Geo data for late blight control in potato
Evaluation of decision support service in Bangladesh, 2017-2018

Annette Pronk, Huib Hengsdijk, Hasib Ahsan, Jean-Marie Michielsen

GEOPOTATO

External Report 5

The GEOPOTATO project develops and implements a decision support service (DSS) in Bangladesh to control the late blight disease in potato. Satellite data and various models are important aspects of the DSS. GEOPOTATO aims at becoming the preferred agricultural advice service for potato farmers in Bangladesh. GEOPOTATO is financed by the G4AW program of the Dutch Ministry of Foreign Affairs, which is executed by the Netherlands Space Office (NSO).

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GEOPOTATO External Report 5

Summary

GEOPOTATO is one of the projects funded within the Geodata for Agriculture and Water (G4AW) facility, which improves food security in developing countries by using satellite data. The Netherlands Space Office (NSO) is executing this programme, commissioned by the Dutch Ministry of Foreign Affairs. The GEOPOTATO project develops a decision-support service (DSS) for farmers in Bangladesh for an optimal control strategy of the late blight disease in potato. Late blight (*Phytophthora infestans*) is a highly infectious and destructive fungal disease in *Solanaceae* crops, i.e. among others potatoes and tomatoes. The DSS is provided through SMS: each time a risk for late blight outbreak is forecasted by the DSS farmers receive a SMS that urges farmers to protect the crop within three days with the widely used fungicide Mancozeb.

The GEOPOTATO project selected major potato producing districts Munshiganj and Rangpur as regions to evaluate the service in the season 2017/2018. The evaluation was accompanied with field demonstrations on the DSS. Furthermore, a customized DSS advising Bayer fungicides was piloted in the sub-district Mithapukur. In this report, findings of the introduction of the DSS in Munshiganj and Rangpur are evaluated and described, and compared with results of the baseline studies in Munshiganj and Rangpur and the first evaluation study in Munshiganj. The findings of the customized service are also described and evaluated.

The objective of this evaluation study is to report on:

- The results of the late blight demonstrations.
- The results and outcome indicators of farmers that used the DSS.
- The results of the customized SMS service in Mithapukur.

Late blight demonstrations

In each sub-district of Munshiganj and Rangpur, a demonstration and sometimes two demonstrations were carried out on the control of late blight. Three treatments were included. Treatment differences concentrated on the type of fungicide used and time and number of application:

- Decision Support Service (DSS^{+}) treatment. In this treatment the SMS service is followed and a modern preventive fungicide Antracol is used (2 times) followed by the preventive fungicide Dithane (2 times) and followed by the preventive and slightly curative fungicide Secure 600 WG (2 times) when late blight was identified in the area;
- Decision Support Service (DSS) treatment. In this treatment the SMS service is followed with the preventive fungicide Revus 25 SC alternated with the preventive and slightly curative fungicide Melody Duo 66.8 WP when late blight was found;
- Farmers Practice (FP) treatment. This treatment is tuned on the local practices and, therefore, differed per sub-district.

Observations on late blight occurrence were done by the field manager before each fungicide spray following a disease occurrence protocol. Input (costs) were registered and yields measured.

With respect to the late blight demonstrations, it is concluded that:

- It is difficult to realise a demonstration, which compares a DSS for late blight control with a control according to farmers' practice.

- The demonstrations included a number of factors that contributed to the yield differences. This makes it particularly difficult to relate yield differences to treatments.
- The demonstrations in Munshiganj suffered from unexpected flooding and heavy rainfall and were partly replanted. Consequently, yields were affected and reduced.
- Fungicide costs per ton product for DSS^{+} in Rangpur were lower compared to FP and DSS and thus improved income.

The late blight alert service for farmers

The late blight alert service in the season 2017/18 consisted of 1,226 and 4,919 farmers in the districts Munshiganj and Rangpur, respectively. Approximately 50 SMS receiving and 50 non-SMS-receiving farmers (control group) in each *upazilla* (sub-district) of Munshiganj and Rangpur were selected to be interviewed on the major characteristics of potato production in the 2017/18 season, late blight control, on data to be able to evaluate the outcome indicators and the use of the late blight SMS advice to spray for late blight control.

Based on the survey results it is concluded that:

- Interviewed farmers in Munshiganj cultivate more land with potatoes compared to Rangpur and SMS-receiving farmers in Munshiganj cultivate more land with potatoes compared to the non-SMS receiving farmers. No difference in land cultivated with potato was found between non-SMS and SMS-receiving farmers in Rangpur.
- According to farmers in Munshiganj, late blight pressure was low (65%) and medium (34%) and in Rangpur low (50%), medium (31%) and high (19%) in the potato season 2017-2018.
- Yield benefit of SMS-receiving farmers was 0.5 t/ha and significant compared to non-SMS-receiving farmers.
- Yield benefit for SMS-receiving farmers who followed the advice was 1.3 and 3.7 t/ha in Munshiganj and Rangpur respectively compared to SMS-receiving farmers that not followed the advice.
- Nearly all SMS receiving farmers, 84 and 92% in Munshiganj and Rangpur, respectively, were satisfied with the SMS-alert service.
- The SMS-alert service was ‘good and helpful’ according to more than 65% of the SMS receiving farmers.
- In Munshiganj 29% and in Rangpur 88% of the SMS receiving farmers is willing to pay for the service.
- On average, 78% of the SMS receiving farmers shared the SMS information with 11 other farmers.
- About 8 and 29% of the non-SMS-receiving farmers in Munshiganj and Rangpur, respectively, heard about the service and 92% and 72% of these farmers would like to receive the service. The willingness to pay for the service of these farmers was 9% in Munshiganj and 79% on Rangpur.
- The cost for late blight control in Munshiganj were lower than in Rangpur but no differences were found for non-SMS and SMS-receiving farmers.

The following outcome indicators have been evaluated: sustainable food production (crop yield, t/ha), input use efficiencies (use of N-fertiliser, kg N/t product; use of fungicides, kg fungicide product/ha and kg active ingredient/ha), income (costs of late blight control, BDT/ha and BDT/t product) and other

outcomes (use of Metalaxyl). Results were compared with outcome indicators of the baseline surveys and the evaluation survey of Munshiganj 2016/17.

With respect to the outcome indicators, it is concluded that:

- Crop yield was lower in Munshiganj and did not change in Rangpur compared to the baseline survey.
- SMS-receiving farmers in both districts following the advice had higher yields than farmers who did not follow the advice.
- N-fertiliser use efficiency in Munshiganj was much higher than in the baseline and evaluation survey, due to the low yields. N-fertiliser use efficiency in Rangpur did not change compared to the baseline survey.
- In Munshiganj, the fungicide use efficiency in terms of kg product per hectare and A.I. per hectare of the participating farmers as well as the farmers in the control group varied in time with no clear trend. In Rangpur, the fungicide use efficiency in terms of kg product per hectare and A.I. per hectare of the participating farmers as well as the farmers in the control group improved compared to the baseline survey.
- The percentage of curative products used with metalaxyl did not differ between districts of non-SMS and SMS-receiving farmers and did not change compared to the baseline survey.
- The percentage of curative applications with metalaxyl decreased in both districts compared to the baseline survey.

Customized SMS service in Mithapukur

In total 200 farmers in the upazilla Mithapukur of Rangpur district received so-called branded SMS alerts, i.e. the SMS contained information on the type of fungicide to use. Together with Bayer, a fungicide application strategy was developed with preventive fungicides in the beginning of the season and more curative fungicides towards the end of the season. Major findings of this customized SMS service were:

- On average 10% of the surveyed farmers did not understand the branded SMS alerts.
- The majority of farmers said to have sprayed at the advised moment, but about 15% of the surveyed farmers did not trust the SMS or had other reasons not to follow the advice.
- In addition, a majority of the surveyed famers indicated to have used the product advised in the SMS alerts. About 19% did not use the advised product for reasons related to the high product price, non-availability of the advised product in the local retail shop, low product quality, etc.
- It is most important that local agro-retailers are part of the service and able to facilitate farmers with the advised product but also with supporting information to mitigate the distrust that farmers may have.

Contents

1. Introduction

GEOPOTATO is one of the projects funded within the Geodata for Agriculture and Water (G4AW) facility, which improves food security in developing countries by using satellite data. The Netherlands Space Office (NSO) is executing this programme, commissioned by the Dutch Ministry of Foreign Affairs.

The GEOPOTATO project develops a decision-support service for farmers in Bangladesh for an optimal control strategy of the late blight disease in potato. Late blight (*Phytophthora infestans*) is a highly infectious and destructive fungal disease in *Solanaceae* crops, i.e. among others potatoes and tomatoes. Especially under favourable weather conditions, i.e. temperatures between 12 and 25°C and a relative atmospheric humidity >85%, the disease spreads very quickly through wind and water and can have devastating effects on the potato crop and production (Hossain, et al. 2008). Through development of a decision-support service (DSS) based on a combination of satellite information and models infection periods of late blight can be forecasted. A timely advice through mobile phone for the application of an appropriate fungicide helps farmers to prevent the infection of the potato crop with late blight. Each time the DSS predicts a risky infection period subscribed farmers receive three days ahead an SMS alert advising farmers to protect their potato crop through a fungicide application.

The objective of the GEOPOTATO project is to reach 100,000 potato farmers with the DSS after three years. Major potato production areas of Bangladesh are in the South, Munshiganj district, and in the North, Rangpur district. Baseline studies were carried out in both Munshiganj and Rangpur to understand better the needs, practices and performance of farmers, and the context of potato farming in these regions (Pronk, et al. 2017a). The introduction of the service in Munshiganj in the season 2016/2017 was accompanied with field demonstrations on the DSS. First findings of the introduction of the DSS in Munshiganj during the 2016/17 season have been evaluated and reported and compared with results found in the baseline study of Munshiganj (Pronk, et al. 2017b).

This report describes the evaluation of the DSS in season 2017/18 in both Munshiganj and Rangpur and comprises results of the late blight control demonstrations and the service evaluation surveys carried out under potato farmers in Munshiganj and Rangpur. The bulk of this report describes the results of this evaluation of the SMS-alert service compared to a group of farmers who did not receive SMS alerts during the potato season 2017/2018. In addition, the report describes results of the service evaluation in the *upazilla* Mithapukur, a sub-district of Rangpur, where farmers received customized SMS alerts including the advice to use a certain type of fungicide of the Bayer brand.

