Thermal weeding

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Factsheet about integrated weed management

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Introduction

Thermal weeding can refer to flame, hot water, steam and electro-weeding.

Flame weeding

Flame weeding is an agronomic tool based on direct elimination of weeds through exposure to heat. Flame weeding is widely used and can both be used before and after crop emergence. Flame weeders can be used when the soil is not suitable for mechanical weeding and when soil disturbance is to be avoided to prevent weed emergence. As with pre-emergence harrowing, the goal of pre-emergence flame weeding is to avoid crop damage and control weed seedlings.

Post-emergence flame weeding can be used in several crops, e.g. onions, chicory and leek. These crops are tolerant to flame weeding in the early growth stages (onion: 4-6 leaves, chicory: 3-4 leaves). In wide row crops (>30 cm spacing), flame weeding can be used between the crop rows.

Efficacy

Efficacy of flame weeding depends on the ratio of sensitivity between crop and weeds. Four different weed groups are identified for their sensitivity to flame weeding[1|]:

1| Weed species with unprotected growth points and thin leaves, such as *Chenopodium album*, *Urtica urens* and *Stellaria media*. A single flaming is enough to completely kills these weeds in 1-4 leaf stages. During the 1-4 leaf stages, 20-50 kg of propane gas per hectare is sufficient for complete control. For weeds with 4-12 leaves, between 50 - 200 kg of propane per hectare results in complete control, depending on species and circumstances.

2| Moderately sensitive species with an upright growth habit and/or more heat-tolerant leaves (e.g. *Polygonum persicaria* and *Senecio vulgaris*) and species with a prostrate habit and protected growth points (e.g. *Polygonum aviculare*). These species can also be completely killed with a single flame treatment, at both early and late developmental stages, but require higher propane rates.

3| Flame-tolerant species that have a prostrate growth habit during the early stages and, especially at later stages, protected growth points (e.g. *Capsella bursa-pastoris* and *Chamomilla suaveolens*).

a| When these species have 2-4 true leaves. *C. bursa-pastoris* requires 35-50 kg ha^{-1} for all plants to be killed, whereas C. suaveolens requires more than 100 kg ha^{-1}.

b| At later stages (five leaves or more) these species cannot be controlled with one treatment regardless of the rate, because of their capacity for regrowth. The plant densities of *C. suaveolens* are only reduced by about 60% at rates of 100-200 kg ha^{-1} and the densities of *C. bursa-pastoris* are reduced even less.

4| Very tolerant species with a creeping habit and protected growth points, such as grasses and root-propagated weeds. Regardless of developmental stage, these weeds cannot be killed completely by a single treatment.

Costs

Flame weeding comes with high costs for investments, energy (propane) and workhours. Flame weeding can prove cheaper than hand-weeding but there is a high machine cost initially.

What to consider?

Small weeds:	Annual weeds are susceptible to heat to the 4th leaf stage. Most broadleaf weeds are more susceptible than grasses.
Dry plants:	Water droplets on the leaves can reduce the effect of heat.
Wind:	A suitably shielded machine is very important in the event of wind.
Fine sowing bed:	Large clods shade weeds. This increases the risk of poor control of weeds under or behind clods.
No effect on:	Perennial weeds such as creeping and common sow thistle or larger grasses (beyond the 2-leaf stage) and broadleaf weeds with more than four true leaves.

The duration and intensity of flame weeding should be chosen carefully, as new weed seeds in deeper soil layer can be stimulated to germinate by heat. Increased emergence at high flaming rates has been found for *Poa annua*, *Stellaria media* and *Capsella bursa-pastoris*.

Fingerprint test

The fingerprint test is the most important aid in adjusting the flame weeder's settings, i.e. the flame-weeding speed, gas pressure and position of the flamer. On pressing the treated – and still green – weed leaf a lasting imprint must remain on the leaf; if this is not the case, then the treatment was insufficient. In the absence of a lasting imprint it will be necessary to reduce the tractor speed or increase the gas pressure. The tractor speed can be increased in the event of scorched brown leaves or leaves that are will smouldering after the flame weeding. The tractor speed for flame weeding is 3-6 km per hour. At higher speeds the effect is very limited, even on very small weeds.

Pre-sprouting window

What is referred to as a 'pre-sprouting window' can be used to predict the precise time of crop emergence. A sheet of glass or plastic film is laid over a small area of the sown field. The soil temperature is higher under the cover, as a result of which the crop seeds will germinate a few days earlier than the remainder of the seeds in the uncovered soil. This method can be used for an accurate determination of the time for flame weeding.

Weed control by electro-weeding

Using electro-weeding, a high voltage current is send through the plant where the natural resistance of the weed transforms the electrical energy into heat and as a result the weed is eliminated. The strength of electric shock, contact or exposure duration, weed species, morphological features and growth stage significantly affect the success of electrocution. The severity of damage is aggravated in drought conditions[2].

The practice of weed control via electric shock is called electrocution. Electrophysical weed treatment is performed via two main methods: non-direct spark discharge and continuous electric shock by direct contact with the plant[3]. For spark discharge, a pair of electrodes is placed at both sides of the plant and the energy is delivered in a short pulse or in a series of pulses. For direct contact he first electrode touches the weed over the course of the electrophysical treatment, whereas the other electrode either touches the weed at a second point or is in contact with the ground.

Zasso

The German Zasso Xpower[4] is an example of an electric weeder that was recently brought to the European market. The machine can be used for weed control in arable and vegetable farming, on hard surfaces and is also used for terminating potato crops.

Machine widths available are 1.5 and 3.0 meters, but wider machines are being developed. The machine comes with a high cost price estimated at approximately €180,000, resulting in an effective cost of about €100 - €200,- per hectare[5]. The machine is being use for control of Japanese knotweed (*Fallopia japonica*) and yellow nutsedge (*Cyperus esculentes*) in the Netherlands[6].

Hot water application

Although hot water application is not a new technique, its adoption for IWM has been minimal. Although hot water application can be effectively used to control most annual weeds and a large number of perennial weed species, its use is often limited to non-agricultural areas. This is mainly due to its non-selective nature.

Weed control by steam

Steam weeding is more efficient at transferring heat than hot-water treatments as it contains more energy per unit mass than liquid water. The required energy for weed control using steam is about 6900 to 8,900 MJ ha^{-1}.

A steam treatment has the potential to provide between 50 and 100% control of 2-leaf-stage common lambsquarters[7| 8|].

Extra information

See *https://iwmpraise.eu/publications/* for all weed management strategies and their definitions, and for more information on integrated weed management and the following inspiration sheets about thermal weeding:

- Flame weeding in no-till vegetable crops
- Killing *Rumex obtusifolius L.* by hot-water application – technical needs and workload

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