Thermal, mechanical and chemical control of ragweed (*Ambrosia artemisiifolia*) in different habitats

Thermische, mechanische und chemische Bekämpfung der Beifuß-Ambrosie (Ambrosia artemisiifolia) in verschiedenen Umwelten

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Abstract

A small plot field experiment with transplanted ragweed (*Ambrosia artemisiifolia*) into gravel and grassland and a large scale field experiment on a roadside banquette in Brandenburg with a natural ragweed infestation were carried out. Thermal control treatments were hot air (gravel and grassland) and hot water (roadside) and flaming, the mechanical treatment was mowing and the chemical treatment was the application of the herbicide combination MCPA and Dicamba. The gravel and grassland experiment was conducted at two growth stages of ragweed (BBCH 16-18 and 22-29), at the roadside ragweed was at BBCH 50-65. Dry matter yield of ragweed was assessed 9 weeks after the treatments were conducted in gravel and grassland and 4 weeks after the treatment at the roadside. In gravel and grassland the best eradication at both growth stages by thermal control was achieved by hot air in comparison to the untreated plots (significant at $P < 0.05$). And at the roadside significant lower dry matter was determined by hot water and flaming in comparison to the untreated plots (significant at $P < 0.05$).

The results of these experiments demonstrated the efficiency of thermal control methods based on hot air and hot water as an alternative to herbicide control and mowing in habitats where herbicide application is not allowed or mowing gives no sufficient eradication results, like on roadside banquettes.

Keywords: Banquette, grassland, gravel, IPM, non-cropping area

Zusammenfassung

Feldversuche mit thermischen Bekämpfungsmaßnahmen wurden als Kleinparzellenanlage auf Grünland und in Schotter mit eingepflanzten Beifuß-Ambrosien (*Ambrosia artemisiifolia*) und im Bankett einer Landstraße in Brandenburg mit natürlichem Beifuß-Ambrosien Vorkommen durchgeführt. Die thermischen Bekämpfungsmaßnahmen waren Abflammen sowie Heißluft in Schotter und Grünland und Heißwasser am Straßenrand. Die mechanische Variante war Mähen und die chemische eine Herbizidkombination: MCPA und Dicamba. Der Schotter- und Grünlandversuch wurde zu zwei unterschiedlichen Wuchsstadien der Beifuß-Ambrosie durchgeführt: BBCH 16-18 und 22-29. Zum Zeitpunkt der Bekämpfung am Straßenrand war die Beifuß-Ambrosie im BBCH Stadium 50-65. Der Trockenmasseertrag wurde 9 Wochen nach den Bekämpfungsmaßnahmen im Schotter und auf Grünland und 4 Wochen nach den Maßnahmen am Straßenrand erfasst. Im Schotter und auf Grünland hatte die thermische Bekämpfung mit heißer Luft die signifikant ($P < 0,05$) höchste Trockenmassereduktion im Vergleich zur unbehandelten Kontrolle. Am Straßenrand wurden in beiden thermischen Behandlungen (Heißwasser und Abflammen) signifikant ($P < 0,05$) niedrigere Trockenmasseerträge im Vergleich zu der unbehandelten Kontrolle bestimmt.

Die Ergebnisse dieser Versuche zeigen die Effizienz der thermischen Behandlung, basierend auf heißer Luft und Heißwasser, in der reduzierten Trockenmasse der Beifuß-Ambrosie. Die thermische Behandlung ist eine Alternative zu Herbizidanwendungen und mechanischen Bekämpfungsmaßnahmen in Umwelten, in denen die Herbizidausbringung nicht erlaubt ist oder Mähen keine befriedigenden Bekämpfungsmaßnahmen zeigt, wie z. B. am Straßenrand.

Stichwörter: Bankette, Grünland, IPM, Nicht-Kulturland, Schotter

Introduction

Thermal weed control is an alternative treatment where neither chemical nor mechanical control is allowed or possible. Research activities are needed to develop innovative control systems especially for non-cropping areas, like roadsides, because herbicide uses are very restricted within the EU. The principle of thermal control is that temperatures above 60 °C in the plant cells lead to nucleic acid denaturalization. This impact causes an irreversible damage of the plant tissue and leads to necrosis. Machinery for thermal weed control is working with flames, infrared or heated air and heated water (steam or boiling water), which is applied on the plants. Since ragweed is also spreading on fields in organic farms there is a strong demand to provide alternatives for organic farmers. Most of the machineries for thermal weed control are hand units that are used for pavements and are not suited for agricultural uses or the use for very long distances like roadsides. MERFIELD *et al.* (2009) made an effort to use a steam weeder for agricultural purposes in New Zealand. Also LATSCH *et al.* (2013) had to rebuild a steam hand unit for the use in agricultural fields. The aim of this work was to identify thermal control strategies as an alternative to mechanical and chemical control strategies.

