Akkerweb: a platform for precision farming data, science, and practice

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Abstract.

The concept of precision farming (PF) was formulated about 40 years ago and the scientific knowledge for some applications of PF in The Netherlands has been available for almost 20 years. Also, in many cases equipment is available to implement PF in practice. In spite of all this PF uptake is still limited. An important reason for the limited uptake of PF is in the challenges that must be overcome to let data flow from sensors to data storage, to combine data sources and process them into recommendations, and to send the recommendations to agricultural implements. These challenges are technical, legal, and ethical in nature. In this paper we describe how Akkerweb is used in The Netherlands to address the above challenges.

Akkerweb (www.akkerweb.eu) is a web-based platform with the following functions. It provides access to external data sources such as weather, parcel boundaries, satellite, and farm management data in commercial Farm Management Information Systems. It stores geo-referenced data, including soil maps and drone imagery. It allows combining data sources and processing of data, through modules ("apps") that are not unlike the apps on a smartphone. It generates prescription maps and other recommendations. Prescription maps can be downloaded to tractor terminals and used to implement the recommendation. Finally, the use of apps can be subject to a fee, i.e. commercial use of the platform is possible.

Currently, approx. 30 apps are available on Akkerweb. We highlight three apps for potato growers. The Potato Haulm Killing app gives a recommendation for desiccant use to terminate a potato crop and leads to an average reduction in herbicide use of 38% and an increase in gross margin of 30 € ha-1. A recent development is the use of drone imagery (0.25 m) instead of the earlier satellite imagery (10 m). The late blight app makes a recommendation when to apply fungicide to *control Phytophthora infestans. Recently, in response to growers' requests, a dynamic crop growth model was added to this app to better describe re-mobilization of reserves and leaf growth immediately following the end of a drought period. Finally, the N sidedress app has recently been modified to work with drone imagery in addition to tractor-based reflectance sensors.*

A number of factors has contributed to the success of Akkerweb. It has been developed and is owned by a consortium consisting of Agrifirm, a farmers' cooperative, and Wageningen University & Research. Growers were involved from the start and have a sense of ownership. This has led to trust that data stored in Akkerweb will only be used in ways that benefit the farmers. The involvement of Wageningen UR guarantees that Akkerweb recommendations are both science-based and effective. For the future, big data analysis of Akkerweb data will lead to new knowledge that is of benefit to growers; it is expected that growers will consent to their data being used because their direct involvement in Akkerweb guarantees that they contribute to setting the research agenda and remain in control of their data.

Keywords.

potatoes, nitrogen, haulm killing, late blight, data portal, big data, satellite, drone.

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Introduction

The concept of precision farming (PF) was formulated about 40 years ago and the scientific knowledge for some applications of PF in The Netherlands has been available for almost 20 years. Also, in many cases equipment is available to implement PF in practice. In spite of all this PF uptake is still limited. An important reason for the limited uptake of PF is in the challenges that must be overcome to let data flow from sensors to data storage, to combine data sources and process them into recommendations, and to send the recommendations to agricultural implements. These challenges are technical, legal, and ethical in nature. In this paper we describe how Akkerweb is used in The Netherlands to address the above challenges.

The remainder of this paper is organized as follows. Below, we first describe the Akkerweb platform. Then we describe three Akkerweb apps in some detail. This is followed by a discussion and a summary.

Platform

Akkerweb (www.akkerweb.eu) is a web-based portal for precision agriculture (Been and Molendijk, 2017). It is the product of a consortium consisting of Agrifirm, the largest farmer's cooperative in The Netherlands, and Wageningen University & Research (WUR), the leading agricultural research center in The Netherlands. Akkerweb has evolved from NemaDecide, a decision-support system for control of plant parasitic nematodes (Been and Schomaker, 2004, Been et al., 2007).

