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Development of a control system in order to estimate the result of flame weeding during thermal weed control

The objective of flame weeding is to eliminate weeds by fast temperature rise in cells and protein denaturation. In present no immediate control is possible. Therefore it seems to be necessary to develop an improved and objective method to control flame weeding. The results of a continuously leaf temperature measurement during the flaming are very imprecise. In the presented study some indicator materials were used to estimate the success of flame weeding. Initial results show a close linkage between heat energy depending on driving speed and changes at test material. In further research this method will be improved.

Keywords
Weed control, flame weeding, efficiency control

Abstract
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The main objective to improve flame weeding is an increase of efficiency through a reduced energy consumption [1; 2; 3]. The immediate control of the success is a sub target and necessary for the optimization of the machine setting. The success of flame weeding is currently checked by squeezing some plants chosen at will between two fingers [4; 5]. If a dark green mark will be left the procedure is classified as successful. The results of this widely used method are hardly to standardize. The date of testing, the placement of the fingers, the pressing power and the interpretation of the leaf color cause to subjective results.

Therefore the objective of this study was the development and test of a practicable method by using special indicators, which make it possible to control the success of flame weeding immediately after the treatment.

Methods

The trails are carried out in a laboratory test on a 6 m test track. A pretest was arranged to estimate the peak temperatures in the plants. Afterwards by using the same machine setting some with impact of heat modifiable temperature indicators were treated. As source of heat a commercial burner Reinert Inc. Typ 111 R which operates with propane gas (2 bar pressure) was used. The burner was mounted in the back of a small tractor. The burner head runs in a 45° angle 100 mm above the 6 m test track. On the test track were 4 measuring points mounted spaced at intervals of 1 200 mm. The trails were carried out with 1.1; 1.7; 3.5 and 6.1 km/h. 10 replicates were used.

At first plants of Ackersenf (*Sinapis alba* L.) and Deutsches Weidelgras (*Lolium perenne* L.) were raised in a pot culture. Both species were flamed in the seed leaf and the 2-leaf- or 4-leaf-stage. The Ackersenf reached 9 days after sowing the seed leaf stage and after 16 days the 4-leaf-stage. The thermal treatment of the Deutschem Weidelgras was carried out 16 days after sowing in the seed leaf stage and after 18 days in the 2-leaf-stage. The temperature was checked by type K thermocouples (DIN EN 60584-01: 1996-10). In each test 40 measured values were automatically recorded.

Afterwards some reference blocks were prepared as temperature indicators from different kinds of soft solder and paper. The deformation and the change in color were used as a scale of the thermal treatment. The pieces of soft solder wire (DIN EN 29453) were 50 mm long and had a diameter of 1.0; 1.5; 3.0 mm. The tin content in composition was 60 %. The paper strips used were from smooth, wood free paper in the quality of 32 g/m², 80 g/m² und 120 g/m² and had a size of 25 cm². On the test track were 4 holders mounted either filled with soft solder in different diameters or with paper strips in different thicknesses. A scale to measure the factor of deformation (soft solder) and the change in color (paper strips) was defined and used as a rating system to quantify the changes at the reference blocks (**table 1** and **2**).

Table 1

Factor of deformation

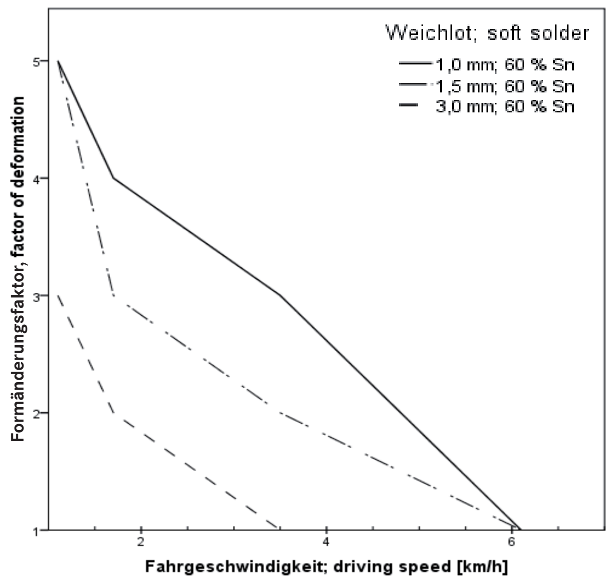
Formänderungsfaktor ***Factor of deformation***	**Beschreibung** ***Description***
1	Keine Veränderung (Testkörper bleibt senkrecht) *No modification (Reference block in a 90° angle)*
2	Testkörper > 10° abgewinkelt *Reference block bend > 10°*
3	Testkörper > 45° abgewinkelt *Reference block bend > 45°*
4	Testkörper berührt Messschiene *Reference block touches measuring bar*
5	Testkörper vollständig geschmolzen *Reference block completely melted*

