O.40 - Use reduction of agrochemical by canopy density spraying of fungicides

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Abstract

Matching spray volume to crop canopy sizes and shapes can reduce chemical application, thus reducing operational costs and environmental pollution. Developments in crop-adapted spraying in arable crop spraying are highlighted. The potential of crop-adapted spraying in bed-grown arable crops is assessed. Potential volume rate savings and therefore agrochemical use are evaluated based on crop canopy structure evaluations during the growing season of bed-grown flower bulbs. It was shown that for the whole season spraying, spray volume could be reduced on average by 25% and at early crop development stage even by more than 90%. The evaluation of spray techniques to apply variable dose rates show that application techniques based on variable rate Pulse Width Modulation spray nozzles (Weed-IT) and individual switchable nozzles in a multiple nozzle holder (Lechler VarioSelect) show the potential of real-time changeable spray volumes of 50-500 l/ha. Based on these possibilities the units of treatment in the field in spraying crop protection products can be decreased from a full boom width treatment to section wise and even nozzle wise variable applications. Individual plant detection in size and place and canopy structure can be achieved with sensors used for weed-control (Weed-IT) based on fluorescence and on fertilizer application (SensiSpray; Greenseeker) based on spectral reflectance. Based on these principles, prototypes have been developed to apply agrochemicals respectively plant-specific or canopy density related. A first field test protecting potatoes against late blight (*Phytophthora infestans*) with a plant-specific sprayer was performed. In early late blight spraying of potatoes spray volume savings of a prototype plant-specific sprayer are shown to be more than 75% compared to conventional applications using a field boom sprayer, while maintaining a similar protection level.

Introduction

In crop spraying the goal is to achieve a uniform spray deposition all over the crop canopy structure or soil surface. Losses to the soil underneath the crop and outside the field, through spray drift are to be minimised. It is known that sprayer settings are important for spray distribution in crop canopy. Matching spray volume and direction to crop size and shape can reduce chemical application, thus reducing operational costs and environmental pollution. Manual or sensor actuated sprayers have shown potential reductions in agrochemical use of 30% and more. Sensors quantifying crop parameters such as quantity of biomass and photosynthesis activity are already commercially available. Sensors to evaluate the plant stress (MLHD 2004; Polder 2004) or spectral analysis of the crop canopy parameters (Bravo *et al.,* 2003; Schut, 2003; Vrindts *et al.,* 2003; Scotford & Miller, 2004) open the potential for more target oriented spraying in crop protection. Spray systems treating individual plants based on fluorescence (Rometron, Weed-It) as used on pavements (Kempenaar *et al.*, 2006) or canopy reflection information (Ntech, GreenSeeker) used for fertilising are already developed. Precise application techniques recently developed able to vary dose rates are obtained by Pulse Width Modulation nozzles (Weed-It) and multi-nozzle holders (SensiSpray; Lechler VarioSelect) with switchable number of nozzles varying in flow rate (Dammer & Ehlert, 2006); respectively in a continuous (50-300 l/ha) and a stepwise way (50-600 l/ha in 12 steps). Based on these possibilities we can achieve smaller units of treatment in the field. In spraying crop protection products this will lead from a full boom width treatment to section wise and even nozzle wise variable applications.

This paper describes an example in which the different elements of precision farming are combined in a Canopy Density Sprayer (CDS) for bed-grown crops like flower bulbs and potatoes which is under

development (Zande *et al.,* 2005). An overview of recent developments and introductions in agricultural practice of crop adapted spraying for crop protection in arable crop spraying is given.

