Compte-rendu de fin de projet

(ANR-18-SUSC-0006)

SusCrop ERA-NET (2019-2022).

ACDC-weeds

A IDENTIFICATION

Acronyme du projet	ACDC-weeds
Titre du projet	Applying and Combining Disturbance and Competition for an agro-ecological management of creeping perennial weeds
Coordinateur du projet (société/organisme)	Prof Bärbel Gerowitt University of Rostock (UR) Faculty of Agricultural and Environmental Sciences - Crop Health Satower Straße 48, 18059 Rostock German
Période du projet	01.04.2019

(date de début – date de fin)	31.12.2022
Site web du projet, le cas échéant	www.acdc-weeds.info

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Liste des partenaires présents à la fin du projet (société/organisme et responsable scientifique)	Partner 1 (Consortium Coordinator) : University of Rostock (UR) Prof Bärbel Gerowitt Partner 2 : Norwegian University of Life Sciences (NMBU), Faculty of Biosciences Prof Lars Olav Brandsæter Partner 3 : Norwegian Institute of Bioeconomy Research - NIBIODr Kirsten Tørresen Partner 4 : Natural Resources Institute Finland Dr Jukka Salonen Partner 5 : University of Copenhagen Dr Jesper Rasmussen Partner 6 : INRA UMR AGIR Dr MH ROBIN Partner 7 : INRA UMR agronomie Dr Muriel VALANTIN-MORISON

B RESUME CONSOLIDE PUBLIC

B.1 INSTRUCTIONS POUR LES RESUMES CONSOLIDES PUBLICS

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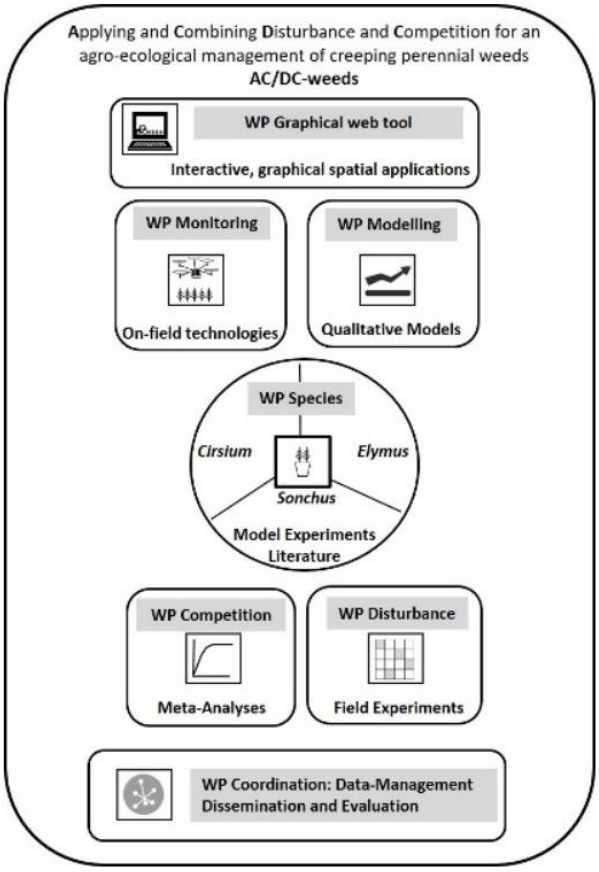
Titre : Develop agro-ecological technologies to manage creeping perennial weeds

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 supress perennials, and support the knowledge and understanding in farming practice for qualified management decisions. Focusing on three important perennial species in central and northern Europe (*Sonchus arvensis*, *Cirsium arvense*, and *Elymus repens*), the objective of AC/DC-weeds is to study these species through systematic literature reviews and experiments.

The project is organized in 7 work packages. Each work package used promising method to contribute to the objectives and to ensure outreach (fig1)



New experimental approaches

New ways of applying disturbance subterranean without turning the soil will be examined in field experiments together with defoliation strategies via cutting or biocompatible herbicides.

Joint experiments will test efficacy and practicability of these new ways. The effects of enhanced competition on creeping perennials are frequently investigated worldwide.

Existing results and grey data will be systematized in a meta-analysis. The excepted information will feed a trait-based joint database. For the most important species in Central and Northern Europe differing in biology and ecology: Elymus repens, Cirsium arvense and *Sonchus arvense* existing data will be pooled, knowledge gaps identified and closed through specific pot and semi-field experiments.

Qualitative models to analyse the impact of cropping practices, soil, weather and field environment on perennial infestations will be designed. These models can combine data from various sources including literature, survey and experimental data, and knowledge generated by expert assessment and simulation models.

Due to their clonal life-style resulting in patches monitoring whole fields is vital for the management of perennials. We follow new approaches to monitor perennials with available technical tools like cameras or sensor installed in drones or vehicles. Reliable algorithms for these applications will be developed. Space and time effects of applying disturbance and competition in whole field scenarios will be visualized in a novel way facilitated by an interactive graphical web tool. Learning about the effects of different tactics virtually applied

on own observed field infestations will support agro-ecological management in on-farm solutions.

Results

New ways of applying soil disturbance were examined in field experiments. Defoliation strategies with bio-based herbicides or cupping above ground biomass were tested.
Results from joint field experiments indicate that disturbance without inverting can almost replace the effect of ploughing between two crops. Combining root cutting with competition by cover crop increases the control effect. Collaborative pot and semi-field experiments at three locations indicate that E. repens and *C. arvense* can be managed with mechanical control strategies, while S. arvensis must be managed by a combination of different non-chemical methods. More research is needed especially with S. arvensis which is not frequently studied.
The article bank also fed a meta-analyses about suitable subsidiary crops performing competition against creeping perennials. Subsidiary crops are able to reduce weed density and biomass for some weed perennial species, with large variability.
Patchiness of perennials is suitable for monitoring. We spatially monitored perennials with cameras installed in drones (UAV). Algorithms to monitor perennials are developed and tested in experiments and in farmers' fields.
A qualitative modelling approach, adapted to creeping perennials, allowed to analyze the impact of cropping practices, soil, weather and field environment on the infestations. The model provides an indicator of the risk of *C.arvense* problems according to cropping practices and the considered production situation. The model has a user-friendly interface.

Species specific videos visualize the importance of the biology for farmers together with recommendations about the effects of disturbance and competition. English videos are subtitled in five languages (German, Danish, Finish, Norwegian, French).

