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Effect of setting the parameters of flame weeder on weed control effectiveness

Vplyv nastavenia parametrov termickej plečky na efektívnosť ničenia burín

Miroslav MOJŽIŠ and František VARGA

Slovak University of Agriculture in Nitra, Faculty of Engineering, Department of Transport and Handling, Tr. A. Hlinku 2, 949 76 Nitra, Slovak Republic, e-mail: miroslav.mojzis@uniag.sk
*correspondence

Abstract

Unconventional ways of growing plants, when we return to non-chemical methods of controlling weeds, require new weed control methods. One of the few physical methods, which found wider application in practice, is a flame weeder with heat burners based on the use of gas (LPG). However, the process of practical use of this flame weeder has a number of factors that positively or negatively affect the effectiveness of weed control. A precise setting of flame weeders is influenced, for example by weed species, weed growth stage, weather, type of crop grown, but also heat transmission and heat absorption by plant. Many variables that enter into the process must be eliminated for their negative impacts on achieving the best results in fighting against weeds. In this paper, we have focused on naming these parameters, on field trials that confirm the justification of the precise setting of parameters, and recommendations for practice to achieve a higher efficiency of thermal weed control.

Keywords: flame weeder, weed control

Abstrakt

Netradičné spôsoby pestovania rastlín, keď sa vraciame k nechemickým spôsobom ničenia burín, vyžadujú nové metódy regulácie zaburinenosti. Jednou z mála fyzikálnych metód, ktoré našli širšie uplatnenie v praxi, je termická plečka s tepelnými horákmi na báze využitia plynu (LPG). Do procesu praktického používania tejto termickej plečky však vstupujú mnohé faktory, ktoré priaznivo či nepriaznivo vplývajú na efektívne ničenie burín. Presné nastavenie termickej plečky podmieňujú napr. druh burín, rastové štádium burín, počasie, druh pestovanej plodiny ale aj prenos tepla a absorpcia tepla rastlinou. Množstvo premenných, ktoré vstupujú do tohto procesu, je nutné eliminovať tak, aby negatívne nevplývali na dosiahnutie čo najlepšieho výsledku v boji s burinami. V práci sa sústreďujeme na pomenovanie týchto parametrov, poľné pokusy, ktoré potvrdzujú opodstatnenie presného nastavenia parametrov a odporúčania pre prax, ktoré umožnia dosiahnuť vyššiu efektívnosť termického ničenia burín.

Kľúčové slová: ničenie burín, termická plečka

Introduction

In this paper, we focus on naming these parameters, on field trials that confirm the precise setting of parameters of flame weeder, and recommendations for practice to enable a more efficient thermal control of weeds. Test evaluation was performed by Abrahám et al. (2011), Abrahám et al. (2007), Bolla et al. (2003) and Majdan et al. (2011).

The present work with a new field trial partially continues trials performed in 1995 in Nova Scotia (Canada) with a Reinert – DA211 flame weeder. Laboratory experiments were carried out at the Department of Transport and Handling by a designed burner connected to a 5 kg bottle of LPG. Field experiments were carried out in cooperation with PD Dolina in years 2008–2012, with a four-row flame weeder Thermec.

Materials and Methods

In the first experiment, we have simulated the passage of the flame weeder over weeds. We used thermocouples Omega 5TC-GG-K-30 connected to a PC through a converter. The ends of thermocouples were placed close to the ground, in the middle of the path between burners. The weeder repeatedly passed over thermocouple. The number of repetitions for one treatment was five. The parameters are listed in Tab. 1.

Tab. 1: Parameters of the flame weeder at temperature curve determination

Treatment	Speed, $km*h^{-1}$	Pressure, MPa	Treatment	Speed, $km*h^{-1}$	Pressure, MPa
O1	2	0.15	O4	4	0.15
O2	2	0.2	O5	4	0.2
O3	2	0.25	O6	4	0.25

In subsequent laboratory experiments, we verified the effect of combinations of burner parameters in weeder travel speed v_p, gas pressure p_p, and weed growth stage (Lorenz et al., 1994). A combination of the first two parameters is a parameter of hourly gas consumption Mp and a parameter of gas consumption, which was converted by the time of treatment $t_{oš}$ to consumption per hectare of treated surface M_H. We determined the gas consumption Mp by repeatedly measuring the difference of LPG bottle weights in 25 minute intervals, and subsequently, we recorded the treatment time of an area of 600 m^2, with conversion to 1 ha.

