ASSOCIATION OF APPLIED BIOLOGISTS
PESTICIDE APPLICATION GROUP

President: **Professor Mike Gooding**

Targeted Application, Spray Technology and Authorisation Workshop

In-person event hosted at WICC Wageningen, The Netherlands

10-11th May 2023

PROGRAMME, ABSTRACTS & DELEGATE LIST

Association of Applied Biologists, Warwick Enterprise Park, Wellesbourne, Warwick CV35 9EF, UK
Registered Charity No. 1195899; http://www.aab.org.uk
Tel: +44 (0)2476 999485 Email: John@aab.org.uk

Targeted Application, Spray Technology and Authorisation Workshop

Scientific organisation by JAN VAN DE ZANDE
WUR Wageningen, The Netherlands

Recent developments of pesticide application technology are in the fields of precision spraying, precise targeting, variable rate application, spot spraying, and improved sprayer efficiency resulting in increased on-target spray deposit and biological efficacy.

These new spray technology developments generally use lower doses of pesticides and can therefore be of influence on spray drift, ground deposition in the field and on the residue levels in produce and the environment.

The lower dose of pesticides used with these techniques and the localised application of e.g. task-map based and spot spray applications result in a lower amount of pesticide applied to the field and a non-homogenous distribution in the field which is at the moment not addressed in the authorisation procedure of pesticides.

This workshop wants to bring together practical experience, scientific knowledge and regulators insights and methodologies to address the potential use of precision application technology in the pesticide authorisation procedure.

PROGRAMME

Wednesday 10th May

9:00 **REGISTRATION**

09:45 **WELCOME and INTRODUCTION**

JAN HUIJSMANS (WUR Wageningen – Spray Technology Research, The Netherlands)

Welcome to WUR Wageningen

EMILIO GIL (Universitat Politécnica De Catalunya, Spain)

Introducing the AAB-PAG and upcoming events

JAN VAN DE ZANDE (WUR Wageningen, The Netherlands)

Introduction to the Workshop

Session One: Practice and Research

CHAIR: JAN VAN DE ZANDE (WUR Wageningen, The Netherlands)

10:00 **Precision dosing and spraying in the Dutch National Fieldlab Precision agriculture and Farm of the Future**

JOS TIELEN (WUR Wageningen, The Netherlands)

10:30 **Targeted spray weed control in specialty crops: Historical and current performance and issues**
DURHAM K GILES (University of California, Davis, USA)

11:00 ***COFFEE***

11:30 **Precision Agriculture and Crop Protection: Definitions and the relation between precision applications and the authorisation procedure of PPPs**
KOEN VAN BOHEEMEN (Agrosystems Research, Wageningen Plant Research, The Netherlands)

12:00 **New application techniques and authorisation of plant protection products**
ANNE STEENBERGH (College voor de toelating van gewasbeschermingsmiddelen en biociden (Ctgb), The Netherlands)

12:30 ***LUNCH***

Session Two: Arable Crops
CHAIR: EMILIO GIL (Universitat Politécnica De Catalunya, Spain)

13:30 **Strategies for the targeted application of herbicides to arable and horticultural field crops**
PAUL C H MILLER (Silsoe Spray Applications Unit Ltd, UK)

13:50 **Innovation in application technology for emission free crop protection**
GERRIT VAN STEENBERGEN (Wageningen Plant Research, The Netherlands)

14:10 **How to better consider targeted spray application: The case of local *vs*. global dosage definition**
JEAN-PAUL DOUZALS (Université de Montpellier, France)

14:30 **Recent advances in ultra-high precision plant-level spot spraying application using AI plant recognition**
STEVE TANNER (Ecorobotix SA, Switzerland)

14:50 **The bumpy road towards innovative spraying techniques**
PETER KNIPPELS (LTO Netherlands, The Netherlands)

Short Poster Talks

15:10 ***P1***
Deposition of pesticides *via* spray drift in off-crop vegetation: Study of the vertical and horizontal distribution in flower strips
THOMAS POIGER (Agroscope, Wädenswil, Switzerland)

15:15 ***P2***
Spray deposition from a remotely piloted aircraft on the corn crop
JOãO PAULO ARANTES RODRIGUES DA CUNHA (Federal University of Uberlândia, Brazil)

15:20 ***P3***
Go-Phytodron project: Unmanned Aerial Spraying Systems (UASS) in forest and 3D crops
ESTHER GARCÍA-MONTERO (Corteva, Sevilla, Spain)

15:30 ***TEA and POSTERS***

Session Three: New technology and Methods

16:00 **Optimum flight height for the control of desert locusts using Unmanned Aerial Vehicles (UAV)**
VIOLET OCHIENG (CAB International (CABI), Nairobi, Kenya)

16:20 **Methods for evaluation of a spot spraying system in combination with weed detection system**
PETER HLOBEN (John Deere GmBH & Co. KG, Mannheim, Germany)

16:40 **Introducing precision applications and risk reduction tools in regulatory dossiers: crop protection manufacturers vision**
ERIC KIERS (CropLife Europe, The Netherlands)

17:00 **Modelling spray drift in precision spray applications**
HENK JAN HOLTERMAN (Wageningen University and Research, Agrosystems Research, The Netherlands)

17:20 **The EU pesticides legislation: Conditions of use to reduce exposure and risk**
MÓNICA GARCÍA AGUILAR (Policy Officer at European Commission, DG SANTE, Belgium)

17:40 ***Plenary discussion***
EMILIO GIL (Universitat Politécnica De Catalunya, Spain)
JAN VAN DE ZANDE (WUR Wageningen, The Netherlands)

18:00-18:45 ***Poster Session and Informal drinks***

19:00 ***Conference Dinner***

Thursday 11th May

Session Four: Bush and Tree Crops
CHAIR: JAN VAN DE ZANDE (WUR Wageningen, The Netherlands)

09:00 **Targeted application to the basal part of trunk to control the woolly apple aphid (*Eriosoma lanigerum*)**
DANIEL BONDESAN (Technology Transfer Centre, Edmund Mach Foundation, Italy)

09:20 **Preliminary analysis of satellite base canopy characterization in the vineyard for prescription map generation**
EMILIO GIL (DEAB, Universitat Politècnica de Catalunya, Barcelona, Spain)

09:40 **Precision application technology in fruit crops in The Netherlands**
MARCEL WENNEKER (Wageningen Plant Research, The Netherlands)

10:00 **Field experiences in flow rate control through pressure changes and PWM control for intelligent application spray systems in 3D-crops**
EMILIO GIL (DEAB, Polytechnic University of Catalonia, Barcelona, Spain)

10:20 ***COFFEE and POSTERS***

Session Four: Bush and Tree Crops (Continued)
CHAIR: JAN VAN DE ZANDE (WUR Wageningen, The Netherlands)

10:50 **Analysis of the Efficiency of a Variable Rate Sprayer**
LARS TORSTEN BERGER (Pulverizadores Fede S.L.U., Valencia, Spain)

11:10 **A non-dietary risk assessors' perspective of precision application and the challenge of conservative assumptions**
ALEX GREGORY (Risk Assessment at Syngenta, Jealott's Hill International Research Centre, UK)

11:30 **Real-time and task map precision spray applications for weeds and diseases: Use cases developed at ILVO Living Lab Agrifood Technology**
DAVID NUYTTENS (Flanders Research Institute for Agriculture, Fisheries and Food (ILVO), Belgium)

12:00 ***Plenary Discussion***
EMILIO GIL (Universitat Politécnica De Catalunya, Spain)
JAN VAN DE ZANDE (WUR Wageningen, The Netherlands)

12:30 ***LUNCH***

Session Five: New Technology and Conclusions

13:30 **Spot spraying in vegetable row crops: Advancing step by step**
MARTINA KELLER (Vegetable-Production Extension, Agroscope, Switzerland)

13:50 **Development of a digital label: DriftRadar as a case study**
ANDREW C CHAPPLE (Bayer AG, Germany)

14:10 ***Plenary Discussion***
EMILIO GIL (Universitat Politécnica De Catalunya, Spain)
JAN VAN DE ZANDE (WUR Wageningen, The Netherlands)

14:40 ***TEA, CONCLUDING REMARKS and CONFERENCE END***

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ENQUIRIES

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Session One: Practice and Research

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Precision dosing and spraying in the Dutch National Fieldlab Precision agriculture and Farm of the Future

CORNE KEMPENAAR, K VAN BOHEEMEN, J TIELEN, F SIJBRANDIJ, J M MICHIELSEN, B VELDHUISEN and A VAN DER MEER

Wageningen Plant Research, P.O. Box 16, 6700 AA Wageningen, The Netherlands

ABSTRACT

Results and views from two ongoing projects will be presented. In these projects, farmers and researcher work on minimum pesticide use by applying advanced technology and knowledge on need, timing and precision application of pesticides in all types of field crops in The Netherlands. In these projects, we used different precision sprayers and different decision support to optimize crop management while meeting environmental and societal challenges. We will present an overview of technologies and decision support applied, and results achieved. We will also share the few on monitoring precision application of pesticides within the National Strategic Plan for agriculture, e.g. the use of as applied maps of variable rate and spot spraying.

