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Plant protection by foam in the thermal control process

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Abstract. During thermal weed control a high temperature medium exterminates weeds and culture plants without distinction. The problem of preserving germinating plants from thermal extermination therefore arises. Stable foam can be used to protect germinating agriculture plants from the thermal extermination. Using 100°C water steam for weed control for the sprouted carrot crop, till 40 days after the sowing, was investigated, and it was found that it is necessary to use preservatives. Extermination of carrots without preservatives depends upon the carrots' development stage. It is advisable to use stable foam for plant protection from extermination, when biometric parameters of weeds and agricultural plants are similar. Sprouting agricultural plants covered with a stable foam layer are completely protected from thermal extermination, when 100°C water steam is sprayed at a distance of 8 cm to the plant. In the foam covered plant medium the temperature reached 39°C ± 4.2.

Key words: weed control, stable foam, thermal weed control, temperature

INTRODUCTION

Thermal weed control technology is based on the plant's thermal-energy exchange in a high-temperature environment. This technology is aimed at affecting, or destroying, vital functions of the plant's above-ground parts (or stem) by a thermal technique (Thompson & Rajamannan, 1995; Rajamannan, 1996; Harry & Rajamannan, 2005; Kerpauskas et al., 2006). In the application of weed control treatment, a high-temperature field is created in the plant's environment that heats the plant and affects the tissues of its vital organs (stem, apical point) through heating to a temperature of 58^{o}C .

Crop protection from thermal destruction is an important and often crucial factor in the technological process of thermal weed control. A different thermal weed control agro-technology must be created and tailored to each type of crop. Each agro-technology has to evaluate the resistance of cultivated plants and weeds to a high-temperature environment during different stages of growth. Thus, there emerges the problem of cultivated plant protection from thermal destruction. Crop protection is especially complicated in a crop area where the biometric indicators of weeds and cultivated plants are very similar. Therefore, there is a threat of killing crops together with weeds in such crop areas. Modern thermal weed control technologies deal with the issues of crop protection in different ways (Sirvydas et al., 2006 b).

Sidelong limiters of a thermal flow are used when temperature-sensitive crops, such as carrots, beans and others, need to be protected. The use of sidelong protection devices is not efficient in the case of onions as they have low sensitivity to a short-term thermal effect. Sidelong guards are especially efficient in case of high weed mass or mature weed plants.

The use of closed-type caps ensures not only the protection of cultivated plants from the effect of a high-temperature environment but also cost-effectiveness due to reduction of heat loss to the environment (Ascard, 1998).

In flaming by gas technology, CO_2 gas emitted in crop beds suppresses the spread of a flame sideways and cools down combustion products. It also prevents the crops from being killed by the high-temperature environment in the process of weed thermal control (Tei et al., 2002). Hot statically stable foam is applied for thermal weed killing. No information is available on the application of cold, statically stable, foam for crop protection from thermal destruction.

The aim of this paper is to investigate the application possibilities of cold statically stable foam for weed thermal control in order to protect crops from thermal destruction.

MATERIALS AND METHODS

An experimental stand was developed to generate and apply a statically stable foam flow for crop protection from thermal destruction. During thermal weed killing wet water steam was released at a height of 3 cm above the soil surface with a steam spreader. The spreader moved at a speed of 0.11 m s^{-1}. The moving spreader produced a 1.0 second thermal effect.

To treat crops with foam, a detergent solution of 0.8% concentration in tap water was used. The foam flow temperature altered, depending on the detergent solution temperature, the mean being 27 ^{o}C ± 3. Foam volumetric flow gas was: φ =0.996-0.998 (Weaire et al., 1997; Weaire et al., 2003).