2. Materials and methods

2.1. Late blight control demonstrations

In each sub-district in Munshiganj[1] and Rangpur, a demonstration was carried out on the control of late blight, in total 21 demonstration sites. Three treatments were included and field meetings of farmers and stakeholders were organised. Treatment differences concentrated on the type of fungicide used (Figure 2.1), the time of application and the number of applications. The demonstrations also included additional aspects of Good Agricultural Practices (GAP) such as fertiliser application, planting distances and seed handling (cutting or not, for detailed information see Annex I). All activities for the production of the potatoes were registered and a cost analysis for fungicide use between treatments was made. Farmers were in charge of the demonstrations and received a half-day training and a protocol on the purpose of the demonstrations and requirements for performing the demonstrations.

2.1.1. Treatments

Three fungicide strategy treatments were included in the demonstrations (see Annex II for details):

1. Decision Support Service treatment (DSS$^+$). In this treatment the SMS service is followed and a modern preventive fungicide Antracol is used (2 times) followed by the preventive fungicide Dithane (2 times) and followed by the preventive and slightly curative fungicide Secure 600 WG (2 times) when late blight was identified in the area;
2. Decision Support Service (DSS) treatment with the preventive fungicide Revus 25 SC alternated with the preventive and slightly curative fungicide Melody Duo 66.8 WP when late blight was found;
3. Farmers Practice (FP). This treatment is tuned on the local practices and, therefore, differed per sub-district.

The DSS$^+$ treatment schedule was followed although Antracol and Dithane were sometimes alternated occasionally Melody duo was used (Annex II). Antracol and Dithane are both preventive fungicides, which were schedules to be alternated after two applications. When late blight was found, Secure was to be used, which also has a slightly curative effect on late blight.
The DSS treatment schedule was comparable to the DSS$^+$ but used more traditional fungicides; Revus as the preventive fungicide to start with and Melody duo when late blight was found.
The FP treatment schedule was based on farmers practice, using local fungicides as the farmer would commonly do. In this treatment a large range of different products were used, from preventive to preventive and curative to some that have no effect on late blight (Table 2.1).
The fungicide applications started approximately three weeks after planting (Table 2.2) and in Rangpur, nine times a fungicide was applied in the FP compared to seven in the DSS and DSS$^+$. In Munshiganj, all demonstrations received the same number of fungicide applications. The application

[1] In Shreenagar, sub district of Munshiganj, two demonstration fields were carried out. In five sub-districts of Rangpur two demonstration plots were done.

rates applied varied somewhat from the recommended dose (Table 2.1). Additional characteristics of used fungicides are presented in Annex II.

Table 2.1 Recommended dose rate and application rate of the fungicides used in potato farming in Bangladesh. Price ranges based on sale prices of five retailers in Rangpur on April 3, 2019.

Product name	Active ingredient	Recommended dosage	Unit	Application rate	Unit	type of active ingredient	Price (BDT/100 g or 100 ml)
Acrobat MZ	Dimethomorph (9%) + Mancozeb (60%)	2	kg	1.6	kg/ha	Preventive + curative	100
Antracol 70 WP	Propineb	2.47	kg	2.5	kg/ha	Preventive	90 - 95
Corozim 50 WP	Carbendazim	1	g/L[1]	0.7	kg/ha	No late blight	-
Cozeb 80 WP	Mancozeb	2	g/L	2.5	kg/ha	Preventive	77.5
Dithane M 45	Mancozeb	2.2	Kg	2.3	kg/ha	Preventive	90 - 95
Ecozim 50 WP	Carbendazim	2	g/L	2.0	kg/ha	No late blight	-
Flumin	Flutriafol (12.5% SC)	-	-	1.6	g/ha	No late blight	-
Folimin	Flumorph 10% + Mancozeb 50%	-	-	2.0	kg/ha	Preventive	106
Golden M 45	Mancozeb	2	g/L	2.3	kg/ha	Preventive	73
Hasim	Mancozeb	2	Kg	1.6	kg/ha	Preventive	73
Indofil M 45	Mancozeb	2	g/L	2.2	kg/ha	Preventive	100
Melody Duo 66.8 WP	Propineb (70%) + Iprovalicarb	2	g/L	2.0	kg/ha	Preventive + slightly curative	180 – 190
Metataf 25 WP	Metalaxyl	2	g/L	1.6	kg/ha	Curative	50
Micra 72 WP	Mancozeb (64%) + Cymoxanil (8%)	2	g/L	1.9	kg/ha	Preventive + curative	125
Naczeb 80 WP	Mancozeb	2	g/L	2.6	kg/ha	Preventive	77.5
Nemispore 80 WP	Mancozeb	2.5	Kg	2.5	kg/ha	Preventive	85
Nuben 72 WP	Mancozeb (64%) + Metalaxyl (8%)	2	g/L	1.6	kg/ha	Preventive + curative	95
Revus 25 SC	Mandipromid	1	g/L	0.7	L/ha	Preventive	365
Secure 600 WG	Mancozeb (50%) + Fenamidone (10%)	1	g/L	1.6	kg/ha	Preventive + slightly curative	128
Zaz	Mancozeb	2	Kg	1.5	kg/ha	Preventive	77.5

[1] spraying liquid

Table 2.2 Days after planting of fungicide applications in the different treatments (see Annex III for details of the sub-districts).

		Fungicide application								
District	Treatment	1	2	3	4	5	6	7	8	9
Munshiganj	DSS+	24	35	47	56	67	77	79	85	
	DSS	24	35	47	56	67	77	79	85	
	FP	23	32	43	53	65	75	77	83	
Rangpur	DSS+	32	39	47	55	63	73	81		
	DSS	32	39	47	55	63	73	81		
	FP	26	33	40	48	53	62	71	75	83
Grand Total		28	36	45	53	62	71	76	78	83

Figure 2.1 *Different fungicides used in the demonstrations: Revus used in the DSS+, Dithane in DSS, Mosum in FP and Secure in all treatments.*

2.1.2. Field layout

Plots of 303 m^2 (7.5 decimal) per treatment were planted with potato variety Diamant in each sub-district in Munshiganj and with Cardinal in each sub-district in Rangpur between 2 and 13 December 2017 and 2 and 8 December 2017, respectively. Harvesting dates varied between 7 and 15 March 2018 in Munshiganj and 2 and 15 March 2018 in Rangpur. All general potato cultivation practices were according to farmers practice (Annex I). The differences between the plots were mainly related to spraying regime, i.e. the type of fungicide and time of application (Table 2.2). Yields were assessed by weighing all potatoes per plot. Results on yield were analysed by a simple ANOVA with GENSTAT 14 with two factors, district and treatment. Sub-district was treated as a replicate.

2.1.3. Late blight observations

The field manager did observations on late blight occurrence before each fungicide spray. The disease occurrence is evaluated through a protocol (Pronk, et al. 2017b). A visible assessment is made and fields are grouped into different severity classes ranging from 0% (no late blight) to 100% (crop is destroyed). Depending on the severity class, the fungicide type is chosen. When no late blight was found, a preventive fungicide was used. When late blight was found, a fungicide was chosen with a preventive and curative active ingredient. Care was taken in the DSS+ and DSS treatments to select fungicides that were able to control the Metalaxyl resistant late blight strain.

2.1.1. Cost components

The costs for field preparation and fertiliser application were collected. Costs for seeds and costs for pesticides were not collected as seeds were provided by the project. Costs for fungicide produces were collected from other sources such as the retailers and used to calculate the financial differences between the three treatments (Table 2.1). Costs for late blight control were expressed per hectare and per kilogram potatoes produced. A standard cost component for labour of 800 BDT/ha per pesticide application was used for cost calculations.

2.2. The late blight service

The late blight alert service consisted of a SMS sent to the subscribed farmers that indicated a risk for late blight outbreak and the need to protect the crop within three days with the widely used preventive fungicide Mancozeb. In total, slightly more than 6,000 farmers participated in the SMS alert service, 1226 in Munshiganj and 4919 in Rangpur (Table 2.3). Each farmer received between 6 to 9 alerts, yielding approximately 48,000 SMS sent to farmers.

Table 2.3 The total number of farmers receiving a SMS alert in Munshiganj, Rangpur, and its sub-districts.

District	sub-district	# of farmers
Munshiganj	Gozaria	178
	Louhojong	157
	Munshiganj Sadar	130
	Serajdikhan	272
	Sreenagar	119
	Tungibari	370
	Total	1226
Rangpur	Badarganj	803
	Gangachara	334
	Kaunia	699
	Mithapukur	805
	Pirgaccha	833
	Pirganj	249
	Sadar	778
	Taraganj	418
	Total	4919
Total		6145

2.3. Evaluation of late blight alert service: farmer survey

The SMS alert service was evaluated through a post-season questionnaire for SMS-receiving farmers and non-SMS-receiving farmers (Annex IV).

2.3.1. Questionnaire

A questionnaire was developed that focused at the major characteristics of potato production, current late blight control by farmers, outcome indicators in the 2017-2018 growing season (section 2.4) and at the use of the late blight SMS advice to spray for late blight control (Annex IV). As the questionnaire from the baseline survey, this questionnaire required relatively little time and effort from the participating farmers to answer (Pronk, et al. 2017a).

All questions referred to the potato season 2017-2018 and to one potato plot (largest or best performing plot) of the interviewed farmer.

2.3.2. Selection of farmers

Between 130 and 370 farmers participated in the SMS service on late blight control in each sub-district of Munshiganj and between 249 and over 800 in each sub-district of Rangpur (Table 2.3). Of the participating farmers, 50 farmers were ad random selected with GENSTAT 14 to be interviewed for the evaluation of the service. Another group of equal size (50 farmers in each sub-district) that did not participate in the SMS service was randomly selected by the local Department of Agricultural Extension (DAE) and served as a control group in the evaluation survey.

2.3.3. Enumerators and survey control

The survey was carried out in the same way as the survey of the baseline study (Pronk, et al. 2017a). In short, nine enumerators, three quality control staff and one team leader of the Development Research Institute in Dhaka performed the survey. Programming for a mobile application and translation into English of the survey results were done by mPower. The survey was carried out between April 28 and May 16 in 2018.

