Control of Rumex Obtusifolius L. in Grassland Using Microwave Technology

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Abstract

Die Bekämpfung des Stumpfblättrigen Ampfers (*Rumex obtusifolius L.*) auf Wiesen und Weiden biologisch wirtschaftender Betriebe wird bislang meist per Handarbeit durchgeführt. Um diese Arbeitsbelastung zu minimieren, werden Mikrowellengeräte mit unterschiedlich starker Heizleistung zur Bekämpfung des Ampfers zum Einsatz gebracht. Ergebnisse der Bekämpfung mit einem selbstfahrenden Prototypen mit 4.8 kW Heizleistung zeigen, dass bei einer Behandlungsdauer grösser 40 s mehr als 80 % der Pflanzen nicht wieder austreiben. Um die Verfahrensleistung zu erhöhen, wurde ein neuer Prototyp mit 18 kW Heizleistung entwickelt. Erste Ergebnisse bestätigen die positiven Resultate des Vorgängermodells. Hier treiben bei Heizzeiten grösser 8 s mehr als 80 % der Pflanzen nicht wieder aus. Zusätzliche Modellversuche zeigen, dass es möglich ist, die Ampferwurzel innerhalb von Sekunden auf 100 °C zu erhitzen, was die Pflanzen nicht überleben. Neben Modellresultaten liegen erste Ergebnisse der Praxisversuche vor.

1 Introduction

Broad-leaved dock (*Rumex obtusifolius*) is a common meadow- and pasture weed in alpine grassland farming. Because of its low palatability in an advanced state of growth, it is only grazed when young by livestock. Depending on its state of development, *Rumex obtusifolius* may contain high concentrations of tannins and oxalic acids [1] [2]. The nutritive value of dock is rated by Klapp et al. [3] as “1” (worthless or very low nutritive value). Thanks to its very good growth performance, broad-leaved dock is able to develop large leaf surfaces quickly on grassland areas that are for the most part very well supplied with nitrogen, and it is consequently highly competitive with desirable fodder plants. The approximately 60,000 seeds a year that a dock plant is capable of generating are extremely robust; they can remain germinable in the soil for up to 40 years, surviving even forage preservation and passage through the animals’ digestive tracts. If the plant is mown before the seeds actually ripen, the seeds can continue ripening in the field or in the feed store, and germinate immediately once ripe. The light-germinating pioneer plant colonises places in which the plant cover has been damaged as a result of inappropriate or careless cultivation. Colonisation by

broad-leaved dock occurs primarily via seeds brought in from the outside, improper grazing (excessively wet soil used too early and too often, too-high stocking density, too-long stocking period), and excessive manuring, and is encouraged by sward damage when forage is yielded.
On conventional farms, control of *Rumex obtusifolius* is usually achieved via the use of suitable herbicides. On organic farms, control is predominantly accomplished by manual means.

In the physically strenuous and time-consuming manual removal of these weeds, “dock diggers” are sometimes used. (Fig. 1). This implement cuts or breaks off the top 10-15 cm of the taproot, which can extend down to a depth of 2 m. The portion capable of regenerating is pulled out of the soil and removed from the spot, together with the aboveground shoots.
Further mechanical dock-control methods are offered by devices that pull out the root using grabbers (Fig. 2), or chop it up with rotary tillers (Fig. 3). Two such devices were tested by Dürr [4]. Since both methods in his studies had serious disadvantages, he discarded them. The use of microwave technology is viewed as a potential thermal measure.

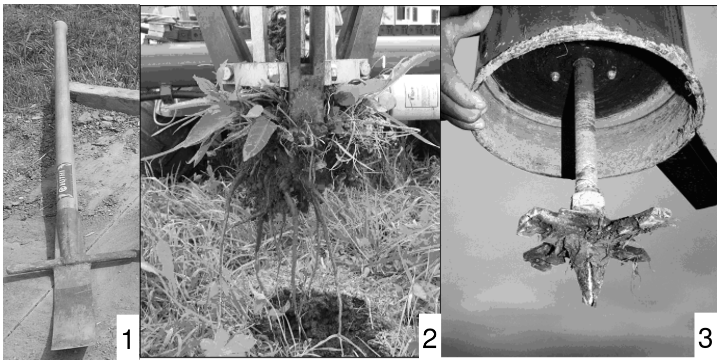


Fig. 1: Dock digger; Fig. 2: Mechanical weed grab; Fig. 3: Rotary-tiller element

2 Purpose

The aim of this project is to develop and test a microwave-based prototype for controlling broad-leaved dock, and to compare it with already existing systems. Microwave technology appears promising, as it is able to influence the root system of dock plants without contact. In this way, soil damage involving the rapid regrowth of undesirable plants can be prevented.

