Electrical weed control in sugar beet - A comparison of pre-emergence methods

Elektrische Unkrautbekämpfung in Zuckerrüben - Ein Vergleich von Vorauflauf-Behandlungen

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Abstract

Competition between sugar beet and weeds can result in tremendous yield losses, which were confined by the use of chemical herbicides in the past. In view to address soil conservation, a reducing number of available chemical herbicides, the need to prevent weed resistances and exacting food security standards, new management approaches must be implemented into modern crop protection. In this context, electrical weed control for pre-emergence in sugar beet, cultivated in mulch sowing to prevent erosion and to improve water infiltration after heavy rainfall, was integrated in chemical and mechanical weed control strategies. A randomized complete block field trial design with three times replicated plots and eight variants was applied, whereby individual plots (100 m length in total) were separated in 50 m, with and without glyphosate as pre-sowing application. The Zasso Electroherb™ was applied with 3 and 5 km h-1 speed and 72 kW nominal electrical power in a 3 m area application.

Weed infestation after the pre-emergence weed control, mainly volunteer grain and dicotyledonous weed plants, with glyphosate averaged densities of 5 to 23 plants 10 m^{-2}, whereas without glyphosate application 5 to 97 plants 10 m^{-2} were counted, respectively. Weed control efficiency indicated that the weed community was controlled best by Electroherb™, leaving in the plots without glyphosate application significantly lower weed numbers (of 5 to 11 plants 10 m^{-2}) behind. Mechanical harrowing on the other side showed here minor efficiency in reducing the volunteer grain weed; averaging weed densities of 72 plants 10 m^{-2}. Results on sugar beet yields and quality are pending but will be included in the data set for comprehensive conclusions. Our results indicate that the integration of electrical weed control methods into existing strategies can reduce the use of synthetic-chemical herbicides and can also make a significant contribution to the prevention of ongoing and future herbicide resistances.

Keywords: Electroherb, electrical weed control, alternatives in weed control, pre-emergence weed control in sugar beet, innovations in sugar beet cultivation

Zusammenfassung

Im Zuckerrübenanbau können schon geringe Unkrautdichten zu enormen Ertragseinbußen führen. Diese wurden in der Vergangenheit durch den Einsatz von chemischen Herbiziden effektiv begrenzt. Mit Blick auf den zunehmenden Wegfall verfügbarer chemischer Wirkstoffe, wachsender Unkrautresistenzen, einen nachhaltigeren Bodenschutz und die Einhaltung anspruchsvollerer Ernährungssicherungsstandards müssen neue Managementansätze für einen moderneren Pflanzenschutz umgesetzt werden. Aus diesem Grund wurde die elektrische Unkrautbekämpfung im Vorauflauf in der Zuckerrübe, im Mulchsaatverfahren angebaut, in chemische und mechanische Unkrautbekämpfungsstrategien integriert. Es wurde ein randomisiertes Blockfeldversuchsdesign mit dreimal replizierten Versuchsplots und acht Varianten angewendet, wobei einzelne Plots (100 m Länge) jeweils in 50 m getrennt, mit und ohne Glyphosat als Vorsaatanwendung behandelt wurden. Das Electroherb™ der Firma Zasso wurde mit 3 und 5 km h^{-1} Fahrgeschwindigkeit und 72 kW elektrischer Nennleistung in einer 3 m Flächenbehandlung angewendet.

Der Unkrautdichte nach der Vorauflauf-Applikation setzte sich hauptsächlich aus Ausfallgetreide und zweikeimblättrigen Unkrautpflanzen zusammen und betrug 5 bis 23 Pflanzen 10 m^{-2}, während ohne Glyphosatanwendung 5 bis 97 Pflanzen 10 m^{-2} gezählt wurden. Der Vergleich der Wirkungsgrade zeigte, dass die Verunkrautung am besten mit der Electroherb™ Technologie kontrolliert wurde, so dass in den Parzellen ohne Glyphosatanwendung deutlich geringere Unkrautzahlen (von 5 bis 11 Pflanzen 10 m^{-2}) vor dem Auflaufen der Zuckerrüben zurückblieben. Mechanisches Eggen auf der anderen Seite zeigte eine geringe Effizienz bei der Reduzierung von Ausfallgetreide; die durchschnittliche Unkrautdichte betrug hier 72 Pflanzen 10 m^{-2}. Die Ergebnisse zum Zuckerrübenertrag und -qualität werden in den Datensatz integriert und erlauben so umfassende Schlussfolgerungen zur Wirtschaftlichkeit des Electroherb™ Verfahrens zu schlussfolgern. Unsere Ergebnisse zeigen, dass die Integration von elektrischen Unkrautbekämpfungsmethoden in bestehende

Strategien den Einsatz von synthetisch-chemischen Herbiziden reduzieren kann und auch einen wesentlichen Beitrag zur Vermeidung von Herbizidresistenzen leisten kann.

Stichwörter: Electroherb, elektrische Unkrautbekämpfung, Alternative Unkrautbekämpfung, Vorauflauf Unkrautbekämpfung bei Zuckerrüben, Innovationen im Zuckerrübenanbau

Introduction

The Electroherb™ technology is based on a systemic electrical flow through the plants' vascular system causing severe cell destruction and finally wilting as mode of action. The physical contact with high-voltage electrodes touching weed plants enables the electric current to operate only at the time of application without residues and genetical selectivity. The minimum energy threshold for a lethal effect is related to the energy transferred to a single plant in dependence of the number and stability of vascular bundles to be damaged, the electrical resistance of the plant and the soil, the contact time and the electrode power output. Furthermore, the efficiency of electro-physical plant treatment in the field depends, in specific, on the plant species, the morphology, the growth stage and the population density. The damage in the subterrestrial plant parts, such as extensive root systems, is of great importance for sustainable plant control. The damage to the root system is more severe under dry than under moist soil conditions, as the electric current can reach deeper root sections before being dissipated into the soil.

