Dock-control in organic farming by hot-water treatment

Roy Latsch and Joachim Sauter, Agroscope, Tänikon 1, CH-8356 Ettenhausen

Abstract

In organic farming, the control of broad-leaved dock (Rumex obtusifolius) via hot-water treatment of the upper root region (hypocotyl) constitutes a new alternative to the current control method by manual digging-out of the roots.

The aim of this study was to identify the potential of hot-water treatment of dock roots by hot-water high-pressure cleaner with rotary nozzle. The benchmark of a minimal dying rate was predefined as 80%.

The influencing parameters that were investigated were: water temperature, water amount, soil-moisture content and soil texture. In total, 2132 plants of varying size were treated. The success of the treatment was rated twelve weeks after application. Additional data of Fuel oil consumption to heat up the water and time requirement are used to calculate the costs of the treatment.

To achieve the aim of 80% dying rate of the treated plants, water temperature has to be higher than 80°C. The needed hot water amount depends on the root dimensions and on the soil moisture. A water amount of at least 1.6 litres per plant leads to the fixed success rate. The average fuel oil consumption lies at 0.02 litres per plant. Approximately 130 plants per hour can be treated with hot-water. In comparison to manual work, hot-water treatment is slightly more expensive but means higher performance and less strenuous work.

Keywords: Rumex obtusifolius, grassland, broad-leaved dock, weed control, thermal treatment

1 Introduction

Broad-leaved dock (Rumex obtusifolius) is one of the most problematic weeds in European organic grassland. The high contents of oxalic acid and oxalates can affect animal health if consumed in larger doses (Brune, 1955; Roth, Daunderer, & Kormann, 2012). Avoided by grazing animals on account of the substances it contains, the plant can cause reductions in livestock performance when present in conserved feed. Oswald and Haggag (1983) reckoned that a ground cover of 20-30% broad-leaved dock would result in a reduction in the vegetation volume of valuable fodder plants of up to 20%.

Due to its reserves storing tap-root with its enormous regeneration power, the non-chemical control is extremely difficult. The current way to control this weed in organic farming is to manually dig up the roots at a depth of about 10 to 15 cm and to remove this part of the plant (hypocotyle), capable of producing shoots. Moreover, the damage to the sward gives dock seeds a chance to germinate.

Preliminary tests showed that hot-water treatment of the tap-roots can reliably kill broad-leaved docks. To transfer this knowledge in practice, we initiated a first field study with hot-
water steam-treatment of dock roots in 2010 (Latsch, Kaeser, & Sauter, 2011). The results showed that the method could be suitable for organic farming, if the time and energy requirement could be decreased. To optimize the hot-water steam application we compared five different application heads in a field study in 2011 (Latsch, Sauter, & Sauter, 2013). The main result of this study showed that the optimization of time and energy requirements was possible. The most practical application head of this comparison was a rotary nozzle that allowed a contactless treatment of the dock roots. This article shows our investigations in 2012-2013 concerning the minimal water temperature and water amount under different soil moisture and soil texture conditions. Also data of energy consumption and working time requirement were collected to calculate the procedural costs.

2 Materials and methods

To generate hot-water under field conditions, a commercially available hot-water high-pressure cleaner (Type HDS 1000 DE, Alfred Kärcher GmbH & Co. KG, Winnenden, Germany), a water tank and additional measurement equipment were installed on a trailer (Figure 1). A rotary nozzle (Kärcher ‘Dirt blaster’) was used to apply the water to the dock roots. The hose was 15 m in length.

![Figure 1: Sketch of the test vehicle](image)

Series of 15 single dock plants in each case were treated with different water amounts and temperatures during two years. The planned duration of treatment was recorded by stopwatch, whilst the amount of water actually required was recorded with the aid of a water meter (SwissFlow, type SF-800-3/8, Maarheeze, The Netherlands) at the inlet of the device. The water temperature was measured with a thermometer capable of working with high pressures (Jumo PT100, Stäfa, Switzerland) at the outlet of the high-pressure cleaner. For each test series, the quantity of fuel oil required to heat the water was determined with a flow meter (Pierburg, type 106 060, Germany). Soil moisture was determined on volume basis by means of undisturbed soil samples (100 cm$^3$) from a depth of 0-10 cm (dried to constant weight at 105°C).

