The Electroherb™ Technology - A new technique supporting modern weed management

Die Electroherb™ Technologie – Ein neues Verfahren zur Unterstützung eines modernen Unkrautmanagements

Maximilian Koch[1*], Tobias Tholen[1], Pascal Drießen[2], Benjamin Ergas[1]

[1]Zasso GmbH, Aachen, Germany
[2]Nufarm Deutschland GmbH, Köln, Germany
[*]Corresponding author, maximilian.koch@zasso.com

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Abstract

The introduction of chemically based weed control has largely replaced mechanical practices. Legal restrictions on chemical herbicides with adverse environmental impacts and developing weed resistances are driving the development of new physical methods. The Electroherb™ technology is based on a non-selective, systemic electrical flow through the plants' vascular system causing severe cell destruction and ultimately 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 avoids 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 soil, the contact time and the electrode voltage and current. The efficiency of weed control in the field depends on the plant species, morphology, growth stage and population density. The damage in the subterrestrial plant parts, such as extensive root systems, is more severe under dry than moist soil conditions because the electric current can reach deeper root parts before being dissipated into the soil. Limitations of electric weed control as primary applications were identified at high lignifying plant densities, as well as multi-stem species due to shielding effects which impede electrode contact. However, combinations of mechanical methods and Electroherb™, integrated desiccation using Electroherb™ and chemicals as well as direct substitution of chemical herbicides for established cultivation methods, such as minimum tillage cultivation, can make this unique technique a sustainable substitute when chemical herbicides lose authority approvals. Hence, an early implementation of the Electroherb™ technology in existing herbicide management strategies appears to offer a successful advantage to eliminate the existing resistance problems, when complied wisely into agricultural practice.

Keywords: Electroherb™, electrical weed killing, electrical plant control, electricity in agriculture, XPower

Zusammenfassung

Die Einführung der chemisch basierten Unkrautbekämpfung hat die mechanische Praxis im vergangenen Jahrhundert weitgehend abgelöst. Gesetzliche Beschränkungen für chemische Herbizide mit negativen Umweltauswirkungen und die Entwicklung von Unkrautresistenzen treiben die Entwicklung neuer physikalischer Verfahren voran. Die Electroherb™ Technologie basiert auf einem nicht-selektiven, systemischen, elektrischen Fluss durch das Gefäßsystem der Pflanzen, der zu einer schweren Zellzerstörung und schließlich zum Welken als Wirkungsweise führt. Der physikalische Kontakt zwischen Hochspannungselektroden und der Zielpflanze ermöglicht es dem elektrischen Strom rückstandsfrei, nur zum Zeitpunkt der Anwendung, zu arbeiten und schließt genetische Selektivität aus. Die minimale Energieschwelle für eine tödliche Wirkung bezieht sich auf die, auf eine einzelne Pflanze übertragene Energie in Abhängigkeit von der Anzahl und Stabilität der zu beschädigenden Gefäßbündel, dem elektrischen Widerstand einer Pflanze und des Bodens, der Kontaktzeit sowie der Elektrodenspannung und -strom. Die Effizienz der Unkrautbekämpfung im Feld hängt von der Pflanzenart, der Morphologie, dem Wachstum und der Bestandsdichte ab. Die Schäden in den unterirdischen Pflanzenteilen, wie z.B. Rhizomen und ausgedehnte Wurzelsysteme, sind unter trockenen Bodenbedingungen schwerwiegender als unter feuchten, da der elektrische Strom tiefere Wurzelbereiche erreicht, bevor er in den Boden abgeleitet wird. Einschränkungen der elektrischen Unkrautbekämpfung, als primäre Anwendung wurden bei Pflanzenarten mit hohem Ligningehalt (höherer Pflanzenwiderstände) und bei Arten die zur Bestockung neigen festgestellt (Abschirmeffekte der Elektroden). Bei der Kombinationen von mechanischen Verfahren und Electroherb™, Sikkationsanwendungen mit Electroherb™ in Kombination mit chemischen Wirkstoffen, sowie die direkte Substitution von synthetisch-chemischen Herbiziden in etablierten Anbaumethoden kann diese innovative Technologie zu einem nachhaltigen Ersatz werden, wenn synthetisch-chemische Wirkstoffe zunehmend die Zulassung verlieren. Eine frühzeitige Implementierung der Electroherb™ Technologie in bestehende Herbizidmanagementstrategien bietet daher auch die Möglichkeit,

voranschreitende Resistenzprobleme zu beseitigen, wenn sie sinnvoll in der landwirtschaftlichen Praxis integriert werden kann.

Stichwörter: Electroherb™, elektrische Unkrautbekämpfung, elektrischer Pflanzenschutz, Elektrizität in der Landwirtschaft, XPower

The Electroherb™ Technology

Weed control with electrical energy is not an invention of the 21st century. For many decades, scientists have been developing plant control methods by destroying plant tissue with electrical energy. The Zasso Group has revived and further developed the principles of an electrical weed control method, which has now the ability to deliver a constant power to the plant irrespective of the electrical total system resistance. First developed in Brazil, Zasso has introduced the Electroherb™ technology in Europe in 2016. The basic principal is the application of a lethal dose of electrical energy to plant tissues via electrodes that are in contact with the plants. This year, a first series of prototypes of the so called "XPower" system, equipped with the latest safety features, have been applied in various field experiments for important agricultural crops.