3 Materials and Methods

3.1 Field Trials

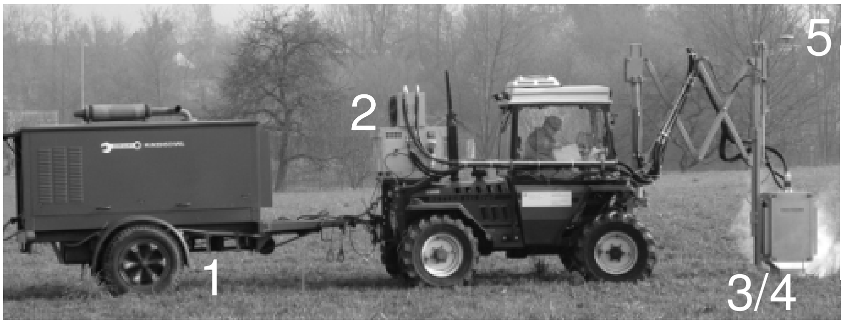
After positive results were achieved in preliminary trials with different low-output microwave devices, it was decided to develop a higher-output self-propelled prototype. **Prototype I** with 4.8 kW heat output (Fig. 4) was developed in close partnership with Gigatherm AG (Grub, Switzerland) and Odermatt AG (Hunzenschwil, Switzerland). The unit consists of a small

tractor with a built-on high-voltage unit, a microwave unit, and a horn antenna, the latter of which is mounted in a hydraulically shiftable fashion transversely to the direction of travel. The ability to relocate the dock plants for purposes of visual appraisal is ensured by the accurate measurement of the site during treatment. For this, we use the R7-type RTK-GPS device made by Trimble in Sweden, which is mounted directly above the horn antenna. The necessary power is supplied by a trailed standby generator petrol engine.
Prototype 1 (Fig. 4) was used to treat 971 dock plants in six test rows at three sites (permanent pasture, mowing pasture, natural meadow). Heating duration was 10 - 70 s, and heating energy used was 5.4 - 27.1 kWh/m^2.

1 – Generator
2 – High-voltage unit
3 – Microwave unit
4 – Horn antenna
5 – RTK-GPS antenna

Fig. 4: Prototype I with 4.8 kW heat output

A **second prototype** with a heat output of 18 kW was developed to increase the efficiency of the method. Here too, the high-voltage unit is mounted on the carrier truck (Fig. 5). In this model, microwave unit and horn antenna are combined in a single structural unit. The microwave head is positioned via a three-dimensionally-movable hydraulic scissor mechanism. The required energy is delivered by a trailed diesel standby generator. This device was used to treat 196 plants at the above-mentioned permanent-pasture site in an initial field trial in spring 2007. The six heating times employed were in the 5 – 20 s range. The first visual appraisal took place after two months.



1 – Generator
2 – High-voltage unit
3 – Microwave unit
4 – Horn antenna
5 – RTK-GPS antenna

Fig. 5: Prototype II with 18 kW heat output

3.2 Laboratory Trials

m600-type fluoroptic temperature sensors made by Luxtron are used to measure the core temperature of the dock roots during the heat treatment. In precision tests, the temperature inside the dock roots can be recorded with the aid of four glass-fibre sensors at one-second intervals for different treatment times and soil-moisture levels. The first measurements were performed in four repetitions (n=4) for a treatment length of 5 and 11 s. The sensors were inserted in the root 2, 4, 8 and 12 cm below the surface, in the longitudinal axis in each case. In a second series of measurements with a 20 s heating period (n=4), there were only three sensors still available. These were used at 3, 6 and 9 cm. The moisture content of the soil (sand) was 7.6 vol. %. In order to record the potential resprouting of the treated roots, and the resprouting spot, the roots "decapitated" before treatment were stored in a moist bed of sand.

4 Results

4.1 Field Trials

The visual appraisal of the plants treated with **Protoype I** showed a treatment success rate of > 80 % for heating periods of over 40 s (Fig. 6). The resprouting was for the most part observed in rootstock just outside of the treatment area. Although the success rate is deemed to be satisfactory, the time taken is considered to be too long for this method to constitute an economic alternative to manual weeding.

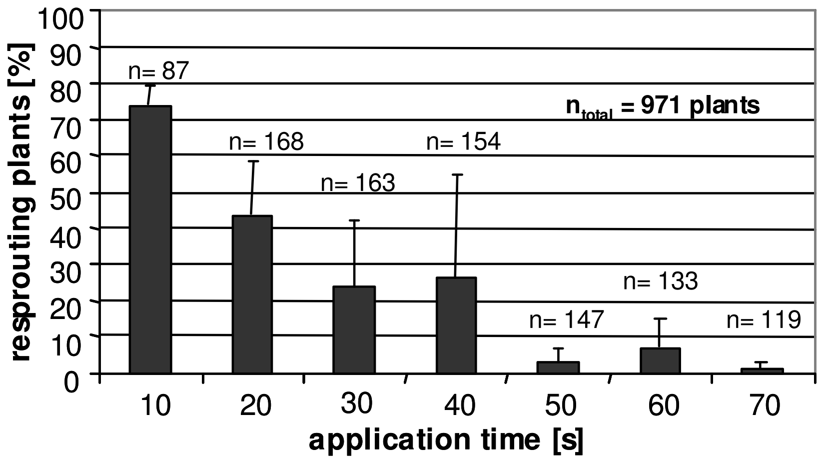


Fig. 6: Correlation between heating duration and resprouting of plants

The first visual appraisal of the plants treated with **Prototype II** confirms the positive trend of the previous studies. Here, a heating duration of over 8 s yields a treatment success rate of > 80 % (Fig. 7).