2.3.4. Data processing

Survey data were cleaned from missing values, outliners, and/or incomplete and unreliable records. In some cases, the total entry of a farmer was dismissed and sometimes records were improved so they could be included in the results. The questionnaire included the entire list of allowed fungicides for late blight control (218 products in total), which was a major improvement compared to the questionnaires of the baseline survey. All mentioned products were included in the results.
The used fungicides were qualified according to the type of active ingredient: preventive, curative or curative resistance when no effect of the active ingredient is to be expected on late blight control, as late blight is resistant to the active ingredient. The overall use of fungicides of one farmer is subsequently grouped into one of the following four categories:

1. Only use of preventive fungicides,
2. use of preventive and curative fungicides,
3. use of preventive and curative resistance fungicides,
4. only use of curative resistance fungicides.

This grouping is used as a factor in the unbalanced analysis of variance to explore effects of the use of active ingredients on yield.
Furthermore, the answers to the question of Annex IV for SMS-receiving farmers (if yes, why were you satisfied with the SMS?) were grouped into a main reason and a sub-reason:

- Timely spraying
- Good production

    - Reduced disease pressure
    - Training
- Helpful
- Reduced costs
- Reduced disease pressure
    - Reduced costs
- Training
    - Reduced disease pressure
- Weather forecast
    - Timely praying
    - Helpful
    - Reduced disease pressure
    - Training

Results were analysed with a simple unbalanced ANOVA using GENSTAT 14 with district (2 levels) and the service (2 levels) as factor. Sub-district was included as a repetition, 6 repetition in Munshiganj and nine repetitions in Rangpur. An interaction between the two factors was also included in the analysis.

2.4. Outcome indicators evaluation

The late blight alert service is evaluated based on different indicators. Following the baseline study of Munshiganj (Pronk, et al. 2017a) outcome indicators have been calculated: sustainable food production, input use efficiencies, income and other outcomes.

The outcome indicator on sustainable food production is:

- Crop yield, t/ha

The baseline survey yield is the basis for this indicator. In subsequent years, yield increase as a result of the service use is calculated.

The indicators on efficiencies are:

- Use of N-fertiliser and
- Use of fungicides.

The use of N-fertiliser is expressed as N-applied (kg N/t product). The use of fungicides is expressed as fungicides applied (kg or L product/ha) and as active ingredient (kg or L/ha). This is done as the expected changes may be on the amount of current products used and/or on the type of products used. Changes on the type of product used may result in lower levels of applied active ingredients where the amount of product is not changing. The improved efficiencies are later on in the project expressed as a percentage improvement also.

The indicator for income is:

- Costs of fungicides used when the service advice is followed compared to the costs of fungicide use when the service is not followed (control group). This is compared with costs for fungicide use of the baseline survey.

The indicator for other outcome is:

- The reduction in the use of curative fungicides containing Metalaxyl when the service is followed compared to the curative fungicides containing Metalaxyl in the baseline survey.

This is evaluated through two indicators. First, the percentage of products mentioned to be used by farmers with curative active ingredients containing Metalaxyl compared to all curative products is identified. This is done as the DSS supports the use of preventive fungicides and reduce the use of curative fungicides and dismisses the use of Metalaxyl containing fungicides (Pronk, et al. 2017a). Second, the percentage of fungicide applications with products containing Metalaxyl compared to all curative applications is calculated. This calculation is done as farmers may use less products but apply one product more often. With these two outcome indicators we can support changes in type of curative product used as well as the number of applications curative products are used.

2.5. Customised SMS service in Mithapukur

The sub-district Mithapukur in Rangpur was selected to introduce a SMS alert service carrying customized information regarding the fungicide product to be applied by the farmer (receiver of the SMS).

2.5.1. Application strategy and selection of farmers

Together with Bayer, a fungicide application strategy was developed and included into the SMS alert. The first SMS informed the farmer to apply Antracol, the second Dithane, the third Melody Duo, etc. (Table 2.4). A maximum of 10 SMS alerts were foreseen in the entire potato growing season.

The SMS was send to 200 subscribed farmers. This group was interviewed on general information such as name, place and land cultivated with potato this season (questions 1 to 12 from Annex V). After each round, a predefined number of farmers, 120 in total, was called to evaluate the SMS alert. A group of 60 farmers (Regular group) was called after each message that was send and a second group of 60 farmers (Random group) was selected from the remaining 140 farmers and also called.

The questionnaire was tested preliminarily by interviewing 50 farmers and adjusted/improved where needed. These interviews are not included in the results.

Table 2.4 The fungicide application strategy of the Bayer SMS alert service in the sub-district Mithapukur.

SMS nr.	Product name	Active ingredient	Type of product
1	Antracol 70 WP	Propineb (70%)	Preventive
2	Dithane M 45	Mancozeb (45%)	Preventive
3	Melody Duo 66.8 WP	Propineb (61.25%) + Iprovalicarb (5.5%)	Preventive + slightly curative
4	Melody Duo 66.8 WP	Propineb (61.25%) + Iprovalicarb (5.5%)	Preventive + slightly curative
5	Secure 600 WG	Mancozeb (50%) + Fenamidone (10%)	Preventive + slightly curative
6	Secure 600 WG	Mancozeb (50%) + Fenamidone (10%)	Preventive + slightly curative
7	Melody Duo 66.8 WP	Propineb (61.25%) + Iprovalicarb (5.5%)	Preventive + slightly curative
8	Melody Duo 66.8 WP	Propineb (61.25%) + Iprovalicarb (5.5%)	Preventive + slightly curative
9	Secure 600 WG	Mancozeb (50%) + Fenamidone (10%)	Preventive + slightly curative
10	Secure 600 WG	Mancozeb (50%) + Fenamidone (10%)	Preventive + slightly curative

2.5.2. Questionnaire

Farmers were asked several questions related to the message, the SMs alert, and their response (questions 13 to 23 of Annex V).

2.5.3. Data processing

Survey data were cleaned from missing values, outliners, and/or incomplete and unreliable records. In some cases, the total entry of a farmer was dismissed and sometimes records were improved so they could be included in the results.

3. Results

3.1. Late blight control demonstrations

3.1.1. Late blight observations

In general, little late blight infection was observed by farmers and local project staff in the demonstration plots in both Rangpur and Munshiganj. Only in Badarganj and Pirgaccha (both in Rangpur) and in Louhoganj in Munshiganj late blight infection levels (< 1%) were observed. However, during harvesting of some of the demonstration plots it became clear that the capacity to identify of late blight in the crop by field staff and farmers was not well developed. Several fields showed symptoms of late blight infection but were not identified as such. It may be well possible that crop infections have been missed or diagnosed wrongly. Considerable late blight infected potato fields were reported by MoA staff especially in Rangpur.

3.1.2. Production

Production in Munshiganj of two demonstration plots was affected by unexpected rainfall mid-December resulting in flooding and the need to replant some plots. This has severely reduced the potato yields of the demonstration plots in Tungibari and Sreenagar-2. In Tungibari, about 30% of the demonstration plot was replanted on December 21, but we do not know which part. In Shreenagar -2, the entire demonstration plot was replanted on December 21. The potato yields in the demonstration plots varied between 22 and 40 t/ha in Munshiganj (Table 3.1). In general, the average yields of the demonstration plots (30 t/ha) was much lower than in the 2016/17 season when it was 46 t/ha (Pronk, et al. 2017b). The spraying strategies DSS and DSS$^+$ reduced crop yields with 7 and 9%, respectively, compared to FP in the demonstration plots in the 2017/18 season in Munshiganj. Especially, yield reductions were large in Sreenagar-1. Without the data of this demonstration site, yield differences compared to FP were small, -1% and -3% for DSS$^+$ and DSS, respectively.

Table 3.1 Potato yields (t/ha) of the Decision Support Service using (DSS$^+$), Decision Support Service using Dithane (DSS) and Farmers Practice (FP) in different sub-districts of Munshiganj and the relative change of yield of DSS$^+$ and DSS compared to FP.

	Yield (t/ha)				Relative increase (%)	
Sub-district	DSS$^+$	DSS	FP	Average	DSS$^+$	DSS
Gozaria	27	25	29	27	-7	-14
Louhazang	32	34	38	35	-15	-10
Munshiganj Sadar	33	32	31	32	8	4
Shreenagar-1	22	20	35	26	-36	-42
Shreenagar-2	40	34	37	37	7	-7
Sirajdikhan	32	35	26	31	23	33
Tungibari	23	23	28	25	-20	-17
Overall yield/relative increase	30	29	32	30	-7	-9

The results of the 14 demonstration sites in Rangpur are shown in Table 3.2. The yields varied between 20 and 45 t/ha. Generally, potato yields in Munshiganj are higher than in Rangpur. However, average yields in the demonstration plots of Rangpur (33 t/ha) were higher than in Munshiganj (30 t/ha; Table 3.1) in the 2017/18 season. In Rangpur, a clear positive yield effect of the DSS was observed: Yields of the DSS and DSS$^+$ were 32 and 14% higher, respectively than the FP.

Table 3.2 Potato yields (t/ha) of the Decision Support Service using (DSS$^{+)}$, Decision Support Service using Dithane (DSS) and Farmers Practice (FP) in different sub-districts of Rangpur and the relative change of yield of DSS$^+$ and DSS compared to FP.

	Yield (t/ha)				Relative increase (%)	
Sub-district	DSS$^+$	DSS	FP	Average	DSS$^+$	DSS
Sadar	45	41	36	41	26	14
Kaunia	35	30	26	30	31	13
Badarganj	32	30	27	30	21	11
Pirgachha-1	32	28	22	27	47	30
Pirgachha-2	40	32	27	33	47	20
Pirgonj-1	35	30	24	29	46	26
Pirgonj-2	38	35	28	34	36	24
Gangachara-1	45	41	36	41	26	14
Gangachara-2	41	36	35	37	19	5
Taragonj-1	37	30	25	31	44	19
Taragonj-2	34	28	26	29	30	5
Taragonj-3	30	26	20	25	50	33
Metro-1	40	35	37	37	8	-7
Metro-2	37	30	27	31	38	11
Overall yield/relative increase	37	32	28	33	32	14

[1] This plot was damaged by rats and as a result, the yields reduced.