Akkerweb provides farmers and their consultants with access to external data sources such as parcel boundaries, global weather, satellite imagery, and farm management data stored in the commercial Farm Management Information Systems (FMIS) Crop-R[1] and CropVision[2].

In addition, Akkerweb allows users to upload their own geo-referenced data. Frequently uploaded data include maps of soil EC_a, drone imagery, and the output of tractor-mounted canopy reflectance sensors. High-resolution, multi-band drone images of several GB in size can be accommodated without problems. A data agreement[3] is in force which states unequivocally that all data remains the property of the party who uploads the data and will not be used by third parties without prior consent given by the owner.

Finally, Akkerweb allows combining data sources and processing of data, through modules ("apps"). A list of apps is given in Table 1. Several apps generate task maps and other recommendations. Task maps can be downloaded to tractor terminals and used to implement the recommendation.

The apps on Akkerweb are offered by a variety of providers. Several apps that offer basic functionality are offered by the Akkerweb consortium and are available free of charge to all users. Other apps are available for a fee. The provider of an app decides on whether and how much to charge for the app, i.e. commercial use of the platform is possible. However, apps must be approved by the consortium before they are made available on Akkerweb.

Akkerweb is implemented using web services. This enables loose coupling between apps. Thus apps can be built using services provided by other apps. A software development kit (SDK) is available to assist developers not directly connected to Akkerweb.

There are currently 4000+ Akkerweb users. In many cases, farmers do not use Akkerweb directly

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[1] https://dacom.farm/products/crop-recording
[2] https://www.cropvision.nl/
[3] https://akkerweb.eu/nl-nl/Contactinfo/Privacystatement

themselves but rather through their consultant. Data of 40,000+ parcel crop years are stored using Akkerweb.

Table 1. Some of the apps available in Akkerweb. From (Been and Molendijk, 2017)

Name	Purpose	Provider	Terms of use
Cropping Plan	Entering grower's fields plus crops, cultivars, soil type, planting and harvesting date either manually or via web services connecting to official bodies and Farm Management Systems.	Akkerweb	Free
Map	Overview of all grower's fields on a map. Add layers of information from your applications: e.g. all fields that have been sampled, all fields with sensor data, etc. Klick on a field polygon and all information available will be listed.	Akkerweb	Free
Sensor data	Upload all types of sensor data and visualize the information. Use these data in the different applications on Akkerweb.	Akkerweb	Free
Satellite	Download satellite imagery – WDVI and NVDI biomass maps for further use in Akkerweb, e.g. Haulm killing (Currently Alterra en NEO WCS services).	Akkerweb	Free
My Advices	Advice generated in the advisory Apps used by third parties and not available to the farmer, can be stored and retrieved for later use.	Akkerweb	Free
Contacts	Connect with another Akkerweb user and share information	Akkerweb	Free
Digital sampling request	Nematodes, phosphate, white rot.	NemaDecide[4]	
Stripbuilder	Program to subdivide fields into sampling units for nematodes, phosphate, white rot, tracks, buffers, in order to supply sampling maps and display results.	WUR	Paid
NemaDecide Geo	Free version of a decision support system for the potato cyst nematode.	NemaDecide	Free
NemaDecide Geo PLUS	Version of NemaDecide including root-knot nematodes (M. chitwoodi) and the root lesion nematode (Pratylenchus penetrans) with extra features.	NemaDecide	Paid
Agrifirm Mineral	Calculate fertilizer needs, based on crop, soil type, acreage for your whole farm.	Agrifirm[5]	Paid
Agrifirm Crop protection	Calculate crop protection product needs, based on crop, soil type and acreage for your whole farm	Agrifirm	Paid
Task map nematostats	Based on soil sampling results a task map will be calculated including official delimitation.	Agrifirm	Paid
Potato information	More than 400 potato cultivars and all their properties, including partial resistance against potato cyst nematodes, blight, etc. including data querying and links to the breeders.	NemaDecide	Paid
Task map haulm killing	Biomass-dependent haulm killing of potatoes based on NDVI and WDVI originating from satellite and E-bee.	WUR	Paid
Task map side dress nitrogen	Biomass-dependent task map for nitrogen side dress for potatoes based on NDVI and WDVI originating from satellite, E-bee or Yara images.	WUR	Paid
Task map herbicides	an application map based on lutum (clay particles < 2 μm), and organic matter content of the soil.	WUR	Paid
Get hold of your grass production	Measure your grass height georeferenced using your mobile and calculate the Feed Wedge on Akkerweb.	WUR	Paid
Bioscope	a service that provides a farmer with different products, among which an WDVI-green biomass map, every 10 days. Imagery is originates from satellites or from drones, when satellite images are unavailable.	Bioscope[6]	Paid
Late Blight	A completely new state of the art decision support system to avoid yield losses by Phytophthora infestans	Agrifirm	Paid
Reglone app	Create task map for application of Reglone in potatoes.	Syngenta	Free[7]

