Session 2: In focus - arable perennial weeds

Sektion 2: Im Focus - Mehrjährige Ackerunkräuter

The challenges of arable creeping perennial weeds in research, management and perception addressed in the joint project AC/DC-weeds

Herausforderungen perennierender Ackerunkräuter für Forschung, Management und Wahrnehmung im Gemeinschaftsprojekt AC/DC-weeds

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Abstract

Creeping perennial weeds are widely distributed on arable fields. The common control practices are intensive inversion tillage and chemical herbicides. However, these methods are under pressure as they negatively affect non-target species and the environment.

The objective of the SusCrop-ERA-NET funded European project 'AC/DC-weeds' is to implement agro-ecological management for creeping perennials in arable farming. Focusing on three important perennial species in central and northern Europe (*Sonchus arvensis*, *Cirsium arvense* and *Elymus repens*), the project addresses these species using and combining different methods. In research, the existing information is checked for the contribution to knowledge. New experimental approaches focus research gaps on biology as well as tools and technologies to enable an agro-ecological management. Paying attention to the needs of farming should raise the probability for a practised agro-ecological management of creeping perennials.

Keywords: Agro-ecological management, *Cirsium arvense, Elymus repens, Sonchus arvensis*

Zusammenfassung

Ausdauernde Wurzelunkräuter sind auf landwirtschaftlichen Flächen weit verbreitet. Die üblichen Bekämpfungsmaßnahmen sind die wendende Bodenbearbeitung und der Herbizideinsatz. Diese herkömmlichen Methoden haben allerdings negative Effekte auf Nicht-Zielorganismen und Umwelt.

Das Ziel des als SusCrop-ERA-NET finanzierten EU-Projektes ‚AC/DC-weeds' ist die Einbindung agroökologischer Managementstrategien in den Ackerbau. Im Projekt werden die drei in Mittel- und Nordeuropa wichtigen Arten *Sonchus arvensis*, *Cirsium arvense* und *Elymus repens* untersucht. Dabei werden verschiedene Methoden genutzt und kombiniert. Vorhandene Informationen werden geprüft, wie sie zu Wissen beitragen können. Neue experimentelle Ansätze sollen bestehende Forschungslücken in der

Biologie der Arten schließen sowie neue Werkzeuge und Technologien prüfen, um agroökologisches Management zu ermöglichen. Die Anforderungen der Landwirtschaft einzubeziehen, erhöht dabei die Wahrscheinlichkeit praktikable agroökologische Managementstrategien gegen Wurzelunkräuter zu finden.

Stichwörter: Agrarökologisches Management, *Cirsium arvense*, *Elymus repens, Sonchus arvensis,* Wurzelunkräuter

Introduction

Creeping perennial weeds have proliferation organs allowing them survival and vegetative spread. Geophytic perennials creep below ground. Creeping organs produce buds (OTT et al., 2021). These abilities help the species to profit in many farming systems. Conventional as well as organic farming suffers from their infestations. ZHANG et al. (2020) introduced a project focusing three perennial species common in arable farming of Central – Northern Europe: *Cirsium arvense*, *Elymus repens* and *Sonchus arvensis*. Being currently widely distributed on arable fields, model studies of TØRRESEN et al. (2020) indicated that all three species will in one way or another benefit from future climate change conditions.

Although currently often propagated, a generally agreed definition of agroecological management is lacking, it is definitely more than using sustainable tools and technologies (MACLAREN et al., 2020). Therefore, the aim of AC/DC-weeds ("AC/DC-weeds- Applying and Combining Disturbance and Competition for an agro-ecological management of creeping perennial weeds") is to support a sustainable weed management rooting deeply in agro-ecological understanding and integrating new tools and technologies herein. In an agro-ecological management of creeping perennials the strong dependencies on chemical (glyphosate) and mechanical (ploughing) methods should be reduced. Replacing those by agro-ecological management requires to make use of existing knowledge on biology and ecology, close research gaps, investigate new possibilities to suppress perennials, and support the knowledge and understanding in farming practice for qualified management decisions.

AC/DC-weeds picks-up these requirements in different research approaches. ZHANG et al. (2020) gave the project structure linking seven European partners in different working packages. The proceeded project addressed these challenges using and combining different methods. In research, the existing information needs to be checked for the contribution to knowledge. New experimental approaches focus research gaps on biology as well as tools and technologies to enable an agro-ecological management. Paying attention to the needs of farming should raise the probability for a practised agro-ecological management of creeping perennials.

Tiding-up knowledge

The term agro-ecological management inherently states the importance of ecological knowledge for the management of creeping perennials in arable farming. It became clear that there is no absolute shortage in biological and ecological knowledge about two of the three species when preparing the project. However, though not quantitatively short in citable sources (except for *S. arvensis*), this knowledge seems scattered and a fundamental understanding of the success of creeping perennial weed species was missing. Therefore, all project partners contributed to a database with relevant articles on the three species. The number of papers collected in this databank so far is 203. These papers were published from 1932 to 2021. The top journals are Weed Science and Weed Research. Three quarters of the papers are comprehensive ones linking management to ecology/biology. Pure biology/ecology papers are only about 10%. About half of the papers focused on investigating and understanding disturbance. Separated for species, *C. arvense* is by far the most investigated one, much more than the second popular species, *E. repens*. In comparison, *S. arvensis* received far less attention in research. In terms of experimental types, field experiments are about double the amount as semi-fields and labs together. Modelling studies are scarce. Two third of the sources

do not concentrate on a main crop. If given, the main crops to investigate creeping perennials are cereals. The type of cropping system is only mentioned in half of the collected papers. Conventional systems are about three times more mentioned than organic systems.