Materials and Methods

A Canopy Density Sprayer (CDS) for bed-grown crops like flower bulbs and potatoes is under development. This CDS prototype spraying system combines detailed crop information (fluorescence and spectral reflectance) with very accurate application techniques. The system sprays only when there are crop plants under the spraying nozzle(s) (Figure 1). When leaves emerge from the soil only the leaves are sprayed: the sprayer operates as a patch sprayer. When the crop develops it forms rows and the CDS becomes a band sprayer. When the crop canopy covers the whole bed, only the bed will be sprayed but not the paths in between. When the crop develops to its maximum height (flowering) spray volume will be adapted to crop height or

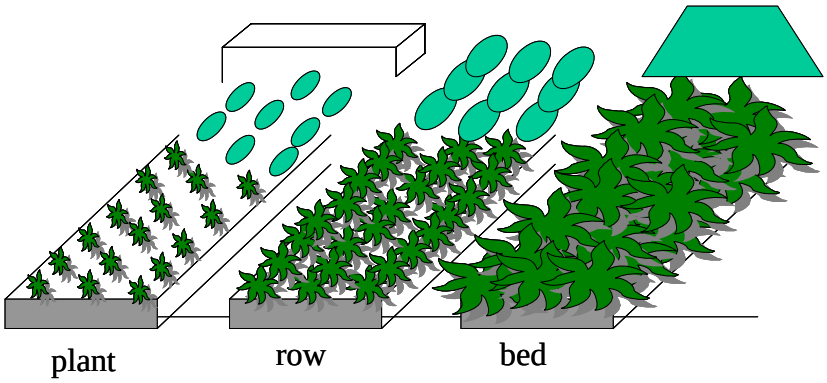

Figure 1: Schematic presentation of the development of a Canopy Density Sprayer for bed grown crops

total leaf area to cover total leaf area uniformly. Expected reductions in agrochemical use vary from 25% in the full-developed canopy to more than 90% in the initial leaf stage based on crop growth development evaluations during the growing season of flower bulb crops grown on beds (Zande *et al.*, 2008).

Canopy adapted spraying systems are momentarily tested in prototype versions in potato and flower bulb crops. Precise spraying and dose adaptation to the canopy volume are elements of research to optimise the spray deposition process. Variable dose rates are obtained by Pulse Width Modulation nozzles (Weed-It) and multi-nozzle holders with switchable number of nozzles varying in flow rate (SensiSpray; NTech Greenseeker + Lechler VarioSelect); respectively in a continuous (50-300l/ha) and a stepwise way (50-600l/ha in 12 steps).

Plant-specific spraying against late blight in potatoes

The first experiments with plant-specific spraying against late blight in potatoes were done in autumn 2007 (WUR-PPO experimental farm, Lelystad). In this experiment it was shown how much chemicals can be saved by switching on and off nozzles when spraying against late blight (*Phytophthora infestans*) and whether biological efficacy remained comparable with conventional application methods. A prototype using Weed It sensor-spray elements was built for this purpose enabling the spray to be placed in 10cm bands and 5cm length direction accuracy. The machine was prepared to work at a width of 2.25m, on the top of 3 potato ridges (Figure 2). The conventional spraying machine (Figure 3) used TeeJet XR11004 nozzles (3 bar spray pressure) at 50cm nozzle spacing applying a spray volume of 300l/ha (5km/h). Boom height between the soil and the crop canopy was 75cm.

The fungicide applied (Shirlan) was made as a tank mix in a jerry can and placed on a ‘Spider 15’ balance with an accuracy of ten grams. The amount of spray volume used was determined by weighing the jerry can with the chemicals before and after every treated field. The average used dosage (l/ha) of every field was compared to that used in conventional spraying.

Figure 2: Pulse Width Modulation nozzles
Figure 3: conventional sprayer applying 300l/ha

The experiment contained seven treatments; untreated plus six treatments sprayed with Shirlan (fluazinam) to protect the crop against late blight (*Phytophthora infestans*). Fields were sprayed with both conventional and Weed-It spray techniques at dose rates of 75% (0.3l/ha) and 25% (0.1l/ha) of recommended dose (0.4l/ha).

After the treatments, leaves were picked to analyse them in the laboratory for protection against late blight. The leaves were inoculated with a few drops of a *Phytophthora* spore suspension and *Phytophthora* development on the leaves was visually evaluated after 6 days.

Theoretical crop coverage and therefore agrochemical saving was calculated based on pictures taken and estimation of plant soil coverage with image analysis.