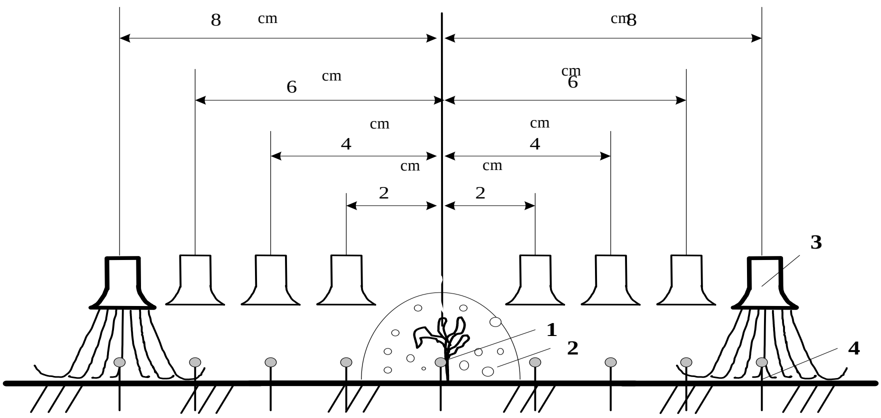

Fig. 1. scheme of temperature spread depending on site of wet steam release: 1 – plant in a bed; 2 – statically stable foam layer; 3 –steam release every 2 cm; 4 – temperature sensors (at a height of 0.5 cm above the soil surface).

The scheme of weed control by steam, when crops are treated with a layer of statically stable foam, is given in figure 1. Temperature sensors were allocated every 2 cm from the crop growth bed. Temperature was measured at a height of 5 mm above the soil surface. Temperature change in the crop bed was measured on 10 occasions; steam was released at distances of 2, 4, 6 and 8 cm from the plant. The most characteristic cases, which identify variations in the temperature, are presented in results.

The temperatures of the medium and of the plant were measured using the ALMEMO 2590–9 device, using the microprocessor data gathering, accumulating and processing system. The thermocouple wires were connected through ALMEMO with a programmable memory circuit. High temperature medium flow and plant tissue temperatures were measured according to the preset tasks and needs, carrying out up to 100 measurements per second. The AMR programmes were used to connect the computer with the data-accumulating device. Data were transferred to the computer for agronomical and thermo-physical analysis using STAT and ANOVA programs. As measurement of local plant tissue temperatures are very complicated (Sirvydas et al., 2006 a). The average temperature variation values in the surroundings of the crop are presented in results.

RESULTS AND DISCUSSION

If thermal weed killing with steam is applied onto a carrot crop area, the carrots may be completely killed. Therefore, protection must be applied to the carrot area 40 days after sowing when weeds are thermally killed with steam (Kerpauskas et al., 2007). Mechanical protection devices do not always serve this purpose. As the temperature measurement data show, the condensation temperature of steamwater moving along a smooth soil surface is almost independent on the site of steam release.

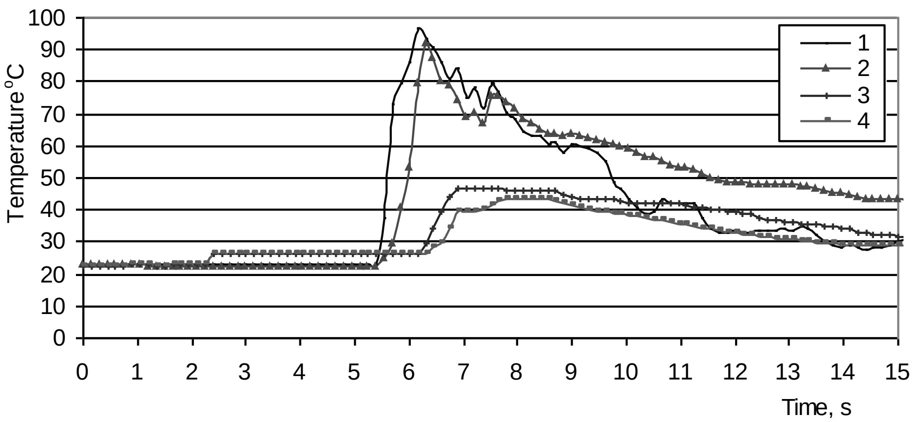

Fig. 2. Temperature change in the surroundings of the crop treated with a layer of statically stable foam when steam released at 6 cm distance from the plant: 1 – temperature in the centre of the steam spreader; 2 – distance from the plant is 4 cm; 3 – distance from the cultivated plant is 2 cm; 4 – temperature in site of crop growth.