Both, *C. arvense* and *E. repens* were recently each subject of an extended review (FAVRELIÈRE et al., 2020; RINGSELLE et al., 2020). Researchers in AC/DC-weeds therefore concentrate on pooling the existing information, identifying research gaps and deriving practical consequences from aggregated knowledge.

The collaborative project benefits from sharing the work for this joint collection. It performs a fundament to avoid repetitions in experimental approaches. Moreover, identifying and excerpting the robust part of the knowledge must pool expertises to avoid biased perspectives.

New experimental approaches

Perennials challenge field experiments like the farming practice through their patchy occurrence, mainly resulting from clonal growth of plants. Aerial mapping will assist both. Advances in mapping creeping perennials are most successful for *C. arvense* in cereals (RASMUSSEN et al., 2019, 2021) because *C. arvense* is occurring in large and dense patches and leaf shape differs from cereal leave shapes. Accuracy in detection has been demonstrated to be about 95% in commercial fields (RASMUSSEN et al., 2021). It is much more challenging to detect *Elymus* in cereals due to similarities in leaf shape, and accuracy will typically be lower than 80%. However, from a technical point of view, it is possible to achieve much higher accuracy but it requires low flight altitudes, and it prolongs flight times. For example, it takes about 40 minutes per hectare to capture images from 10 m flight altitude and less than 1 minute per hectare from 80 m.

A mechanical tool linked to the wish to reduce or even abstain from ploughing and intensive harrowing operations is the Kverneland horizontal rootcutter. An on-going series of supra national field experiments investigates the effect in cereal based crop rotations. WEIGEL & GEROWITT (2022) introduce the machine. The authors established an innovative experimental approach to overcome the problem of the patchy occurrence. By applying the technique of aerial supervision by drone-photographs and visual ground counts, insight in both, patch quality and quantity offers an improved assessment of the efficacy.

A chemical method to control perennial weeds offsprings from the ban or restriction of glyphosate expected or already implemented in EU-member states. The bio-based herbicidal ingredient pelargonic acid (PA) is non-selective like glyphosate, but far less efficient. However, within a framework of “many little hammers” it could be one option. Moreover, internationally, the ingredient would qualify for uses in organic farming. As broadleaved perennials are more susceptible to PA (ANDERT & GEROWITT, 2020; TRAVLOS et al., 2020). GANJI et al. (2022) clarifies the conditions for efficacy of controlling *C. arvense.* PA affects monocots like *E. repens* much less. Therefore integrating chemical control with PA in a systematic control approach is investigated (TØRRESEN et al., 2022).

Obviously, *S. arvensis* is much less investigated than the other two species. Nevertheless, the reaction of *S. arvensis* on environmental conditions seems to be more complex (TØRRESEN et al., 2020). Therefore, an on-going series of semi-field and field experiments concentrates on the ecology of this species and on timing of various mechanical disturbances on this species.

The project benefits from collaborating in experimental work. Exchanging technologies in perennials mappings enabled innovative field experimental approaches. Aerial monitoring allows better handling of creeping perennials in field experiments. On the other hand, the monitoring technologies profit from ground assessments in the experiments.

Perennials in farming

AC/DC-weeds works on four areas to support farming practice with scientific information. These are: (1) realizing general problems with creeping perennials, (2) specifically knowing where and how much, (3)

deciding how to manage them and (4) improving decisions through fundamental knowledge how the species grow and reproduce.

(1) An on-farm survey in eastern Germany indicates that conventional, conservational or organic arable farms suffer from perennial weeds, but with considerably differences between the individual farms (HAMACHER et al., 2022). While *C. arvense* is the major perennial species for conventional farmer participants, conservational and organic farmers are highly concerned about *E. repens* infestations on their fields. In Denmark, conventional farmers consider perennial weeds problematic and they request alternatives to broad applications of glyphosate (LATI et al., 2021).

(2) All steps from image acquisition with consumer-grade drones to spot spraying against *C. arvense* in cereals have been successfully demonstrated and documented (RASMUSSEN et al., 2019, 2020; LATI et al., 2021). Herbicide savings in conventional fields in the range of 70-90% are common.

(3) Practical management decisions in agro-ecosystem are supported with existing scientific and expert knowledge with the help of qualitative modelling. LACROIX et al. (2021) described the approach in details for *C. arvense*. The model provides an indicator of the risk of *C. arvense* problems according to cropping practices and the considered production situation. ROBIN et al. (2022) summarize the model structure and show practical applications**.**

As there seems to be no silver bullet to keep creeping perennials under control, their agro-ecological management require individual adaptations in each farming system. Understanding the preculiarities of the species, especially with respect to their subterranean growth and reproduction, will therefore best prepare farmers to develop own concepts adapted to their agro-ecosystem. To support this, the project partners extract their knowledge to feed a visualisation of important processes and stages in the life cycle of creeping perennial weeds (ANDERT et al., 2022).

Outlook

Joint glasshouse, field and semi-field experiments are currently analysed. Tied-up knowledge will further feed applied tools for advice management. Experimental extensions focus on seizing the effects the technologies on energy consumption and farm economic metrics.

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