Targeted spray weed control in specialty crops: Historical and current performance and issues

DURHAM K GILES

University of California, Davis, Davis, CA 95616 USA

ABSTRACT

While recent developments in autonomous vehicles, image processing and artificial intelligence have advanced highly targeted spray application, the concept has a two-decade history of research and deployment in Western U.S. vegetable crops. Despite the changes in technology of the targeted spray delivery, the selection of the active compound and adjuvants in the spray formulation are a critical component in the efficacy and regulatory approvals for operations. While pest control materials approved for organic production are available, for example for weed control, their efficacy and consistency of performance can be limited. Conventional, synthetic materials can provide reliable control yet may not have registrations for use in target crops at the required stages of crop development. A further complication in the overall process is the use of spray adjuvants for enhanced coverage, penetration and efficacy of herbicides and the management of non-target deposition. Use of common adjuvants can be prevented by lack of registration and approval on organic crops and variability in performance. This presentation will address the historical and current status of material selection and use in targeted weed control.

Precision Agriculture and Crop Protection: Definitions and the relation between precision applications and the authorisation procedure of PPPs

KOEN VAN BOHEEMEN, J F M HUIJSMANS and H J HOLTERMAN

Agrosystems Research, Wageningen Plant Research, The Netherlands

ABSTRACT

Precision crop protection applications have the potential to reduce environmental impact of the crop protection operation. Discussions on which applications deserve the label *precision application* and the lack of reliable figures on the magnitude of beforementioned impact reduction are important topics of research and within authorisation organisations. Clear definitions on precision crop protection have been drafted and illustrated using examples. An application is only considered a precision application when the application, for each location in the field, takes relevant measurements and decides on whether application is required and/or what is the minimum optimal dosage based on the measurements and accurately applies the decision in practice. Applications are characterised based on their approach, where *variable rate* applications treat the entire field while determining the minimum optimal dosage per location and where *spot-spraying* applications aim to treat only where necessary. *Hybrid* applications combining variable rate and spot-spraying are also considered. Furthermore, precision applications can be characterised as *on-the-go* application or *chained* application. Finally, five different meanings of the word *dose* are characterised so that exact descriptions of precision applications and their results can be made, which is of great importance for authorisation. Collectively adopting posed definitions within crop protection could give a substantial boost in the adoption of precision crop protection applications, contributing to reduction of environmental impact of the application of PPPs.

New application techniques and authorisation of plant protection products

ANNE STEENBERGH

College voor de toelating van gewasbeschermingsmiddelen en biociden (Ctgb), Bennekomseweg 41, 6717 LL Ede, Netherlands

ABSTRACT

New techniques for the application of plant protection products (PPP) may lead to a reduced use and emission of PPP and thereby contribute to reaching the Dutch and EU policy goals.

Some types of new techniques can already be used by farmers. For example precision applications such as spot-wise treatment or variable dose rates based on conventional application techniques are possible for authorised (full-field) uses. However, using the full potential of these types of precision applications to reduce the use of PPP is not yet possible; for example, more frequent applications may be needed for precision applications than authorised.

Use-rate reduction by precision-application techniques may therefore be facilitated be allowing farmers more flexibility in their applications. A first step towards this higher flexibility could be to determine the (legal) preconditions to allow a higher flexibility for already approved (conventional) uses and for future authorisations. The areas to be covered include the risk and efficacy assessment and also compliance and enforcement of authorised uses.

For other types of innovative techniques which are not based on ‘conventional’ application techniques, more regulatory hurdles may need to be overcome. In addition to having to take into account a higher spatial and temporal variability in applications, for these new techniques new exposure scenarios may need to be developed.

In addition to use-rate reduction, new application techniques may also serve as a risk-mitigation method; risks to humans, animals or the environment may be lower by targeted applications.

In this talk, possible steps for the uptake of new application techniques with the aim of use-rate reduction and risk mitigation in relation to the authorisation of PPP will be discussed.

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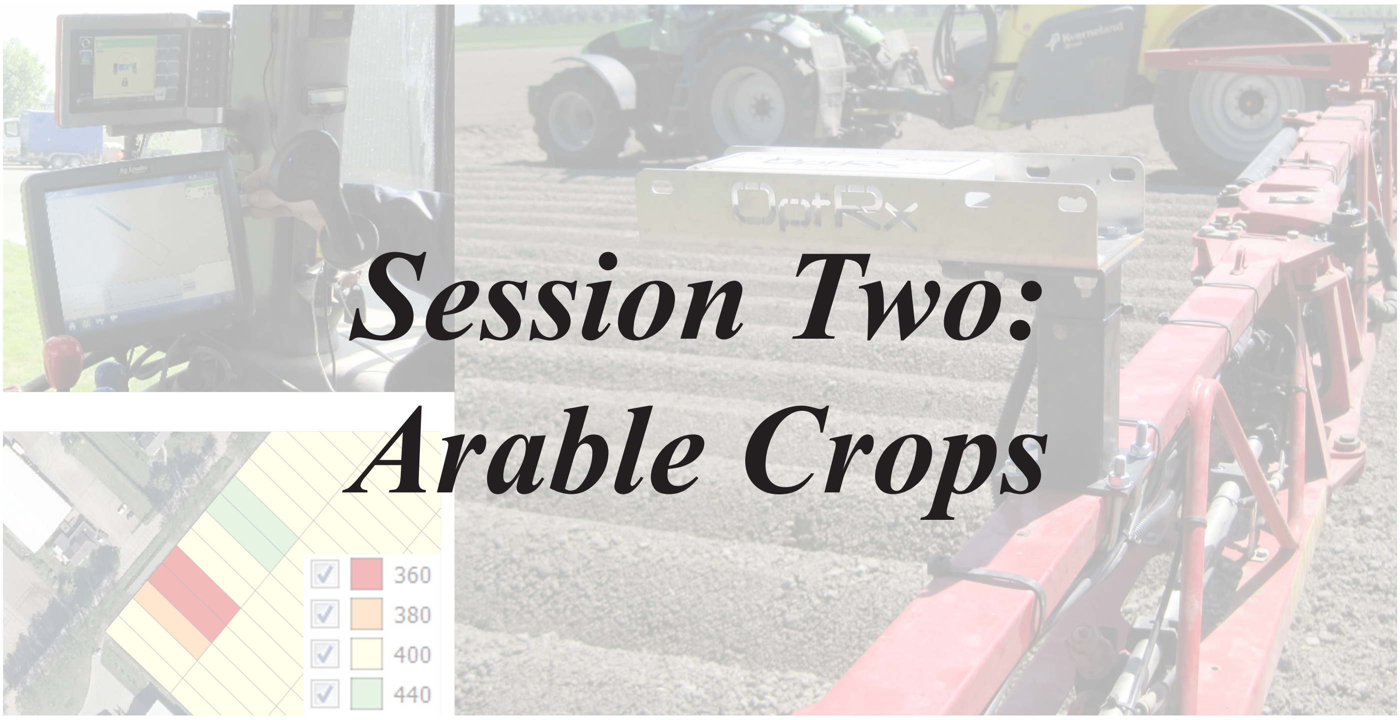

Session Two: Arable Crops

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Strategies for the targeted application of herbicides to arable and horticultural field crops

PAUL C H MILLER[1] and N D TILLETT[2]

[1]*Silsoe Spray Applications Unit Ltd, Building 42, Wrest Park, Silsoe, Bedford, MK45 4HP, UK*
[2]*Tillett and Hague Technology Ltd, Wrest Park, The Mansion, Silsoe, Bedford, MK45 4HR, UK*

ABSTRACT

Targeted herbicide applications can be directed either at defined field areas with a detected weed population (in a **patch application**) or at individual weeds (or clumps of weed) as a **spot application.**

Patch application can be based on the detection of weed patches on to a weed patch map that is then used to control the application system. The use of a map-based approach enables the transformation from weed detected map to application map to take account of a range of factors and examples of these approaches will be included in the presentation.