Tab. 2: Treatment parameters at laboratory trial

Treatment	Speed	Pressure	Consumption	Time of treatment	Consumption

	v_p, km*h^{-1}	p_p, MPa	M_p, kg*h^{-1}	$t_{oš}$, h	M_H, kg*ha^{-1}
O01	2	0.5	2.34	5	11.7
O11	2	0.1	9.69	5	48.45
O21	2	0.15	7.24	5	36.2
O31	2	0.25	12.1	5	60.5
O41	3	0.5	2.34	3.33	7.79
O51	3	0.15	7.24	3.33	24.1
O61	3	0.25	12.1	3.33	40.2
O71	4	0.5	2.34	2.25	5.26
O81	4	0.15	7.24	2.25	16.29
O91	4	0.25	12.1	2.25	27.23

Laboratory experiments we carried out in 2009 – 2012 for radish (*Raphanus sativus L.*) and rice (*Oryza sativa L*.), which were pre-cultivated in containers 30 x 20 x 10 cm (L x W x H) in the minimum quantity of 15 pcs / container. We put the burner to a position of 10 cm above the passing of weeds, in 45° angle. We placed the containers with plants on a car pulled by rail with a small traction member enabling the setting of movement speed using an adjustable transformer 12 V. The treatment parameters are listed in Table 2. The effectiveness of treatment was monitored by counting the plants before and after treatment. We evaluated the degree of plant damage as completely, partially or minimally damaged, based on selected coefficients. Each treatment O01 – O91 was performed in three growth stages of rice and radish and had four repetitions, which represented 120 treatments per plant in total. Results were evaluated using statistical methods in Microsoft Office Excel.

Results and Discussion

Experiments carried out with the four-row flame weeder Thermec were used to determine the intensity of heat effect. Field trials with weeder passages over heat sensors at variable tractor speed v_p and gas pressure p_p indicate a real time of heat application and its real value (Figure 1, Figure 2). While increasing pressure p_p at speed 4 km*h^{-1} leads to a temperature increase from approx. 280 $^{\circ}$C up to 490 $^{\circ}$C, and the time of application is 0.1– 0.2 seconds, we obtain at speed 2 km*h^{-1} and pressure 0.25 MPa a temperature of 760 $^{\circ}$C, and the time of exposure is extended to 0.7 seconds.