3.1.3. Cost of late blight control

The costs for late blight control products varied between 12,232 BDT/ha for FP in Rangpur to 14,006 BDT/ha for DSS$^+$ in Rangpur (Table 3.2). The high costs for DSS are related to the use of Revus, which is an expensive product to buy compared to Dithane or other used fungicides. The number of sprays applied did also contribute to the differences so the costs for fungicide products were also evaluated per spray. An interaction was found for production costs per spray. This means that per spray costs in Rangpur were the lowest for FP, which was lower than all other systems (Figure 3.1). Figure 3.1 also shows that DSS had the highest costs in both Munshiganj and Rangpur, and that costs for DSS$^+$ are the same as for FP in Munshiganj.

The costs per t potato produced was only different per district: costs in Rangpur were lower than in Munshiganj, which is most likely related to the disappointing yields in Munshiganj due to flooding within a month after planting. When only evaluating Rangpur there is an effect of support service: costs per t potato for DSS$^+$ are lower than those for FP and the same as for DSS.

Table 3.3 Statistical analysis of the potato yields (t/ha), the amount of active ingredient used (per ha) and the costs for fungicides per ha, per kg potato and per spray of the Decision Support Service using (DSS+), Decision Support Service using Dithane (DSS) and Farmers Practice (FP) in Munshiganj and Rangpur

			Costs		
District	Support service	Yield	BDT/ha	BDT/t potato	BDT/spray
Munshiganj	DSS+	30	12,712	442	2,022
	DSS	29	13,306	471	2,116
	FP	32	13,636	431	2,050
	All	30	13,218	448	2,062
Rangpur	DSS+	37	14,040	383	2,026
	DSS	32	12,797	405	2,084
	FP	28	12,265	443	1,476
	All	33	13,034	410	1,862
District		***	n.s.	**	***
Support service		***	n.s.	n.s.	***
District * Support service		***	**	n.s.	***

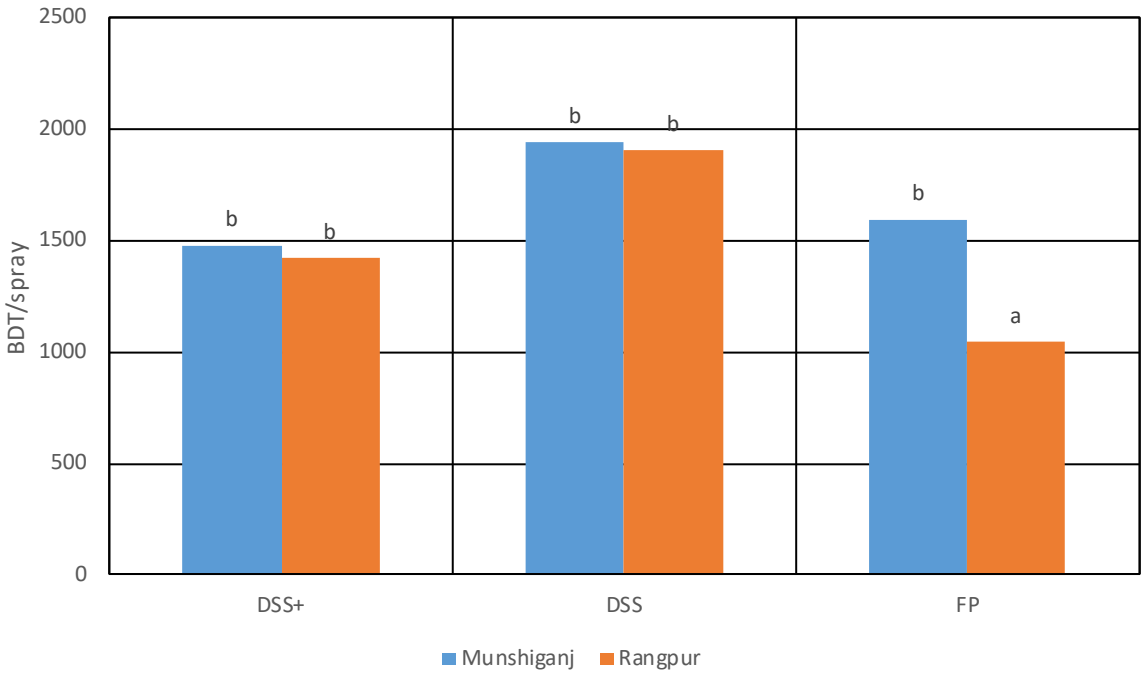

Figure 3.1 The interactive effect of fungicide product cost per spray. Bars with different letters are significant different

3.2. Evaluation late blight control service: farmer survey

3.2.1. Interviewed farmers

Table 3.4 shows the number of farmers interviewed after data were cleaned in the different sub-districts that did receive a SMS and the control group that did not receive a SMS, as well as the total number of farmers interviewed. In total, nine unreliable recordings were removed. The control group was slightly larger than the SMS-receiving group in Munshiganj; in Rangpur, the group sizes were equal. The total number of interviewed farmers per sub-district ranged from 78 to 100. The percentage of SMS-receiving farmers who were interviewed in each district ranged from 6 to 32% and was on average 11%. The number of interviewed farmers per sub-district was comparable to the number of interviewed farmers per sub-district of the baseline study (Pronk, et al. 2017a) and of the evaluation study of Munshiganj (Pronk, et al. 2017b).

Table 3.4 The number of interviewed farmers receiving no SMS and a SMS, the total number of interviewed farmers and the percentage of SMS-receiving farmers interviewed compared to the total number of SMS-receiving farmers in Munshiganj and Rangpur and its sub-districts.

District	Sub-district	Non-SMS-farmers	SMS-farmers	Total	% SMS-received
Munshiganj	Gazaria	50	28	78	15.7
	Louhojong	50	50	100	31.8
	Munshiganj Sadar	50	18	68	13.8
	Sirajdikhan	50	50	100	18.4
	Shreenagar	50	35	85	29.4
	Tongibari	50	50	100	13.5
	Total	300	231	531	18.8
Rangpur	Badarganj	50	50	100	6.2
	Gangachara	50	50	100	15.0
	Kaunia	50	50	100	7.2
	Mithapukur	50	50	100	6.2
	Pirgaccha	50	50	100	6.0
	Pirganj	50	50	100	20.1
	Rangpur Metro	50	50	100	6.4
	Rangpur Sadar	50	50	100	6.4
	Taraganj	50	50	100	12.0
	Total	450	450	900	9.1
Total		750	681	1431	11.1

3.2.2. General characteristics of interviewed farmers

In Table 3.5 the minimum, average and maximum land size with potato are presented in decimals and hectares. The overall average size of the potato fields of approximately 1.0 ha (248 decimals) was smaller than the average potato fields of the baseline survey of 2.4 ha in Munshiganj (Pronk, et al. 2017a) and 2 ha in Rangpur (Pronk, et al. 2017c). The average size of the SMS-receiving farmers was

1.1 ha or 283 decimals which was slightly larger than the average size of the non-SMS receiving farmers of 0.9 ha or 216 decimals. The smallest size was 4 to 6 decimals, corresponding to 0.02 ha and the largest size was 8000 decimals, 32.4 ha. The land size differed between district and service customers (Figure 3.2): land size of SMS and non-SMS receiving farmers in Rangpur was the same (indicated by the same letters in Figure 3.2) where in Munshiganj land size was larger than in Rangpur (indicated by letters differencing from Rangpur) and land size of SMS-receiving farmers was larger than that of the non-SMS receiving farmers (indicated by a different letters).

Table 3.5 *Minimum, average and maximum land sizes with potato in decimal and hectares of the interviewed farmers receiving no SMS (No) or a SMS (Yes) in Munshiganj and Rangpur.*

		Land size (decimal)			Land size (ha)		
District	SMS	Min	Average	Max	Min	Average	Max
Munshiganj	No	10	339	2800	0.04	1.4	11.3
	Yes	4	497	6000	0.02	2.0	24.3
	All	4	407	6000	0.02	1.6	24.3
Rangpur	No	6	134	2500	0.02	0.5	10.1
	Yes	4	173	8000	0.02	0.7	32.4
	All	4	154	8000	0.02	0.6	32.4
All data	No	6	216	2800	0.02	0.9	11.3
	Yes	4	283	8000	0.02	1.1	32.4
	All	4	248	8000	0.02	1.0	32.4
District			***			***	
SMS or not			***			***	
District * SMS or not			**			**	

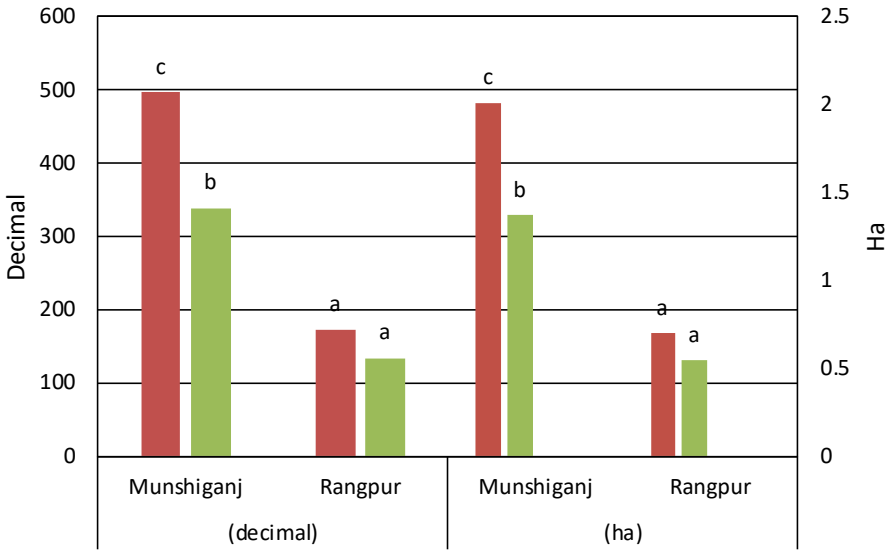

Figure 3.2 *Statistical differences between the land sizes of SMS (red bars) and non-SMS (green bars) receiving farmers in Munshiganj and Rangpur: bars with different letters are significantly different. Land size in decimals in left panel and in hectares in right panel.*

The number of farmers that had potato as a previous crop and other crops is presented in Table 3.6. Differences between SMS-receiving or non-SMS-receiving farmers were very small. However, Table 3.6 shows that 2% of the farmers in Munshiganj had potatoes as a previous crop, with no differences between SMS-receiving or non-SMS-receiving farmers. In Rangpur, farmers had no potatoes as a previous crop. The most common previous crop in both districts was rice, 86% in Munshiganj and 96% in Rangpur.