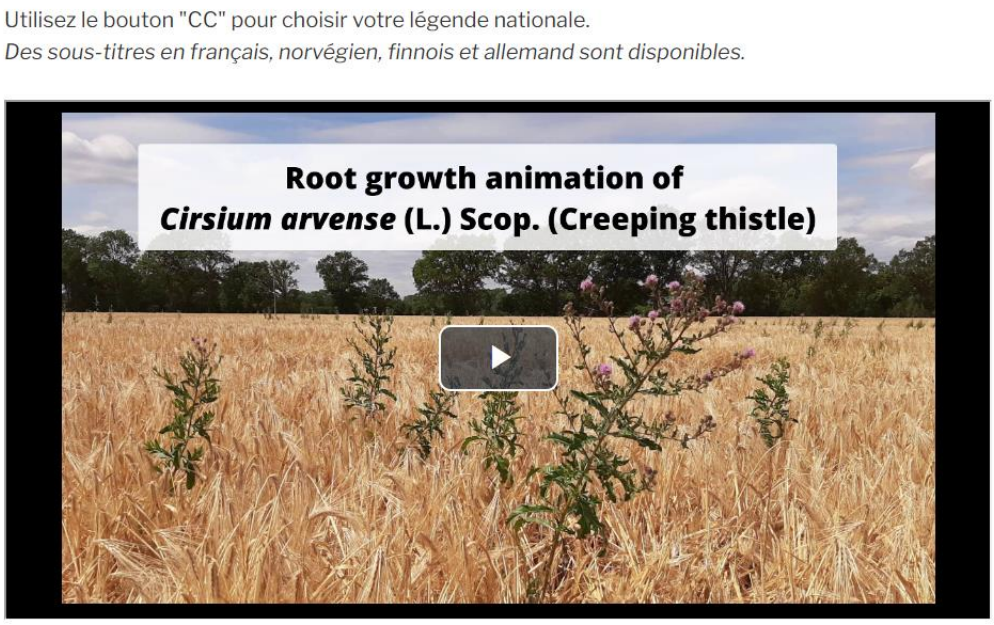


FIG 2 : VIDEO ANIMATION DE LA CROISSANCE DES RACINES C. ARVENSE

A web-site informs all users about creeping perennials and our project efforts to better manage them. The web-site ensure dissemination of the results internationally, while national stakeholders get short information in national languages via applied journals, workshops and direct communication through channels to the extension service and farmers. Hence, AC/DC-weeds addresses a range of stakeholders from the land use sector like advisors and farmers in conventional and organic farming, land owners and nature conservation. Creeping perennials can be successfully suppressed by disturbance and competition.
Based on better understanding of them, we added new knowledge in the agroecological management of creeping perennials weeds.

Le projet AC/DC weeds est un projet de recherche appliquée et innovante coordonné par Prof Bärbel Gerowitt University of Rostock. Il associe 6 autres partenaires. Le projet a commencé en avril 2019 et a duré 45 mois. Il a bénéficié d'une aide ANR de 1436000 € € pour un coût global de l'ordre de 1601000 €

B.2 RESUME CONSOLIDE PUBLIC EN FRANÇAIS

Développer des techniques agro-écologiques pour lutter contre les mauvaises herbes vivaces rampantes

L'objectif du projet AC/DC-weeds était de mettre en œuvre une gestion agro-écologique efficace pour les plantes vivaces rampantes dans les cultures arables afin de réduire le labour dans l'agriculture biologique et conventionnelle et de remplacer l'utilisation du glyphosate dans cette dernière. Le projet se concentre sur trois espèces vivaces importantes en Europe centrale et septentrionale (*Sonchus arvensis, Cirsium arvense et Elymus repens*) et utilise et combine différentes méthodes. De nouvelles approches pour la gestion agro-écologique des mauvaises herbes vivaces ont été exploitées, combinées et évaluées. Des méthodes de lutte culturale et physique ainsi que l'utilisation d'herbicides biologiques ont été testées. La réponse aux besoins des agriculteurs devrait augmenter la probabilité de l'adoption d'une gestion agro-écologique des plantes vivaces rampantes.
Sept partenaires de cinq pays européens, représentant les conditions de l'Europe centrale et septentrionale, ont collaboré à ce projet.

B.3 RESUME CONSOLIDE PUBLIC EN ANGLAIS

Implementation of agro-ecological management for creeping perennials in arable farming.

The objective of AC/DC-weeds was to implement more and better agro-ecological management for creeping perennials in arable farming to reduce plough-tillage in organic and conventional farming and replace glyphosate use in the latter. 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. Novel approaches for agro-ecological management of perennial weeds were exploited, combined and evaluated. Methods of cultural and physical control and the use of bio-based herbicides were

tested. Paying attention to the needs of farming should raise the probability for a practiced agro-ecological management of creeping perennials.
Seven partners from 5 European countries, representing Central and Northern European conditions collaborated.

C MEMOIRE SCIENTIFIQUE

Mémoire scientifique confidentiel : non

C.1 RESUME DU MEMOIRE

The objective of AC/DC-weeds was to implement more and better agro-ecological management for creeping perennials in arable farming to reduce plough-tillage in organic and conventional farming and replace glyphosate use in the latter. 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. Novel approaches for agro-ecological management of perennial weeds were exploited, combined and evaluated. Methods of cultural and physical control and the use of bio-based herbicides were tested. Paying attention to the needs of farming should raise the probability for a practiced agro-ecological management of creeping perennials.
Seven partners from 5 European countries, representing Central and Northern European conditions collaborated.

C.2 ENJEUX ET PROBLEMATIQUE, ETAT DE L'ART

Weeds have strong impact on arable production, causing yield quantity and quality losses unless controlled. On conventionally managed fields, control is usually achieved by frequent herbicide application, both selective herbicides in-crop and glyphosate in the intercrop period. Under organic production the focus is on preventive measures, physical and thermal control, like ploughing, harrowing and flaming. This project concentrates on creeping perennial weeds (= perennials). Perennials ensure their lifeform by subterranean storage organs, like roots or rhizomes. Besides seed dispersal, their subterranean clonal systems facilitates survival and spatial spread in arable fields by vegetative sprouting. They usually perform visibly patches during summer. Perennials are adapted to arable land where conditions vary depending on crops and their sequence. While perennials are ubiquitous and occur in all cropping systems, in organic farming they are particularly problematic. As perennials infest whole fields long-term, their occurrence has a socio-economic impact as they may negatively influence the land value and field renting contracts. Direct physical weeding, like harrowing, inter-row hoeing, brushing and even flaming in the crops has so far not been shown to be sufficiently effective against perennials. Organic farmers are forced to choose between leaving perennials unchallenged or an intense soil cultivation. In conventional agriculture glyphosate, applied either in the intercrop periods or shortly before harvest, has ensured efficient control of perennials during the last four decades. However, as glyphosate is expected to be increasingly restricted and probably long-term banned, reduction strategies and acceptable alternatives are urgently required. Being able

to perform effective management of perennials with less inversion tillage and without glyphosate would minimize the negative environmental impact of the cropping systems. Novel integrated weed management practices (IWM) for perennials demands to exploit, combine and evaluate agro-ecological management (AEM) consisting of cultural, physical and (bio)-chemical control. Crop and intercrop periods can be utilized to build-up a competitive vegetation cover or to disturb perennials as frequent as possible.

Perennial weed management influence several key aspects of arable farming systems, and has both short and long-term effects on environmental and economic targets. The choice of management has far-reaching consequences, whether inversion or non-inversion tillage, defoliation, cover crops or combinations are used. Some effects are direct, e.g. increased costs, nutrient leaching and soil health and erosion. Other effects are indirect: e.g. non-target weeds, other pest groups and biodiversity. Therefore, cropping systems enabling AEM of perennials must be further evaluated from an applied multidisciplinary perspective about environmental and economic effects. Environmental and economic evaluations deliver accompanying information about possible trade-offs. Implementation and up-take of technologies will depend on the general sustainability and manageability of the system. End-users and stakeholders regularly face these issues, and the outcome will make dissemination of the results more informative and successful.

