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Thermal weed control: Experiments to determine the effect

Flame weeding is still an important treatment to control weeds. In the past several researches addressed the improvement of the process. Until now an objective method to measure the result during or short after the treatment is missing.
A current research project at Kassel University tries to estimate the effect of the treatment directly by using indicators.

Keywords
Weed control, flame weeding, energy consumption

Abstract

Landtechnik 66 (2011), no. 5, pp. 363–365, 1 figures, 2 tables, 5 references

The high fuel consumption and the low efficiency of today´s flame weeder is an often described problem [1, 2]. The biggest part of the produced thermal energy, approx. 85 %, does not reach the weed, but disappears. So that only 15 % of the theoretically produced thermal energy is transferred to the weed [3]. Therefore it is very important to measure the effect of this treatment in an objective way and as soon as possible after the treatment. An approach is the usage of indicators which change their properties significantly by a defined thermal action. First experiments with metal alloy and pulp looked promising [4]. An additional test series which focuses on the suitability of thermoplastics is described below.

Material and Methods

In the beginning several experiments with drawn thermoplastics were carried out. In detail:

- Polylactide (PLA)
- Polypropylene (PP)
- Polyamide (PA)

The softening temperatures of these thermoplastics are close to the critical temperature of plants proteins (40–52 °C) [5]. Samples of those thermoplastics (each 30) were flamed by a propane burner (50 kW output, propane consumption 2 500 g/h) with 0.21, 0.42 and 0.63 m/s speed. The change in material i.e. shrinking was measured immediately after the treatment.

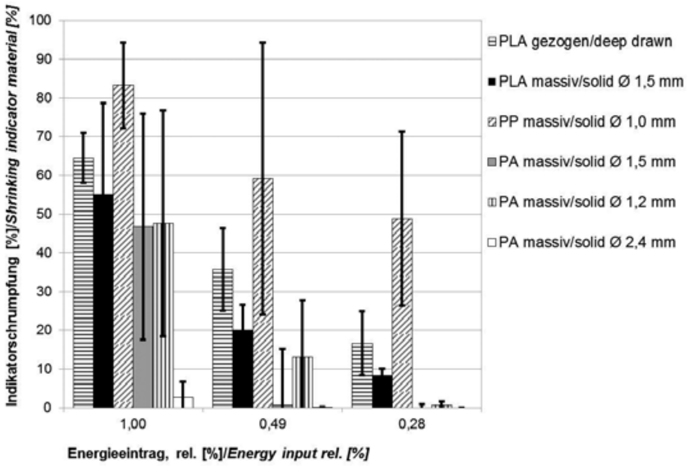
In the next step plant experiments with *Lolium perenne L.* and *Sinapis arvensis L.* were carried out. In this context the correlation of indicator material modification and weed control was checked. Based on the best correlation of heat input and material modification in the previous trial only the indicator material PLA was used in additional experiments. The plants were grown in pots 100 each (100 x 100 x 150 mm) under controlled conditions (14 h illumination 10 000 lux, 15 °C) in a greenhouse and were separated to 50–60 plants per pot. The flame treatment was carried out in the development stage (according BBCH) 10 and 11, i.e. leaf development stage. The propane burner and the speed levels were the same as described above. Three days or in the case of *Lolium perenne L.* ten days after the flame treatment the number of killed plants in each pot was determined und documented in percentage of hundred. At the same time drawn PLA cylinders (mean ø: 55 mm, height: 95 mm) were treated. The design of a cylinder was selected because in comparison to other types it is easy to purchase and produced through deep drawing. Deep drawing generates material stresses which cause characteristically shrinkage when heating again. This shrinkage was used as an indicator for the heat input. The shrinkage of the PLA cylinder was defined by percent of the original size.

Results

Figure 1 shows the results of a regression analysis based on data of the relative energy input (0.47 m/s = 1.0; 0.97 m/s = 0.49; 1.69 m/s = 0.28) and the indicator material shrinkage. The shrinkage behavior of the various indicator materials varied widely. Over all intensity levels the reaction of drawn PLA was relatively uniform. At the maximum energy application levels the solid PLA material showed non uniform results. The standard error was 23.5 %. On average the PP material 1 mm ø showed the maximum shrinkage. The maximum standard error was 35.06 % recorded at the middle energy application level. In the maximum heat level the statistical spread of the PA solid material 1.5 mm ø was high. On the other hand at lower heat levels no shrinking occurred on average. The PA material with 1.2 mm ø reacted similar to the PA material 1,5 mm ø, however, in the middle heat level medium shrinkage occurred. The shrinkage of the PA material 2.4 mm ø reached 5.6 % only at the maximum energy level .

