Intra-Row Weed Control by use of Band Steaming

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Abstract

Soil disinfection by steam is a well-known technique used within horticulture and market gardening. The most common steam application technique is sheet steaming, where the soil is covered with a thermo resistant sheet, which is sealed at the edges and then blowing steam under the sheet so that the steam penetrates through the soil. When the desired soil temperature is reached, the equipment is moved stepwise forward over the area to be treated. The method is effective for control of weed, plant pathogens and nematodes, and it represents a viable alternative to the use of pesticides. However, high fuel consumption and low capacity are serious disadvantages. Moreover all living organisms, harmful and useful, in the treated soil are killed, and therefore the method is not in line with the basis ideas of organic farming.

A new concept and technique for band heating by use of steam has been developed. By heating only a narrow band around the rows to a depth of 5cm, and by optimising the implement control, energy savings of more than 90% can be achieved, compared with a full steaming of the entire soil surface. By this method only a minor part of the soil is affected. The aim has been to develop a machinery system for thermal soil treatment by steaming in close bands covering the crop rows, only. Focus has been at optimization of the technical application for minimum energy consumption and at the same time effective weed control in the intra-row area. Weed control in the area between the rows will be achieved by means of precisions hoeing. The project has included establishment of a laboratory test rig for detailed analyses of the thermal processes involved as well as development of a prototype machine to be used for field trials. An important subject has been the design and construction of application for effective and controlled penetration of the steam in the soil. The effect on the microbiological life in the soil has also been investigated.

Treatment of soil samples containing weed seeds

The purpose of the soil sample steaming was to study the effect on the weed seeds when different soil types with varying water contents were exposed to steaming. Figure 1 shows an example of soil temperature after treatment in the test rig.

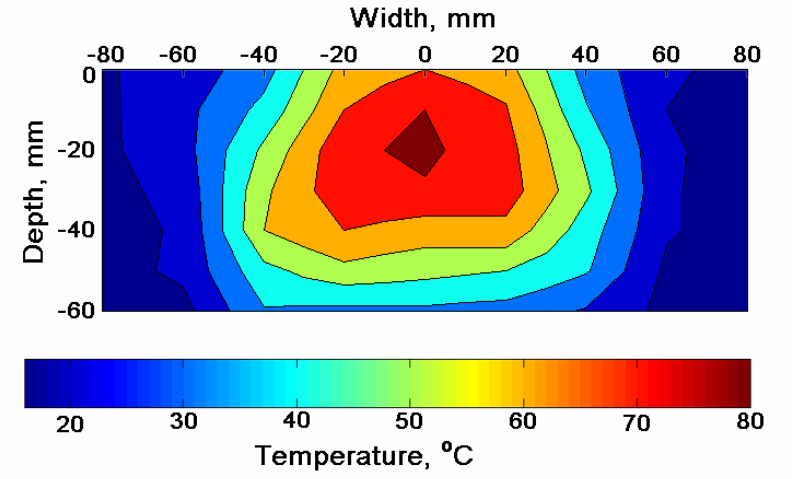

Figure 1. Soil temperatures from a cross-section across the groove, measured 40 sec. after treatment. The width is measured from centre of the treated band. Treated area: With –30 - +30, depth 0 - 50 mm.

The results of the germination tests show that at a temperature of about 65–70°C the weed seeds generally lose their ability to germinate (figure 2). From a technical point of view, this means that the control system for field application has to ensure that the temperature in the processed soil band uniformly reaches at least 70°C. Higher temperatures mean a loss of energy, especially if they rise to above 90°C, when evaporation of soil water starts to take place. In subsequent field trials, increased effects on weed germination were observed at increasing treatment temperatures up to about 90°C. This may be due to uneven heat distribution in the soil and higher heat loss to the surroundings.

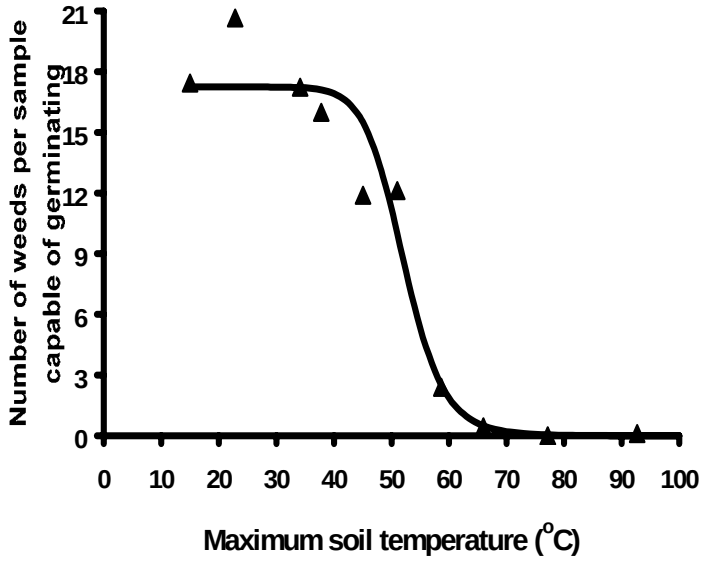

Figure 2. Number of surviving weed plants in relation to the soil temperature

For band heating, such a treatment in 50 cm rows requires about 5.8 GJ/ha. However, the field test with an one-row band steamer prototype machine (figure 3) showed that slightly higher temperatures – about 90°C – are necessary to achieve a good effect in the field. At the field tests, about 9GJ/ha (300 l/ha of oil) were needed.

Figure 3. Prototype band steaming machine

By band steaming the microbiological flora and fauna is influenced in the local area representing less than 10% of the total volume calculated in a 15cm surface layer. The microbiological life is affected during the growing season (Elsgaard et al., 2004), but after a primary tillage operation the influence is erased.

Conclusions

An experimental test rig, used for steaming soil samples mixed with weed seeds and for examining the thermal efficiency involved in soil steaming, has been developed. It was seen that soil temperatures

exceeding 70°C will be needed in order to destroy the germination capacity of the weed seeds. At the field trial slightly higher temperatures, 80-90°C, were needed to achieve god effect. In connection with the transfer of steam energy to the soil, efficiencies of 91–100% were found. Part of the energy will, however, be transferred to the soil surrounding the steamed band, and therefore, in the case where a 6 × 5 cm soil band is exposed to steaming, the efficiency will only be 50–60%. For an efficiency of 55% and a row interval of 50 cm, about 300 l/ha of oil will be needed to heat a 6 × 5 cm soil band to a temperature of 80°C. On the basis of the experiments in the test rig, a prototype one-row band steamer has been developed for field purposes. Good results have been achieved from the preliminary tests.

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