PPP Project Final Report 2018
The PPP-projects that have been established under the direction of the top sectors and will be completed before 1 March 2019 must submit a technical and financial final report. This format is to be used for the technical final report.

The report will be published on the websites of the TKIs/top sector, excluding the blocks 'Approval coordinator/consortium' and 'Changes to the original project plan'. Please ensure that no confidential matters are left in the remaining blocks.

General information	
PPP number	**HT-17221**
Title	Sensors and ICT applications for effective and efficient use of fungicides
Theme	BO-41-002-002 Slimme technologie
Executive knowledge institution(s)	RIKILT Wageningen University & Research BU Toxicology & AgriChains
Research project leader (name + e-mail address)	Cheng Liu (cheng.liu@wur.nl)
Coordinator (on behalf of private parties)	Abram het Lam (Agrovision)
Government contact person	Frans Lips
Total project size (k€)	544 excl. VAT (all years)
Address projectwebsite	https://www.wur.nl/nl/Onderzoek-Resultaten/Topsectoren/show/HT17221-Sensors-and-ICT-applications-for-effective-and-efficient-use-of-fungicides-1.htm
Start date	01-04-2018
End date	31-12-2018

Approval coordinator/consortium *The report should be discussed with the coordinator/the consortium. The TKIs appreciate being informed of possible feedback on the report.*	
The coordinator has assessed the report on behalf of the consortium	■ approved □ rejected
Feedback from the consortium coordinator on the report	The report accurately describes the progress and results of the project. The consortium is very enthusiastic about the first results of high accuracy disease prediction with only few images. These results can be used for further investigation. However, the consortium regrets the fact that the project has stopped after eight months. Because there is still a lot of steps to make from this first analysis to a first version of a DSS in practice. Therefore we hope that this investigation will continue in a way.

Short description/aim PPP What is going on and how is this project involved?

What will be delivered by the project and what will be the effect of this?
Motivation: Mycotoxins are secondary metabolites of fungi that can cause adverse effects to animals and human health upon ingestion. In Europe, *Fusarium* spp. are the main fungal species of small grain cereals; they are encountered throughout Europe with different subspecies producing different mycotoxins. The most important Fusarium toxins in European small grain cereals include deoxynivalenol (DON) and zearalenone (ZEA). Infection of the cereals with *Fusarium* spp. species leads to the crop disease Fusarium Head Blight (FHB), which in results into reduced crop yields and quality of the kernels (kernels are smaller, shriveled and colored). Generally, cereal farmers bear the economic burden due to lower crop yields and the presence of mycotoxins due to *Fusarium* spp. presence. To limit economic losses and health problems, *Fusarium* spp. infection of small grain cereals, fungal growth, and related toxin production can be prevented in the field by applying fungicides against FHB. The same goes with spraying against other wheat pathogenic infections. For sustainability, economic and human health reasons, these fungicides and other pesticides should be applied with care. A dedicated, timely and spatial specific spraying plan is needed to limit infection and mycotoxin contamination in small grain cereals grown in the Netherlands. *Aim:* The aim of the project is to develop a Decision Support System (DSS) infrastructure that can detect and identify FHB at early stage, and distinguish from the main other wheat diseases, in order to assist farmers in the dedicated application of pesticides against *Fusaium* spp./mycotoxins on winter wheat in the Netherlands. To achieve this goal, timely monitoring and cost-efficient measurements are needed by using data from multiple sources such as sensors and multi- or hyperspectral cameras that reside under drones. Images from the cameras will be analyzed based on state of the art deep-learning approaches that have been successfully employed in other similar dealings with image data. Parameters learned from these algorithms will enable in developing a fine-tuned hardware that will be detrimental in the identification of minimum data required for spectral data analysis. This device will, therefore, produce better quality data reducing costs in various levels such as hardware (low-cost sensors), software and computational resources (time) without compromising prediction quality (good and bad indicators in the field). *Deliverables:* The main result of this project will be a DSS for the individual grain farmer with real time *Fusarium* spp infection and mycotoxin predictions and other wheat diseases at detailed farm and field level at a spatial and personalized level. *Impact:* The project will result into dedicated fungicide application, resulting in less fungal infection and mycotoxin contamination of cereal grains. This, in turn, will lead to reduced crop losses, fewer crops that are downgraded in the market, and reduced effects on animal – also increasing animal productivity and reproduction - and human health. Socially, a limited fungicide application will reduce the fungicide pollution in soil, water, and the food chain to ensure the sustainability of agricultural production systems. Both animal and human health will potentially benefit from reduced mycotoxin contamination in grains for food and feed. The economic impacts are the prior concerns for farmers and processors. Consequently, increased yield and improved quality will bring a higher market value of the cereals and less economic losses due to reduced animal diseases and disorders. Scientifically, this multidisciplinary research will bring crop farmers, ICT companies, agrifood companies and research institutes together on the same platform. Another scientific impact is the statistical tools that will be developed to process image data and process it into – at the end – information readily available for the end-users.