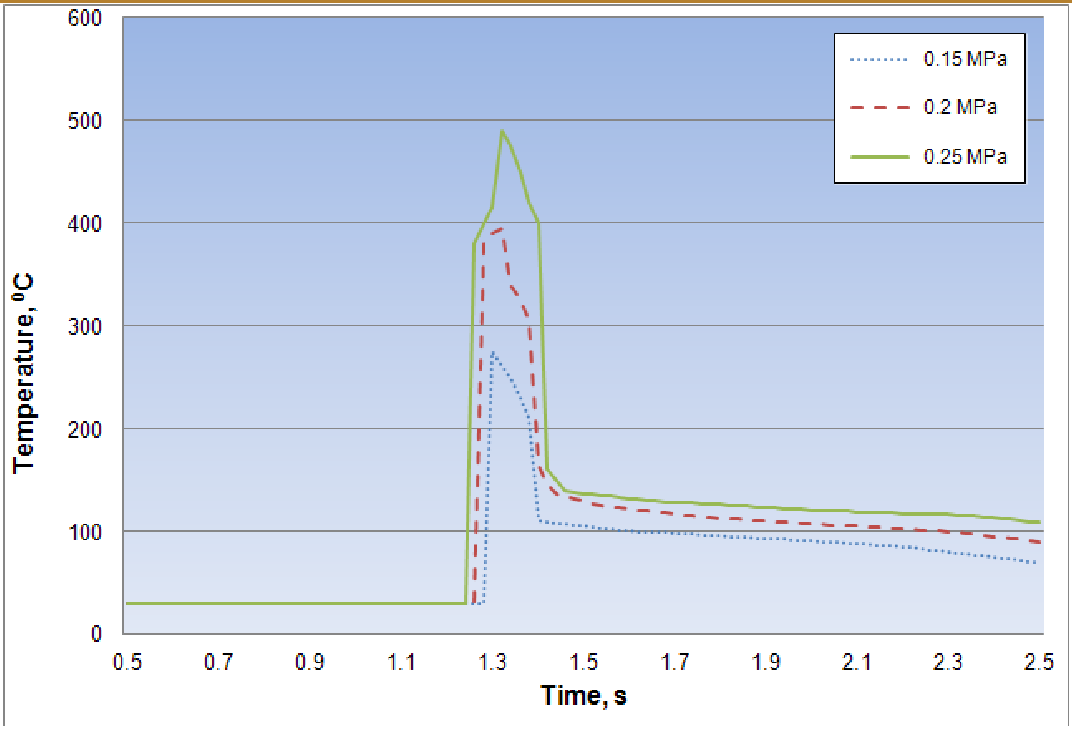

Fig. 1: Measurement of thermal characteristics of flame weeder at the speed of 4 km*h^{-1}

The results help us accurately identify the heat effect on a given plant. Other aspects are the absorption area of plants, which is represented by its gradual development and the number of cotyledons. An important finding is the fact that speed v_p has a more significant effect ($P > 0.5$) on the killing of weeds than pressure change p_p.

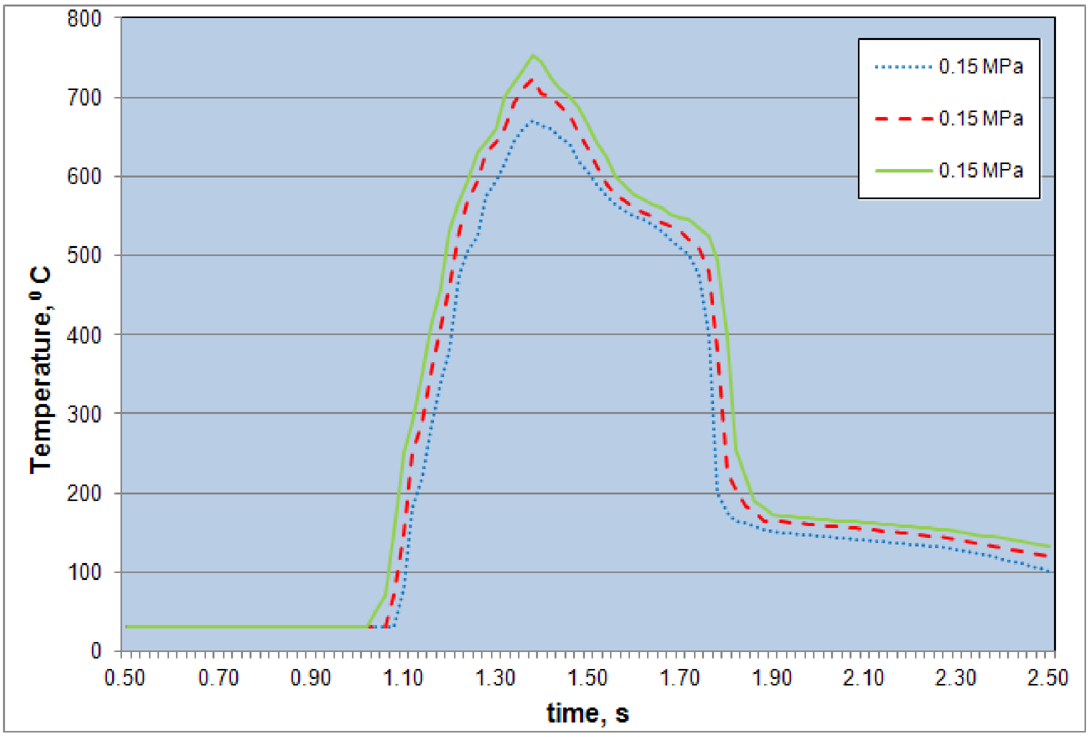

Fig. 2: Measurement of thermal characteristics of flame weeder at the speed of 2 km*h^{-1}

Moreover, setting a higher pressure p_p is limited with respect to the possibility of plant damage by distributed heat from burners. As shown in Figure 3, at higher pressure p_p, there is overlapping of heat flow, which affects not only weeds but also crop. With a selective treatment, this is not a problem because the crop grows with a certain timing advance before weeds and has greater resistance. In early stages of application, this can cause slow-down or even discontinuance of crop growth. On the other hand, as for a change in speed v_p, practical application is demanding in terms of accuracy due to the burner distance from the crop row, either horizontally or vertically, which is difficult to ensure at high speeds.