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C.3 APPROCHE SCIENTIFIQUE ET TECHNIQUE ET C4 RESULTATS OBTENUS

Develop agro-ecological technologies to manage creeping perennial weeds

Partners conducted field experiments with prototypes of the root cutter provided by the committed partner. Designs and assessment information was exchanged. Results of a joint, two years experiment and additional trials are feeding publications. For the control of C.

arvense, deep root cutting (20-25 cm) was performed. Root cutting reduced patch sizes and shoot densities of C. arvense regardless of working depth, application time and field crop when used at least twice per year. Fully similar control effects to mouldboard ploughing are achieved by increasing the cutting frequency to 8 cuts per year. Done twice per year e.g., as a stubble cultivation treatment, and combined with a subsidiary crop root cutting increased the control of C. arvense to the same level as ploughing. The results indicate that it is important to establish the crop shortly after root cutting. Stubble cultivation in the autumn with the root cutter has about the same control efficiency of E. repens and S. arvensis as intensive harrow types like disc-harrows. Results indicate that root cutting in a subsidiary crop (grass/clover or mustard) provides better control of creeping perennial weeds than without a subsidiary crop. Root cutting in a subsidiary crop in autumn reduced the biomass of the subsidiary crop but did not kill the crop.

Optimize crop competition to manage creeping perennial weeds
Different intercropping systems involving an annual main crop from around the world were examined. Data from 48 scientific articles were extracted from published papers and used to build a dataset including weed infestation data covering 769 experimental units. Mixed-effect models were fitted to estimate the reduction of weed infestation associated with the use of subsidiary crops. Finally, we tested the effect of the type of subsidiary crop (monospecific subsidiary crop or mixtures, broad or narrowleaf species, families) and of subsidiary crop management techniques on weed control effectiveness. This meta-analysis shows that subsidiary crops are able to reduce weed density and biomass for some weed perennial species. Although the level effectiveness of this strategy was found to be variable among species and environmental conditions, we were unable to identify the subsidiary crop characteristics explaining this variability. Further research is needed to better identify the conditions under which subsidiary crops offer a satisfactory level of protection.

Use and expand species specific ecological data and knowledge for Sonchus arvensis, Cirsium arvensis, Elymus repens
We collected literature and indexed all article by keywords in a database. With the existing literature specific data for Elymus repens, Cirsium arvense and Sonchus arvense were pooled and knowledge gaps identified. For C. arvense the role of the deep root system for distribution and management; for S. arvensis: the link between management and dormancy in roots, and for E. repens the long-term effect of different integrated weed management strategies on the population dynamics were identified as knowledge gaps. Sonchus arvensis is much less studied than the other two species. Species specific studies resulting in semi-field trials for S. arvensis at 3 locations, field trials for S. arvensis (2 locations in Norway) and C. arvense (3 locations, and field trials for E. repens at 2 locations address knowledge gaps. The trials showed that timing of treatment is highly important for S. arvensis. Carbohydrate content analysed in spouted root fragments in pot experiments gave significant differences between C. arvense and S. arvensis. Controlling C. arvense demands for repeated disturbance during the time without a crop. For E.repens the tested treatments (mowing, pelargonic acid, increased competition) need to be combined to reduce E.repens infestation.

Map, identify and delineate perennial weeds in fields developed and tested two different approaches to pre-harvest weed map in cereals based on drone images.

The simple approach is based on the Thistle Tool programme written in MatLab, which was developed before project start as a tool for scientists. This programme is now useable for end-users. The basic algorithm is separating green plants in senescent crops. The key focus has been on Cirsium arvense (creeping thistle). Practical findings are described in Section I. The programme is applicable when farmers or other end-users know that the main contributor to green vegetation is weeds. The advanced approach is based on object oriented image analysis, which shows great potentials in separating weed species. One main disadvantage with object oriented image analysis is that it requires training and high-resolution images, which is much more demanding than the use of the simplest approach (Thistle Tool).

Support agro-ecological management decisions

Perennial weeds are a major problem in production fields, organic or conventional farming. To control them, a System approach is required. This is the aim of the work package Modelling of the European project AC/DC-weeds. Multi-attribute qualitative modelling, performed thanks to IPSIM (Injury Profile SIMulator, Aubertot et Robin, 2013), enables the evaluation of weed infestation for three perennial weeds: Cirsium arvense, Sonchus arvensis and Elytrigia repens. The models consider the effect of weather, soil and cropping practices, and their interaction on weed infestation One model has been published, IPSIM-Cirsium, that tests the effectiveness of different technical options for managing infestations of the Common thistle. This model can be used for a wide range of soil-climate conditions and cropping systems. Nevertheless, its predictive quality has only been evaluated on a French dataset (Lacroix et al, 2021). It has a user-friendly interface and is now available free of charge (https://shiny.biosp.inrae.fr/app/ipsimcirsium). The IPSIM-Cirsium modeling platform can be used by farmers as a diagnosis to simulate Cirsium damages and as a decision-making tool for their agricultural practices. The model can be used as a training resource in agroecological crop protection. Finally, researchers can use it as a prediction tool and a resource for the exchange of information. IPSIM-Cirsium is the first qualitative model developed for a perennial weed.

Spatial-temporal visualization of agro-ecological management

We systemized the growth of C. arvense and the response to management practices and visualized graphical field scenarios. The focus is on the effects of applying and combining disturbance and competition for agro-ecological management, resulting from the two-year field experiments in WP Disturbance. WP Species developed recommendations for improved management strategies. The next step was to create a storyboard of how the video will unfold, scene by scene. It was made up of several squares with illustrations and pictures representing each shot, with notes about what's going on in the scene and what is being said in the script during that shot. At this point, a visual designer was engaged for input on such elements as imagery and visual style. Based on storyboard, the C. arvense animation video was recorded. A storyboard for S. arvensis is written. The C. arvense video is implemented as an open access web application with a browser-based graphical interface (https://acdc-weeds.info/root-growth-animation). National captions (French, Norwegian, Finnish and German) are available. The Web-based interactive graphical tool (WP Web-tool) is an excellent communication and learning instrument for participatory involvement of stakeholders. The SusCrop-Platform, the European Weed Research Society (EWRS) and

national research societies of the AC/DC project partners are the key channels for distributing new scientific information internationally.

Administration, data management, communication, dissemination, environmental and economic evaluation

We signed the consortium agreement and hold a Kick-off in June 2019. Press releases went out in summer 2019. The web-site was set-up in 2019 and is continously up-dated. Communication between partners was on-line in daily business. Four project meetings happen as scheduled, 2019 and 2020 in presence, one meeting in January 2021 on-line, the last meeting in presence in September 2022 due to the project prolongation until end 2022. A large final stakeholder meeting was organised as a full, half-day session on the German Conference on Weed Biology and Control in February 2022 (on-line, approx. 200 participants from farming, industry, administration and science). National reports about stakeholder meetings were given by each partner in national language. Data about energy use of root cutting collected and measured in a practical approach shows that root cutting needs significantly less fuel than ploughing. An indexed article bank is maintained and ready to be made public. Due to the quilt of the economist scientist in January 2021, economic evaluations were methodology prepared but not performed.