N sidedress app

In The Netherlands, it is standard practice in potatoes to apply an average of 250 kg of nitrogen per hectare just before or just after planting. However, crop N demand varies between fields as well as between years and in addition depends on cultivar, planting date, weather, mineralisation

[4] www.nemadecide.com
[5] www.agrifirm.nl
[6] www.projectbioscope.eu
[7] Users needs to scan the QR code on the packaging to make use of the app

of N in the soil, and productivity of the field. Therefore, Wageningen UR has developed a recommendation system for sidedress N in potatoes which allows the farmer to respond to this variability. Implementation of this system is supported by an Akkerweb app.

In the potato N sidedress system 2/3 of the recommended amount of N is applied at planting. Then, around 1 July, the amount of N already taken up by the crop is determined via a measurement of canopy reflectance. The amount of N taken up by the crop is compared with the amount of N that would have been taken up by a crop growing without N limitation (modelled). The difference is applied as sidedress N. This system maintains yield and results in an average reduction in N use of 15% (Booij et al., 2017, Van Evert et al., 2012, Van Evert et al., 2016)

The canopy reflection measurement can be made using a satellite, using a drone-mounted camera, or using a tractor-mounted instrument. We currently favour using a drone, because this method avoids the pitfalls of satellite imagery (often not available in The Netherlands due to clouds) and tractor-mounted instruments (they often become poorly calibrated over time).

The farmer's workflow consists of the following steps. First, the field for which a recommendation needs to be generated is selected in Akkerweb. European Union regulations require farmers to provide the national government with the boundaries of all their fields before the growing season starts. This information is available in a national database (Land Parcel Information System). Akkerweb is linked to this database. Thus, the farmer can select the field in question without the need to enter boundaries a second time.

Second, a measurement of canopy reflectance must be obtained. A satellite image can be obtained by right-clicking on the field, this brings up a list of images that are available for this field. The images are bought by the Dutch government. They are processed by Wageningen UR to calculate NDVI and WDVI (http://www.groenmonitor.nl/). A drone image can be obtained by right-clicking on the field and filling out an order form requesting a flight. This will be processed the next day by Dronewerkers (http://www.dronewerkers.nl/), a collaboration between several small companies that use one type of drone and camera, and have a common processing pipeline. The third option is to upload the log file that was created with a Yara N-Sensor.

Third, the farmer must enter information about the crop: cultivar, planting date, and expected yield. Once this information has been entered, the app calculates nitrogen uptake from the canopy reflection (using sensor-specific calibration curves) and recommends a sidedress N rate. The app can be used to display each step, as an example the calculated N uptake is shown in Figure 1.

In the fourth and last step, the user selects the type of fertilizer (and thus the nitrogen content), the minimum and maximum application rate (which will override the recommendation), and the grid size. Then a task map is generated which can be used in an ISOBUS tractor terminal.

Figure 1. Screen shot of the potato N sidedress Akkerweb app. Shown is crop N uptake calculated from a drone image.