Changes to the original project plan and follow-up	
Have there been any changes in the consortium/project partners? If yes please explain	The private partner 'SPECIM' (hyperspectral camera provider) withdrew before the project started. An external partner Stichting Proefboerderijen Noordelijke Akkerbouw (SPNA) has

	joined the consortium.
Have there been any changes in the project set up? If yes please explain.	The consortium decided to use multispectral camera in the second half of the project instead of the beginning of the project.
Do you expect a patent application to arise from this PPP? If yes please explain	No.
Do you expect spin offs to arise from this PPP? (including new projects) If yes please explain	Not at this moment. The project has stopped after only eight months.
in how many years will the private parties use results from this project in practice?	The result and experience obtained from the first year can be used directly for private parties.
How has the project contributed to developments within the involved knowledge institution(s)? (e.g. scientific breakthroughs, new collaborations etc)	This project has contributed to the developments within RIKILT as following: - Research experience on fast on-site screening of mycotoxins - Applied application of mycotoxin prediction models developed under previous PPS mycotoxins project - New network contacts in the research area of precision farming
What will be the follow up of this project?	Both RIKILT and some of the private parties are willing to continue to work on this topic in the following aspects: - Field study to collect more hyperspectral image data - Algorithm to detect mycotoxin presence using hyperspectral imaging - Improved mycotoxin prediction model using hyperspectral imaging

Achieved Results

Describe the deliverables of the project?

- Literature review.
  State of art detection of fungal diseases on winter wheat using spectral imaging.
- First results from imaging analysis.
  With limited number of pictures, private partner WINGs used image classifier to detect various diseases in .png photos. The accuracy of identifying Fusarium and brown rust are already above 98% and 96% respectively. It is also capable to identify different diseases at the same time on one picture. Of course more work need to be done to stabilize the accuracy and improve the results for some cases by using hyperspectral information and extra image data. For the rest of the year, WINGS will keep working on it and adding hyperspectral information in the model.

What is the effect and for whom?

- Literature review on recent studies has provided a good overview of methods and equipment used in the topic of fungal detection using spectral imaging. This overview has been beneficial for the consortium in camera selection, imaging analysis and work planning.
- The very first positive results of imaging analysis has enlighten the private partner WINGs to explore and apply their expertise on food safety sector. The high accuracy of identifying Fusarium has proved that it is possible to identify Fusarium (and potentially mycotoxins) with hyperspectral imaging.

Which project parts differed from the original plan and what was the reason for this?

The consortium has decided to use hyperspectrual camera first to identify the broad bands of different fungal diseases, and then use multispectral camera to zoom into the specific bands. Therefore the in-kind contribution from Ocean Optics (multispectral camera provider) has been postponed from first year to the later stage of the project.

Number of delivered products in 2018 *(in an appendix, please provide the titles and/or description of the products or a link to the products on public websites)*			
Academic articles	Reports	Articles in journals	Introductions/workshops
	1		
Titles/ description of the most important products in 2018 (5 at max) and their target group			
Report: Detection of fungal diseases on winter wheat using spectral imaging systems. Marcel Kluche and Cheng Liu 2018. Target group: project consortium			

Appendix: Names of the products or a link to the products on a public website including the link to the project summary on Kennisonline