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Geodata for the control of potato late blight in Bangladesh

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INTRODUCTION

In Bangladesh, fresh market potatoes are grown as a winter crop on approximately 450.000 ha. Due to frequently occurring fog periods, late blight (caused by *Phytophthora infestans*) is common and highly destructive. Annual yield losses have been estimated at 25-60%. Late blight can be controlled but only by highly frequent, costly fungicide applications. Nevertheless, control failures are common due to challenges presented by the local weather, lack of knowledge and continuous natural pathogen population changes.

The control efficacy achieved primarily depends on the timing of the fungicide applications. Complicating factors are found in crop growth, (absence of) disease pressure and the choice of fungicide. Mancozeb and Metalaxyl are the most commonly used a.i.'s in Bangladesh but the countries *P. infestans* population was found to be 100% EU_13_A2 and therefore metalaxyl resistant. Overall, the general late blight control efficacy can be significantly improved, e.g. by providing farmers with guidance on late blight control. A tailor made near day-to-day decision support system, giving advice on optimal spray timing and choice of fungicides, was developed for this purpose. This GeoPotato system was developed from 2014 – 2019 under the umbrella of the G4AWII program (https://g4aw.spaceoffice.nl/en/).

MATERIALS AND METHODS

The GeoPotato service provides subscribed farmers with preventive spray advice and a suggestion for the type of fungicide (preventive, curative). This advice is communicated through a short text message and/or voice message when a late blight infection event is predicted three

days ahead. In addition, capacity building on integrated control of potato late blight for farmers and extension workers (Training of Trainers for the Agricultural Information Service (AIS) and the Department of Agricultural Extension (DAE)) was carried out to allow for a better understanding of disease development, the GeoPotato advice and disease management. AIS and DAE then train the farmers and encourage and help farmers to subscribe to the free GeoPotato service.

The GeoPotato Service

Technically, the GeoPotato service takes into account and evaluates: the planting date, crop growth, the weather and the most recent spray applied (Figure 1).

Planting date

When growers subscribe for the service, the automated system asks for a planting date. Planting dates in October, November and December are then aggregated in 4 crop cohorts per month each spanning approximately 1 week. These three months cover the complete potato planting season.

Crop cohorts and crop growth data

Satellite data are used to identify potato fields belonging to each of the 12 crop cohorts. Subsequently, the NDVI is measured during each overpass. The LAI is then derived from a time series of (Sentinel 2A and 2B) NDVI measurements for the individual crop cohorts. A simple temperature-based crop growth model is run in the background to fill inevitable gaps in the satellite data occurring e.g. when it is cloudy during the overpass.

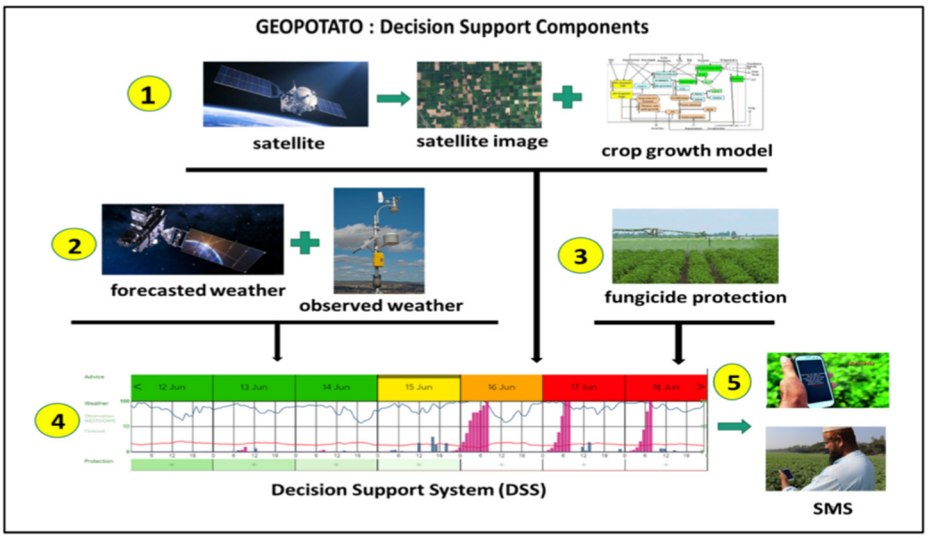

Figure 1. *The various information sources of the GEOPOTATO decision support system to control late blight in potatoes*

Weather data

Weather data serve to identify infection events in the near future (weather forecast) and in the recent past (data from automated weather stations). For this purpose we have assessed the performance of two well-known weather forecasting models, i.e. the Global Forecasting System (GFS) and the Weather Research and Forecasting (WRF) model. Based on a three-days forecasting, the skill of the WRF model was better than the GFS model but both models seriously underestimated the relative humidity, a key parameter driving the biological model simulating the *P. infestans* life cycle. Incorporation of the results (forecasts) of both models in the DSS would therefore underestimate the risk of late blight infection.