C.4 EXPLOITATION DES RESULTATS

IMPACTS :

- Important for agro-ecological management of creeping perennials is to integrate new technologis with respect to biological knowledge about differences in the species. Pure technology based management strategies are much less efficient and highly endangered to create new problems. Elymus repens is vulnerable to disturbance and competition due to weak seasonal dormancy, shallow creeping rhizomes and short-lived and low-spreading seeds. Cirsium arvense creeping roots grow deeper in the soil can sprout from the intact root system even below the plough layer. Sonchus arvensis creeping roots sprouts mainly in spring and summer, thus indicating seasonal dormancy

Knowledge gaps focus on the deep root system and sexual reproduction (C. arvense), the link between withering and dormancy in roots (S. arvensis), and the long-term effect of different integrated weed management strategies on the population dynamics (E. repens). Impact in all time perspectives from short to long term.

- Using new mechanical tools can reduce undesired effects of the management of creeping perennials, while delivering satisfactory control. Varying in details caused by the biology of the species, the mainly tested equipment root cutter delivers control results high enough to maintain creeping perennials. Used as stubble cultivation (working depth approx. 10-12 cm) the root cutter has about the same control efficiency of E. repens and S. arvensis than intensive harrow types like disc-harrows. In contrast to a disc-harrow, the root cutter does not increase soil erosion and leaching of nutrients compared to untreated stubble. For the control of *C. arvense*, deep root cutting (20-25 cm) in the spring has given somewhat variable control efficiency, under optimal conditions similar effects as ploughing to the same depth. Root cutters used by partners were prototypes. Commercially produced machines must become available on the market, medium-term effects.

- A meta-analysis of available experimental data assessed if subsidiary crops are effective in controlling creeping perennial weeds and identified plant traits associated with high levels of weed control. Data from 48 scientific articles, extracted from published papers build a dataset. The results show that, subsidiary crops were able to reduce S. avensis aboveground biomass and density, and C. arvense belowground biomass and density, significantly. On the contrary, no significant effect was found for E. repens and for C. arvense aboveground biomass. The effect of subsidiary crop on C. arvense and E repens is significantly positive when it is a monospecific one and/or implemented after the harvest or when a previous tillage was realized. For S. arvensis the effect is positive when there was no previous tillage and with an undersown strategy. Subsidiary crops are able to reduce weed density and biomass for some weed perennial species, with large variability. Short term impact.

- We have succeeded in developing and testing two different approaches to pre-harvest weed mapping in cereals based on drone images (our work with deep learning is not included). A simple approach, which has been implemented in two IT-platforms used by farmers, and a more advanced approach, which has been developed and evaluated during the project. The advanced approach is considered too complex for end-users. The advanced approach is based on object based image analysis and gives the opportunity og classify different weed species based on color, size and shape. A key finding in the project is, that more advanced image analysis procedure demands high resolution images, which challenges the practical aspects of implementing UAV imagery in weed mapping and management. Short-term impact

- Multi-attribute qualitative modelling, performed with IPSIM (Injury Profile SIMulator), enables the evaluation of weed infestation for three perennial weeds, most advanced for *Cirsium arvense*. The models consider the effect of weather, soil and cropping practices, and their interaction on weed infestation. The model outputs were confronted to independent field observations collected across 6 fields, over a 16- year period in 3 sites. IPSIM-Cirsium showed a satisfactory predictive quality (accuracy of 78.2%). IPSIM-Cirsium can be used as a tool for crop advisors and researchers to assist the design of systems less reliant on herbicides, for farmers and advisers to assess ex-ante prototypes of cropping

C.5 DISCUSSION

Key practical findings / innovative solutions thanks to the project :

-Bio-based control represent alternative technologies for weed management. Bioherbicide products such as pelargonic acid can assist in agro-ecological management by terminating (1) the shoots of perennial weeds without inversion tillage. Applications at the growth stages late-elongation and seven-to-ten-leaf stages of C. arvense showed a high efficacy on shoot biomass for the application volume 400l ha-1 water. (2) Subsidiary crop in spring/autumn can be controlled by pelargonic acid without the use of glyphosate. Our results indicate a reasonable high efficacy of pelargonic acid to control subsidiary crop seven days after application. For volatile weather conditions or work bottlenecks, a short-term, but rapid destruction of subsidiary crops could be useful in arable farming.

- Prototypes of a horizontal root cutter (delivered by the committed partner Kverneland) were tested in three locations in Northern Europe. Besides the experimental results about the control

efficacy, we gained and exchanged experience on how and when to use the root cutter. This concerns soil type, soil moisture and the frequency of cutting. Moist soils prohibit the soil loosening and root cutting effect. Cutting in wet soils leads to soil compaction. It is important to set the disc coulters exactly in front of the legs. To bring down the cutter in firm soil the toplink has to be shortened. Besides serving scientific papers, these experiences were shared with farmers on field days. Moreover, they induced follow-up research to even better guide farmers in using the root-cutter in a sustainable way.
-Thistle Tool, a program not useable for end-users has been integrated into two user-friendly IT-platforms and tested in large commercial fields in Denmark. Danish farmers are in general satisfied with the weed detection power. The basic algorithm is separating green plants in senescent yellowish cereals, and the program is used when end-users know that the main contributor to green vegetation is weeds. The key focus has been on Cirsium arvense. Algorithms and procedures have been extensively tested in farmers' fields and factors affecting the detection power have been investigated. The implantation has also shown that poor image quality may constitute an issue, which reduce the weed detection power. An important factor in optimizing the weed detection is training of end-users. Especially, basic knowledge about camera settings and factors that may reduce image quality are important

New collaborative projects:

- "Spot cutting - a spatially precise technique to manage creeping perennials – development and evaluation from an environmental and farm economic perspective lead by P1, protoptype machine from committed partner, National Project Germany submitted proposal for a PhDgrant
- "Subsidiary crops, root cutting and alternative herbicides for weed management in cereals (FRAKK)" (2021-2023, lead by P3, P2 participates) -national project Norway
- "SUSWECO – Sustainable weed control in cereals by combining subsidiary crops and minimal soil disturbances" (2023-2026, lead by P2, P3 participates) - mainly national project Norway

Several articles are being written and planned for publication

P6 : IPSIM Cirsium will be re-evaluated with a new database (INRAE Dijon France), and its results transferred to stakeholders thanks to a 6 months internship (February to July 2023)

C.6 CONCLUSIONS

Key practical findings / innovative solutions:

1- Bio-based control represent alternative technologies for weed management. Bioherbicide prod-ucts such as pelargonic acid can assist in agro-ecological management by terminating (1) the shoots of perennial weeds without inversion tillage. Applications at the growth stages late-elongation and seven-to-ten-leaf stages of C. arvense showed a high efficacy on shoot biomass for the application volume 400l ha-1 water. (2) Subsidiary crop in spring/autumn can be controlled by pelargonic acid without the use of glyphosate. Our results indicate a reasonable high efficacy of pelargonic acid to control subsidiary crop seven days after application. For volatile

weather conditions or work bottlenecks, a short-term, but rapid destruction of subsidiary crops could be useful in arable farming.

2- Prototypes of a horizontal root cutter (delivered by the committed partner Kverneland) were tested in three locations in Northern Europe. Besides the experimental results about the control efficacy, we gained and exchanged experience on how and when to use the root cutter. This concerns soil type, soil moisture and the frequency of cutting. Moist soils prohibit the soil loosening and root cutting effect. Cutting in wet soils leads to soil compaction. It is important to set the disc coulters exactly in front of the legs. To bring down the cutter in firm soil the toplink has to be shortened. Besides serving scientific papers, these experiences were shared with farmers on field days. Moreover, they induced follow-up research (P1, P2, P3) to even better guide farmers in using the root-cutter in a sustainable way.