Table 3.6 *Number (n) and percentage (%) interviewed farmers with potato as previous crop and the number (n) of interviewed farmers with other previous crops per district receiving no SMS (No) or a SMS (Yes).*

		Potato		Rice		Jute		Wheat		Others[2]	
District	SMS	n	%[1]	n	%	n	%	n	%	n	%
Munshiganj	No	7	2	261	87	19	6	0	0	12	4
	Yes	5	2	198	86	13	6	1	0	11	5
	All	12	2	459	86	32	6	1	0	23	4
Rangpur	No	0	0	434	96	0	0	0	0	8	2
	Yes	0	0	434	96	0	0	0	0	10	2
	All	0	0	868	96	0	0	0	0	18	2
All		12	1	1327	93	32	2	1	0	41	3

[1] as percentage of farmers in related sub-district and SMS group

[2] Other's: Mung bean, Banana, Groundnut, Black gram, Pointed gourd, Cauliflower, Bitter Gourd, Chili, Coriander, Ginger, Eggplant, Onion

The percentage of smartphone owners is calculated as the percentage of the number of farmers in the district per type of farmer (no or SMS-receiving). For example, in Munshiganj 57 of the non-SMS-receiving farmers owned a smartphone. Compared to the 300 non-SMS-receiving farmers interviewed in Munshiganj (Table 3.4), this is 19%. These data should be used with care: In the questionnaire, we did not distinguish between smartphones and feature phones, which are much more common in rural Bangladesh than smart phones. A feature phone is common cell phone that contains a fixed set of functions beyond voice calling and text messaging but not as extensive as smartphones. For example, feature phones may offer Web browsing and email, but they generally cannot download apps as smartphones offer. Hence, the number of smart phone ownership shown in the next paragraph may be overestimated.

Twenty one percent of the interviewed framers owned a smartphone (Table 3.7). Farmers in Munshiganj more often own a smartphone (26%) than farmers in Rangpur (18%), and farmers that received the SMS service owned more often a smartphone (28%) than farmers that did not participate in the SMS service (15%). Based on the ownership of smartphones, these results suggest that the SMS customers of the GEOPOTATO service were more well-endowed than the other farmers, the none customers. In addition, farmers in Munshiganj are more endowed than farmers in Rangpur, which is in line with the baseline studies of both districts (Pronk, et al. 2017c, Pronk, et al. 2017a).

Table 3.7 *The percentage of farmers owning a smartphone in Munshiganj and Rangpur divided in non-SMS-receiving (No) and SMS-receiving farmers (Yes).*

District	SMS	Smartphone (%)
Munshiganj	No	19
	Yes	36
	All	26
Rangpur	No	12
	Yes	24
	All	18
All data	No	15
	Yes	28
	All	21
District		***
SMS or not		***
District * SMS or not		n.s.

3.2.3. Planting

Table 3.8 shows an overview of the potato varieties used by the interviewed farmers. Variety 'Diamant' is by far the most used potato variety in both districts, followed by the variety 'Asterix' in Rangpur. In Munshiganj, most farmers cultivate Diamant where in Rangpur besides Diamant and Asterix also Cardinal and Granola are cultivated. In the baseline study in Munshiganj, Diamant was also the most frequently used potato variety (Pronk, et al. 2017a). In the baseline study of Rangpur Cardinal was mostly used followed by Granola, Diamant, Asterix and a few other local varieties (Pronk, et al. 2017c).

Table 3.8 The potato variety planted by interviewed non-SMS-receiving (No) and SMS-receiving farmers (Yes) in Munshiganj and Rangpur.

District	SMS	Diamant	Asterix	Cardinal	Granola	Kupri Sindur	Elgar	Others
Munshiganj	No	292	2	0	0	0	5	1
	Yes	224	4	1	0	0	2	0
	All	516	6	1	0	0	7	1
Rangpur	No	63	158	68	46	9	6	100
	Yes	66	127	80	57	20	2	98
	All	129	285	148	103	29	8	198
All		645	291	149	103	29	15	199

Table 3.9 gives an overview of the percentage of farmers (control group (No) and SMS-receiving farmers (Yes)) that used an authorized dealer as seed source, those that used farm-saved seed and those that bought seeds from an unauthorized dealer. On most farms farm-saved seeds were used, 48%, followed by farm-saved seeds, 40% and only 11% buys seeds from a non-authorized dealer. Table 3.9 also shows that in Rangpur more seeds were bought from authorised dealers.

The results found in this evaluation survey differ from the results of the baseline study where 98% of the farmers indicated to use seeds from an authorized dealer. It is also different from the results found

in the evaluation study for Munshiganj, where 15% of the farmers indicated to use seeds from an authorized dealer (Pronk, et al. 2017b). Despite these differences between surveys, within the surveys differences between non-SMS-receiving and SMS-receiving farmers were small: in the first evaluation survey of Munshiganj 1%, this survey 0% in Munshiganj and 5% in Rangpur (Table 3.9).

Table 3.9 *Overview of seed source of potato varieties used by interviewed farmers (expressed as %) receiving no SMS (No) or a SMS (Yes) in the different sub-districts of Munshiganj and Rangpur.*

District	SMS	Authorized dealer	Farm-saved seed	Non-authorized dealers
Munshiganj	No	45	52	4
	Yes	45	50	6
	All	45	51	5
Rangpur	No	48	37	15
	Yes	53	32	15
	All	51	34	15
All data	No	47	43	10
	Yes	50	38	12
	All	48	40	11

[1] Sums may differ from 100% due to rounding

Table 3.10 shows the earliest, average and latest planting date in 2017 of the control group (No) and SMS-receiving farmers (Yes). The earliest planting date was 1 October 2017 and the latest was 8 January 2018 with an average planting date of 23 November, with small differences between districts and farmer groups. Compared to the baseline study and the evaluation study (Pronk, et al. 2017b, Pronk, et al. 2017a), the planting period had widened, especially to a later planting date. This was due to heavy rainfall late in the ”dry season”, which also caused some farmers to replant as seeds were washed away.

Table 3.10 *Overview of earliest, average and latest planting date in the 2017/18 growing season of interviewed farmers receiving no SMS (No) or a SMS (Yes) in Munshiganj and Rangpur.*

District	SMS	Earliest	Average	Latest
Munshiganj	No	01/Oct	22/Nov	28/Dec
	Yes	10/Oct	23/Nov	05/Jan
	All	01/Oct	23/Nov	05/Jan
Rangpur	No	10/Oct	23/Nov	30/Dec
	Yes	10/Oct	24/Nov	08/Jan
	All	10/Oct	23/Nov	08/Jan
All data	No	01/Oct	23/Nov	30/Dec
	Yes	10/Oct	23/Nov	08/Jan
	All	01/Oct	23/Nov	08/Jan

Figure 3.3 shows the weekly distribution of planting dates in Munshiganj and Rangpur. Because the differences between SMS clients and the control group were small (Table 3.10), the distribution of the entire farmer population in both districts is shown. The timing of planting in both districts was quite similar in the 2017/18 season with 90% of the plots planted by December 10.

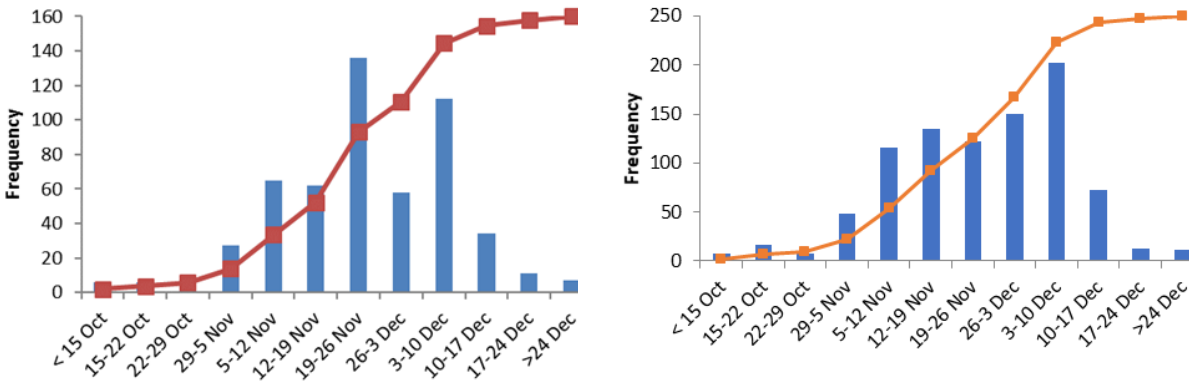

Figure 3.3 Weekly frequency distribution of potato planting dates in Munshiganj (left panel) and Rangpur in the 2017/18 season.

Table 3.11 shows the use of cut seed or entire seed for potato planting in both Munshiganj and Rangpur and for both the control group (No) and SMS-receiving farmers (Yes). The majority of the farmers (88%) used cut seed with small differences between the control group and GEOPOTATO customers: 90% of the control farmers *vs*. 86% of GEOPOTATO customers used cut seed. Differences between the districts in using cut seed were larger, i.e. 98% of the farmers in Munshiganj and 82% of the farmers in Rangpur used cut seed.

Table 3.11 Overview of the percentage of interviewed farmers receiving no SMS (No) or a SMS (Yes) that indicated to use cut or whole seeds for planting in the different sub-districts of Munshiganj and Rangpur.

