The genus *Ambrosia* consists of about 40 species, five of which are present in Europe: *Ambrosia artemisiifolia* L., *A. trifida* L., *A. coronopifolia* Torr et Gray, *A. maritima* L. and *A. tenuifolia* Spreng. Only *A. maritima* is native to Europe. The most common in Europe is *Ambrosia artemisiifolia* L. - common ragweed (Tutin et al., 1976).

According to Huth, common ragweed, a native in North America, was introduced in Europe in 1863 (in Kovačević and Groman, 1964). Comtois noted that *Ambrosia artemisiifolia* L. came into Europe with red clover seed and grain seed, and its distribution began probably from European ports: e. g. from Rijeka towards Croatia and the Danube valley, from Trieste and Genoa towards Northern Italy, and from Marseille towards the Rhone valley (in Makra et al., 2005). In southern parts of the Danube area ragweed was found in the 1920s (western part of Hungary) and 30 years later it had colonized the whole region.

Croatian herbologist Kovačević J. first mentioned *Ambrosia artemisiifolia* L. in Croatia in 1940. Examining impurities in red clover seeds originating from Pitomača, he found common ragweed seeds (Ostojić et al., 1992). In the former Yugoslavia, according to Kovačević and Groman (1964), Maly noticed the common ragweed in 1935 in the village of Osojci near Derventa. These authors note that Horvatić in Zagreb and Slavnić in Vojvodina recorded this specie soon after the Second World War. Igrc (1987) noted ragweed colonization in Vojvodina according to Šajinović and Koljadžinski. In "Jugoslavenski imenik bilja" Šulek mentioned common ragweed even earlier, in 1879.

Chauvel et al. (2006) investigated the introduction and spread of common ragweed based on herbarium specimens stored in France and in neighbouring countries. They stated that before 1890 common ragweed was mostly described in cultivated fields (in 80% of specimens), favouring the theory that common ragweed came in with seeds. During the first half of the 20th century in 42% of herbarium specimens, ragweed was described as a weed but was also found along communication lines (33%) and on waste land (25%). During the last 50 years the main common ragweed habitats were communication lines (50%) but it was still present in fields (34%). Similarly Kazinczi et al. (2008) showed that rapid distribution of common ragweed was observed at first along the transport lines of agricultural products, mainly along the roads and railway lines, while at present it is distributed throughout Hungary. The success and dissemination velocity of common ragweed is represented by Béres (2003) who noted that ragweed was 21st on the list of the most common Hungarian weeds in 1950, 8th in 1980, 4th in 1988 and from the early 1990s it was the most widespread weed in Hungary.

Chauvel et al. (2006) indicated that main reasons for ragweed introduction in France were anthropogenic, more precisely, the increase of the agricultural trade between America and Europe in the 19th century and First World War. Kiss and Béres (2006) indicate that the massive spread of the common ragweed could be a result of the political and socio-economic transitions in Eastern European countries. In Hungary many large agricultural co-operatives collapsed and land was subdivided and returned to former and new private owners who did not continue to cultivate the land properly. Thus previously well maintained fields were abandoned and quickly colonized by ragweed (Makra et al., 2005).

Ambrosia artemisiifolia L. is an annual thermophilic plant. It grows to 20-90 cm, even 120 cm in height. It begins to emerge early in the spring and continues to emerge through the summer. Plants that emerge early in the spring have a longer vegetation period (150-170 days). They are higher, more ramified and produce more seeds. Kazinczi et al. (2008) noted that the time between germination and flowering was considerably reduced when the seeds germinated later, while the time between flowering and seed ripening remained relatively constant. Thisproves high adaptability of common ragweed that allows its spread towards north. The common ragweed is a short-day plant. Pollen production begins during summer (July-August) and lasts till the first frosts. As an annual plant it reproduces by seed and has abundant seed production. One plant produces on average 1000-4000 seeds but that number can be significantly higher (as high as 150,000 seeds per plant annually). Seed can remain viable in the soil for 35 years and even more (Ostojić et al., 1992; Ostojić, 2005). Solitary, individual plants are more ramified and generally pollinate more. Common ragweed plants react with high phenotypic plasticity to population density and competition from other plants (Brandes and Nitzsche, 2006).