Patch applications can also be made using detection methods (where developed) at the time of application providing that the detection process can be completed to give an appropriate lead time for the application system to respond. Examples, including those based on the detection of weeds against a soil background, will be discussed.

Spot application systems have also been developed mainly for treating weeds in high value row crops. Results from field trials over several seasons have demonstrated the ability to achieve high levels of weed control in a range of conditions while typically using less than 5% of the herbicide that would have been used for overall applications. In one approach, weed detection in real time defines a polygon area around each detected weed and then controls specialist spray nozzles to treat the polygon area. When using total herbicides, the risk balance between the levels of weed control achieved and potential crop damage can be adjusted by varying the proportion of the polygon area that is treated. Results from a field trial conducted in a commercial leek crop will be used to examine how such an approach could be used in practice. Spot applications can also be made using selective herbicides where the risks of crop damage can be further reduced while maintaining high levels of weed control.

It is concluded that there a range of approaches to the targeted application of herbicides with the potential to deliver high levels of weed control and with substantial reductions in herbicide use. The details of the most appropriate strategy to employ when making such applications will depend on the opportunities and constraints associated with each situation.

Innovation in application technology for emission free crop protection

GERRIT VAN STEENBERGEN and AT NIEUWENHUIZEN

Wageningen Plant Research, P.O. Box 16, 6700 AA Wageningen, The Netherlands

ABSTRACT

The ambition of the Dutch government is to have nearly no emission of plant protection products (PPP) and nutrients to ground and surface water by 2030. The project ”innovative emission-free application techniques 4.0” targets to develop and validate spray techniques which reduce emissions to surface water, soil and air and reduce PPP usage. In five different cases for fruit orchards and arable farming spray application is optimized by adjusting the dose to the crop, improve deposition on the target or spray only on the locations required. Development of the application techniques is done by the involved sprayer manufacturers. By performing research the technology is benchmarked to validate if the common goals of the project are met.

A spray technology in which these items are combined is the crop adapted pulse-width modulation (PWM) sprayer for the bed-grown crop onions, which was developed in 2022. The spray rate was adjusted based on Normalized Difference Vegetation Index (NDVI) and changed by the PWM duty cycle, deposition was improved and emissions were reduced by lowering the boom height in combination with air assistance and the paths in between the onion beds were not sprayed by directing the spray above the paths towards the bed. Spray deposition on the onions and emission to the soil surface was measured in three crop stages. In the last two crop stages relative deposition on the onions was on average 25% and 50% higher compared to the reference sprayer. No difference was found in the first crop stage. Deposition on the paths between the onion beds decreased by 30% compared to the reference sprayer in all crops stages.

By increasing deposition on the crop, the input of PPP’s can be reduced, which consequently results in a decrease of emissions as well.

How to better consider targeted spray application: The case of local *vs*. global dosage definition

JEAN-PAUL DOUZALS[1], INGRID ZWERTVAEGHER[2], DAVID NUYTTENS[2] and SYLVAIN VILLETTE[3],

[1]*INRAE, UMR ITAP, Université de Montpellier, 34196 Montpellier, France*
[2]*Flanders Research Institute for Agriculture, Fisheries and Food (ILVO), Belgium*
[3]*Agroécologie, AgroSup Dijon, INRAE, Univ. Bourgogne, Univ. Bourgogne Franche-Comté, F-21000 Dijon, France*

ABSTRACT

Targeted spray application is a way to reduce the use of plant protection products where the sprayed area represents a more limited area of the field. The commercial use of targeted application systems mounted on boom sprayers is now effective with single nozzle control systems on a voluntary basis. But these systems still face a relative lack of consideration from the regulatory side which mostly considers broadcast application scenarios. On the other hand, the variety of targeted application systems, from variable rate application, boom section control, single nozzle management or variable nozzle spacing, in the absence of standardized assessment methods does not make the regulator's task easier. Since the natural variability of weed patches (number, size) is mostly unpredictable, this situation highlights a need for a better characterization and classification of targeted spray application systems using complementary approaches provided by simulations and test benches. Two case studies are discussed in this presentation. First, the case of a spot application of herbicide is discussed, simulating either target patch sizes/numbers and nozzle types and section widths (Villette *et al*., 2021). Second, the case of a bed-adapted spraying system is considered, where nozzle type, spacing and height were adapted to the target width taking into account the lateral spread of carrots grown on beds during the growing season. In this latter case, test bench measurements of lateral distribution were achieved (Zwertvaegher *et al*., 2022) to select a better nozzle configuration with the objective of concentrating the spray on the targets and minimizing off-target losses. Both cases reveal issues when comparing the local/on target and global/field dosages with or without consideration for over- or underdosing situations. Potential benefits in terms of local and dosage reduction are discussed by defining standardized methods/situations and their implementation in regulatory schemes.

References

Villette S, Maillot T, Guillemin J P, Douzals J P. 2021. Simulation-aided study of herbicide patch spraying: Influence of spraying features and weed spatial distributions. *Comp. Elec. Agric*. **182**. https://doi.org/10.1016/j.compag.2020.105981.

Zwertvaegher I, Lamare A, Douzals J-P, Balsari P, Marucco P, Grella M, Caffini A, Mylonas N, Dekeyser D, Foqué D, Nuyttens D. 2022. Boom sprayer optimizations for bed-grown carrots at different growth stages based on spray distribution and droplet characteristics. *Pest Manag Sci*, **78**:1729–1739. https://doi.org/10.1002/ps.6792.

Recent advances in ultra-high precision plant-level spot spraying application using AI plant recognition

STEVE TANNER and SIMON GASSER

Ecorobotix SA, Rue Galilee 6, 1400 Yverdon-les-Bains, Switzerland

ABSTRACT

An ultra-high precision plant-level spot spraying technology using AI plant recognition has been developed and introduced on the market. The imaging system provides high quality images with depth map and uses controlled illumination under a light cover. The classifier is based on semantic segmentation and gives robust classification of various crops and weeds. High precision 3D plant mapping and high frame rate plant tracking is also implemented. The spot spray system is based on an array of high speed electrovalves with small divergent angle nozzles placed on a boom with active height control. The nozzles are separated by 4 cm and have a minimal aperture and cycle time of 10 and 30 ms, respectively. Individual nozzle control and overall image to spray synchronization is guaranteed below the ms. Minimal spray spot size is about 6 × 6 cm at a speed of 2 m s^{-1}. Droplet size is optimized for contact herbicide.

The cumulated 3D mapping, tracking, timing and geometry error results in a measured X/Y spot positioning error of +/- 1.5 cm in standard conditions and machine speed of 2 m s^{-1}. The system provides various spray modes such as spray only weeds, only crops, all but crop, only weeds with safety buffer around crop, etc. The classifier recognizes more than 10 crops, >50 weed species and features typical F1 scores of 90% for weeds. The ultra high precision allows to weed with non selective herbicide on row crops. Herbicide reductions of typically 80% and up to 95% for grassland weeding were measured through various field/crop trials in Europe. A summary of the most relevant field test results are presented. The technology is being deployed at a larger scale in Europe and provides an efficient and robust way to drastically reduce chemicals usage.

The bumpy road towards innovative spraying techniques

PETER KNIPPELS

LTO Netherlands, Bezuidenhoutseweg 105, 2594 AC Den Haag, The Netherlands

ABSTRACT

Dutch farmers and market gardeners are working on making crops more sustainable. This is done in various ways, including searching together with technology suppliers for spraying techniques in which crop protection products are only used when necessary and only end up in places where necessary. Think of the specific control of weeds or fungal infections in a fruit orchard, partly based on camera techniques. Steps are being taken in this direction together with technology suppliers and techniques are being developed and tested. This is not something of the last few years. For twenty years, a bulb grower dreamed aloud about a robot technique that could recognize plants affected by viruses based on camera techniques and smart software. A few years later, WUR had developed a prototype and it was successfully tested in practice. Due to technical challenges, development was then stopped. Now several bulb growers use advanced robotic techniques to recognize virus-sick plants. The entire process took almost 20 years. In the meantime there are other challenges.