District	SMS	Cut	Whole
Munshiganj	No	99	1
	Yes	97	3
	All	98	2
Rangpur	No	84	16
	Yes	80	20
	All	82	18
All data	No	90	10
	Yes	86	14
	All	88	12

Table 3.12 shows the minimum (Min), average (Avg) and maximum (Max) row and intra-row distance and the calculated plant density of the control group (No) and SMS-receiving (Yes) farmers. Differences between the two groups of farmers are small and within the variation of farmers. However, the plant

densities in Rangpur are lower than those in Munshiganj, compare ± 219,000 in Munshiganj to ± 130,000 in Rangpur. The difference is most likely related to the cutting of seed. Each cut potato seed piece is counted as one plant in Munshiganj, where the non-cut whole potatoes in Rangpur are counted as one plant. Cutting seed has advantage but even more disadvantages. The most important advantage is that in case there are small quantities of seeds available, the seed pieces are better able to cover the total soil area, and thus intercept light better with subsequently better yields compared to large plant densities when not cutting. However, the major disadvantages are that cut seeds have large area's diseases can enter and germination can be severely reduced by fungi infections. Fungicides are needed to protect the cut-seed potato pieces. Second, cutting increases the risk of spreading diseases through the seed stock. One infected and diseased potato infects this knife when cut and this knife will infect all subsequent cut seeds: 'one bad apple in the basket causes the whole basked to be lost!'. These two major disadvantages are much more damaging to yields than the advantage of a better distribution of stems for maximum light interception.
Planting distances of Munshiganj and Rangpur are in agreement with those of the studies of Munshiganj (Pronk, et al. 2017b, Pronk, et al. 2017a) and of Rangpur (Pronk, et al. 2017c).

Table 3.12 *Minimum (Min), average (Avg) and maximum (Max) row and intra-row distance (cm), and the calculated plant density (plants/ha) of non-SMS (No) and SMS (Yes) receiving farmers in Munshiganj and Rangpur.*

		Row distance (cm)			Intra row distance (cm)			Plant density		
District	SMS	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max
Munshiganj	No	30	40	46	10	12	18	130,252	222,349	322,917
	Yes	30	40	56	10	12	20	107,639	215,950	322,917
	All	30	40	56	10	12	20	107,639	219,565	322,917
Rangpur	No	30	50	69	10	17	25	57,408	128,887	322,917
	Yes	30	50	64	10	17	25	70,455	131,775	322,917
	All	30	50	69	10	17	25	57,408	130,331	322,917
All data	No	30	46	69	10	15	25	57,408	166,272	322,917
	Yes	30	46	64	10	15	25	70,455	160,328	322,917
	All	30	46	69	10	15	25	57,408	163,443	322,917

3.2.4. Fertilisation

Table 3.13 shows the minimum, average and maximum doses of applied urea and triple super phosphate (TSP) fertiliser of the control group (No) and SMS-receiving (Yes) farmers. The application doses have been converted to hectares instead of decimal as in the questionnaire. The minimum, average and maximum applied amounts of urea and TSP have also been converted into the amounts of applied nitrogen (N) and phosphate (P_2O_5), respectively.

The advised doses of fertilisers for potato in Bangladesh for a yield target of 30 t/ha are 91 to 135 or 136 to 180 N kg/ha, 50 to 70 or 71 to 92 P_2O_5 kg/ha and 110 to 163 or 164 to 217 K_2O kg/ha, depending on the soil status 'low' or 'very low' according to the soil analysis interpretation, respectively (FRG 2012). Table 3.13 ,shows that the current average application rates in Munshiganj for N (223 kg/ha) and P_2O_5 (238 kg/ha) are much higher than the recommendations, as was also found in

the baseline and evaluation study, and in agreement with application rates found in Munshiganj in 2009 (Rabbani, et al. 2010). The current application rate in Rangpur for N (± 150 kg N/ha) is in agreement with the recommendations where the rate for P_2O_5 (188 kg/ha) is again higher than the recommendations. Also, these rates are in agreement with those found in the baseline study of Rangpur (Pronk, et al. 2017c).

The application rate of Urea and TSP is higher in Munshiganj than in Rangpur. Furthermore, the non-SMS-receiving farmers apply more Urea than the SMS-receiving farmers do.

Table 3.13 Minimum, average and maximum applied urea and triple super phosphate (TSP, kg/ha) of non-SMS-receiving (No) farmers and SMS-receiving (Yes) farmers in Munshiganj and Rangpur, and the minimum, average and maximum applied N and P_2O_5 (kg/ha).

		Urea (kg/ha)			TSP (kg/ha)		
District	SMS	Min	Avg	Max	Min	Avg	Max
Munshiganj	No	494	744	989	247	708	989
	Yes	247	736	989	247	729	989
	All	247	741	989	247	717	989
Rangpur	No	74	342	989	74	420	989
	Yes	62	325	741	62	418	989
	All	62	334	989	62	419	989
All data	No	74	503	989	74	535	989
	Yes	62	465	989	62	524	989
	All	62	485	989	62	530	989
Kg N / P_2O_5/ha		28	223	455	28	238	445
District			***			***	
SMS or not			**			n.s.	
District * SMS or not			n.s.			n.s.	

3.2.5. Production

Table 3.14 shows the harvest time and the number of growing days, i.e. the difference between harvest and planting date of the control group and SMS-receiving farmers in both districts. The growing season in Munshiganj of 96 days was longer than the growing season in Rangpur (93 days), and 8 days shorter than in the baseline study of 104 days (Pronk, et al. 2017a). For Rangpur, the difference in growing periods with the baseline was small, it was only one day more in this study (Pronk, et al. 2017b).
Furthermore, the growing season of SMS-receiving farmers of 93 days was shorter than the growing season of the non-SMS-receiving farmers of 95 days. This difference is not expected as a good late blight control strategy aims to prolong the growing season.

Figure 3.4 shows the frequency distribution of the growing periods of farmers in Munshiganj and Rangpur. Both distributions indicates that most farmers harvested between 91 and 98 days after planting. In Munshiganj, the second group of farmers harvested between 98 and 105 days after planting where in Rangpur the second group of farmers harvested earlier, 84 to 91 days after planting.

Table 3.14 Minimum, average and maximum harvest date and number of growing days in Munshiganj and Rangpur of non-SMS (No) and SMS-receiving farmers (Yes).

		Harvest date			Number of growing days		
District	SMS	Min	Avg	Max	Min	Avg	Max
Munshiganj	No	03/Jan	27/Feb	02/Apr	66	97	116
	Yes	07/Jan	26/Feb	04/Apr	65	95	114
	All	03/Jan	27/Feb	04/Apr	65	96	116
Rangpur	No	30/Dec	24/Feb	02/Apr	65	93	115
	Yes	25/Dec	23/Feb	16/Apr	66	92	114
	All	25/Dec	24/Feb	16/Apr	65	93	115
All data	No	30/Dec	25/Feb	02/Apr	65	95	116
	Yes	25/Dec	24/Feb	16/Apr	65	93	114
	All	25/Dec	25/Feb	16/Apr	65	94	116
District						***	
SMS or not						**	
District * SMS or not						n.s.	

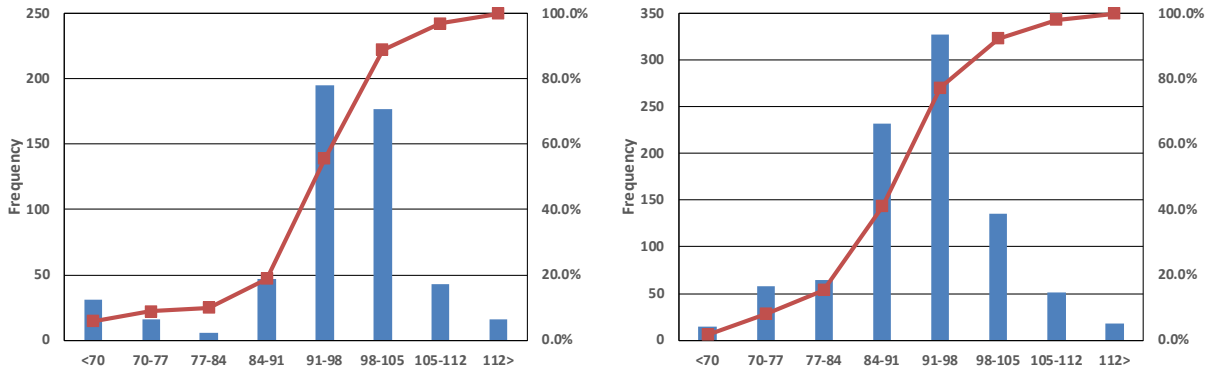

Figure 3.4 Frequency distribution of potato growing periods in both Munshiganj (left panel) and Rangpur during the 2017/18 growing season.

Yield differences between Munshiganj and Rangpur as shown in Table 3.15 were significantly but the difference was relatively small: the average yield was 25.2 t/ha in Munshiganj and 23.6 t/ha in Rangpur. The small difference may be related to the almost similar growing period in both districts this season (Table 3.14), while commonly the growing season in Munshiganj is about 10 days longer than in Rangpur (see above).

Table 3.15 Potato yield (in t/ha) of farmers in Munshiganj and Rangpur divided in non-SMS and SMS-receiving farmers.

District	SMS	Yield
Munshiganj	No	24.6
	Yes	26.0
	All	25.2
Rangpur	No	23.3
	Yes	23.6
	All	23.5
All data	No	23.9
	Yes	24.4
	All	24.1
District		***
SMS or not		***
District * SMS or not		n.s.

The yield data indicate that non-SMS-receiving farmers have significantly lower yields than SMS-receiving farmers: compare 23.9 with 24.4 t/ha in Table 3.15. Receiving the SMS does not automatically mean that the SMS has been followed up by farmers. Therefore, we also analysed the yields of SMS farmers that followed the advice, sometimes followed the advice and farmers that did not follow on the advice. Table 3.16 shows that farmers acting upon the service "sometimes" or "always" (Yes) have higher yields in both districts than farmers that did not (No) follow the advice. In Munshiganj, farmers that always acted upon the SMS alert achieved a yield benefit of 1.3 t/ha compared to farmers that did not act upon the advice provided by the SMS alert. In Rangpur, this difference was even 3.7 t/ha. The average yield of farmers that answered this non-mandatory question (53%) is 24.4 t/ha and differs from the average yield of 24.1 t/ha of Table 3.15.

Table 3.16 The yield (t/ha) of SMS-receiving farmers not following (No), sometimes following (sometimes) or following (Yes) the advice of the SMS alert in Munshiganj and Rangpur (letters indicate significant different yields).