The cause of the underestimation of the boundary layer rH lies in the specific geography of Bangladesh in combination with typical regional winter weather conditions. During the winter, northerly winds pass over the Himalaya mountain range rendering the air cold and dry due to the altitude and the Fohn effect. When this cold and dry air comes in contact with "warm" water in Bangladesh's many river systems, dense, late blight conducive, fog often is the result. The lower relative humidity of the higher atmospheric layers is forecasted reasonably well. The high relative humidity of the boundary layer typically is (severely) underestimated.

As a last resort, 10 years of locally measured weather data was analyzed for *P. infestans* infection events. The results were summarized in a "late blight calendar" containing the chance (%) on a late blight infection event for each calendar day. In the final operational version of the GeoPotato system, this calendar replaced the (GFS or WRF) weather forecast.

The DSS

Potato farmers in Bangladesh need approximately three days to discuss, plan and execute a spray application. Thus, the DSS keeps track of the number of infection events since the last spray application plus the infection events predicted for the next three days. From the Euroblight foliar protection score of Mancozeb, the most commonly used fungicide in Bangladesh, it was derived that a Mancozeb application will protect the foliage against approximately five infection events. Thus, when the sum of infection events since the last spray plus the next three days exceeds five, a new spray advice is issued using a short text messaging (SMS) service and a voice message for illiterate farmers.

The user subscription system

Figure 2 shows a schematic of the user subscription system and its components including the DSS. Farmers subscribe to the GEOPOTATO service by dialing a telephone number with an interactive voice response (IVR) system (1 in Figure 2). Extension agents have been trained to support the subscription of those farmers that are not familiar with IVR. The farmers mobile number is automatically recorded while the farmer needs to provide the location of farming, the planting date and the sub-district (*upazilla* in Bangladesh). This information is stored in the aggregator platform that is connected with the DSS (2 in Figure 2). Updated DSS information is shared with the aggregator platform (3 in Figure 2). When the DSS identifies an infection period three days ahead an SMS is prepared for farmers with crops in cohorts and upazilla's at risk (Number 4 in Figure 2). The SMS gateway connects to the mobile networks to send farmers an SMS containing information when to spray and, in general terms, what to spray.

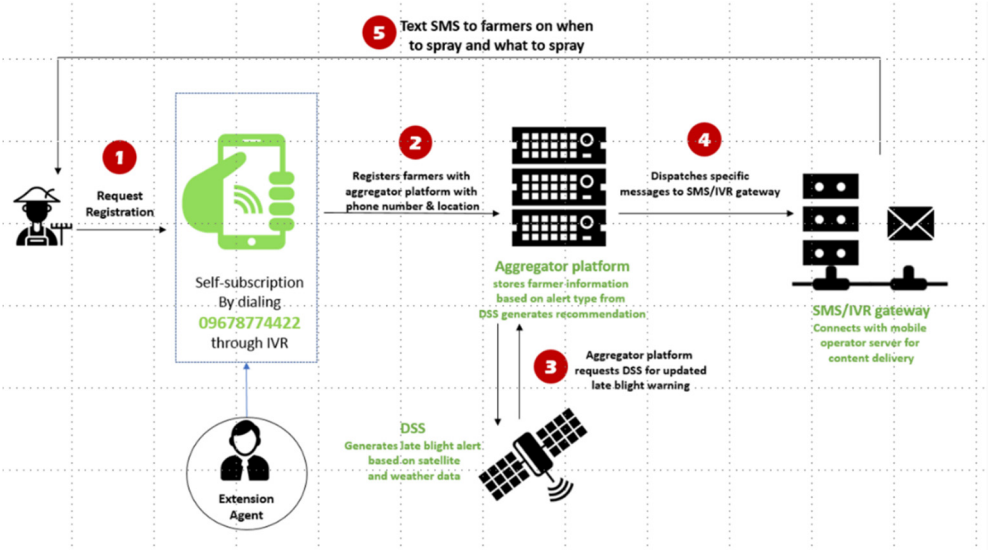

Figure 2. *GEOPOTATO's user subscription system*

The service area's

GEOPOTATO started its services in the 2016-2017 potato season in Munshiganj district just south of the capital Dhaka. Each consecutive year a new district was added, Rangpur for 2017-2018 and Dinajpur for 2018-2019. All districts included are major potato producing areas.