3- Thistle Tool, a programme not useable for end-users has been integrated into two user-friendly IT-platforms and tested in large commercial fields in Denmark. Danish farmers are in general satisfied with the weed detection power. The basic algorithm is separating green plants in senescent yellowish cereals, and the programme is used when end-users know that the main contributor to green vegetation is weeds. The key focus has been on Cirsium arvense. Algorithms and procedures have been extensively tested in farmers' fields and factors affecting the detection power have been investigated. The implantation has also shown that poor image quality may constitute an issue, which reduce the weed detection power. An important factor in optimizing the weed detection is training of end-users. Especially, basic knowledge about camera settings and factors that may reduce image quality are important

4- The IPSIM method with DEXi software was successfully applied. The conception of the Cirsium arvense model relies on the IPSIM platform. IPSIM is a generic modelling platform which aims at apprehending cropping practices, pedoclimates and environment factors to explain injury profiles of a single or several pests, on a specific or a set of crops. Cropping practices refer to all the cultivation techniques used in the process of crop production (e.g., tillage, harvest, sowing) pedoclimates refer to all the soil and weather components (e.g., soil texture, temperature), and environment to the abiotic or biotic parameters encountered on the field or its surrounding. All these components can be selected according to their significance in the explanation of the injury profile of the pest or pests.

5- Based on the experimental results (P1, P5) we recommend a methodological expansion when investigating creeping perennials in field experiments. Their clonal lifestyle demands to adapt the experimental design to the existing patches rather than preplanning the design. Applying this method allows to measure the spatial expansion of patches before and after a control treatment besides assessing sprouts, plants and cover in the plots. Patch expanison of creeping perennials appeared to be a crucial criterion to assess the success of control methods. We tested the root cutter cultivation tool in spring, summer and autumn on infestations of C. arvense. Here, its thistle controlling effects were best defined by its effect on reducing thistle patch size and thistle shoot density. This is fundamentally different to annual weeds, which dominate in weed control experiments.

D LISTE DES LIVRABLES

Date de livraison	N°	Titre	Nature (rapport, logiciel, prototype, données, …)	Partenaires (souligner le responsable)	Commentaires
09/2020	1	Mid-work	Rapport	Tous partenaires responsable Partenaire 1	

E IMPACT DU PROJET

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 broadcast application of glyphosate (Lati et al., 2021).

(2) All steps from image acquisition with consumer-grade drones to spot spraying against *Cirsium* in cereals have been successfully demonstrated and documented (Rasmussen et al., 2019, 2029, 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. The model has a user-friendly interface which is now available : https://shiny.biosp.inrae.fr/app/ipsimcirsiu

(4) As there seems to be no silver bullet to keep creeping perennials under control, their agro-ecological management require individual adaptions in each farming system. Understanding the peculiarities 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).

ANDERT, S., WEIGEL, M.M., GANJI, E.,GEROWITT, B., 2022: Visualizing growth of *Cirsium arvense* (L.) scop. for farmers. Julius-Kühn-Archiv

HAMACHER, M., ANDERT, S., ZHANG, H., GEROWITT, B. 2022: Praxiserfahrungen zu Wurzelunkräutern im Ackerbau. Julius-Kühn-Archiv

LACROIX, O., AUBERTOT, J., BOHANEC, M., CORDEAU, S., CORRALES, D.C., ROBIN, M., 2021: IPSIM-Cirsium, a Qualitative Expert-Based Model to Predict Infestations of *Cirsium arvense*. Frontiers in Agronomy. DOI: 10.3389/fagro.2021.655383.

LATI, R.N., RASMUSSEN, J., ANDUJAR, D., et al., 2021: Site-specific weed management—constraints and opportunities for the weed research community: insights from a workshop. Weed Research 61, 147–153. DOI: doi.org/10.1111/ wre.12469.

RASMUSSEN, J., AZIM, S., NIELSEN, J., 2021: Pre-harvest weed mapping of *Cirsium arvense* L. based on free satellite imagery – The importance of weed aggregation and image resolution. European Journal of Agronomy 130, 126373.

RASMUSSEN, J., AZIM, S., NIELSEN, J., MIKKELSEN, B.F., HØRFARTER, R., CHRISTENSEN, S., 2020: A new method to estimate the spatial correlation between planned and actual patch spraying of herbicides. Precision Agriculture 21, 713–728.

RASMUSSEN, J., NIELSEN, J., STREIBIG, J.C., JENSEN, J.E., PEDERSEN, K.S., OLSEN S.I., 2019: Pre-harvest weed mapping of *Cirsium arvense* in wheat and barley with off-the-shelf UAVs. Precision Agriculture 20, 983–999.

E.1 INDICATEURS D'IMPACT

Nombre de publications et de communications (à détailler en E.2)

Aucune publication monopartenaire

		Publications multipartenaires	Publications monopartenaires
International	Revues à comité de lecture	50	
	Ouvrages ou chapitres d'ouvrage	4	
	Communications (conférence)	25	
France	Revues à comité de lecture		
	Ouvrages ou chapitres d'ouvrage		
	Communications (conférence)		
Actions de diffusion	Articles vulgarisation	2	
	Conférences vulgarisation	1 tech et bio	
	Autres		

Autres valorisations scientifiques (à détailler en E.3)

	Nombre, années et commentaires (valorisations avérées ou probables)
Brevets internationaux obtenus	
Brevet internationaux en cours d'obtention	
Brevets nationaux obtenus	
Brevet nationaux en cours d'obtention	
Licences d'exploitation (obtention / cession)	
Créations d'entreprises ou essaimage	
Nouveaux projets collaboratifs	
Colloques scientifiques	
Autres (préciser)	1 logiciel et 2 vidéos