	Acted upon			
District	No	Sometimes	Yes	Total
Munshiganj	25.5	25.1	26.8	26.0 a
Rangpur	20.6	23.6	24.3	23.6 b
Total	23.1 b	24.1 ab	25.0 a	24.4

Table 3.17 shows the minimum, maximum and average potato sales prices in Munshiganj and Rangpur of non-SMS and SMS-receiving farmers. There is no clear difference between SMS-receiving and non-SMS receiving farmers. In general, potato prices were 1,325 BDT/t higher in Munshiganj, which is most likely related to the nearby Dhaka market.

Table 3.17 *The minimum (min), average (avg) and maximum (max) sales price of potatoes (BDT/t) of non-SMS (No) or SMS (Yes) receiving farmers Munshiganj and Rangpur and all farmers.*

District	SMS	Min	Avg	Max
Munshiganj	No	3,000	8,813	13,000
	Yes	5,000	8,627	13,000
	All	3,000	8,737	13,000
Rangpur	No	3,000	7,227	18,000
	Yes	3,000	7,597	18,000
	All	3,000	7,412	18,000
All data	No	3,000	7,782	18,000
	Yes	3,000	7,876	18,000
	All	3,000	7,826	18,000

3.2.6. Control of late blight

On average, farmers in Rangpur observed late blight three days later than in Munshiganj, i.e. 39 vs. 36 days after planting, with only small a difference ($p < 0.1$) between SMS-receiving and non-SMS receiving farmers (Table 3.18). In addition, the average number of fungicide applications of SMS receiving farmers and non-SMS receiving farmers did not differ in both Munshiganj and Rangpur. In Rangpur, farmers sprayed on average seven times in the season, while in Munshiganj farmers sprayed less, on average only five times.

Table 3.18 *The minimum (min), average (avg) and maximum (max) number of days after planting (DAP) that late blight was observed and the number of fungicide applications per season (times per season) for the non-SMS (No) or SMS (Yes) receiving farmers Munshiganj and Rangpur, all farmers and the results of the statistical analysis.*

		DAP			# of applications		
District	SMS	Min	Avg	Max	Min	Avg	Max
Munshiganj	No	3	36	51	2	5	9
	Yes	4	36	69	2	5	10
	All	3	36	69	2	5	10
Rangpur	No	2	39	76	1	7	14
	Yes	0	39	90	1	7	14
	All	0	39	90	1	7	14
All farmers	No	2	37	76	1	6	14
	Yes	0	38	90	1	6	14
	All	0	38	90	1	6	14
Sub-district			***			***	
SMS or Not			*			n.s.	
Sub-district * SMS or Not			n.s.			n.s.	

Table 3.19 shows the date that farmers observed late blight for the first time, the date of the first fungicide spray and the percentage of farmers that applied the first spray after late blight was observed. The difference between SMS-receiving farmers and non-SMS receiving farmers was only one or two days in the first observation of late blight and the first spray moment. In addition, the first late blight observation was two days earlier in Munshiganj and the first spray to control late blight was on average three days earlier than in Rangpur. The data that late blight was first observed was on average 6 days earlier in Munshiganj in this survey than in the Baseline survey (Pronk, et al. 2017a) and 16 days earlier than the growing season 2016-2017 (Pronk, et al. 2017b). The average data that the first spray was applied however, did not differ from the data found in the Baseline survey but was about 10 days later than the growing season 2016-2017. In Rangpur, late blight was first observed on exactly the same date as found in the Baseline survey (Pronk, et al. 2017c) but the first spray was applied 5 days later than indicated in the Baseline survey, 3 January compared to 28 December.

Remarkably, more than 90% of the farmers started to control late blight with a fungicide application after the first observation of late blight. This percentage is much higher than found in the Baseline surveys for Munshiganj, 50% and Rangpur, 10%, and in the evaluation survey of Munshiganj for growing season 2016-2017, 12% for non-SMS receiving farmers and 4% for SMS-receiving farmers. As predominantly mancozeb or mancozeb containing fungicides are used by potato farmers (Table 3.21), which a preventive working, not much effect can be expected from this applications, it should be applied before observing late blight symptoms.

Table 3.19 *The average day that late blight was first observed, the average day the first fungicide spray was applied and the percentage of farmers that applied the first spray after late blight was observed of non-SMS-receiving farmers (No) and SMS-receiving farmers (Yes) in Munshiganj and Rangpur.*

District	SMS	first observed	first spray	after
Munshiganj	No	28/Dec	29/Dec	88
	Yes	29/Dec	31/Dec	94
	All	29/Dec	30/Dec	91
Rangpur	No	31/Dec	01/Jan	95
	Yes	02/Jan	03/Jan	93
	All	01/Jan	02/Jan	94
All data	No	30/Dec	31/Dec	92
	Yes	01/Jan	02/Jan	93
	All	31/Dec	01/Jan	93

The SMS alert advised farmers to apply a preventive fungicide within a short period. Table 3.20 shows that most farmers indeed sprayed a preventive fungicide as a first spray, with little differences within the districts between farmers that said to act upon the alert service or not or sometimes. In Rangpur, farmers applied more often a preventive + curative fungicide, where half of the curative applications had metalaxyl as curative component and was thus not effective against late blight.

Table 3.20 The type of fungicide applied of the first spray of farmers (%) that said to acted upon (yes) or not (no) or sometimes in Munshiganj and Rangpur.

		Acted upon		
District	Type of fungicide first spray	yes	no	sometimes
Munshiganj	Preventive	86	75	71
	Preventive + curative	4	7	6
	Curative	1	0	0
	Curative resistance	1	0	0
	Preventive + curative resistance	7	14	13
	Preventive + slightly curative	1	3	10
	No late blight	2	0	0
	All data[1]	100	100	100
Rangpur	Preventive	65	70	68
	Preventive + curative	13	20	12
	Curative	2	0	0
	Curative resistance	0	2	4
	Preventive + curative resistance	12	3	9
	Preventive + slightly curative	8	5	7
	No late blight	1	0	0
	All data[1]	100	100	100

[1] Only fungicides that have an effect on late blight

Table 3.21 shows the number of farmer recordings of specific active ingredients used and the percentage of total recordings of these active ingredients for SMS-receiving farmers and non-SMS receiving farmers. In Munshiganj, between 1100 and 1500 times a product was used, where in Rangpur this was 2500 times, leading to the conclusion that in Rangpur more products are applied. In both Munshiganj and Rangpur, Mancozeb 80% containing fungicides were the most frequently reported products with little difference between SMS-receiving farmers and non-SMS receiving farmers, 81% in Rangpur and 58% in Munshiganj. Metalaxyl containing fungicides are still used in both Munshiganj and Rangpur, both by SMS-receiving farmers and non-SMS receiving farmers: between 11 and 16% of the fungicide recordings contained metalaxyl as active ingredient. The prevailing late blight strain in Bangladesh, so-called Blue 13, is resistant against metalaxyl and thus cannot be controlled with products that contain metalaxyl (Pronk, et al. 2017a). Since the start of GEOPOTATO, this resistance against metalaxyl is known and communicated to extension staff and stakeholders, but apparently, this information does not reach farmers, or at least the fungicide choice behaviour of farmers is not affected.

Table 3.21 The number of recordings (#) of farmers receiving no SMS (Non-SMS) or a SMS (SMS) that mentioned to use an active ingredient, the type of fungicide and the percentage total recordings (%).

			Non-SMS farmers		SMS-famers	
District	Active ingredient	type of fungicide	#	%	#	%
Munshi-ganj	Copper oxychloride (50%) Copper oxychloride (50%)	No late blight	2	0.4	2	0.5
	Dimethomorph (9%) + Mancozeb (60%)	Preventive + curative	20	4.1	6	1.6
	Mancozeb (45%)	Preventive	116	23.6	91	24.2
	Mancozeb (63%) + Carbendazim (12%)	Preventive	3	0.6	2	0.5
	Mancozeb (64%) + Benalaxyl (8%)	Preventive + curative	1	0.2	-	-
	Mancozeb (64%) + Cymoxanil (8%)	Preventive + curative	27	5.5	12	3.2
	Mancozeb (64%) + Metalaxyl (4%)	Preventive + curative resistance	46	9.3	28	7.4
	Mancozeb (64%) + Metalaxyl (8%)	Preventive + curative resistance	37	7.5	35	9.3
	Mancozeb (80%)	Preventive	92	18.7	77	20.5
	Metalaxyl (25%)	Curative resistance	1	0.2	2	0.5
	Phosphorous Acid	Curative	-	-	1	0.3
	Propineb (61.25%) + Iprovalicarb (5.5%)	Preventive + slightly curative	21	4.3	17	4.5
	Propineb (70%)	Preventive	113	23.0	90	23.9
	Zineb	Preventive	13	2.6	13	3.5
	Total number of active ingredients		492		376	
Rang-pur	Bismerthiazol	No late blight	2	0.2	3	0.4
	Chlorothalonil	Preventive	-	-	1	0.1
	Copper hydroxide	No late blight	1	0.1	1	0.1
	Copper oxychloride (50%) Copper oxychloride (50%)	No late blight	-	-	1	0.1
	Dimethomorph (9%) + Mancozeb (60%)	Preventive + curative	92	11.4	85	10.1
	Mancozeb (12%) + Copper (30%)	Preventive	5	0.6	3	0.4
	Mancozeb (45%)	Preventive	164	20.3	146	17.4
	Mancozeb (45%) + Fosetyl Al (25%)	Preventive	1	0.1	-	-
	Mancozeb (50%) + Fenamidone (10%)	Preventive	54	6.7	49	5.8
	Mancozeb (63%) + Carbendazim (12%)	Preventive	30	3.7	27	3.2
	Mancozeb (64%) + Cymoxanil (8%)	Preventive + curative	96	11.9	58	6.9
	Mancozeb (64%) + Metalaxyl (4%)	Preventive + curative resistance	19	2.3	28	3.3
	Mancozeb (64%) + Metalaxyl (8%)	Preventive + curative resistance	72	8.9	72	8.6
	Mancozeb (75%)	Preventive	1	0.1	2	0.2
	Mancozeb (80%)	Preventive	200	24.7	247	29.4
	Mandipromid	Preventive	-	-	2	0.2
	Metalaxyl (25%)	Curative resistance	7	0.9	11	1.3
	Phosphorous Acid	Curative	16	2.0	14	1.7
	Propineb (61.25%) + Iprovalicarb (5.5%)	Preventive + slightly curative	26	3.2	51	6.1
	Propineb (70%)	Preventive	21	2.6	38	4.5
	Pyraclostrobin (5%) + Metiram (55%)	Preventive	1	0.1	-	-
	Quardartary Ammonium	Preventive	1	0.1	2	0.2
	Zineb	Preventive	2	0.2	4	0.5
	Total number of active ingredients		809		841	

Table 3.22 shows the number and percentage of SMS-receiving farmers and non-SMS receiving farmers in Munshiganj and Rangpur that used a knapsack, power sprayer or both types of sprayers. In both Munshiganj and Rangpur, the difference between SMS-receiving farmers and non-SMS receiving farmers was small. The majority of farmers used a knapsack sprayer in both Munshiganj and Rangpur. However, the use of power sprayers is considerably higher in Munshiganj than in Rangpur.