In addition it is known as a strong competitor, particularly in row crops (corn, sunflower, sugar beet, soybean) in which can maintain large populations. Ragweed also grows in vegetable crops, on stubble, along roadsides and on other non-agricultural areas. Common ragweed is a widespread weed in sunflower because both are members of the same (*Asteraceae*) family. Thus, ragweed escapes the effect of applied herbicides and in large populations infests sunflower fields. Herbicides selective to the sunflower are usually selective to the ragweed. In Croatia there are no efficient herbicides for ragweed control in sunflower, as compared with other crops. In dense crops it can also be present, although in those conditions its competitive strength is lower due to strong competitiveness from the crop itself. In these conditions ragweed will not dominate except in reduced crop stands (empty areas in the field, water stands), but after harvest it can cover most of the stubble (Ostojić et al., 1992). Due to lack of competition, common ragweed can become dominant very fast, which is almost the rule in open and disturbed habitats.

The interest of the public was mostly linked to the development of strong allergies caused by *Ambrosia artemisiifolia* L. pollen. According to data of the Croatian Public Health Department, in Croatia around 10% of population is sensitive to ragweed pollen. Causing allergenic rhinitis and asthma, it has become significant medical problem. Ragweed pollen monitoring in Europe has quite a long history. Monitoring started

in France (1960), then in Italy, Hungary and Slovenia (1989) (Peternel et al., 2005), in Switzerland in 1979, and in the Czech Republic in 1992. The first traps for pollen monitoring in Croatia were established in the year 2001 in Osijek (Štefanić et al., 2005). Since then, other cities have started to monitor pollen (Zagreb, Ivanić-grad, Samobor, Varaždin, Rijeka, Split, Dubrovnik and Bjelovar) (www.plivazdravlje.hr). Since autumn 2003 Croatia has been a member of two European associations, the European Aeroallergen Network (EAN) and European Pollen Information (epi), and has been included in information exchange about pollen progression in Europe (www.publichealth-zagreb.hr). Peternel et al. (2005) showed that ragweed pollen is in the third place considering the total amount of pollen in Central Croatia. It is present early in the summer, but maximum concentrations are reached during August and September. According to Makra et al. (2005), the highest pollen concentrations in Europe are recorded in the Carpathian Basin, Serbia and Hungary, southern parts of Southwest Hungarian Plain (Szeged) and Southwest Hungary (Pecs). According to our observations, in north-eastern Croatia (Osijek) the pollen concentrations are also high (Štefanić et al., 2005).

The impact of global climatic change has recently become a matter of concern. It is possible to assume that climatic changes will have an impact on the pollen concentrations of allergenic plants. Ziska et al. (2003) have calculated that higher temperatures and CO_2 concentrations due to urbanization could cause increased pollen production in urban areas compared with rural areas. Further, ragweed plants in urban areas grow faster, flower earlier and develop more aboveground mass. Additionally, ragweed spread is enhanced by its resistance. Long-term application of the same herbicides, especially triazines, in the countries of south-eastern Europe selected resistant biotypes of ragweed that can spread efficiently (Brandes and Nitzsche, 2006).

Material and methods

During three years (2004, 2005 and 2006) of the project, current distribution ("mapping") of *Ambrosia artemisiifolia* L. was determined by recording the presence or absence of the species. We observed localities in settlements of districts in the 21 counties of Croatia. Observation encompassed agricultural fields that were sown with row crops (corn, sunflower, sugar beet, and soybean), with vegetable crops (cabbage and onion), ruderal areas (uncultivated) and urban areas (bands alongside communication lines – roadsides, railways, parking places, parks, etc.). After observations were completed, the localities surveyed were marked on prepared map of Croatia.