As mentioned in table 1 a correlation between shrinkage and relative energy input was given for all indicator materials

Fig. 1



Shrinking of different indicator materials as a function of relative energy input

but the correlation varied. The correlation coefficient of relative energy input and shrinkage of the PLA indicator material was very high and reached 0.920 %. The calculated coefficient of determination (R^2) of 0.847 shows that an exact conclusion of the material shrinkage and the energy input can be drawn. In the repetition PA solid 1,5 mm ø (R^2 = 0.804) und PLA solid (R^2 = 0.725) is this conclusion also feasible.

All the other indicator materials showed a lower coefficient of determination of relative energy input and shrinkage. Therefore conclusions to the energy input are not possible in those cases. According to this there were only drawn PLA cylinders used for the following experiments. In table 2 the coefficients of the correlation between material shrinking and the result of flame weeding are shown. In the experiments with *Lolium perenne L.* only the data of the second counting, 10 days after the flame treatment, were used for the calculation of the correlation coefficient. This procedure was chosen because of the fact that monocotyledonous plants normally produce new shoots after the first treatment and sure reduction can only be evaluated after several days. In all variants a significant correlation of indicator material shrinkage and the success of flame treatment could be observed. A close correlation was existent in the variant PLA with *Sinapis arvensis L.* in the development stage BBCH 10 (R = 0.847) **(Table 2)**. Over all PLA variants a correlation coefficient of 0.60 came out.

The correlation coefficient of the later flame treatment of *Sinapis arvensis L.* was always lower as in the cotyledon stage. In all test series with *Lolium perenne L.* the two leaf stage showed higher correlation coefficients than the series in the cotyledon stage **(Table 2)**. In all variants with *Lolium perenne L.* the correlation coefficients were lower than in the variants with *Sinapis arvensis L.* In regard of the fact that the reduction of *Lolium perenne L.* is more difficult than the reduction of *Sinapis arvensis L.* this was expected.

Conclusions

The results show that the prediction of the success of flame weeding with the help of indicator materials is possible. It was shown that a correlation of indicator material shrinkage and success of flame weeding not only by *Sinapis arvensis* but also by *Lolium perenne L.* exists.

The indicator material research showed that drawn PLA is best suitable because of the significant correlation of material modification and success of flame weeding.

Table 1

Correlation coefficient and significance of the indicator material of PLA, PP and PA and the effect of treatment

Indikatorkörper *Indicator material*	**Korrelationskoeffizient** *Correlation coefficient*	**Bestimmtheitsmaß** *Coefficient of determination* **(R^2)**	**Signifikanz** *Significance* **(P < 0,05)**
PLA gezogen/*deep drawn*	0,920	0,847	< 0,001
PLA massiv/*solid*, 1,5 mm	0,851	0,725	< 0,001
PP massiv/*solid*, 1,0 mm	0,556	0,309	0,061
PA massiv/*solid*, 1,5 mm	0,897	0,804	< 0,001
PA massiv/*solid*, 1,2 mm	0,772	0,596	0,003
PA massiv/*solid*, 2,4 mm	0,626	0,392	0,053

Table 2

Correlation coefficient, coefficient of determination (R^2) and significance of the indicator material of PLA

Indikatorkörper *Indicator material*	**Korrelationskoeffizient** *Correlation coefficient* **(n = 200)**	**Signifikanz** *Significance* **(P < 0,05)**
PLA gesamt/*PLA cumulativ*	0,603	< 0,001
PLA (*Sinapis arvensis* – BBCH 10)	0,847	< 0,001
PLA (*Sinapis arvensis* – BBCH 11)	0,793	< 0,001
PLA (*Lolium perenne* – BBCH 10)	0,501	0,002
PLA (*Lolium perenne* – BBCH 11)	0,732	< 0,001

In additional experiments the energy input will be more differentiated and the results described above will be verified in field trials.

Literature

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Acknowledgment

The described study was financed by the Federal Office for Agriculture and Food (BLE): Reference: PGI-06.01-28-1-53.039-07).