The XPower system consists of two components: an electric generator unit mounted on the tractors rear and an applicator unit at the front of the tractor (Fig. 1). The electric generator is driven by the tractors power take-off (PTO) at a speed of 1000 rpm. This enables the system to supply the applicator independently with electrical energy. Insulated copper cables are used to connect the electric generator to the applicator unit in the front. Rectifier circuits in the high-voltage transformers mounted on the applicator convert 230 V alternating current to 700 to 8000 V direct current. The applicator unit in the front has two rows of positive electrodes and one row of negative electrodes (Fig. 1). With 24 high-voltage transformers working on a width of 3 m, the XPower works as an area applicator with a maximum output of 3 kW per electrode. This leads to a maximum power output of 72 kW, whereby the output of each electrode can be set individually.

The Electroherb™ technology can only be operated with direct current. This guarantees a constant electrical power strength over the entire time of application and allows to set a defined lethal application rate, comparable to the application dosages of chemical active agents. Correspondingly, the interaction of electrical power, driving speed, electrode contact time and electrode-surface area forms the formulation. The application rate of the Electroherb™ technology is specified with kilowatt hours per hectare [kWh ha-1]. To avoid sparking during the application due to the high-voltage, the current in the transformers is clocked via a high-current frequency and electrode tips are shielded with rubber.

The circuit closes on contact with the electrodes (1st contact, positive electrode). The current flows through the plant into the root and is derived through the soil to the second set of electrodes (2nd contact, negative electrode) where it is absorbed again. The electrical power dosages in this electrical circuit is constant and controlled by an output power control in accordance to the soil-physical conditions. The ratio of voltage to amperage is modulated according to the total system resistance, including the specific plant and soil resistance. The electrical flow from the leaf surfaces into the below-ground parts of the plant includes a systemic mode of action to control the root system of plants, making this technique comparable to the translocation of synthetic-chemical herbicides within a plant.

The Electroherb™ technology can be used in a wide range of agricultural crops and cultivation practices. In table 1, tested and recommended applications of the Electroherb™ technology for a variety of areas of application in different crop and non-crop systems with specific prototypes are outlined. Field experiments carried out in 2019, in different crops and soil orders with varying conditions, showed promising results and electric weed control can be seen as a supplement of commonly applied mechanical, thermal or chemical methods for plant control. The environmental impact of this technology can be considered very small, as experiments to monitor the population behaviour of earthworms and springtails showed that population density, 4 weeks after electrical

treatment was comparable or more stable than after chemical and mechanical treatments. Further developments of the Electroherb™ technology aim to precisely determine lethal doses of energy output required to sustainable control plants; to minimize excess energy usage and thus any impact on the environment.

Tab. 1 Application scenarios of the Electroherb™ Technology in different crops with specific applicators and prototypes which are currently developed by Zasso.

Tab. 1 *Anwendungsbereiche der Electroherb™ Technologie sowie Prototypen mit angepassten Applikatoreinheiten in verschiedenen Anbauverfahren.*

Area of application	Scenario	Type of applicator
Potato	Potato siccation	Area applicator
Sugar beet	Weed and bolter control	Area & in-row applicator
Default rape	Field preparation	Area applicator
Catch crop	Field preparation	Area applicator
Orcharding	Weed control	Bottom-stock applicator
Viticulture	Weed control	Bottom-stock applicator
Urban	Control of invasive species	Area & manual applicator
Railway	Weed control	Railway applicator

The implementation of the Electroherb™ technology for applications in urban areas, for weed control on pavements, gravel beds, railways, water ways, streets or highways showed that its usage goes beyond agricultural application scenarios. Especially reduced plant densities, and thus higher energy per plant ratios, allow this technology to control weeds and invasive species effectively in these areas.

In the beginning of 2020, final reports will summarize the results from of 2019 efficacy field trials and aim to provide the user with a general overview on the best-practice conditions for the usage in 2020.

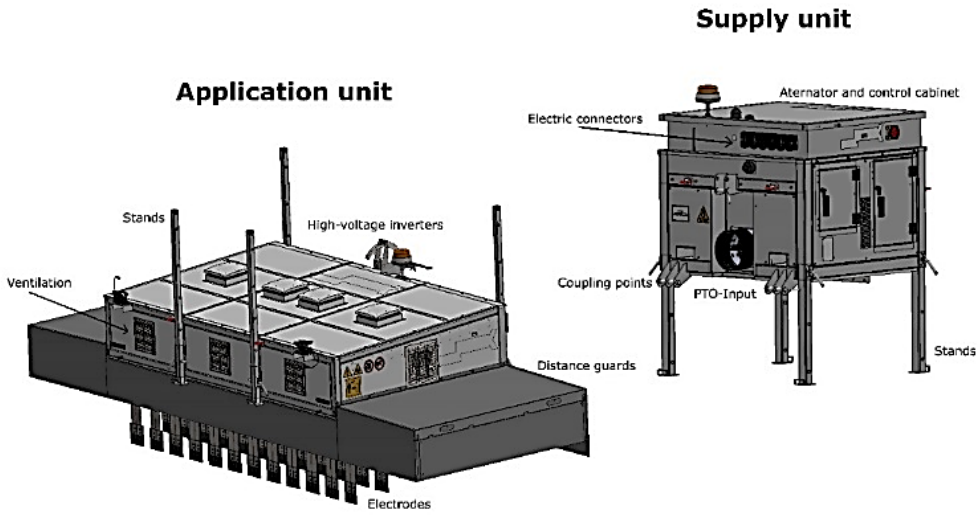

Fig. 1 Technical illustration of a Electroherb™ system (XPower) – with separated application unit and supply unit.

Abb. 1 *Technische Zeichnung eines Electroherb™ systems (Xpower) – mit separater Applikationseinheit und Versorgungseinheit.*