Results and discussion

Monitoring results are shown in Tables 1 and 2, and on the distribution map (Figure 1) according to municipalities and counties. During three monitoring years, 1937 surveys were carried out. Surveys were made in 521 districts or 84% of the total district number in Croatia (620 districts). *Ambrosia artemisiifolia* L. was found in 490 districts or 94% of the total number of municipalities surveyed. Ragweed absence was recorded in 31 districts (6%). As shown in Tables 1 and 2, surveys were repeated in 90 municipalities during monitoring in subsequent years. Surveys were completely done in the following counties: County of Zagreb, County of Sisak-Moslavina, County of Varaždin, County of Virovitica-Podravina, County of Požega-Slavonija, County of Brod-Posavina, County of Osijek-Baranja, County of Vukovar-Srijem, County of Karlovac and City of Zagreb. All the mentioned counties are situated in the continental part of country.

Tables 1 and 2 show that *Ambrosia artemisiifolia* L. was observed in all counties. For coastal parts of Croatia and the islands we have insufficient data. There are several explanations for this. The coastal area is wide and very complex with respect to topography. This could be very important as we noticed that ragweed is in the early stages of invasion in the coastal area. Accordingly it was mostly possible to observe settlements along main roads only. We considered it appropriate to receive general information about ragweed presence in this area. During observation, vigilance was needed. Firstly, ragweed was not present in all the surveyed areas so more detailed observation in some locations was needed. Secondly, due to its morphological similarities in the early growth stages to *Verbena officinalis* and *Tagetes spp.* (very frequent plant species in this area) additional attention

Table 1. Mapping results according to counties and districts in three years of research in the inland parts of Croatia

No.	County of	District no.	Number of observed districts			Total observation number		
			2004	2005	2006	2004	2005	2006
1.	Zagreb	34	14	21 [1]	0	77	63	0
2.	Krapina-Zagorje	32	5	23	4 [5]	9	182	67
3.	Sisak-Moslavina	19	7	12	0 [3]	57	56	13
4.	Karlovac	22	11	5	6 [8]	28	6	42
5.	Varaždin	28	10	21 [3]	0 [6]	43	69	8
6.	Koprivnica-Križevci	25	6	13	6	15	58	24
7.	Bjelovar-Bilogora	26	9	11	6 [3]	54	40	35
10.	Virovitica-Podravina	16	9	8 [1]	0	26	37	0
11.	Požega-Slavonia	10	9	2 [1]	0	53	5	0
12.	Slavonski Brod-Posavina	28	16	22 [12]	0	32	104	0
14.	Osijek-Baranya	42	7	11	24 [9]	13	40	78
16.	Vukovar-Srijem	31	11	10 [5]	15 [4]	24	21	52
20.	Međimurje	24	13	7	4 [3]	54	36	21
21.	City of Zagreb	70 settlements	10	12	48	34	17	53
Totally		407	137	178 [23]	113 [41]	519	734	393

(*) – number of observed districts in which *Ambrosia artemisiifolia* L. was not found; [ ] – number of revised districts

Table 2. Mapping results according to counties and districts in three years of research in the coastal parts of Croatia

No.	County of	District no.	Number of observed districts			Total observation number		
			2004	2005	2006	2004	2005	2006
8.	Primorje-Gorski Kotar	35	6 (1*)	11 (5*) [1]	14 [5]	14	38	32
9.	Lika- Senj	12	2	5 [2]	3	2	6	10
13.	Zadar	32	6 (3*)	14 (3*) [4]	1 [7]	19	20	12
15.	Šibenik-Knin	18	4 (2*)	2 [1]	1	17	2	4
17.	Split-Dalmatia	55	14 (9*)	11 (5*) [6]	0	34	19	0
18.	Istria	39	6	0	30	10	0	47
19.	Dubrovnik-Neretva	22	1	4 (3*)	0	1	4	0
Totally		213	39 (15*)	47 (16*) [14]	49 [12]	97	89	105

(*) – number of observed districts in which *Ambrosia artemisiifolia* L. was not found; [ ] – number of revised districts

was needed. Regarding all this, we consider that mapping, especially of this area, should be done in future with a more accurate methodology. Many countries have organized monitoring and developed ragweed distribution maps (Slovenia, Hungary, Switzerland, Czech Republic, Germany etc.).