RESULTS

The GEOPOTATO service has run for three consecutive potato growing seasons: 2016/17, 2017/18 and 2018/19. During the first season, the service was only operational in Munshiganj to test the user ICT system and the technical components of the DSS including the GFS weather forecast. In total, 111 farmers received eight SMS alerts during the potato growing season (Pronk *et al.*, 2017). In the post-season evaluation, 94% of the farmers that received SMS alerts were satisfied with the service. A large majority of the participating farmers (92%) faced no problems in understanding the content of the SMS alerts and 87% of the farmers acted upon the alerts received. Based on the favorable farmer response to the GEOPOTATO service, the service was expanded to the Rangpur district in 2017/18 and Dinajpur in 2018/19.

Table 1. *Number of subscriptions to the GeoPotato service in three consecutive growing seasons*

Year	# Subscriptions	Area coverage (districts)
2016/17	111	Munshiganj
2017/18	6,762	Munshiganj + Rangpur
2018/19	42,000	Munshiganj + Rangpur + Dinajpur

The number of subscriptions for all three seasons are given in Table 1. In general, climatic conditions are more favorable for late blight in the Northerly districts of Rangpur and Dinajpur as compared to Munshiganj. In total, 6762 farmers subscribed to the GEOPOTATO service in the 2017/18 season and around 42,000 farmers in the 2018/19 season.

Potato yield was quantified on a limited number of potato fields subscribed to the GeoPotato service and compared to common practice without access to GeoPotato advice. In general, potato yields were positively influenced by the GeoPotato service (Table 2).

Table 2. *Yield change as a result of adhering to GeoPotato late blight spray advice in Munshiganj, Rangpur and Dinajpur*

Potato season	Number of fields	Yield change	District
2016/17	6	+7%	Munshiganj
2017/18	6	-1%	Munshiganj
	14	+22%	Rangpur
2018/19	7	+13%	Rangpur
	6	+20%	Dinajpur

The greater impact of the service on potato yields in Rangpur and Dinajpur is also reflected in the satisfaction of farmers that received SMS alerts in the 2017/18 potato season. In Rangpur, 89% of the SMS farmers was satisfied with the GEOPOTATO service, while a high but significantly lower percentage of farmers (72%) was satisfied with the service in Munshiganj.

DISCUSSION AND CONCLUSIONS

A large part of the rural population of Bangladesh depends on agriculture: crops, livestock, fisheries and forestry. Due to climate change, weather conditions become less predictable and farmers cannot rely on experiences from the past. Additional knowledge and information is needed to upgrade the knowledge and tools used by the farming population. Access to knowledge and information is however a major challenge for farmers.

The GEOPOTATO service is the first operational form of precision agriculture in Bangladesh. SMS alerts aimed at optimized potato late blight control were received and used by >40.000 smallholder farmers in 15 different sub-districts (upazilla's). In its current form, the GeoPotato system is a "one way" decision support system, information is sent to the farmer and hopefully used, but the farmer does not report back. More 'precision' can be achieved by turning the system into a two-way system in which the farmer would report back on the activities carried out. This would however necessitate the use of smart phones or computers instead of the currently widely used GSM phones.

Technical improvements would include a significant improvement of weather forecast models. With a reliable weather forecast, the climate statistic currently used could be replaced by forecasted weather data. That would allow the GeoPotato system to take into account actual forecasted weather instead of a climate statistic based on 10 years of historic weather data.

Despite drawbacks mentioned above, the results achieved with the GEOPOTATO service clearly show the (monetary) value of the service to the farmers subscribed. Significant yield increases are common and common over-spraying is avoided.

Despite the promising results it is not expected that small and resource-poor farmers are willing to pay for the GEOPOTATO service. Farmers in Bangladesh are used to receive public extension services for free, while many inputs (fertilizers, agri machineries, seed, etc.) are also subsidized.

The private agro-advisory service sector in Bangladesh is still in its infancy as in many other less-developed countries. Partners in the GEOPOTATO project are therefore cooperating with various input supply companies and other sector industries to assess whether they are willing to adopt the service for their clients and contract farmers. Agro-input suppliers could e.g. include the GeoPotato service as an add-on service on goods or services they already provide to win more clients and drive market expansion. For potato processing companies it can be part of a strategy to increase farmer production and to reduce potato sourcing costs. Further assessment of the GEOPOTATO service in terms of benefit(s) for farmers, retailors and other private sector companies is part of the strategy to develop a sustainable advisory service for the potato sector in Bangladesh.

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