If steam is released at a distance of 6 cm from the plant, the temperature in the plant bed reaches 91°C ± 2. The findings show that crop guards limiting steam flow from entering crop beds should be used together with open–type spreading devices. Statically stable foam may be used for limiting the water steam flow from entering crop beds.

The distribution of temperature in statically stable foam depending on the site of steam release was investigated by forming equal-sized sleeves of statically stable foam on a smooth soil surface (Fig. 2).

The dependence of temperature change on the distance of steam release from the sowing bed treated with foam layer is shown in Fig. 3.

After releasing steam at a distance of 4, 6 and 8 cm from the sowing bed treated with a statically stable foam layer, temperature significantly decreased at the site of plant growth (Fig. 3). When steam was released at a distance of 4 cm from the sowing bed treated with a layer of statically stable foam, temperature at the site of plant growth reached 58.6°C ± 2.3; at a distance of 6 cm – 46.6°C ± 2.0, at a distance of 8 cm – 38.6 °C ± 1.8.

After summarizing the data it is clear that when treating a plant bed with a layer of statically stable foam temperature changes in the plant bed depend on the site of release of steam (Fig. 3). It is advisable to use stable foam for plant protection from extermination, particularly when the biometric parameters of weeds and agricultural plants are similar. Sprouting agricultural plants covered with stable foam layer are protected 100% from thermal extermination, when 100°C steam is sprayed at a distance of 8 cm from the plant. In the foam covered plant medium the temperature reaches 39 °C ± 4.2. This short-term temperature rise is not dangerous for the plants. At the same time weeds at a distance of more than 2 cm from agricultural plants are destroyed.

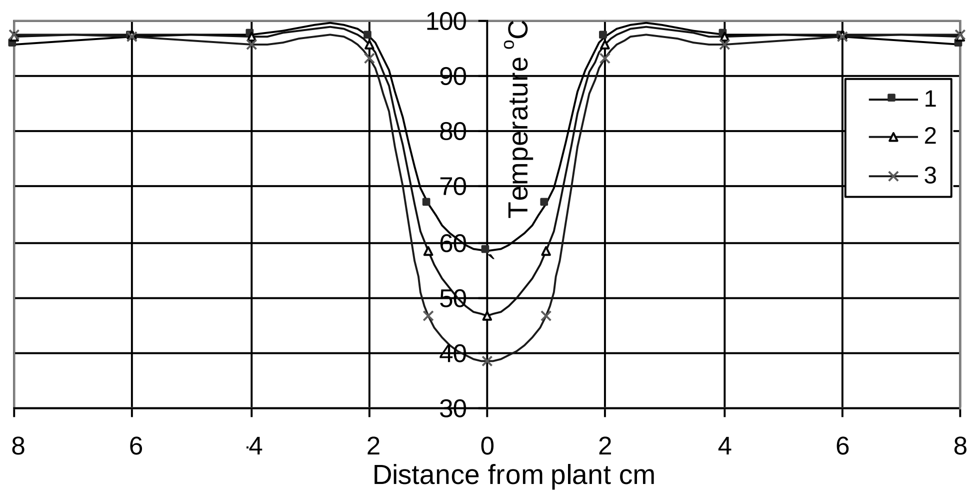

Fig. 3. Temperature in the bed after treating crops with foam: 1, 2, 3 – temperature change after releasing steam at a distance of 4, 6 and 8 cm from the plant in the bed, respectively.

CONCLUSIONS

When applying 100°C steam for weed control, stable foam can be successfully used for crop protection from thermal destruction.

Crops treated with a stable form layer are protected from thermal destruction when steam is released no closer than 6 cm from the plant. The temperature in the plant environment reaches 46 °C ± 2.

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