Late blight app

Potato late blight is the most serious disease of potato, globally responsible for an annual loss of around M€4800 (Haverkort et al., 2008). Traditionally, potato late blight is controlled using (highly) frequent fungicide applications (Cooke et al., 2011). Optimization of the timing of fungicide applications normally reduces the fungicide input and improves the quality of control. The Akkerweb late blight app is a decision support system implementing a preventive late blight control strategy aiming to only apply fungicides just before predicted late blight infection events.

Local, forecasted and historical, hourly weather data are analyzed to identify infection events in the near future and near past. Ideally, preventive fungicides are applied just before predicted future infection events when the remaining fungicide protection is insufficient. When necessary, curative fungicides are recommended up to 24 hours after calculated infection. Eradicant fungicide combinations are recommended on older, untreated latent- and active infections.

Qualitative and quantitative fungicide characteristics are taken from the annually updated Euroblight fungicide table (www.euroblight.net). This includes e.g. the preventive capability on foliage and tubers, curative ability, rain fastness and drying time.

The late blight app interface allows farmers an instant, map based, overview of the late blight situation in all their potato crops. Field specific details and recommendation are available simply by selecting the field of interest (Figure 2).

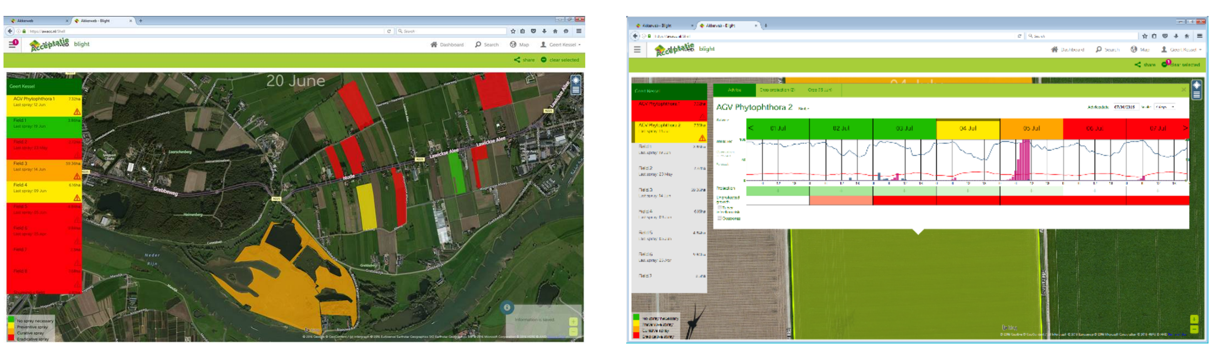

Figure 2. Left panel: Overview of the late blight situation in potato crops at farm level. Right panel: details on the late blight situation in a single, selected, potato crop including weather data, predicted infection events, remaining fungicide protection, quantity of unprotected foliage and overall recommendation. Colors indicate the spray recommendation: Green: fungicide application not recommended. Yellow: preventive fungicide application recommended. Orange: curative fungicide application recommended. Red: eradicant fungicide application recommended.

Potato haulm killing app

In The Netherlands, potatoes are harvested before the natural maturity of the crop. Typically, the aboveground part of the crop is killed about three weeks before the harvest date to ensure that the skin of the tubers has hardened when the crop is harvested. The most common method to kill the potato is to use defoliant herbicides (Kempenaar and Struijk, 2008). Herbicide dose can be based on the aboveground amount and activity of the biomass. The more biomass there is, the higher the dose of the defoliant should be (Kempenaar et al., 2014). Aboveground biomass can be measured for example using crop reflectance sensors. In this way a reduction in herbicide use between 20 and 47% can be achieved (Kempenaar et al., 2018, Van Evert et al., 2017).

The potato haulm killing app allows farmers to generate a task map for variable rate herbicide application based on a satellite or a drone image (Figure 3).

