

Regional adjustment of management options of common ragweed (*Ambrosia artemisiifolia*) along roadside verges in Bavaria (2018-2022)

*Entwicklung regional angepasster Bekämpfungsmaßnahmen gegen das Beifußblättrige Traubenkraut (*Ambrosia artemisiifolia* L.) entlang des Straßenverkehrsnetzes in Bayern (2018-2022)*

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Abstract

Common ragweed (*Ambrosia artemisiifolia* L.) is an invasive annual plant with highly allergenic pollen. Its spread often occurs along roadsides, where it builds stable and rapidly growing populations. The most sustainable way of controlling the species is to prevent seed production in order to deplete the soil seed bank. Therefore, in a 4-years field (2019 to 2022) trial four different cutting regimes differing in timing and frequency of cuts as well as two different means of physical control are tested on eight roadside verges in Bavaria, characterized by different climatic conditions and traffic densities. On the basis of soil seedbank samplings along these roadside verges as well as on the road embankments the study should reveal which cutting regime is most effective in the prevention of flower and seed formation of common ragweed.

In addition, a 3-years field trial (2019 to 2021) on the competitive suppression of common ragweed by four different seed mixtures combined with three different cutting regimes was implemented on three different sites. First results showed that the primary habitat of common ragweed is the roadside verge: 97.9% of all plants counted as well as 96.7% of all seeds found in the soil seed bank were concentrated on the first 1.5 m next to the lane, irrespective of the soil properties and the inclination of the embankment.

Keywords: Cutting regime, invasive alien species, physical weed control, soil seed bank

Zusammenfassung

Das invasive Ragweed (*Ambrosia artemisiifolia* L. (Asteraceae)), ist eine einjährige, zweikeimblättrige Pflanze, deren Pollen sehr schwere Allergien beim Menschen auslösen kann. Die primäre Verbreitung erfolgt i. d. R. entlang von Straßen, wo Ragweed überaus stabile und schnellwachsende Populationen bildet. Die nachhaltigste Form der Bekämpfung der Pflanze ist es, die Samenproduktion zu verhindern und damit die Bodensamenbank abzubauen. In Rahmen dieses vierjährigen Feldversuches (2019 bis 2022) sollen deshalb unterschiedliche Schnittersysteme (verschiedene Zeitpunkte und Häufigkeiten) sowie zwei Methoden der physikalischen Bekämpfung, auf ihre Effizienz zur Verhinderung der Pollen- und Samenausbildung bei Ragweed getestet werden. Der Versuch wird auf acht Straßenstandorten in Bayern durchgeführt, die sich durch ein unterschiedliches Verkehrsaufkommen auszeichnen und in verschiedenen Klimaregionen liegen.

Zusätzlich dazu, wurde ein dreijähriger Feldversuch auf drei Standorten eingerichtet, auf denen zwischen 2019 und 2021 die unterdrückende Wirkung von heimischen Konkurrenzsaaten auf das Wachstum und Entwicklung von Ragweed getestet wird. Bereits in der ersten Phase des Versuches, der sich mit der potenziellen Wanderbewegung von Ragweed in die Böschungen befasste, wurde klar, dass Ragweed tatsächlich ein Phänomen des Bankettes ist. Da die Pflanze anscheinend Konkurrenz meidet, wurden 97,9 % aller Pflanzen sowie 96,7 % aller Samen in der Bodensamenbank auf den ersten 1,5 m zum Fahrbahnrand gefunden, unabhängig von den Bodenbeschaffenheiten auf den Standorten und der Böschungsneigung.

Stichwörter: Bodensamenbank, invasives Unkraut, Mahdregime, physikalische Unkrautbekämpfung

Introduction

Common ragweed (*Ambrosia artemisiifolia* L.) is an annual Asteraceae species with high economical impact as its pollen causes allergies and asthma, and it causes yield losses in different crops, such as sunflower, maize and pumpkin (D'AMATO et al., 2007; KAZINCZI et al., 2008; ESSL et al., 2009). Its main naturalization and establishment in Europe began after World War II due to a steadily increasing trade volume between Europe and the USA which also included seeds (clover, maize etc.) that were contaminated with seeds of common ragweed. Thus, the geographical routes of distribution can be clearly traced back to European harbors such as Rijeka, Trieste or Genoa (KAZINCZI et al., 2008; KARRER