According to the survey results we have confirmed the assumption that ragweed is present in the whole of the inland part of Croatia (Table 1). Cultivated fields were infested with common ragweed at different rates, depending on weed control management practice (agro technical and chemical measures) so we can conclude that infestation of these areas was high to moderate. Ragweed was generally present in sunflower fields. Fields sown with sugar beet, corn or soybean were less infested than sunflower fields. There are several reasons for this. We have already mentioned that for ragweed control in sunflowers there are no registered herbicides with good efficiency. But in other crops, situation is very different. For example, 122 herbicides were registered for weed control in corn in 2007 (Ostojić, 2007). Among these herbicides, there are a few with good efficiency against ragweed. That is why ragweed is not so numerous in these crops, always assuming that all the agro technical demands are satisfied. Abandoned fields and stubble were completely infested. Along roadsides, railways and highways ragweed was always present. Between settlements we observed ragweed in large populations as mowing was not done regularly and on time. Those plants produced seeds freely. In settlements the situation was different. Depending on residential practice and municipal bye-laws, ragweed was present in proportions that varied from place to place. The biggest problems in each place are the abandoned areas, which are quite numerous. In these areas, ragweed grows and produces seeds freely and is a constant source of seed for the infestation of neighbouring areas and an important source of ragweed pollen. The area between two major rivers Sava and Drava (Figure 1) is heavily infested with ragweed and in this area it is considered to be the most damaging (Ostojić et al., 1992). Ragweed pollen concentrations could be taken as an indicator of ragweed presence although its pollen can be widely distributed over long distances. This is borne out by the research of Peternel et al. (2005), who examined variations in ragweed pollen concentrations in northwest Croatia among three distinct localities (Zagreb, Ivanić Grad and Samobor). The highest pollen concentrations were measured in Ivanić Grad because it is a typical rural area with a lot of abandoned fields. Furthermore, the main crops grown in this area are corn and sunflower, crops in which ragweed is an important weed. Significantly lower pollen concentrations were measured in Zagreb and the lowest were measured in Samobor, which can be explained by their location and topography. In both years pollen concentration showed a declining tendency from east to west (Ivanić Grad-Zagreb-Samobor). Similar research was conducted in north-eastern Croatia (Štefanić et al., 2005; 2007). North-eastern Croatia is a flat and open area situated between the rivers Drava and Danube (Figure 1) and it is the main agricultural part of the country. In this region the ragweed population is well established and thus its pollen is most abundant in the atmosphere of north-eastern Croatia. In Vinkovci, a city between the Danube and Sava rivers, non-arboreal pollen, which includes *Ambrosia* pollen, are also dominant in the air, due to the agricultural background of the territory.

In the coastal part of Croatia ragweed infestation is still at a low level. After surveys conducted in three years we observed an increased presence of ragweed in this area too (Table 2). However, Ostojić et al. (1992) had referred to its harmful effects on the cultivated areas of PK Vrana, PPK Zadar, PIK Neretva and in Istria even earlier. Further, Igrc (1987) notes that ragweed was distributed in Lika, Gorski Kotar, in the Croatian Littoral, Dalmatia and Istria. In most of the surveyed settlements individual (solitary) plants were present, mostly along roadsides. In our opinion the main pathway of ragweed dispersal is by vehicles (tires of vehicles, tarpaulins of trucks etc.). We must emphasise that last year ragweed was found in localities where it had not been present in the first two years of monitoring (Krk). In some localities (Punat, Baška, Cista Provo, Pag, Opatija, Malinska) individual plants were found. We recommend therefore organized systematic monitoring and applied ragweed control measures in the coastal area, mostly along roadsides, to reduce its progression at relatively low costs. This is particularly due to the natural topographic advantage of the mountain range, which significantly reduces the possibility of ragweed seed introduction to this area by wind. Cvitanović et al. (2007) investigated patients sensitive to ragweed pollen in southern Croatia (Sinj and Split). In this area the pollination season lasted from mid August to mid October. Peak values, presented as percentages of ragweed pollen grains in total pollen, were 12% (in 2003), which is considerably lower than in Zagreb where ragweed pollen amounted to 80% of the total count in September and October in 2002. Their results confirmed ragweed presence near or in coastal area. This area should be especially monitored in subsequent years.