Material and Methods

Two experiments on thermal control of ragweed were conducted in two consecutive years (2012 and 2013). Small plot (2*3 m) field experiments with transplanted ragweed in gravel and grassland (10 plants per treatment, each plant was a replication) and large scale field experiments (0,80-1,50 * 50 m, 4 replications) on a roadside banquette in Brandenburg with a natural ragweed infestation were carried out. In the gravel and grassland plots one part of the ragweed plants was transplanted with a two week gap between the other parts in order to get plants in two different growth stages at the day of treatment. The experimental layout was a partly randomised block design.

The following treatments were conducted in comparison to untreated plots:

a) Thermal: Flaming 600 °C (Green-Flame 850 E, Green-Flame, Vordingborg, Denmark)
b) Thermal (in gravel and grassland only): Hot Air 370 °C (Combi Compact, Adler Arbeitsmaschinen, Nordwalde, Germany)
c) Thermal (at the roadside banquette only): Hot Water 99 °C (Wave High Series hand unit, Wave Europe, Wekerom, Netherlands)
d) Mechanical: mowing (with a brushcutter in gravel and grassland and with a selfpropellered mower by road maintenance staff at the roadside banquette at a height of approx. 6-10 cm)
e) Chemical: Herbicide application with a hand unit (Banvel M: Dicamba and MCPA, 6 l * ha^{-1})

The transplanted ragweed plants in grassland and gravel were treated at BBCH 16-18 and 22-29 at the end of July in both years (Tab. 1). The roadside banquette trial was conducted at BBCH 50-65 also at the end of July in 2012 and 2013.

Tab. 1 Experimental layout.

Tab. 1 *Versuchsdesign.*

habitat	grassland and gravel	roadside banquette
Plot desgin	2*3 m, 10 plants per treatment (each plant is a replicate = 10 replicates)	0,80 * 50 m 4 replicates
BBCH growth stage at treatment	16-18 and 22-29	50-65
treatment	Flaming, Mowing, Herbicide Hot Air	Flaming, Mowing, Herbicide Hot Water
harvest of ragweed DM	9 weeks after treatment	4 weeks after treatment

Dry matter of the remaining ragweed plants was determined 9 weeks after the treatment in gravel and grassland and 4 weeks after the treatment on two 0,25 m^2 areas at the roadside banquette.

At the roadside banquette ragweed infestation was very low in 2013. Therefore the results of this year were really unrepresentative, resulting in almost no ragweed dry matter before and after the treatment. A reason therefore was not found. These data were excluded from statistical analysis.

The statistical analysis was carried out with Statgraphics Plus 5.1 (StatPoint Technologies, Inc.) using the Tukey-Test for determining the significant differences at P<0.05.

Results

The results of the gravel and grassland experiment showed that ragweed dry matter in grassland was significantly reduced by thermal control at BBCH 16-18 and 22-29 (Fig. 1). In gravel thermal control by hot air at BBCH 16-18 and 22-29 led to significant lower ragweed dry matter compared to the untreated plots. Mowing (mechanical control) lead to significant lower (P<0.05) dry matter at both growth stages in both habitats. All treatments at BBCH 16-18 were more effective in reducing ragweed dry matter compared to ragweed dry matter of plants treated at BBCH 22-29.

The herbicide treatment was most successful in ragweed suppression: This treatment resulted in a complete eradication of the Ambrosia plants in grassland and gravel, both in the plots with treatment at BBCH 16-18 and 22-29, too.