et al., 2011). Outgoing from these Eastern and Southern European sites of introduction a steady spread of the plant towards Western and Northern Europe was observed in the last decades, primarily along the high-capacity road system. As its large ecological amplitude enables common ragweed to be a successful pioneer in several types of environments (FUMANAL et al., 2008); it can establish and grow even under harsh environmental conditions. Common ragweed can deal with de-icing salt, tire abrasions and heavy metals but also with extreme soil compaction, drought and very nutrient-poor conditions (CECCHI et al., 2006; FUMANAL et al., 2007; SMITH et al., 2013) which makes these habitats very unfavorable for other (native) plant species. Once established along the roadside verge, seeds of the plant can be easily transported by water run-off and wind and particularly by machinery of the road maintenance services. KARRER et al. (2011) showed that one flail mower can have a seed contamination of up to 40,000 seeds. Another factor accelerating the spread of ragweed is the traffic volume: The higher the traffic frequency, the faster ragweed seeds can be distributed (NAWRATH and ALBERTERNST, 2008; LEMKE et al., 2018). For example in Eastern Austria the tense and highly frequented road networks in the greater Vienna area promoted the distribution of common ragweed not only to various road verges but also to surrounding areas like agricultural sites, and ruderal sites. In contrast, in the lower frequented Western parts of Austria ragweed stands can be clearly linked to the linear structures of the high-capacity road system (KARRER, 2008; ESSL et al., 2009). The same linear patterns like in Western Austria can also be observed in Bavaria where common ragweed is increasingly spreading along road verges, but has not yet reached other habitat types like agricultural areas, so far (NAWRATH and ALBERTERNST, 2010; StMUG, 2013).

To avoid the further spread of the plant in these surrounding habitats, a sustainable control of the plant is essential but difficult because a single plant can produce more than 60.000 seeds (DICKERSON and SWEET, 1971) which may stay germinable in the soil for up to 40 years (TOOLE and BROWN, 1946). Therefore, the management solution for the control of common ragweed must aim at a continuous depletion of the soil seed bank. Actually along road verges, mowing is the most common vegetation control measure, primarily to ensure visibility and for other security reasons as the use of herbicides is often prohibited by law due to environmental concerns. Nevertheless, the influence of different mowing practices on the growth and reproduction of common ragweed is quite complex as this annual plant usually reacts to mowing like a perennial plant by resprouting from the basal buds and remaining on the main axis below the cutting height (BRANDES and NITZSCHE, 2007; BOHREN et al., 2008). Therefore, the timing of the cut can be essential: If done too early, mowing could enhance the production of male flower heads (BÉRES, 2004). If done too late, seeds might already have ripened before the cut (BOHREN et al., 2008). In addition, former experiments in Austria showed that an important factor influencing the growth potential of common ragweed along roadsides is the presence and the composition of (native) competitors which can be very effective in prohibiting the successful emergence of ragweed seedlings.

Thus, the aims of the study which is carried out on behalf of the Bavarian State Ministry of Housing, Construction and Traffic (Bayerisches Staatsministerium für Wohnen, Bau und Verkehr) are:

- Evaluation of the diffusion potential of common ragweed into the embankment
- Development of a regionally adjusted mowing regimes taking into account different climatic conditions, which should effectively contain the seed production of common ragweed and can therefore contribute to a sustainable eradication of the plant along these roadside verges
- Evaluation of the effectiveness of physical control options (hot foam and electro shocking)
- Evaluation of the suppressive effect of competition seeding on the establishment success of common ragweed

Materials and Methods

Ragweed diffusion to the embankment

On eight sites from Southern to Northern Bavaria we implemented in 2018 a grid design with 10 x 0.25 m² plots over the length of the ragweed population next to the lane and over the total width of the embankment (40 to 100 plots per site depending on the width). On each plot, the number of plant individuals was counted and soil samples were taken (10 cm diameter, 10 cm depth) with a standardized hammer core cutter. The seeds in the soil samples were washed out and germinated in petri dishes in a climate chamber with 12 hours full light at 30 °C and 12 hours darkness at 15°C (optimum conditions; LEIBLAIN-WILD et al., 2014) and incubated for 30 days. Petri dishes were checked every second day. Seeds with a visible radicle were recorded as germinated and removed.

Regional adjustment of mowing regimes

On eight different Bavarian highways and federal roads (Tab. 1) we implemented five trial plots of 20 m length and 1.5 m width (= standard cutting width of the mowing machinery) in two replications on which four different mowing regimes varying in time and frequency as well as the effectiveness of two physical control options are tested from 2019 to 2022. (Fig. 1). With variant 2, 3 and 4 (V2-V4) the effectiveness of different cutting dates throughout the vegetation period should be tested with a view to avoid flower and/or seed formation. Particularly an early cut in June (V3 and V4) during the vegetative growth phase before flowering, can reduce mass flowering and therefore pollen production.