This example shows that the road to using advanced techniques can be long and bumpy at times. This also applies to the techniques that many farmers and horticulturists are interested in and want to move towards: place specific application techniques for plant protection products: less use of resources, good for the environment (less emission to the environment). These steps are welcomed by companies and governments, but there are several issues that need to be addressed before these innovations can be widely applied in practice. First of all, the techniques must be recognized as low-drift techniques. The assessment methods must be supplemented with innovative techniques. The development of new techniques is not standing still and the range is becoming wider and wider. In addition, the authorizations of plant protection products are based on application to the entire plot, on the basis of the regulations. The regulations do not have a location-specific application and the associated risk assessment. The Dutch Board for the Authorisation of Plant Protection Products and Biocides (Ctgb) has started to bring together the application of the rules and the innovative techniques, whereby many new questions have to be answered. The challenge is that there are multiple innovative techniques. Third and last point is the correct application of the innovative techniques. This requires new knowledge and skills from the user.

The conclusion is that the road towards the broad application of innovative techniques is bumpy.

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Session Three: New technology and Methods

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Optimum flight height for the control of desert locusts using Unmanned Aerial Vehicles (UAV)

VIOLET OCHIENG[1,2], IVAN RWOMUSHANA[1], GEORGE O ONG'AMO[2], PAUL N NDEGWA[2], SOLOMON KAMAU[3], FERNADIS MAKALE[1], DUNCAN CHACHA[1], KUSH GADHIA[4] and MORRIS AKIRI[1]

[1]*CAB International (CABI), P. O. Box 633-00621 Nairobi, Kenya*
[2]*Faculty of Science and Technology, Department of Biology, University of Nairobi, P. O. Box 30197-00100–00625, Nairobi, Kenya*
[3]*Faculty of Agriculture, Department of Land Resource Management and Agricultural Technology (LARMAT), University of Nairobi, P. O. Box 29053-00625, Nairobi, Kenya*
[4]*Astral Aerial Solutions, P.O. Box 594, Nairobi, 00606), Kenya*

ABSTRACT

Desert locusts are the most destructive migratory pest in the world. Current methods of control rely on the use of vehicles, aircraft and hand held sprayers as the platforms. However, these control methods have some challenges, hence the need to supplement them with suitable alternatives platforms. Successful use of drones to manage pests makes it an attractive and potential technology for desert locusts' management. However, the available studies have not optimized the key parameters for desert locusts' management. Therefore, this study was conducted to assess how different drone atomizers (emulsifiable concentrates – EC and ultra-low volume - ULV) and flight height affect droplet characteristics. White A4 papers were pinned on the ground and the drone was flown to spray the mixture of black ink and water on the papers for ULV and EC atomizers respectively at five heights; 2.5 m, 5 m, 7.5 m, 10 m and 12.5 m. Sprayed papers were scanned and imported to dropleaf app which approximated the droplet density deposited on each paper sprayed at different heights and the atomizer. Since ULV atomizer is preferred for desert locust control, the standard droplet density was calculated and compared at each height for ULV atomizer. To assess the effects of spraying heights on mortality of desert locusts,500 grams of Novacrid was sprayed at different heights on the caged 3rd and 4th and adult locusts and their mortality determined. Results showed that droplet density was not significantly. Mortality varied among the locust development stages within heights and between heights. Survival probability varied between heights for 3rd instar forth and adults This study confirms that 10m is the optimum flight height as it delivers droplet density within the acceptable range. All the developmental stages of the desert locust were susceptible to Novacrid and the recommended target stage is the 3rd instar.

Methods for evaluation of a spot spraying system in combination with weed detection system

PETER HLOBEN, FLORIAN REINMUTH and RICHARD HUMPAL

John Deere GmBH & Co. KG, Mannheim Regional Centre, Mannheim 68163, Germany

ABSTRACT

The paper deals with methodologies proposed for an evaluation of the John Deere See&SprayTM spot spraying system. In principle, there are two approaches which can be used for the system evaluation. The first approach is a pure „technical” method which aims to evaluate the capability of the system to detect, identify and to precisely spray a target area, so called “hit-rate” measurement. The second approach is an “agronomical” evaluation which focuses on weeding efficiency.

The “technical” and “agronomical” evaluations of the spot sprayers and weed detection systems can be used for different purposes. For a basic evaluation of the technical functionality of the system, which can be simply standardized, couple of critical parameters e.g. identification of normalized plant objects under different light and terrain profile conditions, or measurement of the accuracy of spraying of the pre-defined area at different forward speeds. Such an evaluation can be then used for a quick comparison of the performance of different weed detection systems, or to check the minimum performance criteria when the spot spraying systems will be in the future accepted by authorities as a risk reduction measure and will be considered during the plant protection product approval process.

The “agronomical” evaluation is primarily of interest to growers. It is usually requiring multi-year field studies conducted in different filed crops. The field studies are used for an investigation of different application strategies and weed sensitivity levels with an aim to determine optimal efficiency i.e., to find a balance between highest possible herbicide savings and maximum crop yield. The paper will further describe a method proposed for the bonification of the weeds located in sugar beet testing plots.

Introducing precision applications and risk reduction tools in regulatory dossiers: Crop protection manufacturers vision

ERIC KIERS

CropLife Europe, Postbus 80523 // 2508 GM Den Haag, The Netherlands

ABSTRACT

Growing more with less is not a contradiction, optimizing resource use is at the heart of modern agricultural production. The EU Green Deal, and specifically the Farm to Fork and Biodiversity Strategies have set forth an ambitious policy direction with a more sustainable food production model as the ultimate goal. Digital and Precision Agriculture will enhance the farmer's tool-box, and provide the primary means by which more sustainable and productive agriculture can be delivered for all models of production and land holding sizes.

It is useful to define – very briefly - several key terms that are constituents of Digital and Precision Agriculture as it relates to agriculture in general, and particularly to crop protection:

Precision Application: Refers to applications of crop protection products or fertilizers that are accurately focused on the target (pest, weed, plant affected by disease, and nutrition needs) at optimum rate and timing.

Precision Agriculture: Refers more widely to practices that use on-farm temporal, spatial, and other relevant data as a basis of seeding, irrigation, harvesting and other decision making on farm management by farmers. It includes collection and analysis of any data that can influence management decisions such as weather, soil quality, water flows etc.:

Digital Agriculture*:* Broadly involves the collection, storage, reporting, analysis and use of electronic data and information along the agricultural value chain to achieve a wide variety of objectives, including crop protection planning, execution, and reporting. Farmers have been using various forms of Digital and Precision Agriculture for over 20 years, and recent years have seen a paradigm shift in the amount of data collected as well as in the ways these data can be interconnected and utilised. Phones, tractors and machinery can carry sensors that provide information about how a specific crop has been managed or treated, the weed/pest pressure the crop is subject to, and what volume and quality of crop is harvested.

Roadblocks to adoption of Digital and Precision Agriculture tools

The use and full development of digital and precision tools is currently limited or restricted in the EU Member States, and even at regional level in some Member States. Some major roadblocks lie in **policy and regulatory frameworks** that can for example: Limit funding support for innovative technologies, restrict use of automated land vehicles and aerial drones, or discourage technology uptake through tax and insurance regulations etc. But, also **data availability/ accessibility** and a **good investment climate** to support precision execution of agricultural practices in the field are also important roadblocks. But, above all we need to dive into hurdles caused by the regulatory system. The current risk assessments of crop protection products relates to representative uses and aim to cover worst case scenarios. Precision applications on the other hand are limited to spot or band applications, treated seeds or injections. Together with new equipment like smart sprayers, drones for scouting and advanced Farm Management Systems a whole new world emerges. Current labels do not match the future use of the products because, besides the fact that applications are spot-on, much more information is available - *in situ* - on, for example, pest development, crop condition, soil moisture, wind speed, soil and plant nutrient content etc. This requires a different regulatory framework as we are moving from a worst case scenario to a real case scenario.

Modelling spray drift in precision spray applications

HENK JAN HOLTERMAN, K VAN BOHEEMEN and J F M HUIJSMANS

Wageningen University and Research, Agrosystems Research, The Netherlands

ABSTRACT

In general, precision application of plant protection products (PPPs) results in a reduction of the amount applied compared to a full field application. Therefore, a lower exposure to PPPs of different off-field areas is expected. At present, precision applications are not adequately acknowledged or assessed in the authorisation process of PPPs.