E.2 LISTE DES PUBLICATIONS ET COMMUNICATIONS

1. Journal article; Andert, S., Weigel, M., Ganji, E., and Gerowitt, B., Visualizing growth of Cirsium arvense (L.) scop. for farmers. Julius-Kühn-Archiv, 2022. 468: 105-109.
2. Journal article; Ganji, E., Andert, S., and Gerowitt, B., The herbicidal potential of pelargonic Acid to control Cirsium arvense (L.) scop. in relation to the timing of application and the application volume. Julius-Kühn-Archiv, 2022. 468: 86-93.
3. Journal article; Gerowitt, B., Andert, S., Brandsæter, L.O., Rasmussen, J., Robin, M-H., Salonen, J., Tørresen, K.S., and Zhang, H., The challenges of arable creeping perennial weeds in research, management and perception addressed in the joint project AC/DC weeds. Julius-Kühn-Archiv, 2022. 468: 68-72.
4. Journal article; Hamacher, M., Andert, S., Zhang, H., and Gerowitt, B., Praxiserfahrungen zu Wurzelunkräutern im Ackerbau. Julius-Kühn-Archiv, 2022. 468: 73-78.
5. Journal article; Weigel, M., and Gerowitt, B., Mechanical disturbance of Cirsium arvense - Results from a multi-year field study. Julius-Kühn-Archiv, 2022. 468: 79-85.
6. Journal article; Zhang, H., Andert, S., Brandsæter, L.O., Rasmussen, J., Robin, M-H., Salonen, J., Tørresen, K.S., Valantin-Morison, M., and Gerowitt, B., Future management of arable perennials - an introduction to the project AC/DC-weeds. Julius-Kühn-Archiv, 2020. 464: 280-285.
7. Journal article; Andert, S., Rohde, S., and Tackenberg, M., Betrieblicher Herbizid-Einsatz zur Kontrolle von Cirsium arvense in Winterweizen. Julius-Kühn-Archiv, 2022. 468: 345-352.
8. Journal article; Andert, S., Ziesemer, A, and Zhang, H., Farmers' perspectives of future management of winter oilseed rape (Brassica napus L.): A case study from north-eastern Germany. European Journal of Agronomy, 2021. 30: 126350.
9. Journal article; Andert, S., Hamacher, M., and Gerowitt, B., Hier hilft nur eine Wurzelbehandlung. Bauernzeitung, 2020. 51: 22-24.
10. Journal article; Andert, S., and Gerowitt, B., Wurzelunkräuter im Ackerbau kontrollieren – Strategien gegen Quecken und Disteln. Lumbrico, 2020. 7: 39-42.
11. Journal article; Ganji, E., and Andert, S., The herbicidal potential of pelargonic acid to control Cirsium arvense in arable farming. Book of Abstracts 19th EWRS Symposium 2022 “Lighting the Future of Weed Science”, 2022. Athens (Greece), p. 154.
12. Journal article; Ganji, E., and Andert, S., The potential of natural substances as bio-based herbicides to control arable weeds. Book of Abstracts 19th EWRS Symposium 2022 “Lighting the Future of Weed Science”, 2022. Athens (Greece), p. 205.
13. Journal article; Weigel, M., Brandsaeter, L.O., Berge, T.W., Salonen, J. Lötjönen, T., and Gerowitt, B., Two years multi-site field experiments to control perennial weed species without herbicides. Book of Abstracts 19th EWRS Symposium 2022 “Lighting the Future of Weed Science”, 2022. Athens (Greece), p. 123.
14. Journal article; Weigel, M., Andert, S., and Gerowitt, B., Monitoring patch size changes of the creeping perennial Cirsium arvense to evaluate the efficiency of control treatments. Book of Abstracts 19th EWRS Symposium 2022 “Lighting the Future of Weed Science”, 2022. Athens (Greece), p. 82.
15. Journal article; Ganji, E., Salonen, J., Gerowitt, B., and Tørresen, K.S., Sprouting potential of Sonchus arvensis under defoliation treatments in Northern Europe. Book of Abstracts 19th EWRS Symposium 2022 “Lighting the Future of Weed Science”, 2022. Athens (Greece), p. 225.
16. Journal article; Andert, S., in preparation. Working title: Controlling arable weeds with natural substances as bio-based herbicides in the intercropping period.
17. Journal article; Andert, S., in preparation. Working title: Effects of different adjuvant products on the efficacy of pelargonic acid to control arable weeds.
18. Journal article; Ganji, E., Grenzdörffer, G., and Andert, S., in preparation. Working title:

Cover crop termination by pelargonic acid as bio-based herbicide using visual and UAV assessment methods.
19. Journal article; Ganji, E., Andert, S., and Gerowitt, B., in preparation. Working title: Efficacy of pelargonic acid on Cirsium arvense and Sonchus arvensis as influenced by different initial creeping root sizes.
20. Journal article; Ganji, E; Andert, S.; and Gerowitt, B., in preparation. Working title: Effect of growth stage, adjuvant and carrier volume on the efficacy of pelargonic acid used to control perennial weeds.
21. Journal article; Ganji, E., Defant, F., Tørresen, K., Salonen, J., Gerowitt, B., in preparation. Working title: Shoot cutting of Sonchus arvensis effects the plant productivity in the following year depending on season and site – two years experiment on three sites in Northern Europe.
22. Journal article; Weigel, M., Gerowitt, B., Andert, S., Alt, M., Weiß, K., and Müller, J., in preparation. Working title: Carbohydrate dynamics in roots of Cirsium arvense (L.) Scop. and Sonchus arvensis L. - a contribution to the compensation point debate.
23. Journal article; Weigel, M., Andert, S., and Gerowitt, B., in preparation. Working title: Monitoring patch size changes of the creeping perennial Cirsium arvense to evaluate the efficiency of control treatments.
24. Journal article; Weigel, M., Brandsaeter, L.O., Berge, T.W., Salonen, J. Lötjönen, T., and Gerowitt, B., in preparation. Working title: Controlling perennial weeds non-chemically: two years multi-site field experiments in Northern Europe.
25. Journal article; Hamacher, M., Guguin, J., Andert, S., Valantin-Morison, M., and Gerowitt, B., in preparation. Working title: How farmers perceive perennial weeds in Northern France and Eastern Germany.
26. Journal article; Hamacher, M., Weigel, M., Andert, S., and Gerowitt, B., in preparation. Working title: Do farmers save diesel by replacing ploughing with root cutting to control perennial weeds?
27. Journal article; Bergo, K., Tørresen, K.S., and Brandsæter, L.O., Leter etter alternativer. Norsk Landbruk, 2021. 6.
28. Journal article; Brandsæter, L.O., Salonen, J. Lötjönen, T., Skagestad, Ø., Torp, T., and Tørresen, K.S., in preparation. Working title: Experiments with subsidiary crops and mechanical weeding in Norway and Finland.
29. Journal article; Brandsæter, L.O., Mangerud, K., Skagestad, Ø., Lundkvist, A., Verwijst, T., and Børresen, T., in preparation. Working title: Kverneland root cutter: Effects on creeping perennial weeds, crop yield, soil erosion and nutrition leaching.
30. Journal article; Skagestad, Ø., Tørresen, K.S., and Brandsæter, L.O., Effect of early and late mechanical treatments in autumn on bud growth and long-term control of Sonchus arvensis in spring cereals. Book of Abstracts 19th EWRS Symposium 2022 “Lighting the Future of Weed Science”, 2022. Athens (Greece), p. 32.
31. Journal article; Skagestad, Ø., Tørresen, K.S., and Brandsæter, L.O., in preparation. Working title: Effect of timing of mechanical treatments in autumn on bud growth and control of Sonchus arvensis in spring cereals.
32. Journal article; Tørresen, K.S., Ringselle, B., Brandsæter, L.O., and Salonen, J., in preparation. Working title: Management of Elymus repens by combining autumn mowing, pelargonic acid and crop competition.
33. Journal article; Tørresen, K.S., Fykse, H., Rafoss, T., and Gerowitt, B., Autumn growth of three perennial weeds at high latitude benefits from climate change. Global Change Biology, 2019. 26 (4): 2561-2572.
34. Journal article; Tørresen, K.S., Ringselle, B., Brandsæter, L.O., and Salonen, J., Autumn mowing and pelargonic acid can suppress Elymus repens abundance especially when combined with increased crop competition. Julius-Kühn-Archiv, 2022. 468: 100-104.
35. Journal article; Tørresen, K.S., Salonen, J., Brandsæter, L.O., Ringselle, B., Weigel, M., Ganji,