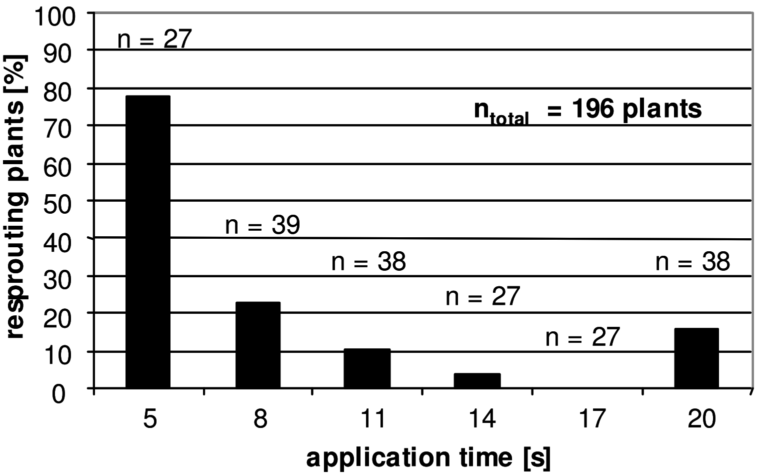


Fig. 7: Percentage of resprouting plants with varying treatment length

4.2 Laboratory Trials

The desirable threshold value for denaturing plant proteins and nucleic acids stands at around 80 °C. With a treatment time of 5 s, this temperature is achieved at a depth of 4 cm (Fig. 8). The deeper regions of the root are not heated sufficiently. With a treatment duration of 11 s, the temperature at 8 cm depth approximately reaches the threshold value. At 12 cm, a temperature of around 64 °C is measured.

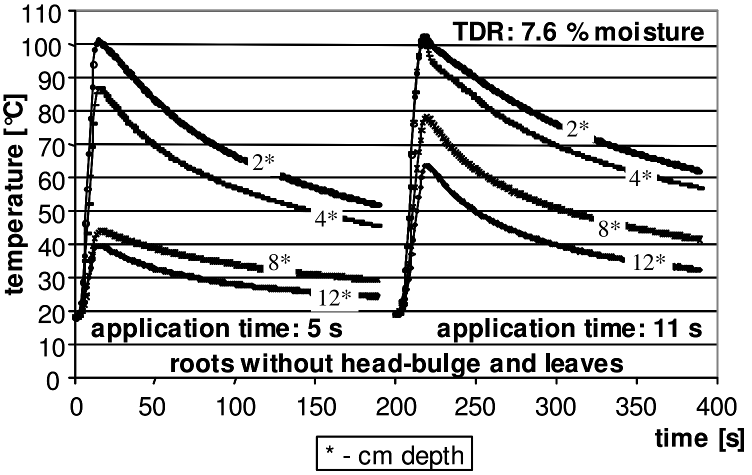


Fig. 8: Root core temperatures with different treatment times (n=4)

Trials with a heating duration of 20 s were performed at the same soil moisture levels on roots with and without aboveground plant material (Fig. 9). The average core temperature of the roots without leaves follows a steeper trend and achieves higher values than that of roots with foliage. It is plain to see that the aboveground plant mass has a major impact on the temperature trend in the root. Even so, with this long heating period a temperature of around 95 °C is still reached at a depth of 9 cm. Further clarifications of details are underway.

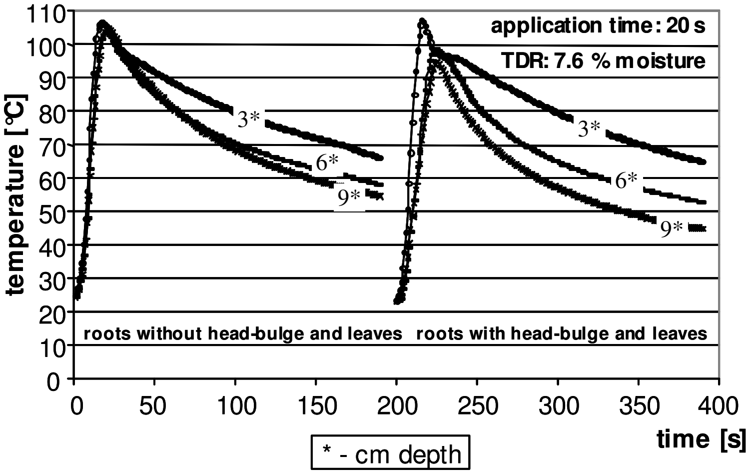


Fig. 9: Root core temperatures with and without leaves with the same treatment time (n=4)

5 Conclusions

The development and testing of different prototypes of a microwave apparatus for controlling *Rumex obtusifolius* has led to positive interim results. According to the current state of research, control of this problem plant by means of microwave technology is possible. Further precision tests must be carried out in order to enable optimisation of the previous test settings of the device. This applies in particular to the necessary duration of treatment on soils with different moisture levels. In addition, the method has yet to be assessed in energetic and monetary terms.

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