Typically, variable-rate and spot-spraying applications can be distinguished. Variable-rate application is a whole field treatment where the minimally effective dose is applied based on the conditions for each location in the field. In a spot-spraying application the decision is made whether or not a (full dose) spray application is required for each location. Finally, a hybrid form exists where variable-rate and spot-spraying are combined.

The effects of precision spray applications in arable crops are assessed regarding the downwind off-field deposits of spray drift. A spray drift model was developed that takes into account the non-uniform dose rates on the crop field. In the model, field sections receiving a certain PPP dose rate are identified as polygons, which act as (very) small crop fields, treated independently. Each polygon contributes to downwind deposits of spray drift, depending on its area, the applied dose rate and the effective distance to the off-field area. The total off-field deposits of spray drift are computed as the sum of the contributions of the polygons. Test cases are elaborated with edge-of-field watercourses as the off-field areas exposed to PPP. Watercourses are imaginarily divided into smaller segments, for each of which spray drift deposits are determined. Example computations indicate that drift reductions can be higher or lower than the reduction merely based on the lower amount of PPP used in precision application. This depends not only on the location and distribution of treated polygons, but also on wind direction.

The EU pesticides legislation: Conditions of use to reduce exposure and risk

MÓNICA GARCÍA AGUILAR

Policy Officer at European Commission, DG SANTE, Belgium

ABSTRACT

For a fair, healthy, and environmentally friendly food system, the European Green Deal and the Farm to Fork Strategy have introduced measures to reduce by 50% the use and risk of chemical plant protection products by 2030 as well as to stimulate the use of non-chemical alternatives and low risk plant protection products.

Regulation (EC) No 1107/2009 sets rules and procedures for placing Plant Protection Products (PPPs) on the market and how they can be used. The Sustainable Use Directive 2009/128/EC establishes a framework to achieve a sustainable use of PPPs. Under Regulation (EC) No 1107/2009, active substances can be approved (and their approval renewed), if a comprehensive scientific evaluation shows that products containing them can be used without harmful effects on human health or unacceptable effects on the environment. If necessary, specific conditions can be set in the approval to ensure a safe use. After that, Member States need to authorise each PPP (that contains the active substance) in their territory. The authorisations can be granted for other uses with different conditions but always ensuring a safe use. Furthermore, Member states can impose complementary conditions of use for all the PPPs based on their relevant national regulatory provisions (e.g. National Action Plans under the Sustainable Use Directive) or under specific circumstances (e.g. close to water sources) to ensure protection of human health and/or the environment.

Personal protective equipment, specific spraying technologies, application rates, time restrictions, pre-harvest intervals, indoor use and other land use measures as buffer zones are examples of conditions that ensure a safe use of a PPP by reducing the exposure and potential risks to humans and the environment. These conditions of use can be integrated in the regulatory process at the EU level and/or at Member State level during the preparation of the application dossier, the risk assessment and/or the risk management process. The user of a PPP is obliged to implement the conditions of use granted in the authorisation.

Application techniques that reduce human and/or environmental exposure to PPPs are continuously developing, such as targeted application technologies or drift reduction techniques among others. Innovations related to application technologies are ready to be placed in the market and used in the field. Furthermore, these technologies can contribute to achieve the targets on the reduction of pesticide risk set by the Green Deal and Farm to Fork Strategy.

The European Commission is interested in the collection, compilation, and dissemination of available data and knowledge of these techniques. Building on the outcome of the Workshop of 2020 on Risk Mitigation Measures with Member States, EFSA and other experts, the EU Commission intends to draft a document that includes the regulatory context and examples of conditions of use that reduce exposure to PPPs. Furthermore, the EU Commission participates in a Working Group with Member

States to discuss how specific conditions of use can be implemented during the risk assessment and risk management procedures, promotes training on the topics via a Better Training for Safer Food (BTSF) and funds research projects on innovative pesticides technologies under the programme Horizon 2020.

With this data and knowledge, in the medium-longer term, specific and innovative conditions of use that reduce exposure could be considered in the risk assessment and in the regulatory framework of plant protection products. This would support the harmonisation of the decisions taken by the national regulatory authorities when imposing similar conditions of use as risk mitigation measures in the authorisation of PPPs.

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Session Four: Bush and Tree Crops

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Targeted application to the basal part of trunk to control the woolly apple aphid (*Eriosoma lanigerum*)

DANIEL BONDESAN, CLAUDIO RIZZI and MARIO BALDESSARI

*Technology Transfer Centre, Edmund Mach Foundation, Via E. Mach, 1,
I-38010 S. Michele all'Adige (TN) – Italy*

ABSTRACT

In recent years, the presence of the woolly apple aphid (*Eriosoma lanigerum*) has increased in apple orchards in both integrated production and organic farming. Possible reasons include reduction in organophosphate insecticide use, negative side effect of pesticides on natural enemies and increased overwintering survival. As a result of the aphid's feeding stings, tumours and knots appear on young branches and on old wood. This results in a general weakening of the plant, which is more susceptible to other plant diseases and attacks by other pests. In addition, the emission of honeydew can sully the fruit, compromising its aesthetic characteristics.

Part of the biological cycle of the insect is carried out at root level with the crawler moving up the trunk in spring to colonise the plant. Localised application at the trunk can therefore be an effective strategy to contain the insect populations and allows rationalisation of the doses used.

In field tests, three equipment were compared to preliminarily check tracer mixture deposits on the trunk: an axial sprayer with air injection nozzles, a hand lance with triple jet, a spray boom with mechanical sensor. The equipment that performed better in terms of deposition efficiency were consequently used in full field trials. The efficacy was compared for one or two applications with mineral oil (Polithiol). The equipment with intermittent jet opening (boom) allowed a high level of efficacy and a reduction in the use of the plant protection product.

The possibility to reduce the use of PPP even by using basic sensing technologies is shown by this work. Therefore, the adoption of precision spraying technologies recently developed could hugely increase the sustainability of treatments in near future.

Preliminary analysis of satellite base canopy characterization in the vineyard for prescription map generation

FRANCISCO GARCIA-RUIZ[1], RAMÓN SALCEDO[1], JAVIER CAMPOS[2] and EMILIO GIL[1]

[1]*DEAB, Universitat Politècnica de Catalunya, Barcelona, Spain*
[2]*FABE, The Ohio State University, Columbus, Ohio, USA*

ABSTRACT

Accurate canopy characterization is crucial for a targeted application of plant protection products following variable rate application (VRA) concept. Remote sensing offers a robust and rapid monitoring tool that allows determining the characteristics of the vegetation from aerial platforms at different spatial resolutions. Previous work have demonstrated that drone-based imagery can be used to estimate canopy height, width, and canopy volume accurately enough to allow a full automation of VRA prescription maps in vineyards using Dosaviña® DSS. In this work, high-resolution satellite imagery was used to estimate canopy characteristics from vineyards planted in a hedge. A total of 655 vines from 5 different vineyards located in El Penedès region (Spain) were manually measured in different growth stages during 4 seasons (2018-2022). Vegetation indices were calculated from high-resolution satellite imagery (Planet Labs constellation) acquired on the same dates as manual measurement collection in the field. Correlation analysis was conducted to determine the ability of different single spectral bands as well as vegetation indices to predict canopy characteristics from remote sensing data. Preliminary results showed that Red-Edge-based indices increase the reliability of the predictions. Furthermore, one important conclusion drawn was that satellite imagery with a spatial resolution of 3 m pixel^{-1} was not useful for early growth stages due to the spectral mixture of vegetation and soil. Given these limitations, further results will be obtained after the completion of the EU project Novaterra where a new system for ground data collection was designed to obtain massive data capture in the vineyard to be later compared with satellite imagery to improve the robustness of the models.

Precision application technology in fruit crops in The Netherlands

MARCEL WENNEKER, DIRK DE HOOG, JEAN-MARIE MICHIELSEN, MOSTAFA SNOUSSI, HEIN STALLINGA, PIETER VAN DALFSEN, PETER FRANS DE JONG and JAN VAN DE ZANDE

Wageningen Plant Research, Wageningen UR – P.O. Box 16 – 6700 AA Wageningen, The Netherlands

ABSTRACT

The Dutch government aims to nearly no emission of plant protection products (PPP) and nutrients to ground and surface water by 2030. In projects (i) Innovative efficient application techniques and (ii) FRUIT4.0, application techniques were developed which improve spray deposition at target and therefore reduce PPP emissions and usage.