The spread of ragweed is monitored in the majority of European countries. Literature data reveals that ragweed is wide-

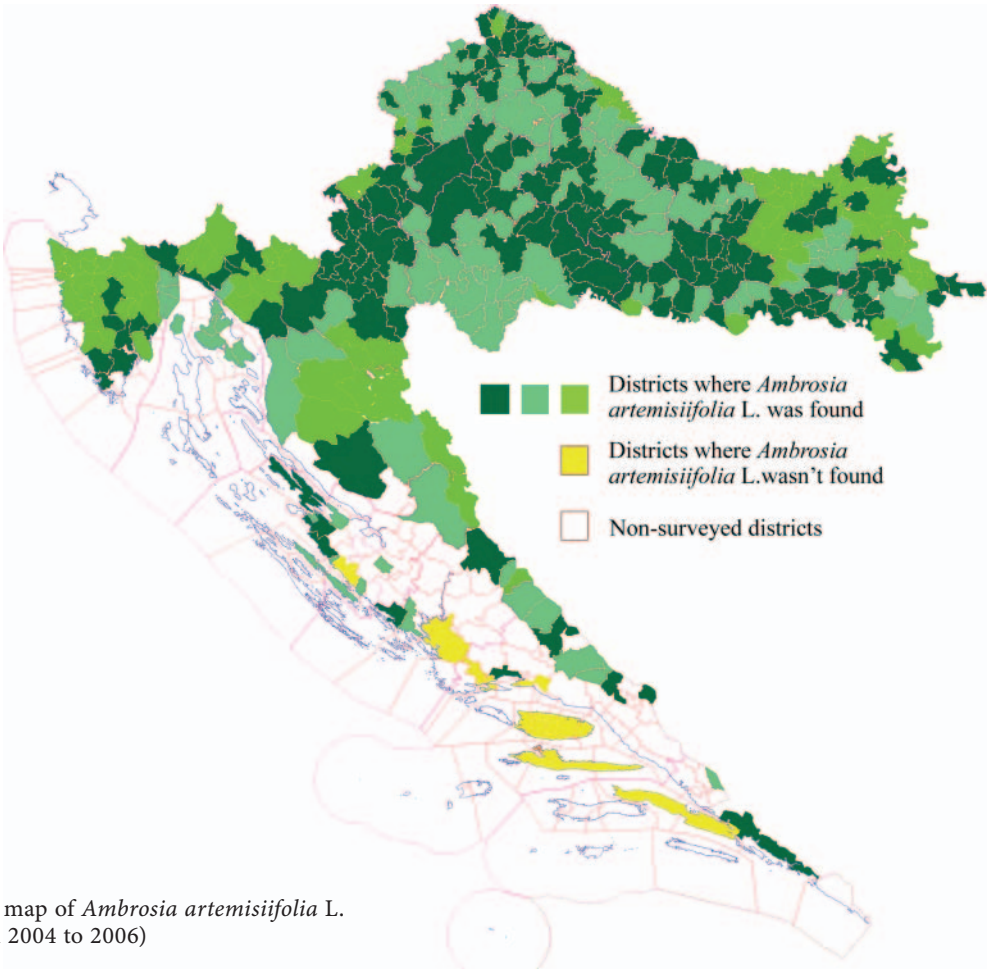

Figure 1.
Distribution map of *Ambrosia artemisiifolia* L. in Croatia (from 2004 to 2006)

spread in Europe. While it is harmful and damaging in Central and Eastern Europe, its presence is not doubtful in other areas.