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36. Journal article; Tørresen, K.S., and Gerowitt, B., in review: Late autumn ramet sprouting of three arable creeping perennial weed species, Agronomy.
37. Journal article; Tørresen, K.S., and Gerowitt, B., in preparation. Working title: Frost affects ramet sprouting of arable perennials.
38. Journal article; Rasmussen, J., Azim, S., and Nielsen, J., Pre-harvest weed mapping of Cirsium arvense L. based on free satellite imagery – The importance of weed aggregation and image resolution. European Journal of Agronomy, 2021. 130: 126373.
39. Journal article; Lati, R.N., Rasmussen, J., Andujar, D., Dorado, J., Berge, T.W., Wellhausen, C., Pflanz, M., Nordmeyer, H., Schirrmann, M., Eizenberg, H., Neve, P., Jørgensen, R.N., and Christensen, S., Site-specific weed management—constraints and opportunities for the weed research community: Insights from a workshop. Weed Research, 2021. 61: 147-153.
40. Journal article; Rasmussen, J., Azim, S., Nielsen, J., and Andreasen, C., in preparation. Working title: Detecting weeds in pre-harvest cerials based on UAV images - the importance of image quality.
41. Journal article; Salonen, J. and Lötjönen, T., Agrologista otetta kestorikkakasvien torjuntaan. Kasvinsuojeluseuran ”Kasvinsuojelupäivä 2020”, 2020. 36.
42. Journal article; Salonen, J., Brandsæter , L.O., Gerowitt, B., Rasmussen, J., Robin, M-H., Tørresen, K. and Valantin-Morison, M., Agro-ecological management of creeping perennial weeds (AC/DC-weeds). Suomen Maataloustieteellisen Seuran Tiedote, 2020. 37: 313.
43. Journal article; Salonen, J., and Lötjönen, T., Uutta tietoa ja tekniikkaa kestorikkakasvien mekaaniseen torjuntaan. Suomen Maataloustieteellisen Seuran Tiedote, 2022. 39: 45.
44. Journal article; Lötjönen, T., Virkkula, V. & Valtonen, O., Luomukoetoiminnalla parempia satoja ja päästösäästöjä. Research brings better yields and decreases emissions in organic farming. Suomen Maataloustieteellisen Seuran Tiedote, 2022. 39: 148
45. Journal article; Lötjönen, T., Rikkakasvien hallinta uudistavassa viljelytavassa. Luomulehti, 2020. 5: 16-17.
46. Journal article; Heikkilä, M., Kestorikkakasvit kuriin ilman kemiaa. Maatilan Pellervo, 2021. 12: 44-45.
47. Journal article; Robin, M-H., Lacroix, O., Aubertot, J.-N., Bohanec, M., and Cordeau, S., IPSIM-Cirsium, a qualitative expert-based model to predict infestations of Cirsium arvense. Julius-Kühn-Archiv, 2022. 468: 94–99.
48. Journal article; Robin, M-H., Lacroix, O., Aubertot, J.N., and Doizy, A., Un OAD pour gérer le chardon des champs. Phytoma, 2022. 751.
49. Journal article;Guguin, J., and Valantin-Morison, M., Les couverts végétaux, un levier dans la gestion des vivaces (chardon, laiteron, chiendent, rumex) en grandes cultures? Enquêtes auprès d’agriculteurs et d’autres experts. Revue AE&S 12-1, Adventices et couverts végétaux, 2022. Numéro ISSN 1775-4240.
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51. Book section; Gerowitt, B., and Baraibar, B., Advances in managing arable weed propagules. In: Kudsk, P. (Ed.), 2022. 47-84.
52. Book section; Tørresen, K.S., Jordbruket trenger alternativer til glyfosat, Baumann, C. (ed.). Grønn kunnskap – 39 smakebiter fra NIBIOs virksomhet i 2020, NIBIO Bok 7(2) 2021, page 8. ISBN: 978-82-17-02750-8.

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55. Masterthesis; Hass, F., Eindringwiderstand und Gefügemerkmale des Bodens unter dem Einfluss des Root-Cutters - ein neues Gerät zur mechanischen Bekämpfung von Wurzelunkräutern, Agrar- und Umweltwissenschaftliche Fakultät, Universität Rostock, 2020.
56. Masterthesis; Hamacher, M., Farmers perceptions of perennial arable weeds - results of a survey in Eastern Germany, Agrar- und Umweltwissenschaftliche Fakultät, Universität Rostock, 2022.
57. Masterthesis; Skagestad, Ø., Effect of early and late mechanical treatments in autumn on bud growth and control of Sonchus arvensis in spring cereals. Norwegian University of Life Sciences, Faculty of Biosciences.
58. Masterthesis; Lacroix, O., Qualitative modelling of perennial weed management Elytrigia repens, Cirsium arvense and Sonchus arvensis. Agrocampus Ouest, Rennes, France, 2020.

59. Presentation, oral; Weigel, M., Brandsaeter, L.O., Berge, T.W., Salonen, J., Lötjönen, T., and Gerowitt, B., Two years multi-site field experiments to control perennial weed species without herbicides, 19th EWRS Symposium 2022 "Lighting the Future of Weed Science", Athens, Greece, 2022.
60. Presentation, oral; Weigel, M., Andert, S., and Gerowitt, B., Monitoring patch size changes of the creeping perennial Cirsium arvense to evaluate the efficiency of control treatments, 19th EWRS Symposium 2022 "Lighting the Future of Weed Science", Athens, Greece, 2022.
61. Presentation, oral; Ganji, E., and Andert, S., The herbicidal potential of pelargonic acid to control Cirsium arvense in arable farming, 19th EWRS Symposium 2022 "Lighting the Future of Weed Science", Athens, Greece, 2022.
62. Presentation, oral; Ganji, E., and Andert, S., The potential of natural substances as bio based herbicides to control arable weed, 19th EWRS Symposium 2022 "Lighting the Future of Weed Science", Athens, Greece, 2022.
63. Presentation, oral; Andert, S., Weigel, M., Ganji, E., and Gerowitt, B., Visualizing growth of Cirsium arvense (L.) scop. for farmers, 30th German Conference on Weed Biology and Weed Control, online, 2022.
64. Presentation, oral; Ganji, E., Andert, S., and Gerowitt, B., The herbicidal potential of pelargonic Acid to control Cirsium arvense (L.) scop. in relation to the timing of application and the application volume, 30th German Conference on Weed Biology and Weed Control, online, 2022.
65. Presentation, oral; Gerowitt, B., Andert, S., Brandsæter, L.O., Rasmussen, J., Robin, M-H., Salonen, J., Tørresen, K.S., and Zhang, H., The challenges of arable creeping perennial weeds in research, management and perception addressed in the joint project AC/DC weeds, 30th German Conference on Weed Biology and Weed Control, online, 2022.
66. Presentation, oral; Hamacher, M., Andert, S., Zhang, H., and Gerowitt, B., Praxiserfahrungen zu Wurzelunkräutern im Ackerbau, 30th German Conference on Weed Biology and Weed Control, online, 2022.
67. Presentation, oral; Weigel, M., and Gerowitt, B., Mechanical disturbance of Cirsium arvense - Results from a multi-year field study, 30th German Conference on Weed Biology and Weed Control, online, 2022.
68. Presentation, oral; Zhang, H., Andert, S., Brandsæter, L.O., Rasmussen, J., Robin, M-H.,