Results

Field test of a CDS sprayer in potato leaf blight control

The Weed-It sprayer, as used now on pavements for weed control, sprays only green areas as the sensor used detects chlorophyll reflection and was adapted to apply fungicides against late blight in an early potato crop. Evaluation of the plant canopy covering soil surface showed that at spray times only 13-14% of the soil surface was covered with green tissue (Figure 4). Theoretically savings in agrochemical use could therefore be more than 85%. The measured quantity of sprayed volume during applications on the different dates varied between 75% and 84%.

Figure 4: Over view of potato field at third application time, covered soil surface with potato canopy is 14%

No difference in protection against late blight was found between the spray techniques and dose rates, except for the Weed-It 75% dose on October 23 which was significantly lower than the other techniques.

Remarkable is that for the 'not treated' treatment the percentage of leaves infected decreased from 100% on 16 October to 49% on 23 October. Explanation for this can be that, due to the senescence of the leaves due to the cold circumstances of the potatoes, less visualisation of the Phytophthora was possible.

From these first experiments it can be concluded that individual plant spraying gave equally good protection against late blight while using less than 25% of the standard applied amount of fungicide.

Discussion

Canopy Density Spraying on bed-grown crops, like potatoes and flower bulbs, has shown a potential reduction in PPP use, especially with first sprayings of the crop early in the growth season. Also when the crop covers the soil surface completely but still develops in crop height and leaf mass, a reduction in PPP is possible maintaining biological efficacy. Further development of Canopy Density Spray systems and more target oriented sprayings can be realised when diseases are detected before visual appearance. Sensor evaluation shows potential in this direction. The evaluation of combinations of sensor and spray systems on the market show that some steps are still to be made before a good working Canopy Density Spray system is fully operational in practice (Zande *et al.*, 2008). First field tests of a prototype plant-specific fungicide application with a CDS-prototype (Weed-It) show a reduction of 75-84% in agrochemical use for the first 3 fungicide applications maintaining a good protection against late blight in potato. Potato plants were still individually standing and crop coverage during these applications was around 30%.

References

Bravo C, Moshou D, West J, McCartney A & Ramon H, 2003. Early disease detection in wheat fields using spectral reflectance. Biosystems Engineering 84(2003)2: 137-145

Dammer KH & Ehlert D, 2006. Variable-rate fungicide spraying in cereals using a plant cover sensor. Precision Agriculture 7(2006): 137-148

Kempenaar C, Groeneveld R M W, Uffi ng A J M. 2006. Evaluation of Weed IT model 2006 MKII: spray volume and dose response tests. Plant Research International, Note 418, Wageningen.

MLHD, 2004. Minimum Lethal Herbicide Dose, MLHD online; manual for the herbicide dose calculation module V2.0. Opticrop, Plant Research International, Wageningen. 2004. http://mlhd.opticrop.nl/

Polder G, 2004. Spectral imaging for measuring biochemicals in plant material. PhD Thesis Wageningen Agricultural University, Wageningen. 2004. 150pp.

Schut AGT, 2003. Imaging spectroscopy for characterization of grass swards. PhD Thesis Wageningen University, Wageningen, The Netherlands. 2003. 264p

Scotford I.M. & P.C.H. Miller, 2004. Combination of spectral reflectance and ultrasonic sensing to monitor the growth of winter wheat. Biosystems Engineering 87(2004)1: 27-38

Vrindts E, Reyniers M, Darius P, DeBaerdemaeker J, Gilot M, Sadaoui Y, Frankinet M, Hanquet B & Destain M-F, 2003. Analysis of soil and crop properties for precision agriculture for winter wheat. Biosystems Engineering 85(2003)2: 141-152

Zande JC van de & Achten VTJM, 2005. Precision agriculture in plant protection technique. Annual Review of Agricultural Engineering 4(2005)1:217-228

Zande JC van de, Achten VTJM, Michielsen JMGP, Wenneker M & Koster, AThJ, 2008. Towards more target oriented crop protection. International advances in pesticide application. Aspects of Applied Biology 84(2008):1245-252