Recently Juhász pointed out three main European areas infected with *Ambrosia artemisiifolia* L. Valley of the Rhone (France), Northern Italy and the most infected region, the Carpathian Basin (in Makra et al, 2005). In Hungary, 90% of the country is infested with ragweed, whereas in the countries of the former Yugoslavia ragweed is widely distributed on fallow land as a consequence of the war (Bohren, 2006). Our opinion that ragweed is spreading mostly along communication lines is supported by numerous investigations of ragweed presence across Europe. According to Bohren (2006) ragweed in Switzerland is still present at a low level and its progression can be reduced with effective low-cost control. In Switzerland it is mostly situated along communication lines, in arable fields and private gardens. There are few known foci in arable fields, but ragweed grows mainly in private gardens all over the country. Taramarcaz et al. (2005) also noted that ragweed has been found preferentially along the communication lines such as railways and highways and that Geneva and Ticino, the two main traffic entries into the country, are colonised with ragweed. Further, this author notes that climatic changes will also favour ragweed colonisation towards the more northern and higher areas, which were initially too cold for its spread. An example is Czech Republic. Rybníček et al. (2000) report that in Czech Republic ragweed is not observed as dangerous so far, but that it is spreading very expansively. In Germany ragweed is only partly naturalized but it is considered that under present conditions ragweed could build up considerable populations. Currently, there are three centres of distribution. As in other countries, ragweed on farmlands grows at the edges of corn fields, on fallow land and stubble fields, near silage deposits, on roadsides. Harbours and river-banks are not usual habitats in Germany (Brandes and Nitzsche, 2006). It is also spreading in central Italy, Austria and Bulgaria and it is even appearing in Sweden and the Baltic states, notes Taramarcaz (2005). Regarding pathways of dispersal, Bohren (2006) and Brandes and Nitzsche (2006) noted that birdseed mixtures containing sunflower seeds should be regarded as the main source of introduction to Germany and Switzerland recently, together with agricultural machines (combine harvesters) and excavated soil from building sites. In the building of new communication lines, at building sites, shopping centres, etc., landscape management has not been of major concern, which has resulted in the wide disturbed areas favoured by the common ragweed (Kiss and Béres, 2006).

In countries neighbouring Croatia ragweed is also present and causes same problems. In Bosnia and Herzegovina, ragweed is spreading starting from the north, west, and northeast to the

central part of Bosnia. In Herzegovina it can be found along the valley of the Neretva River. A tendency to spreading has been observed especially in the valley of the rivers and canyons from the north to south and in the opposite direction (Šoljan and Muratović, 2002, 2004). According to Selinger ragweed arrived in Slovenia during the Second World War. After mapping was done in 1978 its appearance was considered to be temporary, but ragweed spread widely in the lowlands (in Makra et al., 2005). It became very frequent and is spreading still. It is present along roadsides, on gravel sites and more rarely in fields or stubble, but it is the most common on embankments along recently constructed roads (Šilc, 2002). According to Konstantinović et al. (2005) ragweed is present in Serbia on the banks of the Danube, in the Bačka and Banat regions (Vojvodina). Spreading alongside Serbian rivers, the common ragweed has invaded the city of Niš in the southern part of Serbia.