A precision orchard sprayer was developed capable of task map-based spraying. The task map created contains on and off commands for spraying per individual tree. Chlorophyll sensors to indicate the presence of plant material added on the sprayer enable a more precise identification for present plant material at 8 height bands and at sub-tree level in the driving direction. Therefore, precise spraying combining map-based and real time chlorophyll sensor-based spraying, only when a tree requires a specific action, and only there where tree material is present can be performed. Spray deposition measurements with this machine were performed in comparison with a standard cross-flow fan orchard sprayer. Results showed an increased spray deposition at leaf canopy of the apple trees with about 20% compared to that of the reference sprayer. The accuracy and precision of this H.S.S. sprayer showed a 10 cm precision is possible when spraying on a task map which is improved when using chlorophyll green detection sensors additionally to detect the target within the mapped application window of the individual tree.

Ground deposition underneath the trees is reduced by 30%–50% using the precision orchard sprayer in the taskmap + chlorophyll operation modus. Whereas the distribution of ground spray deposition was fairly equal for the bare-soil strip under the trees and the grass strip in between the tree rows (23%–24%) for the standard orchard sprayer, large variations occurred for the precision sprayer being 16%–17% at the grass strips and 7%–10% at the bare-ground strips under the trees. Reduction of spray deposition on those strips were 20%–30% on the grass strips and 50%–70% on the bare soil strips for the precision orchard sprayer, with the lower reductions in June applications (BBCH72-74) and the higher reductions in August applications (BBCH88-91).

Growers mention savings of 20% for all spray application done during the whole growing season, whereas individual apple thinning operations showed reductions of up to 80% less trees sprayed. In our experiments we measured reductions in spray volume use of 15% using the taskmap mode and of 30% using both the taskmap mode and the chlorophyll sensors in the full leaf growth situations of a spindle apple tree orchard.

These changes in spray deposition and use reduction of PPP are important to be taken into account for future evaluation of PPP in the authorization procedure.

Field experiences in flow rate control through pressure changes and PWM control for intelligent application spray systems in 3D-crops

RAMÓN SALCEDO, FRANCISCO GARCÍA, JORDI BISCAMPS, BERNAT SALAS and EMILIO GIL

DEAB, Polytechnic University of Catalonia, Barcelona, Spain

ABSTRACT

Currently, many research studies are being carried out around which is the most suitable detection technique of plants and trees for variable-rate application systems. However, there is still much to be done in defining the best flow rate control system to achieve precision treatments. This work compares the experiences obtained with the two main alternatives in regulating spray volume in 3D-crops: 1) varying spray pressures to modify the application volume; and 2) an intermittent control of the flow rate with PWM-controlled nozzles without manipulating the pressure. The spraying technology based on pressure changes consisted of an experimental airblast sprayer with ultrasonic sensors to evaluate the dimensions of the canopies during apple tree applications. Pressure was regulated through the use of motor valves connected to groups of 3-4 nozzles on both sides of the sprayer. The sensors were characterizing the canopies by different heights and a computer processed this information to produce the necessary flow rate of each section through the valves. It showed the capacity to correctly adjust flow rates within a specific interval of pressures. However, limitations were detected above this range. On the other hand, a multirow sprayer for vineyards with PWM-valves was tested. This sprayer could perform variable-rate applications from the maps generated with remoting sensors. The sprayer had a computer connected to a GNSS system indicating in real time the equipment position within the plot to apply the corresponding flow rate by sending electrical signals to the PWM valves regulating the nozzles. Trials exposed that, with a previous assessment of the PWM valves, the sprayer was able of providing the required flow rates. But again, there are limitations on these valves above a certain pressure or flowrate. It is necessary to compare both methods together for the same sprayer in the same application.

Analysis of the Efficiency of a Variable Rate Sprayer

F ANDREU[1], LARS TORSTEN BERGER[1], F ROVIRA[2] and S BALASCH[2]

[1]*Pulverizadores Fede S.L.U., Valencia, 46380 Cheste, Spain*
[2]*Universitat Politècnica de València, Valencia, 46022 Valencia, Spain*

ABSTRACT

Agriculture is facing the pressing demand of reducing the use of pesticides by 50% by 2030, a goal stipulated by the EU's "Farm to Fork" strategy within the Green Deal.

In the specialty crops segment, variable rate application technology has shown great potential. However, some studies that evaluate the accuracy and effectiveness of variable rating application often mask a deficient use of sprayers that theoretically are equipped with the most advanced technologies. In practice, major limitations are due to volume changes between zones and the reaction time of the sprayers' mechanical components.

The presented work measures the efficiency of a *Fede* hydro-pneumatic sprayer (Berger *et al*., 2022), with variable rate application according to prescription maps, *i.e.*: two artificially-created maps are used to test the reactivity of the equipment to high and low rate changes, and a third prescription map is created based on real remotely sensed vegetation mass.

It is confirmed that variable rate application efficiency depends on the morphology of the prescription maps, the forward speed and the correct map adaptation to the features and limitations of the equipment. Efficiency increases with: a.) faster mechanical components (*e.g.* fast electronically regulated valves); b.) more precise *global navigation satellite system* (GNSS) positioning.

The presented work, carried out in vineyards, demonstrate that the variable rate *Zone Spray* adaptation of *Fede*'s sprayer in combination with *Fede*'s agronomic digital management tool (*Specialty Crops Platform*) reduces the use of pesticides by up to 25%. Apart, variable rate application also lowers the air volume, which in the sequel leads to fuel savings and GHGs emission reduction.

Acknowledgements

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A non-dietary risk assessors' perspective of precision application and the challenge of conservative assumptions

ALEX GREGORY

Risk Assessment at Syngenta, Jealott's Hill International Research Centre, Bracknell, Berkshire RG42 6EY, UK

ABSTRACT

As part of the "Green Deal" the European Commission has a goal of reducing pesticide usage by 50% by 2030.

Precision application is a fantastic way of lowering pesticide usage and maintaining productive, high yielding food production within Europe.

As a non-dietary risk assessor in industry there are a few hurdles standing in our way before these precision application uses can be taken forward at pace.

Due to a lack of regulatory guidance each new project must be assessed and discussed with member states individually which takes time and presents a higher risk to the business.

In this presentation I hope to propose the key questions that must be answered from a non-dietary perspective and gain consensus on the best way to approach PA risk assessment:

- The GAP – Standardising wording (clear for farmer and realistic for risk assessment)
- Operators - Scaling down exposure (reduced treatment area)
- Workers - Scaling down exposure (reduced treatment area)
- Resident/Bystander - Reduced drift (to reflect the accuracy of the precision application technique)

Looking forward: Standardisation of equipment with regard to spray drift and off target contamination would aid the development of robust risk assessment models for precision application.

Real-time and task map precision spray applications for weeds and diseases: Use cases developed at ILVO Living Lab Agrifood Technology

A WILLEKENS, J WIEME, R VAN DE VIJVER, J VAN BEEK, J WINDELS, DAVID NUYTTENS and S COOL

Flanders Research Institute for Agriculture, Fisheries and Food (ILVO), Belgium
contact: info@agrifoodtechnology.be | www.agrifoodtechnology.be

ABSTRACT

To reduce its impact on the biodiversity and soil quality, the EU Green Deal aims to reduce plant protection products (PPP) use with 50% by 2030. The reduction of PPP can be achieved using precision spraying where camera technologies and computer vision algorithms are combined to generate a perception map of weeds and diseases. The past years, ILVO living Lab Agrifood Technology -in collaboration with different stakeholders- developed and demonstrated several precision spraying use cases which will be presented at the workshop.

Case 1 describes real-time precision spraying on the bare soil strips under blue berries. A multispectral camera was mounted on a short spray boom and local perception based on the NDVI index was used to target individual weeds or weed patches. Spot spraying was carried out using Pulse Width Modulation nozzles mounted at 10 cm intervals.

