

Using Microwave Soil Heating to Inhibit Invasive Species Seed Germination

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Abstract Successful long-term invasive plant eradication is rare. The methods target only the adult stage, not taking into account plant development capacities from a large seed bank. Heating by microwave has been considered because it offers a means to quickly reach the temperature required for the loss of seed viability and therefore inhibit germination. Previous results were not encouraging because homogenous and deep penetration of the waves was not achieved and the various parameters that can modify the effectiveness of treatment were rarely properly addressed as a whole. The aim of this study was to determine, under experimental conditions, the best microwave treatment to inhibit invasive species seed germination, in terms of power (2, 4, 6 kW) and duration (2, 4, 8 min) of treatments, and depending on the soil moisture (10, 13, 20, 30%) and seed depth in the soil (2, 12 cm). This was tested on 3 invasive species: Bohemian knotweed, giant goldenrod and jimsonweed. The most effective treatments required relatively high power and duration (2kW8min, 4kW4min, 6kW2min and 6kW4min; 4kW8min and 6kW8min were not tested for technical reasons), and their effectiveness diminished with increasing soil moisture: germination percentage between 0 and 2% for the lowest soil moisture and between 0 and 56% for the intermediate soil moisture compared with germination percentage between 27 and 68% in control treatments while for the highest soil moisture, only 2kW8min and 4kW4min lowered germination percentage between 2 and 19%. In some cases, the germination of seeds located at 12 cm depth during treatment was more strongly affected. Seeds of giant goldenrod were the most sensitive, probably due to their small size. Results are sufficiently encouraging to justify further experiments to determine the most effective treatments that would be applied following development of a microwave device to treat large volumes of soil infested by invasive seed efficiently and with reasonable energy requirements. Other types of soil, in terms of texture and organic matter content, should also be tested in future experiments because they influence soil water content and consequently microwave heating.

Nomenclature: Bohemian knotweed, *Fallopia× bohemica* (Chrtek and Chrtková) J. Bailey; giant goldenrod, *Solidago gigantea* Aiton; jimsonweed, *Datura stramonium* L.

Key Words: Invasive plant species, microwave heating, seed bank, germination inhibition, soil moisture, seed depth, power, duration

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Management Implications

Alien plant species often show a strong vegetative (e.g. rhizomes) and sexual (seeds) reproductive capacity, which together represent dispersal and resistance organs contributing to species invasiveness and affecting native community. However, seeds are the most highly resistant organs of plants, and preventing their germination from the seed bank impedes a species to recruit individuals and thus to persist in a community, but this is often underestimated. Inhibition of invasive seed bank germination relied on the use of a variety of methods and their combination which involve a range of constraints and are often not wholly effective. New and innovative methods for rapidly inhibiting invasive seed bank germination need to be explored to treat contaminated soil *in situ* in different ecosystem types (croplands, natural environments or construction sites). Heating by microwave has been considered because it offers a means to quickly reach the temperature required for the loss of seed viability and therefore inhibit germination. In order to determine the technical characteristics of a mobile continuous conveying tunnel with microwave equipment allowing the treatment of infested soil *in situ*, we carried out two experiments under laboratory controlled conditions. Our results showed that treatments 2kW8min and 4kW4min, requiring about 3.05kWh.m⁻² (1097J.cm⁻²), allowed the relatively efficient inhibition of seed germination under different soil moisture levels (10 to 31.4%) and down to a depth of 12 cm, making this equipment potentially suitable for treating larger soil volumes compared to other equipment described in the various existing works. The use of microwave systems to inhibit rapidly and fully the invasive seed bank germination is promising, and today may be one of the most effective methods available. Results are sufficiently encouraging to justify further experiments to determine the most effective treatments that would be applied following development of a microwave device to treat large volumes of soil infested by invasive seed efficiently and with reasonable energy requirements. Other types of soil, in terms of texture and organic matter content, should be tested in future experiments because they influence soil water content and consequently microwave heating.