Generally, ragweed control measures should be conducted. A systematic approach should be followed in all areas, especially along roadsides in the coastal part of Croatia. Due to its current infestation rate, organized campaigns should be carried out to achieve satisfactory results. As in the European countries mentioned, activities directed towards public sensitization have been carried out for the last few years in Croatia, in order to acquaint the public with the effects of ragweed. Different organizations and associations have printed leaflets describing ragweed morphology and harmful effects and gave recommendations for its control. At lectures intended for the professional and general public, experts and public were confronted with ragweed pollen allergy problems. Regarding administrative measures, the Ministry of Agriculture, Forestry and Water Management in 2004 announced a "Decree for the obligatory control of *Ambrosia artemisiifolia* L. " (NN 66/04) and a revised one in 2006 (NN 90/06). According to these, all land owners are obligated to remove ragweed during vegetation from their areas with agrotechnical, mechanical or chemical weed control measures, for the control and prevention of its spread. Workshops and other activities have also been organized on local levels.

Mechanical measures (hoeing or cultivation) are rarely conducted on cultivated fields. Control results are often low as ragweed emerges during the whole of the summer (Ostojić et al., 1992). Mowing is one of possibilities for ragweed control in urban areas and along roadsides as herbicide application is restricted in those places. It is necessary to take into consideration the fact that ragweed, after mowing, can ramify from a lateral shoots and thus, one mowing in the growing season will not be sufficient. In crops, ragweed can be significantly reduced with herbicides, except in the sunflower.

Conclusions

1. In 521 districts 1937 surveys were conducted in all. Among those agricultural and non-agricultural areas and different urban locations were examined. In 90 districts, the surveys were revised i.e. they were conducted in two or three years of mapping.
2. After weed control measures, infestation in surveyed areas was weak to moderate. A smaller percentage of the surveyed areas were heavily infested.
3. A significant presence was observed along communication lines, particularly roadsides and railways, which indicate the important role of vehicles in ragweed spread and dispersion. This is especially noticeable in coastal and upland regions of Croatia.
4. It is obvious that existing measures for common ragweed control and maintenance of rural and urban areas are not sufficient, which increases the harmful effects and dispersion of the invasive plant *Ambrosia artemisiifolia* L.

References

Béres I. (2003). The distribution, importance and biology of common ragweed (*Ambrosia artemisiifolia* L.). Növényvédelem, 39, 293-302

Bohren C. (2006). *Ambrosia artemisiifolia* L.-in Switzerland: concerted action to prevent further spreading. Nachrichtenbl. Deut. Pflazenschutzd., 58(11), S. 304-308

Brandes D., Nitzsche J. (2006). Biology, introduction, dispersal, and distribution of common ragweed (*Ambrosia artemisiifolia* L.) with special regard to Germany. Nachrichtenbl. Deut. Pflazenschutzd., 58 (11), S. 286-291.

Chauvel B., Dessaint F., Cardinal-Legrand C., Bretagnolle F. (2006). The historical spread of Ambrosia artemisiifolia L. in France from herbarium records. Journal of Biogeography. 33, 665-673.

Cvitanović S., Znaor Lj., Kanceljak-Macan B., Macan J., Gudelj I., Grbić D. (2007). Allergenic Rhinitis and Asthma in Southern Croatia: Impact of Sensitization to Ambrosia elatior. Croat Med J., 48:68-75.

EPPO list of invasive alien plants, October 12th, 2007., http://www.eppo.org/QUARANTINE/ias_plants.htm, November 8th, 2007.

Igrc J. (1987). Investigation of the Zygogramma suturlis Fabricius (Coleoptera: Chrysomelidae)-as a potential agent for biological control of the Ambrosia artemisiifolia L.. Ph.D. Faculty of Agriculture, University of Zagreb.