In case 2, an autonomous drone with an RGB camera was flying over a maize field (in proximity of a 5G antenna) transmitting images of the field and GNSS positions in real time via the 5G network to the cloud. Trained deep learning algorithms calculated the local weed density in real-time and converted that information into a task map for a smart sprayer with individual nozzle control. Immediately after the flight, the task map was transmitted to the tractor *via* the cloud and started its (GNSS-controlled) spray job resulting – in this case- in about 80% less herbicide use for the present field variability compared with a blanket spraying.

Case 3 used similar technologies and weed detection algorithms as in case 2 but applied to potatoes. Only in this case, the site specific weed treatment was performed completely autonomous by our CIMAT robot equipped with a variable rate weed burner (Vanhoucke Engineering).

This year, we will extend the applications to potato diseases like Alternaria, Phytophthora and Colorado beetle. Multiple approaches of deep learning models were developed in the past few years (Van De Vijver *et al*., 2022; Wieme *et al*., 2022) and are now transferred towards practical implementation.

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Session Five: New Technology and Conclusions

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Spot spraying in vegetable row crops: Advancing step by step

MARTINA KELLER[1], PASCAL HABEREY[1], RENE TOTAL[1], JOSHUA WITSOE[1], THOMAS ANKEN[2] and THOMAS POIGER[3]

[1]*Vegetable-Production Extension, Agroscope, Müller-Thurgau-Strasse 29, 8820 Wädenswil, Switzerland*
[2]*Digital Production, Agroscope, Tänikon, 8356 Ettenhausen, Switzerland*
[3]*Plant Protection Products - Impact and Assessment, Agroscope, Müller-Thurgau-Strasse 29, 8820 Wädenswil, Switzerland*

ABSTRACT

Spot spraying exhibits great potential to significantly reduce the environmental risks related to pesticide use while maintaining efficient crop protection. In a series of projects, technical aspects, pesticide use savings and reduction of spray drift losses are investigated in typical vegetable row crops.

In a first project, a spot spraying system was built on an already marketed hoeing machine (Steketee IC Weeder). The prototype hoes between and within the rows using camera and sensor technology. At the same time, fungicides and insecticides are precisely applied on the crop plants. In lettuce and bok choy trials, pesticide saving potential and efficacy of insecticide treatments with the prototype were compared to standard spraying applications. Target pests were aphids (lettuce) and flea beetles (bok choy). Up to 75% of insecticides could be saved compared to the standard in the trials. No significant differences in efficacy were observed between spot spraying and standard treatment (Haberey *et al*., 2021).

The combination of hoeing and spot spraying in one machine comes with disadvantages, such as limited working speed (1.5 km h^{-1}). Therefore, in a second project, a new prototype was built which is specifically designed for spot spraying. This project is ongoing.

A third project (2023–2026) focuses on environmental aspects. Pesticide saving potentials will be determined in vegetable row crops at different crop stages. Based on these data and measured crop parameters, the potential reduction in run-off will be calculated. Drift experiments are also scheduled. It is planned to include other spot spraying systems to separate the technology and device specific effects on drift reduction.

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Development of a digital label: DriftRadar as a case study

ANDREW C CHAPPLE[1], JEAN-PAUL DOUZALS[2] and
GRZEGORZ DORUCHOWSKI[3]

[1]*Bayer AG, Monheim, 40769 Germany*
[2]*INRAE, UMR ITAP, 34196 Montpelier, France*
[3]*INHORT, 96-100 Skierniewice, Poland*

ABSTRACT

Farming is rapidly "going digital". However, one cannot run a digitalised farming operation using plant protection products (PPPs) that are supported by paper labels. Paper labels are limited in their complexity, are static in their interpretation, and are driven by human and environmental protection limitations based on country-specific scenarios. The latter are by necessity driven by percentile approaches to PPP use and their routes of exposure. Precision agriculture has the possibility of leading farming into field specific risk assessments (RA): this is in its initial stages in the EU in particular. The principal advantage of field specific RA is that all fields can be protected exactly as the regulations are designed without the uncertainty of a percentile protection approach. To demonstrate what can be done with a digital label and its supporting infrastructure, two proof-of-concept field trials have been done using an Amazone towed sprayer. The attendant software has been adapted such that at all points in a field, the label recommendations for drift mitigation and control are followed for all human and environmental safety compartments affected by spray drift. This system – DriftRadar – can deal with tank mixes and effectively removes operator error in terms of drift buffer planning and the difficulties of adhering to often complicated drift mitigation label requirements. An additional component demonstrated is the ability to deal with changing wind direction in the field in real time.

This talk will showcase the digital label using the DriftRadar approach and its testing in two proof-of-concept trials done in France (courtesy INRAE, FR with ARVALIS, FR) and Poland (courtesy Inhort, PO). The overall operation will be demonstrated as well as the lessons learned.

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DriftRadar: https://go.bayer.com/driftradar

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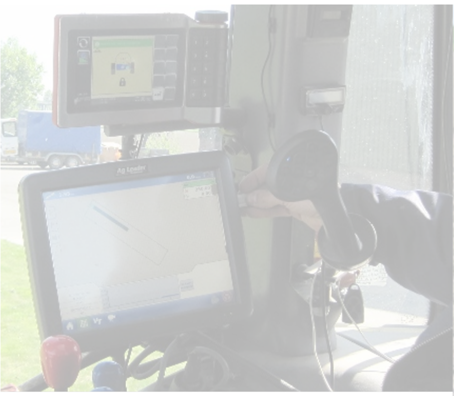

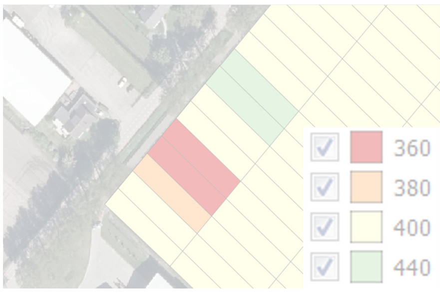

Posters

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P1
Deposition of pesticides *via* spray drift in off-crop vegetation: Study of the vertical and horizontal distribution in flower strips

FABIENNE MAIRE, THOMAS POIGER, MIKKO LEHTO-HÜRLIMANN, and JUDITH F BLOM

Agroscope, Müller-Thurgau-Strasse 29, 8820 Wädenswil, Switzerland

ABSTRACT

The authorization process for plant protection products (PPP) includes an assessment of adverse effects on non-target arthropods (NTA) both in the treated field and off the field ("off-crop" areas). While the exposure assessment for e.g. aquatic species is well established, a solid experimental basis is still lacking for exposure assessment in off-crop vegetation. Particularly, information about the distribution of PPP deposited in off-crop vegetation via spray drift is limited. One of the objectives of the Swiss Biodiversity Strategy and the Swiss Action Plan for Risk Reduction and Sustainable Use of Plant Protection Products (AP PPP) is therefore to further develop the risk assessment of PPP towards NTA in off-crop vegetation. To characterise the horizontal and vertical distribution of PPP deposited in off-crop vegetation via spray drift, we conducted extensive field experiments using a fluorescent tracer. The tracer was applied with a conventional boom sprayer onto a surrogate crop (artificial meadow). The spray drift in the adjacent vegetation (a 6 m wide flower strip) was collected on filter paper targets (area per target, 500 cm^2) positioned at different heights (at the level of the leaf canopy, half way up and a few centimetres above the ground), and at distances of 1, 2, 3, and 6 m, respectively, from the edge of the treated field. Wind speed and direction were recorded with high temporal resolution during each tracer application. Data analysis was carried out using a linear mixed-effect model using R Studio. First results indicate similar dependence of spray drift on the distance from the edge of the field, both for spray drift deposition on ground level and on off-crop vegetation. Additionally, interactions between different variables such as the pressure / nozzle type and wind speed are evaluated.