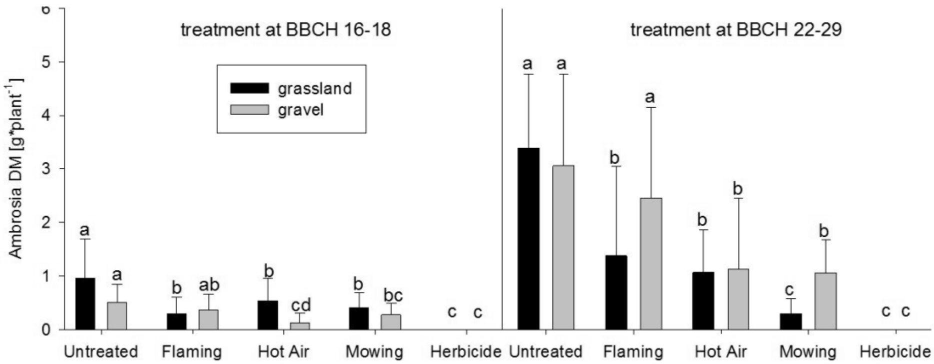

Fig. 1 Ambrosia dry matter [DM g*plant^{-1}] (data from 2012 and 2013) in grassland and gravel 9 weeks after treatment, columns of the same colour with different letters differ significantly at P<0.05; bars indicate standard deviation.

Abb. 1 *Beifuß-Ambrosientrockenmasse [DM g *plant^{-1}] (Daten aus den Jahren 2012 und 2013) in Grünland und Schotter 9 Wochen nach der Behandlung, Säulen mit der gleichen Farbe und unterschiedlichen Buchstaben unterscheiden sich signifikant bei P<0,05; Fehlerbalken zeigen die Standardabweichung.*

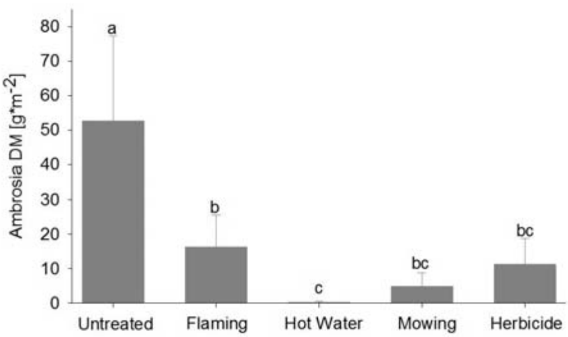

Fig. 2 Ambrosia DM [g *m^{-2}] (data from 2012) at roadside banquette 4 weeks after treatment, columns with different letters differ significantly at P<0.05; bars indicate standard deviation.

Abb. 2 *Beifuß- Ambrosie Trockenmasse [DM g *m^{-2}] (Daten aus 2012) am Straßenrand 4 Wochen nach der Behandlung, Säulen mit der gleichen Farbe und unterschiedlichen Buchstaben unterscheiden sich signifikant bei P<0,05; Fehlerbalken zeigen die Standardabweichung.*

The results of the roadside banquette trial showed that the thermal control treatments flaming and hot water led to significant lower ragweed dry matter than the untreated plots (Fig. 2). The hot water treatment resulted in the lowest dry matter which differed significantly from flaming. The following order of the treatments point out the best eradication: Hot Water > Mowing > Herbicide > Flaming > Untreated.

It was observed that the surviving vegetation in the plots consists of grasses mainly.

Discussion

The results of these experiments demonstrated the efficiency of thermal control methods based on hot air and hot water. Recent investigations in Germany and other European countries also identified hot water systems as a promising tool (RASK *et al.*, 2007; DITTRICH *et al.*, 2012). They concluded that at least 2 applications are necessary for successful weed control. In general the hot water treatment is applied up to 4 times during the vegetation period but in our studies it was carried out one time only with very promising results. However, there are still gaps of knowledge in terms of the dose-response relation for Ambrosia (e.g. propane consumption in $kg*ha^{-1}$) and also the correct timing of the application is often difficult (ASCARD, 1995). Investigation of the earlier Euphresco project on Ambrosia clearly pointed out the low competitiveness of Ambrosia (HOLST, 2010). Therefore any direct control method should be as selective as possible to inhibit growth of Ambrosia by the competition of the surrounding vegetation. Despite its high regrowth capacity, there are no indications that Ambrosia is less susceptible against heat treatments like most of other weed species. Additional information is still required to develop a more specific guidance which enables the practical implementation. Focusing on eradication of Ambrosia we should know more about heat effects on seed viability in the soil seed bank in non-cropping areas. A critical point of thermal control methods is the energy input and the corresponding costs. Although a lot of improvement was achieved to optimise the cost-benefit ratio, this will require an economic evaluation specified for different uses and scenarios.

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