Kazinczi G., Béres I., Novák R., Bíró K, Pathy K. (2008). Common ragweed (*Ambrosia artemisiifolia*): A review with special regards to the results in Hungary. I. Taxonomy, orign and distribution, morphology, life cycle and reproduction strategy. Herbologia, Vol. 9, No. 1: 55-93

Kiss L., Béres I. (2006). Anthropogenic factors behind the recent population expansion of common ragweed (*Ambrosia artemisiifolia* L.) in Eastern Europe: is there a correlation with political transitions? Correspond in: Journal of Biogeography 33, 2156-2157

Konstantinovic, B.; Meseldzija, M.; Konstantinovic, B.; Marisavljevic, D. (2005) Determination of the occurrence and spread of the allergenic weed *Ambrosia artemisiifolia* in the territory of Vojvodina (Serbia). Introduction and spread of Invasive Species, 9-11 June 2005, Humboldt University, Berlin, Germany

Kovačević J., Groman E. (1964): Korov limundžik (*Ambrosia artemisiifolia* L.) u Jugoslaviji. Zaštita bilja, 77, XV, str. 81-85, Beograd.

Makra L., Juhász M., Bécszi R., Borsos E. (2005). The history and impacts of airborne Ambrosia (Asteraceae) pollen in Hungary. Grana 44: 57-64.

Ostojić Z. (2005). Limundžik (Ambrozija)-kako suzbiti opasnu pridošlicu. Gospodarski list, 8, 57

Ostojić Z. (2007). Herbicidi. U. Pregled sredstava za zaštitu bilja. Glasilo biljne zaštite, 2-3, 138-174.

Ostojić Z., Zadro J., Radiković Đ. (1992). Naši napasni korovi. Limunđik - *Ambrosia artemisiifolia* L. Glasnik zaštite bilja 9-10: 259-265

Peternel R., 14.3.2005.,http://www.publichealth-zagreb.hr/zrak/zrak_pol_uvod.htm, 8.11.2007.

Peternel R., Čulig J., Srnec L., Mitić B., Vukušić I., Hrga I. (2005). Variation in ragweed (*Ambrosia artemisiifolia* L.) pollen concentration in central Croatia, 2002-2003. Ann Agric Environ Med, 12, 11-16.

Peternel R., Počinje sezona peludnih alergija, 21.3.2005., http://www.plivazdravlje.hr/?section=arhiva&cat=t&acat=t&show=1&id=9168, 8.11.2007.

Rybníček O., Novotná B., Rybníčkova E. Rybníček K. (2000). Ragweed in the Czech Republic. Aerobiologia 16: 287-290.

Šilc U. (2002). Odontito-Ambrosietum Jarolímek et al. 1997-a ruderal association new to Slovenia. Acta Bot. Croat. 61 (2), 179-198.

Šoljan D., Muratović E. (2002). Distribution of *Ambrosia artemisiifolia* L. in Bosnia and Herzegovina. Herbologia, 3 (1), 109-115

Šoljan D., Muratović E. (2004). Distribution of *Ambrosia artemisiifolia* L. in Bosnia and Herzegovina (II). Herbologia, 5 (1), 1-5

Stefanić E., Kovacevic V., Lazanin Z. (2005). Airborne ragweed pollen concentration in north-eastern Croatia and its relationship with meteorogical parameters. Ann Agric Environ Med, 12, 75-79

Stefanić E., Rasic S., Merdic S., Colakovic K. (2007). Annual variation of airborne pollen in the city of Vinkovci, northeastern Croatia. Ann Agric Environ Med, 14, 97-101

Šulek B. (1879): Jugoslavenski imenik bilja. Str. 564. Jug. akadem. znan. i umj., Zagreb

Taramarcaz P., Lambelet C., Clot B., Keimer C., Hauser C. (2005). Ragweed (Ambrosia) progression and its health risks: will Switzerland resist this invasion? Swiss Med Wkly, 135: 538-548.

Tutin T.G., Heywood V.H., Burges N.A., Mor D.., Valentine D.H., Walters S.M., Webb D.A. (1976). Flora Europea. 4, 142-143. University Press, Cambridge

Ziska L. W., Gebhard D. E., Frenz D. A., Faulkner S., Singer B.D., Straka J. G. (2003). Cities as harbingers of climate change: Common ragweed, urbanization, and public health. J. Allergy Clin Immunol, 111: 290-295.

acs75_11