Tab. 1 Information on the trial sites of the eight different Bavarian highways and federal roads where four mowing regime and two physical control measures will be tested from 2019 until the year 2022.

Tab. 1 Informationen zu den Testflächen auf acht verschiedenen Bayerischen Autobahnen und Bundesstraßen, auf denen unterschiedliche Mahdregime oder Schnittersystem sowie zwei physikalische Bekämpfungsmaßnahmen von 2019 bis 2022 getestet werden.

Site Code	Site Description	Coordinates (decimal degrees)
BY066	A99 Munich, highway around Munich	48.226579, 11.551578
BY101	A9 Munich, highway through the city of Munich	48.215778, 11.626861
BY198	A8 Lake Chiemsee, highway connecting i.e. Munich with Austria	47.817436, 12.371588
BY133	A6 Nuremberg; highway connecting Nuremberg with the Czech Republic	49.399122, 11.216390
BY279	A3 Nuremberg; highway junction with A6	49.408089, 11.293777
BY348	B2 Gersthofen; highly frequented federal road connecting i.e. Augsburg with Nuremberg	48.523671, 10.834224
BY276	St2092 Mühldorf am Inn; highly frequented federal road connecting a large region of Oberbayern with the highway A 94	48.269753, 12.549329
B22	B22 Bamberg; highly frequented federal road connecting i.e. Bamberg with Würzburg	49.867940, 10.865577

However, as the plant can easily resprout after cutting a second (V4) or even a third mowing measure (V3) has to be undertaken to avoid flower and seed formation on resprouted shoots. However, the major aim in fighting ragweed should be the prevention of seed formation. Thus, V2 should reveal if seed formation can be more effectively reduced with a late first cut during male flowering (August). As ragweed inflorescence is proteandric, the probability of the presence of viable seeds is quite low during male flowering. In addition, during male flowering a huge part of the assimilates of the plant have already been mobilized and invested into flower formation and are therefore no longer available for resprouting (FUMANAL et al., 2007; KARRER, 2008; SMITH et al., 2013). Due to safety reasons (clear view on traffic signs etc.) the implementation of a non-cut control variant was not possible. Therefore, mowing regime V5 which is actually common practice along Bavarian road systems serves as control.

Month	Hot foam	Electro shock	V2	V3	V4	V5	V5	V4	V3	V2
	20 m	20 m	20 m	20 m	20 m	20 m	20 m	20 m	20 m	20 m
May										
June										
July										
August										
September										
October										

Fig. 1 Arrangement of the trial plots on each site in driving direction and time schedule of the four different mowing regimes (V2-V5) and the physical control measures (Hot foam & Electro shock). The months in which the management measures have to be executed are marked in black.

Abb. 1 Anordnung der Versuchsflächen auf jeweiligen Standorten entsprechend der Fahrrichtung sowie die Darstellung des Zeitplans der vier einzelnen Mahdregime (V2-V5) und der physikalischen Bekämpfungsmaßnahmen. Die Monate in denen die Maßnahme zu treffen ist, sind schwarz markiert.

The first alternative approach is the rootwave system (© Ubiquetek) which uses electricity to “boil” weeds inside out from the root upward by initiating an electric shock into the xylem of the plant, that goes through the plant with the water stream and therefore kills off the plants, including the surface near buds from which common ragweed can regenerate after cutting. The second physical control measure is the IproGreen HWS 24 (© IproTech) that uses hot foam consisting of sugar tensides and fat. The foam should supply effective heat utilization and a longer exposure time on the plant and should therefore kill off the plant more reliable than other heat control measures like hot water or steam.

This trial started in autumn 2018 with an initial soil sampling to determine the primary contamination of each plot. Thereby, 15 soil samples per 20 m were taken (= 150 samples per site). Again, seeds of the soil samples were washed out and germinated in petri dishes following the same protocol as in the embankment trial. From 2019 to 2022 we will execute a monthly monitoring from April until October on 10 subplots (0.25 m²) per plot (= 100 subplots per site) on which the following parameters are counted and measured: number of ragweed individuals, average plant height of ragweed, mean coverage of ragweed, date of male flower appearance, number of male flowers, date of female flower appearance, and number of seed agglomerations.

