The common practice for fungicide use is to apply a single blanket rate across the whole crop, yet many fungal diseases initiate in patches. Early identification of hot spots of diseases such as *septoria tritici* before an infection threshold is reached followed by targeted application of fungicide to these areas would greatly reduce fungicide inputs.

In the absence of sensor based technology for automated, early detection of pathogens, a method for optimising fungicide application in real-time was developed. This system for cereals based application rate on local plant surface (Leaf Area Index (LAI)) or biomass.

Crop growth is likely to vary across a field in relation to moisture and nutrient availability. This system to regulate fungicide amount was based on reducing applications to areas of crop with low LAI or biomass without changing the concentration of liquid in the spray tank.

The use of LAI of biomass will work with both protective fungicides, which require the plant surface to be fully wetted and systemic fungicides where a certain concentration of fungicide needs to be absorbed into the plant to kill the pathogenic tissue.

**A physical sensor for fungicide rate**

To automate the rate applied by a field sprayer, the sensor signal must correlate with LAI or plant biomass. The team at the Leibniz Institute for Agricultural Engineering (ATB) developed and commercialised a mechanical sensor for precise fungicide application in cereal called CROP-Meter.

Mounted on the front of the tractor, the sensor consists of a horizontally pivoted metal rod (Figure 1). The rod was deflected by the level of resistance provided by the cereal stalk. The degree of deflection was correlated to both plant surface and biomass and this was used to vary the fungicide application rate.

Information from CROP-Meter and from the decision support system proPlant expert.precise (map) was combined to provide a real-time spraying system with a map overlay.

In long term field trials a 22% saving in fungicide was achieved with no increase in plant disease or reduction in yield, when compared to a blanket spray.

The prototype decision support system proPlant expert.precise estimated infection risks from fungal diseases using weather and field-specific data (variety, sowing date, plant density, growth stage, nutrition and soil moisture). Fungicide rates were produced for up to three zones with different yield expectations. The result was an application map which was combined with the CROP-Meter measurements in real-time.

In tests carried out in 2007 in three paddocks of winter wheat, the combined system resulted in a 32.6% saving in fungicide compared to a blanket spray.
A non-contact sensor

With cameras and ultrasonic sensors becoming cheaper, smaller and more robust, we saw the opportunity to develop sensors which are not in contact with the crop canopy while measurements are gathered. Those sensors can be easily adapted to agricultural machines. In the project, a field sprayer will be controlled either by ultrasonic or camera sensor.

The active ultrasonic sensors generate high frequency sound waves and evaluate the echo received back by the sensor. By measuring the time interval between sending the signal and receiving the echo, the distance to an object can be determined and in this case an ‘ultrasonic height’ is calculated. One ultrasonic sensor will be attached to each section of the boomspray to provide section control based.

A 3-chip CCD multispectral camera which takes red, infra-red and green images simultaneously was used in the trial. Computer vision is used to calculate a binary image which represents the percentage of the local green crop tissue (Figure 2).

In calibration experiments we found that the sensor signals either from the ultrasonic or camera were correlated in a linear manner with LAI and biomass at different growth stages and in different varieties of winter wheat.

The coverage level coming from the sensor is converted to a certain voltage which serves as the signal to adapt the local spraying rate of a field sprayer in real-time.

During a 2014 field experiment, we tested the technology in sparse canopy areas. With a low green coverage level, the spraying amount was reduced. In dense canopies spray was increased and vice versa.

No yield reduction and no higher disease occurrence had been obtained in the camera controlled strip compared with the neighbouring common uniformly sprayed strip.

In 2015 and 2016 extended spraying experiments in more fields and wheat varieties are planned.

In the future the new sensor controlled spraying technology will provide grain growers with a more precise application of fungicides. The local crop surface and biomass as the target of spraying liquid serve as parameters to vary the spraying amount.

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Figure 1. CROP-Meter mounted on the front three point linkage of a tractor is a tool to measure crop surface area and biomass.

Figure 2. Black/white binary image of the local green cereal crop in the same field at the same time - a) dense canopy, coverage level 95% b) sparse canopy coverage level 33%.