Limitations of Electroherb™ technology for primary applications were identified at high plant densities and at high lignifying plants, as well as multi-stem species (such as grasses) due to a great and dense root system and aboveground shielding effects which impede electrode contact. Combinations of processing methods for, e.g., desiccation approaches using Electroherb™ and chemical agents together, as well as direct substitution of chemical herbicides for established field preparation managements, e.g., in sugar beet cultivation, can provide farmers with efficient alternatives for weed control. An early implementation of the Electroherb™ technology in existing herbicide management and cultivation strategies appears to offer a successful advantage when complied wisely into agricultural practice.

In general, weed control in sugar beet is cost and time expensive. Average costs often exceeding 300 € ha-1 and thus account for over 20% of the total cultivation costs (LFL, 2019). Due to the high sensitivity of the sugar beet plants in the early stages of growth (< 8 leaf-stage), weed competition must be excluded in total in order to avoid yield losses. In the past, several approaches were undertaken to control weed beet and bolter populations in sugar beet cultivation with electrical power (DIPROSE et al., 1980; DIPROSE et al., 1985) and electrical weeding has proven efficacy. Legal restrictions on synthetic-chemical herbicide usage (loss of approval), increasing herbicide resistances and a more sustainable usage of pesticides (Directive 2009/128/EC), now, promoting alternative and more innovative methods for effective weed control. The application of the Electroherb™ technology as a non-chemical weed control in sugar beet have driven a series of tests in a field trial at the experimental farm Kirschgartshausen by Südzucker AG together with Zasso GmbH in 2019.

Material and Methods

The experimental trial in Kirschgartshausen comprised of two pre-emergence treatments 3 and 7 days after sowing (Tab. 1), with a mechanical (variant 2; Harrow) and three electrical treatments (variant 6 to 8; with 3 and 5 km h-1; 72 kW over 3 m application width), each in plots which were treated with and without glyphosate after field preparation and 25 days before sowing, to control elder weed plants on the site. The weed densities on 10 m2 were counted 18 days after sowing.

Tab. 1 Comparison of weed control strategies in sugar beet with focus on pre-emergence mechanical and electrical methods; here the "XPower", a prototype series of Electroherb™, was used. Glyphosate application on one half of the trial area took place 25 days before sowing (25.02.2019).

Tab. 1 *Vergleich verschiedener Unkrautregulierungsmaßnahmen im Zuckerrübenanbau. Der Fokus liegt hier auf der Vorauflaufbehandlung mit einem mechanischen und elektrischen Verfahren. Der Glyphosateinsatz erfolgte auf einer Teilfläche 25 Tage vor der Aussaat (25.02.2019).*

Variant	Pre-emergence 1	Pre-emergence 2	Weeds per 10 m² * with Glyphosate pre-sowing	without
1	-	-	23[a]	97[a]
2	-	-	14[a]	72[a]
3	-	-	17[a]	54[a]
4	-	-	13[a]	88[a]
Mean ± standard deviation			17 ± 5	78 ± 19
5	Harrow 5 km/h	Harrow 4 km/h	21[a]	72[a]
6	X-Power 3 km/h	-	16[a]	5[b]
7	-	X-Power 3 km/h	6[a]	7[b]
8	X-Power 5 km/h	-	5[b]	11[b]
Date	*25 March 19*	*29 March 19*	*9 April 19*	
Days after sowing	*3*	*7*	*18*	

** Mean across 3 replicated strips (n = 6 plots); comparisons within columns followed by different letters are significant at the 0.05 probability level (Tukey-Test)*

Results and Discussion

Outlined in Table 1, average weed densities (n=6) in a 10 m^2 area of variant 1 to 4 (no pre-emergence treatment) without glyphosate accounted for 78 ± 19 plants, 18 days after sowing. With glyphosate application before sowing, weed densities were reduced to 17 ± 5 plants 10 m^{-2}. Here, main weed species comprised of *Chenopodium album, Aethusa cynapium, Galium aparine* and *Fallopia convolvulus* L.; but also default cereal, default oilrape, and remnants of greening crops were present. The mechanical pre-emergence treatment (variant 5) showed comparable weed densities to the treatments without pre-emergence treatment, either with or without glyphosate application. In comparison, pre-emergence treatments treated with Electroherb™ (variant 6 to 8) showed significantly lower weed densities, especially in the treatments without glyphosate pre-application. In variant 6, with glyphosate application, in average 16 weed plants 10 m^{-2} were counted. This finding seems to be related to a new emerging weed population between day 3 and day 18 after sowing, especially in the area of this variant. Any significant differences between pre-emergence treatment 1 (3 days after sowing) and pre-emergence treatment 2 (7 days after sowing) were detected in weed control. However, reduced growth vitality on emerging sugar beet plants due to the rollover with the tractor even with wide tyres and low pressure under 1 bar were detected. This was more severe in pre-emergence treatment 2, with more developed seedlings. Therefore, a technical solution could be to use dual tires with sugar beet rows in between guided by RTK GPS, which will be implemented in field trials in 2020. The gained results from this well-documented field trial in sugar beet indicated that electrical weeding could have positive benefits on future weed management in sugar beet cultivation, offering additional non-chemical methods to the growers.

Overall, the effectiveness of this technology beyond the agricultural sector, e.g., in urban and home implementation presents an excellent opportunity to provide supplementary method to contentious plant protection and pest management practices.

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