Table 2

Factor of change in color

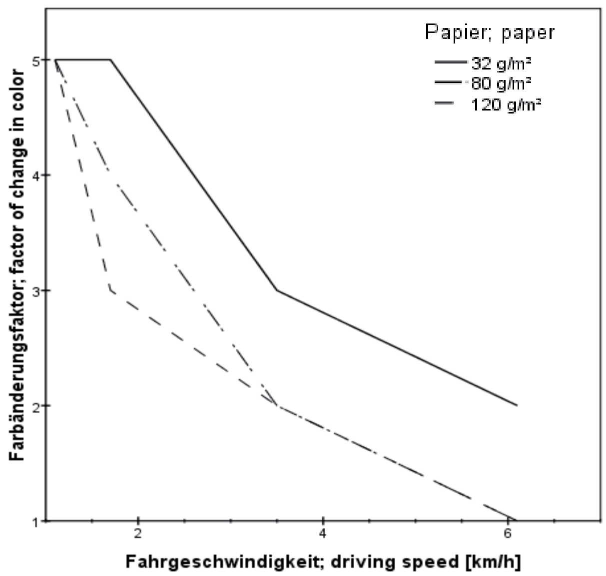
Farbänderungsfaktor ***Factor of change in color***	**Beschreibung** ***Description***
1	Keine Veränderung *No modification*
2	Vergilbungen am Rand *Yellow edges*
3	Verkohlungen am Rand *Black edges*
4	Verkohlungen > 50 % des Papierstreifens *Black color exeeding 50 % of the paper strip*
5	Vollständige Verbrennung des Papierstreifens *Complete burning of the paper strip*

Fig. 1



Deformation of the soft solder pieces under different driving speeds

Fig. 2



Change in color of the paper strips under different driving speeds

Results

As expected the pretest for the heat treatment showed an evenly distributed heat effect over all measuring points on the test track. A value above 500°C was reached as a maximum temperature. This showed that the test design was close to the machine setting in practice.

In the tests with the reference blocks some different reactions could be observed during the thermal treatment. **Figure 1** shows the deformation of several soft solder pieces at different driving speeds.

A close linkage between the deformation of the soft solder pieces and the different heat treatments depending on the driving speed could be observed whereas the soft solder pieces with a bigger diameter were less modified. Their reaction was less fast than by the thinner pieces.

As well the use of paper as a temperature indicator showed similar changes influenced by the heat treatment (**figure 2**).

In **figure 2** a dependency of the color change from the paper strips by different driving speeds and heat treatments can be observed. The modification reaches from the total burning of the paper strips to unmodified strips. The reaction of the lighter papers is faster than the response of the heavier ones. The differences in heat treatment under practical conditions were well covered by the tested paper strips.

Conclusions

By using a test stand the influence of heat treatment depending on the driving speed to the leaf temperature could be simulated under repeatable conditions. By using the conventional temperature measuring a widely used machine setting could be defined and afterwards more trails to observe the deformation and change in color of the indicators were carried out. In these experiments a close linkage between driving speed and modification of the material was determined.

Based on the favorable results a further development of the temperature indicators is from particular interest. A practicable possibility to control the result of flame weeding seems to be possible with them.

Additional trails are required to work out how good the indicators can be adjusted at the behavior of different plant species. Therefore some plant tests would be necessary to treat a temperature indicator and a plant with heat at the same time to compare the destruction of the plant with the reaction of the indicator. It appears to make sense to include examples of the different weed groups in the field (esp. *Chenopodium album*, *Polygonum ariculare*, *Chamomilla suaveolens*, *Poa annu*a). A distinction for class (monocotyledonous/dicotyledonous), necessary injury depth, kind of plant surface (hairs on the cuticula, wax coating) and development stage would be also useful [3]. Thereby bigger diameters of soft solder pieces or paper strips represent the rather difficult to damage species and the thinner ones represent the species which are easier to damage.

Based on the close relation between heat treatment and reaction of the temperature indicator already now can be said that using this method a fast and precise control of flame weeding after the thermal weed control could be possible. By this way the not repeatable current method of squeezing one leaf between the fingers could be drastic improved. The repeatability of the indicator method will be guaranteed by using standardized material and a defined attachment of the reference blocks.

Literature Books are signed with ●

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