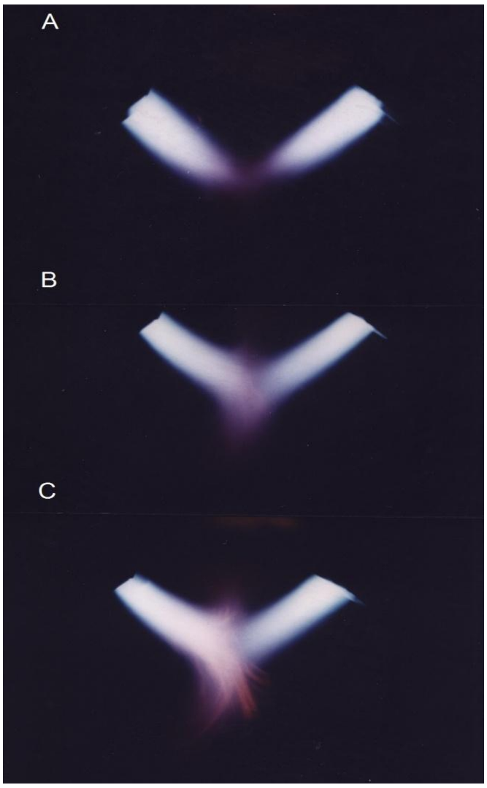

Fig. 3: Flame shape of Thermec flame weeder at pressure: A –1.5 MPa, B – 2.0 MPa, C – 2.5 MPa

Laboratory experiments with pre-cultivated dicotyledonous and monocotyledonous plants have been carried out mainly to ascertain the impact of changes in ground speed v_p and pressure changes p_p at different stages of plants. The results of control in radish (*Raphanus sativus L.*) are shown in Figure 4. A change in gas consumption M_H caused a significant effect ($P > 0.5$) on control change in all growth stages. Several experiments were performed even at later growth stages of radish; however, the efficiency of thermal application did not reach statistically significant values.

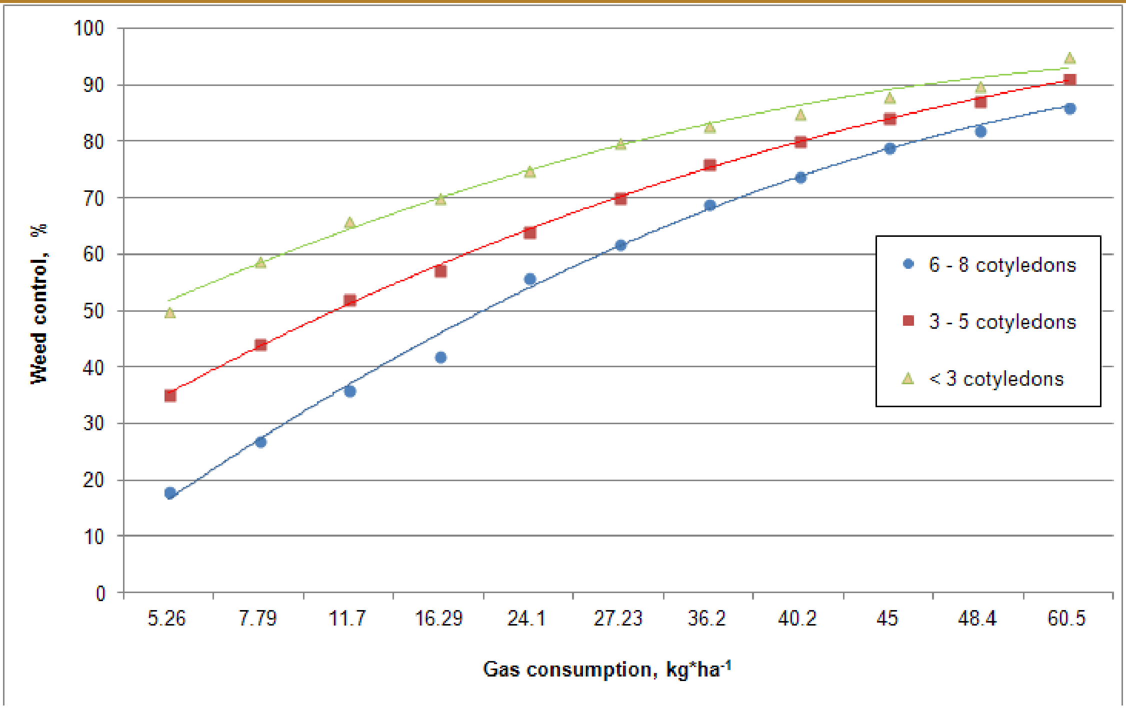

Fig. 4: Effect of parameter changes on the efficacy of heat treatment in *Raphanus sativus L.*