Effectiveness of competition seeding

To test the establishment success of native plant species on road verges and consequently their effectiveness in the suppression of common ragweed establishment, the road verges on three different sites (Munich, Nuremberg and Augsburg) were completely removed and renewed with standard substrate frequently used along Bavarian highways. In spring 2018 three different seed mixtures were sown: 1) a Bavarian standard seed mixture usually used on nutrient poor, dry sites, and two special mixtures developed by the University of Natural Resources and Life Science Vienna, which mainly contain 2) fast growing *Lolium perenne*, and 3) dominated by undemanding tussock-forming *Festuca*-species. These seed mixtures were contaminated with ragweed seeds based on three contamination levels of (0, 5 and 50 plants per square meter). In addition, we wanted to test the effects of three different cutting regimes (Variant 2, 4, 5 in Figure 1) on the establishment success and the growth performance of the seed mixtures and common ragweed all together in three replications (= 810 m per site; plot length: 10 m, plot width: 1.5 m). Furthermore, additional 200 m of the renewed road verge were left without any seeding to monitor the natural establishment on these renewed road verges.

First results

Results of the embankment trial showed clearly that 97.9% of all ragweed plants were found in 1.5 m distance to the lane. This result was confirmed by the soil seedbank analysis: 96.7% of all seed

were found in a distance of max. 2 m to the edge of the road, irrespective of soil properties and the inclination of the embankment (Fig. 2). Thus, it can be assumed the ragweed seeds show only a very little movement from the road edge into the embankment.

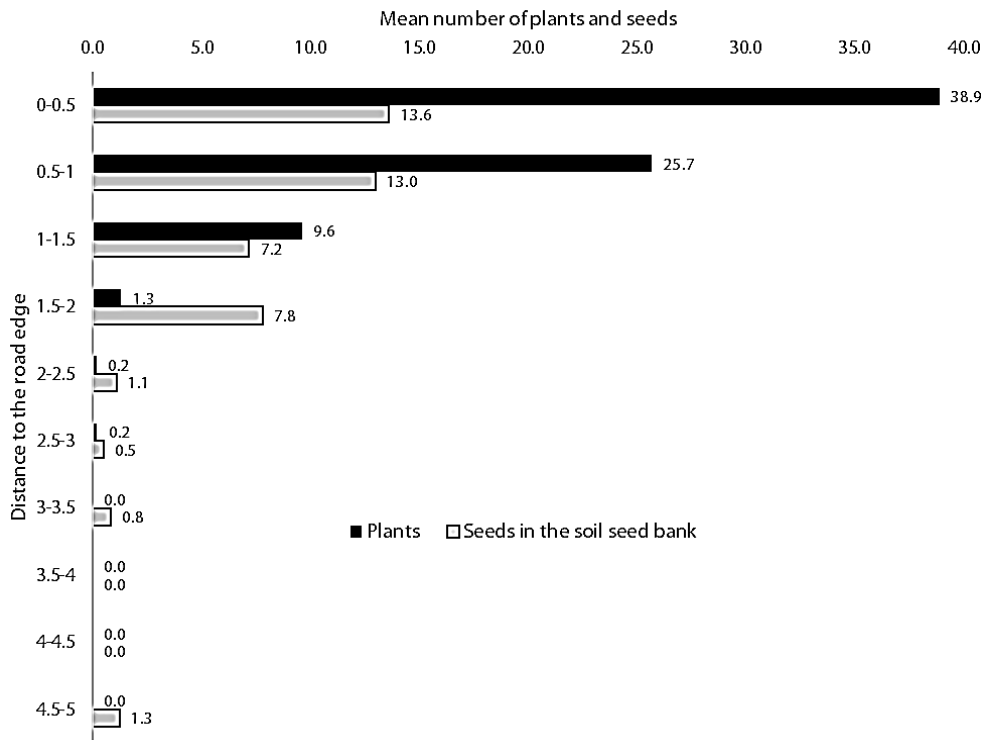


Fig. 2 Mean number of counted plant individuals and seeds in the soil seed bank of common ragweed along eight different Bavarian highways and federal road embankments in dependency of the distance to the road edge (n = 530 plots).

Abb. 2 Durchschnittliche Anzahl der Pflanzenindividuen und Samen in der Bodensamenbank von *Ambrosia artemisiifolia* in Abhängigkeit vom Fahrabstand entlang acht Bayerischer Autobahnen und Bundesstraßen (n = 530 Probeflächen).

In addition, we found huge differences in the ragweed contamination of the sites. Particularly, the roads in Munich-Fröttmaning (BY101), Lake Chiemsee (BY198), and Gersthofen (BY348) showed significantly higher numbers of ragweed individuals than all other sites. Despite that, we did not find any differences in the number of seeds in the soil seed bank, indicating that the majority of newly built ragweed seeds, already germinated in the year after formation and that only a small portion is entering the soil seed bank. In total we found only 308 seeds in the soil samples, of which 51.3% were still germinable.

Outlook

First results of the other trials will be available at the beginning of 2020. Until then all the data gained during the vegetation period 2019 is fully analysed and authorized for communication through the contracting authority.

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