P2
Spray deposition from a remotely piloted aircraft on the corn crop

JOãO PAULO ARANTES RODRIGUES DA CUNHA and
MARIA ROSA ALFERES DA SILVA

Federal University of Uberlândia, Uberlândia, Brazil

ABSTRACT

The use of remotely piloted aircraft (RPA) has grown in agricultural spraying around the world, but there is a lack of research data to assist users in making more assertive decisions due to its recent nature. This study aimed to evaluate spray deposition in corn using an RPA DJI AGRAS-MG-1 at two application heights compared to the application using a knapsack sprayer. Sprayings were carried out in the corn crop at the phenological stage V5–V6. The experiment consisted of three treatments and eight replications, applied with an RPA at heights of 1.5 and 3.0 m and a CO_2-pressurized knapsack sprayer. The application rate was 10 L ha^{-1} for RPA and 115 L ha^{-1} for the knapsack sprayer. Flat fan spray tips were used for all treatments. Tracer deposition in the corn canopy and spray loss to the soil were evaluated using spectrophotometric detection, while coverage, density, and droplet spectrum were evaluated on water-sensitive paper. Total and effective deposition swath were also evaluated for RPA. Although droplet density provided by RPA varied between 26 and 39 droplets cm^{-2}, the coverage was lower than 1.3%. Application using RPA at the height of 1.5 m provided tracer deposition on corn leaves similar to that carried out with the knapsack sprayer. The increase in application height to 3.0 m promoted a reduction in the deposition. Ground spraying promoted higher spray loss to the soil. The effective deposition swath consisted of 5.7 and 7.6 m for application heights of 1.5 and 3.0 m, respectively.

P3
Go-Phytodron project: Unmanned Aerial Spraying Systems (UASS) in forest and 3D crops

ESTHER GARCÍA-MONTERO[1], JORGE MARTÍNEZ-GUANTER[1] and
Mª DEL CARMEN MÁRQUEZ-MADRID[2]

[1]*Corteva, Sevilla, Spain*
[2]*AEPLA, Madrid, Spain*

ABSTRACT

Precision farming and new technologies are offering agricultural effectiveness and competitiveness, towards sustainability goals established by Farm to Fork strategy. Particularly plant protection products (PPPs) applications with drones seem a promising tool in the short term. UASS (Unmanned Aerial Spraying Systems) can introduce precision agriculture techniques, increasing spatial resolution and optimizing the amount of product applied, towards a friendly environmental agriculture. UASS combine reduction of PPPs, water volume and Carbon footprint.

However, since drones are nowadays catalogued as aerial application, these treatments are forbidden according to Sustainable Use Directive 2009/128/EC. This is a paradoxical situation, were legislation that takes care of sustainability is blocking technological progress aligned with sustainability.

GO_PhytoDron project (https://gophytodron.es/), co-funded by Spanish Ministry of Agriculture and European Agricultural Fund for Rural Development (EAFRD), aims to promote the use of UASS as a precise and safe tool for PPPs application, and to advance in its regulatory framework and use scenarios. The project compares environmental and humans' exposure in UASS and terrestrial treatments. Trials have been carried out representing Spanish diversity in plant health management of three-dimensional crops and forestry, validating the use of UASS.

GO_PhytoDron project compares preliminary results of drift potential (air borne and sedimenting) from UASS and conventional ground sprayers, with drift values currently used in EU risk assessment for AS and PPP approval, with the aim of developing of specific scenarios for UASS treatments in the future. Treatment efficacy, residues at harvest and humans' health exposure have been also analysed.

Through a holistic, realistic, and pragmatic study, GO_PhytoDron project has proven that treatment with drones is different to manned aerial treatment. These encouraging results could be considered to speed up EU processes towards considering drones as valid tools for precision agriculture that contribute to meeting sustainability goals, while addressing farmers requirements and needs.

TASAW DELEGATES: MAY 9TH 2023

João Paulo	Arantes Rodrigues da Cunha	jpcunha@ufu.br
Jørgen	Audenaert	AudenaertJorgen@JohnDeere.com
Geraldine	BAILLY	GERALDINE.BAILLY@FMC.COM
Michael	Beeston	mike.beeston@oxfordlasers.com
Lars Torsten	Berger	info@fedepulverizadores.com
Wouter	Berkhout	berkhout.wouter@gmail.com
Olaf	Beuckmann	olaf.beuckmann@hardi.com
Daniel	Bondesan	daniel.bondesan@fmach.it
Katrijn	Boshoven	katrijn.boshoven@basf.com
Annette	Bulle	annette.bulle@certisbelchim.com
Clare	Butler Ellis	clare.butlerellis@ssau.co.uk
Andrew	Chapple	andrew.chapple@bayer.com
Andrew	Christie	andrew.christie@hutton.ac.uk
Basma	DARRAJI	basma.darraji@adama.com
Dirk	de Hoog	dirkdehoog@hotmail.com
Meriem	Djouhri	djouhrimeriem@gmail.com
Jean-Paul	DOUZALS	jean-paul.douzals@inrae.fr
Steven	Droge	steven.droge@wur.nl
Edgars	Felkers	edgars.felkers@bayer.com
Lucas	Franca	lucas.franca@syngenta.com
Marion	Gagniarre	marion.gagniarre@adama.com
Esther	García	esther.garcia@corteva.com
Emilio	Gil	emilio.gil@upc.edu
Durham (Ken)	Giles	dkgiles@ucdavis.edu
Bernhard	Gottesbüren	bernhard.gottesbueren@basf.com
Alex	Gregory	Alex.gregory@syngenta.com
Jeremy	Harwood	jeremy.harwood@ssau.co.uk
Joachim	Herfort	j.herfort@agrotop.com
Henk Jan	Holterman	henkjan.holterman@wur.nl
Jan	Huijsmans	jan.huijsmans@wur.nl
Pamela	Johnson	pamela.johnson@hse.gov.uk
Martina	Keller	martina.keller@agroscope.admin.ch
Corne'	Kempenaar	corne.kempenaar@wur.nl
Eric	Kiers	kiers@brabers.nl
Findlay	Kinloch	wendy.patterson@hutton.ac.uk
Peter	Knippels	pknippels@lto.nl
Jaco	Kole	j.kole@sklkeuring.nl
Stefan	Kuebler	kueblerstefan@johndeere.com
Olivier	Langevoort	olivier.langevoort@ctgb.nl
Philip	Lenaers	philip.lenaers@teejet.com
Neil	Mackay	neil.mackay@fmc.com
Jorge	Martinez Guanter	jorge.martinezguanter@corteva.com
Walter	Mayer	walter.mayer@bayer.com

Rachel	Merrick	rachel.merrick@hse.gov.uk
Miriam	Messelhäuser	Miriam.messelhaeuser@lechler.de
Jean-Marie	Michielsen	jean-marie.michielsen@wur.nl
Paul	Miller	paul.miller@ssau.co.uk
Sebastian	Multsch	sebastian.multsch@basf.com
Ard	Nieuwenhuizen	ard.nieuwenhuizen@wur.nl
David	Nuyttens	david.nuyttens@ilvo.vlaanderen.be
Violet	Ochieng’	violetochieng2030@gmail.com
Thomas	Poiger	thomas.poiger@agroscope.admin.ch
Bastian	Polst	bastian.polst@wur.nl
Christian	Popp	christian.a.popp@basf.com
Carsten	Puth	carsten.puth@bayer.com
Christoph	Schulze Stentrop	christoph.schulze-stentrop@hardi.com
Tobias	Schwaben	Tobias.Schwaben@basf.com
Balthasar	Smith	balthasar.smith@bvl.bund.de
Hein	Stallinga	hein.stallinga@wur.nl
Anne	Steenbergh	anne.steenbergh@ctgb.nl
Sam	Stephenson	samuel.stephenson@syngenta.com
Steve	Tanner	steve.tanner@ecorobotix.com
Jack	Thibaudier	jt@homburg-holland.com
Jos	Tielen	jos.tielen@wur.nl
Christy	van Beek	christy.vanbeek@bayer.com
Koen	van Boheemen	koen.vanboheemen@wur.nl
Jan Renger	van de Veen	janrenger.vandeveen@arcadis.com
Jan	van de Zande	jan.vandezande@wur.nl
Piet Jan	van der Marel	pietjan.vander.marel@kvernelandgroup.com
Gerrit	van Steenbergen	gerrit.vansteenbergen@wur.nl
Jan	Vanwijnsberghe	jan.vanwijnsberghe@inagro.be
Miriam	Visser-Pek	miriam.visser@basf.com
Austin	Weiss	Austin.weiss@syngenta.com
Marcel	Wenneker	marcel.wenneker@wur.nl
Hans	Willems	hans.willems@syngenta.com

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Association of Applied Biologists, Warwick Enterprise Park, Wellesbourne, Warwick CV35 9EF, UK
Registered Charity No. 1195899; http://www.aab.org.uk
Tel: +44 (0)2476 999485 Email: John@aab.org.uk