The results of control effectiveness in rice (*Oryza sativa L.*) are shown in Figure 5. A change in gas consumption M_H caused a minimal effect ($P < 0.5$) on control change in all growth stages. The previous experiments indicate that for the control of rice, it is important to set the flame flowing from the burner under a right angle so that the whole plant is reached and especially to place the burner as close as possible to the monocotyledonous plant.

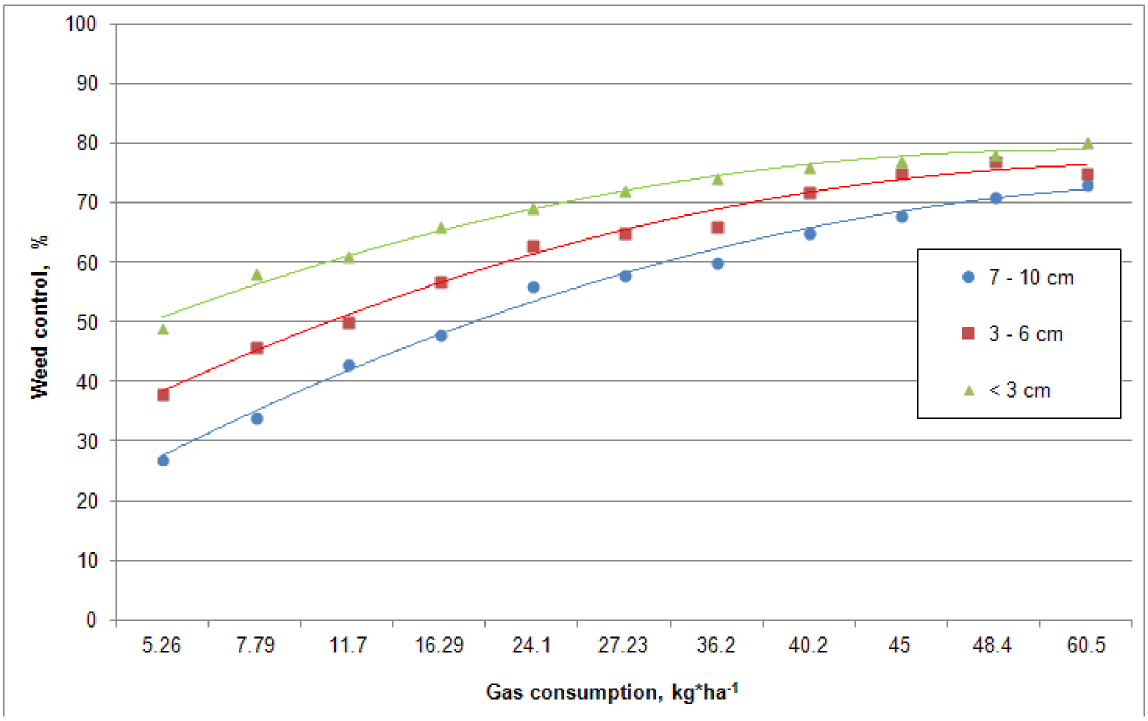

Fig. 5: Effect of parameter changes on the efficacy of heat treatment in *Oryza sativa L.*

Conclusion

We can deduce from the results obtained that for practical use of flame weeders or mechanisms operating on a similar principle (using e.g. steam), more relevant seems to be changing the travel speed v_p than changing the gas pressure p_p. However, this strategy is necessary to be properly changed according to the type of weeds present in the crop or their growth stage when treated. The flame weeder cannot compete with chemical or mechanical cultivators, mainly due to financial but also other factors that limit the use of this method e.g. only for row crops. An important factor is also the time of treatment and labour input. However, in the field of alternative, non-chemical growing of bio-products, this method can find a wider application, particularly when eliminating a high labour cost. The difference in the price of products with a higher added value can eliminate higher inputs in using flame weeders. Now we have big greenhouses in Slovakia that use track rollers with mounted burners for the control of weeds. The accuracy of these pathways allows increasing the efficiency and speed of application.

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