In total, 2132 plants were treated within two years on five sites with three different soil types (medium sandy loam, clay loam, weakly silty clay). The following data were recorded and a logistic regression was performed with a generalised linear mixed model (GLMM): water amount, water temperature, soil moisture, soil type, amount of fuel oil and dying rate. The dying rate was determined by visual rating of the potential re-sprouting three month after the treatment. Therefore, the plants were localized with a RTK-GNSS (Trimble R8, Sunnyvale, CA, USA). The benchmark of a minimal dying rate was predefined as 80%.
Working time requirements were identified via pocket-PC (Dell Axim, Round Rock, USA) and software Ortim b3 (dmc-ortim, Kiel, Germany) in a separate trial. Therefore the single steps in hot-water treatment of docks were monitored and measured during almost two hours on a grassland site with weakly silty clay soil texture.

3 Results

3.1 Water requirement

The statistical analysis shows that water temperature, water amount, soil moisture and soil texture influenced the dying rate. To achieve good results, the water temperature at the high-pressure cleaner’s water outlet had to be minimal 80°C. Lower temperatures significantly reduced the dying rate of the treatment (Figure 2). The differences between soil textures were marginal. A tendency could be found that at heavier soils more water was required to achieve the wanted dying rate.

As an example, 1.6 litres of water with 80°C were needed to achieve a dying rate of 80% in medium sandy loam with soil moisture of 42.5 vol.-%. At the high-pressure cleaner’s minimal water flow rate of 7.5 litres per minute, this meant a treatment of 13 seconds per plant.

![Figure 2: Dying rate of 80% as a function of water amount and temperature for three different soil textures at a soil moisture of 42.5 vol.-%.](image)

3.2 Fuel oil requirement

Figure 3 shows the linear increasing fuel oil requirement to heat up the water. The graph is including the measurement of 478 plants. To stay with the example named above, a treatment of 13 seconds per plant requires 0.02 litres of fuel oil. So with one litre of fuel oil the water to treat 50 plants can be heated up to the necessary temperature of 80°C.

![Figure 3: Fuel oil requirement per treated plant with high-pressure cleaner Kärcher HDS 1000 DE](image)
3.3 Working time requirement and procedural costs

The time requirement study lasted 1 h 50 min. In this time 236 plants were treated and the trailer was moved forward twice. With an average of 19.76 s per plant the treatment took longer than the time detected by statistical analysis. The performance lay at 128.7 plants per hour.

Assuming that a manual worker can dig out 60 plants per hour and take them off the site, the procedural costs of the hot-water treatment lie slightly higher than those of manual work under European (German) conditions. The break-even point lies at 160 plants per hour (Figure 4).

Owing to higher wages in Switzerland the break-even point lies at 110 plants per hour, which means, that the procedural costs of the hot-water treatment lie slightly lower than those of manual work (Figure 4).

The costs include the costs of the hot-water high-pressure cleaner and a small standard tractor (33 kW) to pull the trailer according to “Maschinenkosten 2013” (Gazzarin & Lips, 2013).

Figure 4: Procedural costs – comparison between hot-water treatment and manual work under European conditions.

4 Discussion

The hot-water treatment is an effective method of dock control. The contactless application with a rotary nozzle is a quick and handy way to get the hot water directly to the roots. Direct contact to the root is important for the success of the treatment. The required treatment time depends on the size of the dock roots, the hourly performance depends also on how dense the stock of dock plants really is. The difference between the calculated treatment time and the average treatment time of the time requirement study shows the potential of optimisation.

The measured performance of 128.7 plants per hour seems to be the lower limit of the treatment. Compared to methods like mechanical digging (Pötsch, 2003) there is no need to remove the roots off the site and no big holes are created. The energy use, creation of exhaust gases and noise are the main inconveniences.

In the given example procedural costs lie slightly higher (Europe) or rather slightly lower (Switzerland) than the costs for manual digging. The efficiency of the hot-water treatment is in any case at least twice as much as the manual work and a lot less strenuous.

Fuel oil used for hot-water production averages out at 0.02 litres per plant. So with one litre of fuel oil, 50 plants can be treated. In grassland with a weed stocking of 2000 dock plants
per hectare, 3200 litres of water and 40 litres of fuel oil are needed for hot-water dock control. The energy efficiency is about five times higher than that of dock treatment with microwaves (Latsch & Sauter, 2010).

Since two years hot-water treatment of dock plants is used in farm practice. It is estimated that about 40 machines are in use. Many demonstration events, training courses and the currently sales of 35 hot-water high-pressure cleaners that were especially constructed for dock control approve.

5 Acknowledgement

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6 References