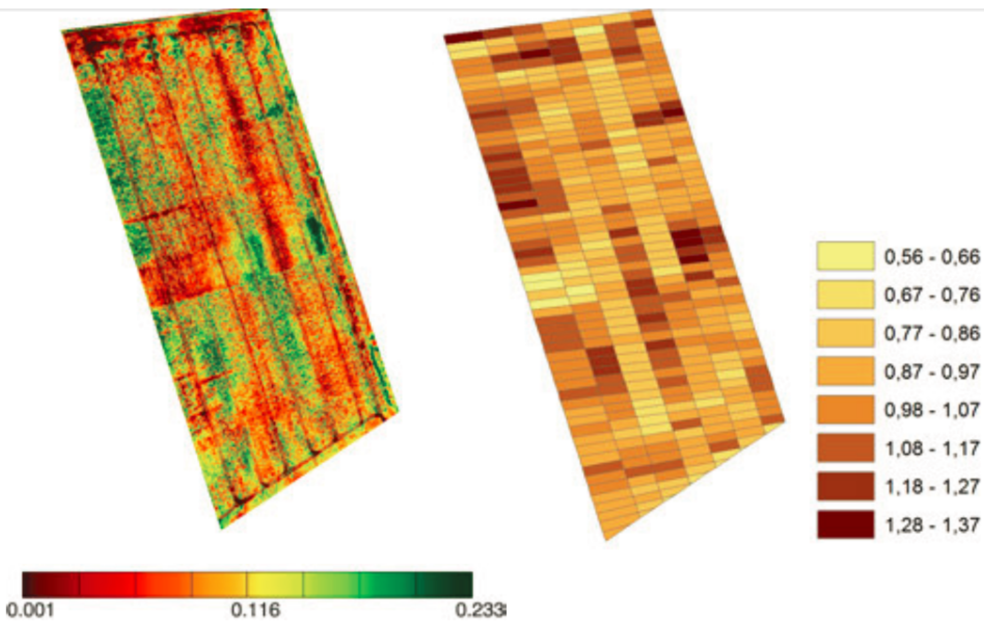

Figure 3. Left: Weighted Difference Vegetation Index (WDVI) of a potato field, measured with a drone. WDVI varies from 0 (no crop at all) to approx. 0.7 for full ground cover by a healthy, vigorous crop. Right: task map for the haulm killing herbicide Reglone. The legend represents application rate in l ha^{-1}.

Discussion

Akkerweb is considered a success by the consortium partners. It has attracted more users than other, similar initiatives in The Netherlands. For Agrifirm, it leads to cost savings. For WUR, it provides a channel to bring science to practice. It seems likely that this success is due because farmers' interests are represented by one partner, while another partner provides the science. Importantly, the IT is provided by an independent software company.

Akkerweb therefore seems to have implemented a multi-stakeholder process that is sometimes seen as the model for innovation in agriculture (EU SCAR, 2013, EU SCAR, 2016). Importantly, Akkerweb respects the interests of all parties involved (Kritikos, 2017), While Akkerweb has achieved some important goals already, it can be argued that the biggest benefits are still ahead. There is tremendous opportunity to collect, combine and analyze large amounts of data in agriculture, and use it to make better decisions (van Evert et al., 2017, Wolfert et al., 2017). Advances in the use of big data will require the collaboration of all supply chain partners, even if they are commercial competitors. Farmers' cooperatives, as representatives of farmers, and having more power than individual farmers, can play an important role in establishing effective working relationships between supply chain partners. It is expected that growers will consent to their data being used in big data analyses because their direct involvement in Akkerweb guarantees that they contribute to setting the research agenda and remain in control of their data. Ultimately, this will lead to new knowledge that is of benefit to growers.

Summary

Akkerweb is a web-based portal that offers apps to support currently established precision agriculture techniques. In the coming years, Akkerweb will play an important role in developing new knowledge using big data analysis.

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