Salonen, J., Tørresen, K.S., Valantin-Morison, M., and Gerowitt, B., Future management of arable perennials - an introduction to the project AC/DC-weeds, 30th German Conference on Weed Biology and Weed Control, online, 2022.
69. Presentation, oral; Andert, S., Rohde, S., and Tackenberg, M., Betrieblicher Herbizid Einsatz zur Kontrolle von Cirsium arvense in Winterweizen, 30th German Conference on Weed Biology and Weed Control, online, 2022.
70. Presentation, oral; Gerowitt, B., Weeds in a Changing Climate, Workshop of the Aspen Global Change, Institute (AGCI) on Food System Impacts of Pests & Pathogens in a Changing Climate, Aspen, CO, US, 2019.
71. Presentation, oral; Gerowitt, B., Pflanzenschutz mit weniger oder anderer Chemie? DAF Tagung, Ökologisierung der Landwirtschaft, online, 2020.
72. Presentation, oral; Ganji, E., Salonen, J., Gerowitt, B., and Tørresen, K.S, Sprouting potential of Sonchus arvensis under defoliation treatments in Northern Europe. 19th EWRS Symposium 2022 "Lighting the Future of Weed Science", Athens, Greece, 2022.
73. Presentation, oral; Skagestad, Ø., Tørresen, K.S., and Brandsæter, L.O., Effect of early and late mechanical treatments in autumn on bud growth and long-term control of Sonchus arvensis in spring cereals. 19th EWRS Symposium 2022 "Lighting the Future of Weed Science", Athens, Greece, 2022.
74. Presentation, oral; Robin, M-H., Lacroix, O., Aubertot, J.-N., Bohanec, M., and Cordeau, S., (2022). IPSIM-Cirsium, a qualitative expert-based model to predict infestations of Cirsium arvense, 30th German Conference on Weed Biology and Weed Control, online, 2022.
75. Presentation, oral; Rasmussen, J., Implementing spot spraying against Cirsium arvense based on UAV imagery in commercial farming – a case study. European Weed Research Society Working Group Meeting on Site Specific Weed Management, 30.October 1.November, University of Southern Denmark Odense, Denmark, 2019.
76. Presentation, oral; Salonen, J., Uutta tietoa ja tekniikkaa kestorikkakasvien mekaaniseen torjuntaan. Maataloustieteen Päivät, Helsinki, 2022.
77. Presentation, oral; Lötjönen, T., Virkkula, V. & Valtonen, O., Luomukoetoiminnalla parempia satoja ja päästösäästöjä. Maataloustieteen Päivät, Helsinki, 2022.
78. Presentation, oral; Agrologista otetta kestorikkakasvien hallintaan. Luomupäivät, online, 2020.
79. Poster presentation; Tørresen, K.S., Ringselle, B., Brandsæter, L.O., and Salonen, J., Autumn mowing and pelargonic acid can suppress Elymus repens abundance especially when combined with increased crop competition. 30th German Conference on Weed Biology and Weed Control, online, 2022.
80. Poster presentation; Tørresen, K.S., Salonen, J., Brandsæter, L.O., Ringselle, B., Weigel, M., Ganji, E., and Gerowitt, B., Managing Cirsium arvense, Sonchus arvensis and Elymus repens in northern European arable farming – where are significant knowledge gaps?, 19th EWRS Symposium 2022 "Lighting the Future of Weed Science", Athens, Greece, 2022.
81. Poster presentation; Robin, M-H., IPSIM-Cirsium, a qualitative expert-based model to predict infestations of Cirsium arvense, 19th EWRS Symposium 2022 "Lighting the Future of Weed Science", Athens, Greece, 2022.
82. Poster presentation; Salonen, J., Brandsæter, L.O., Gerowitt, B., Rasmussen, J., Robin, M H., Tørresen, K. and Valantin-Morison, M., Agro-ecological management of creeping perennial weeds (AC/DC-weeds). Maataloustieteen Päivät, Helsinki, 2020.
83. Poster presentation; Salonen, J. and Lötjönen, T., Agrologista otetta kestorikkakasvien torjuntaan. "Kasvinsuojelupäivä 2020", Hämeenlinna, 2020.
84. Poster presentation; Guguin, J., and Valantin-Morison, M., Impact of subsidiary crops through competition on major creeping perennial weeds: a meta-analysis, 19th EWRS Symposium 2022 "Lighting the Future of Weed Science", Athens, Greece, 2022

E.3 LISTE DES ELEMENTS DE VALORISATION

2 videos :

ANIMATION DE LA CROISSANCE DES RACINES C. ARVENSE : HTTPS://ACDC-WEEDS.INFO/ROOT-GROWTH-ANIMATION

ANIMATION DU CYCLE DE VIE S. ARVENSIS : HTTPS://ACDC-WEEDS.INFO/LIFECYCLE-ANIMATION-S-ARVENSIS

1 logiciel :

IPSIM-CIRSIUM

La plateforme de modélisation IPSIM-Cirsium peut être utilisée par les agriculteurs comme diagnostic pour simuler les dégâts de C. arvense et comme outil d'aide à la décision pour leurs pratiques agricoles. Le modèle peut être utilisé comme ressource de formation en protection agroécologique des cultures. Enfin, les chercheurs peuvent l'utiliser comme un outil de prédiction et une ressource pour l'échange d'informations.
IPSIM-Cirsium est le premier modèle qualitatif développé pour une adventice vivace.

http://shiny.biosp.inrae.fr/app/ipsimcirsium

E.4 BILAN ET SUIVI DES PERSONNELS RECRUTES EN CDD (HORS STAGIAIRES)

Ce tableau dresse le bilan du projet en termes de recrutement de personnels non permanents sur CDD ou assimilé. Renseigner une ligne par personne embauchée sur le projet quand l'embauche a été financée partiellement ou en totalité par l'aide de l'ANR et quand la contribution au projet a été d'une durée au moins égale à 3 mois, tous contrats confondus, l'aide de l'ANR pouvant ne représenter qu'une partie de la rémunération de la personne sur la durée de sa participation au projet.
Les stagiaires bénéficiant d'une convention de stage avec un établissement d'enseignement ne doivent pas être mentionnés.

Les données recueillies pourront faire l'objet d'une demande de mise à jour par l'ANR jusqu'à 5 ans après la fin du projet.

Identification				Avant le recrutement sur le projet			Recrutement sur le projet				Après le projet				
Nom et prénom	Sexe H/F	Adresse email (1)	Date des dernières nouvelles	Dernier diplôme obtenu au moment du recrutement	Lieu d'études (France, UE, hors UE)	Expérience prof. Antérieure, y compris post-docs (ans)	Partenaire ayant embauché la personne	Poste dans le projet (2)	Durée missions (mois) (3)	Date de fin de mission sur le projet	Devenir professionnel (4)	Type d'employeur (5)	Type d'emploi (6)	Lien au projet ANR (7)	Valorisation expérience (8)
LACROIX Octave	H	octave.lacroix@inrae.fr	Décembre 2022	ingénieur	France		Partenaire 6	Stage puis CDD ingénieur	15 mois		Recherche emploi				
CORRALES MUNOZ David Camilo	H	David-Camilo.Corrales-Munoz@inrae.fr	Janvier 2023	Post doc	Colmbie	Post doc	Partenaire 6	CDD ingénieur	9 mois	31/8/2020	CDD	INRAE	ingénieur	non	