Table 3.22 *The number (#) and percentage (%, of total number per district) of non-SMS (No) or SMS (Yes) receiving farmers in Munshiganj and Rangpur that used a specific type of sprayer to apply fungicides.*

		Knapsack		Power sprayer		Both	
District	SMS	#	%	#	%	#	%
Munshiganj	No	173	33	125	24	2	0.38
	Yes	143	27	87	16	1	0.19
	All	316	60	212	40	3	0.56
Rangpur	No	419	47	31	3	0	0.00
	Yes	426	47	22	2	2	0.22
	All	845	94	53	6	2	0.22
All data	No	592	41	156	8	2	0.14
	Yes	569	40	109	19	3	0.21
	All	1161		265		5	

The statistical analysis showed that yields were significantly lower in Rangpur than in Munshiganj and that the SMS-receiving farmers had a higher yield than the non-SMS-receiving farmers did. Effects of type of fungicide were not significant (Figure 3.5).

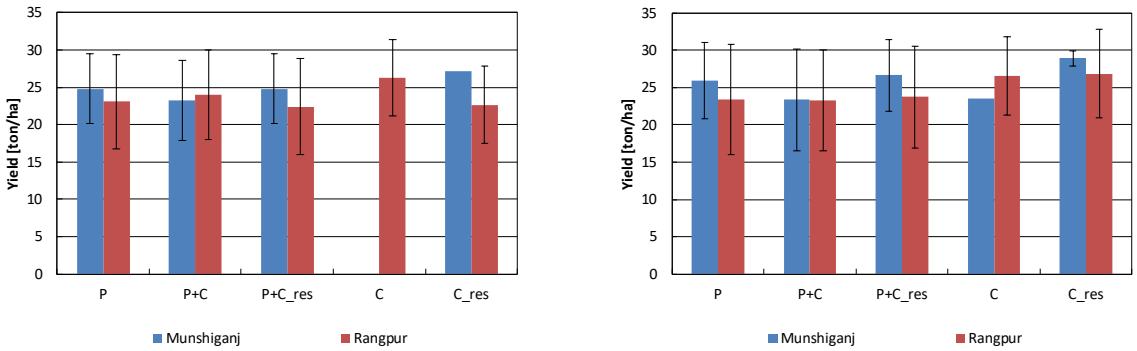

Figure 3.5 *The effect of different types of active ingredients on yield of non-SMS-receiving (left) and SMS-receiving (right) farmers in Munshiganj and Rangpur (P = preventive; P + C = preventive = curative; P + C_res = Preventive and curative resistant; C = curative; C_res = curative resistant)*

3.2.7. Service evaluation

This potato season, farmers in Munshiganj did not have a high late blight pressure (Table 3.23), but a high late blight pressure was indicated by almost 20% of the farmers in Rangpur. Sixty percent of the farmers in Munshiganj and slightly more than half of the farmers in Rangpur indicated a low late blight pressure. There were no differences in late blight pressure between farmers not or receiving a SMS alert.

Table 3.23 *The total number of recordings and the percentage of recordings with Low, Medium or High late blight pressure (%) according to non-SMS-receiving (No) and SMS-receiving (Yes) farmers in Munshiganj, Rangpur and all recordings.*

District	SMS	n	Low	Medium	High
Munshiganj	No	300	61	39	0
	Yes	231	65	34	0
	All	531	63	37	0
Rangpur	No	450	51	31	18
	Yes	450	50	31	19
	All	900	50	31	19
All data	No	750	55	34	11
	Yes	681	55	32	13
	All	1431	55	33	12

SMS-alerts were sent to 321 farmers in Munshiganj and 450 farmers in Rangpur. All farmers were asked if they received the SMS's. They had two answer options: do not know and yes, and if yes the number of SMS's received was asked and if they understood the message. The results are presented in Table 3.24. Between 76 and 86% of the farmers in Rangpur and Munshiganj, respectively, said to have received a SMS, 7 to 8 SMS's on average. This means that 21% answered: Do not know. Those farmers were not included in the results on the other questions related to the SMS's received.
Most farmers that had received SMS's understood the message, 86 and 76% in Munshiganj respectively Rangpur. In Munshiganj 7% of the farmers indicated not to understand the message, which is the same as in the evaluation study of Munshiganj, season 2016/17 (Pronk, et al. 2017b).

Table 3.24 *The percentage of farmers per district that received an SMS, the average number of received SMS's reported and the percentage of farmers per district that understood the SMS in Munshiganj, Rangpur and all data.*

			Understand SMS (%)		
District	SMS received (%)	# SMS's	Yes	No	Partially
Munshiganj	86	7	87	7	6
Rangpur	76	8	89	1	10
All data	79	8	88	3	9

It is most important to know if farmers acted upon the SMS-alert and when not, why. Table 3.25 shows that 50 and 69% of the farmers acted upon the SMS-alert in Munshiganj and Rangpur, respectively. The majority of the farmers in Munshiganj (74%) and almost half of the farmers in Rangpur (47%) also sprayed on other times as well.

Table 3.25 *The percentage of farmers per district that acted upon the SMS advice and reasons why not, and the percentage of farmers per district that sprayed on other times additionally to the advice.*

	Acted upon SMS advice (%)					Sprayed on other time(s) (%)		
District	Yes	No	Sometimes	Why not?	# mentioned	Yes	No	Sometimes
Munshiganj	50	19	31	Other reason	32	74	13	13
				I did not trust the service	4			
				Had no time	1			
				I had sprayed just before receiving message	3			
Rangpur	69	7	24	Other reason	8	47	5	48
				I did not trust the service	6			
				Had no time	3			
				I had sprayed just before receiving message	7			
All data	62	11	26			57	8	35

On average 78% of SMS-receiving farmers shared the alert message with other farmers, with little difference between farmers in Munshiganj and Rangpur (Table 3.26). On average, the alert message was shared with 11 other farmers, with no difference between Munshiganj and Rangpur. In the first evaluation of Munshiganj 2016/17 season sharing of the alerts was slightly higher, i.e. messages were shared on average with 13 farmers (Pronk, et al. 2017b).

Table 3.26 *The percentage of farmers that shared the SMS information with other farmers and the average number of farmers that the SMS was shared with.*

	Shared SMS with others (%)		
District	Yes	No	Average number of farmers shared with
Munshiganj	81	19	11
Rangpur	77	23	11
All data	78	22	11

Table 3.27 shows the percentage of farmers that answered to have received SMS's in both Munshiganj and Rangpur that was satisfied and dissatisfied with the service, including the reason for dissatisfaction. More farmers in Rangpur (92%) were more satisfied with the service than in Munshiganj (84%). In Munshiganj, the majority of the farmers (41%) that was not satisfied with the service did not give a reason for dissatisfaction. Low trust (≈ 20%) and little usefulness of the service (22%) were other major reasons mentioned by dissatisfied farmers in Munshiganj. In Rangpur, also a fair share of the dissatisfied farmers found the service not useful (36%), but here also other reasons were mentioned: Farmers did not see the SMS (11%) and the SMS was not received on time (32%).

Table 3.27 *The percentage of farmers (that received the SMS) that was satisfied with the SMS service in Munshiganj (n = 199) and Rangpur (n = 341) and if not, why (percentage of answers, n=60).*

	Satisfied (%)			
District	Yes	No	Why not?	%
Munshiganj	84	16	No comment	40.6
			Didn't trust	18.8
			It's not useful at all	21.9
			Didn't understand SMS	9.4
			Didn't see SMS	6.3
			I can't read	3.1
Rangpur	92	8	Didn't trust	7.1
			It's not useful at all	35.7
			Didn't see SMS	10.7
			Didn't come in time	32.1
			It's an incomplete service	3.6
			I will leave the cultivation of potatoes	3.6
			It's only about potato	3.6
			Need name of different product	3.6
All data	89	11		

About two third of the SMS receiving farmers found the service good and useful (Table 3.28). In Munshiganj, 26% of the farmers found the alerts helpful instructions, while in Rangpur 10% of the farmers mentioned the same reason. Increased production thanks to the service was mentioned by 6 and 8% of the farmers in Munshiganj and Rangpur, respectively.

Table 3.28 *Reason mentioned by farmers in Munshiganj (n= 167) and Rangpur (n=313) why they were satisfied with the SMS service.*

District	Why satisfied?	%
Munshiganj	Good and useful	66.5
	Helpful instruction	25.7
	Increased production	6.0
	Reduced cost	1.2
	SMS in time	0.6
Rangpur	Good and useful	68.1
	Helpful instruction	9.6
	Increased production	8.0
	SMS in time	6.7
	Advanced info was helpful	7.3

Table 3.29 shows the diverging willingness of farmers that answered to have received a SMS in Munshiganj and Rangpur to pay for the service: In Rangpur, 88% of the farmers was willing to pay and in Munshiganj only 29%.

Table 3.29 The percentage of SMS-farmers per district willing to pay for the service.

District	No	Yes
Munshiganj	71	29
Rangpur	12	88

The same tendency is observed in Table 3.30 under non-SMS receiving farmers in Munshiganj and Rangpur, 79% of these farmer in Rangpur was willing to pay for the service, while only 9% in Munshiganj. However, the same Table shows that more than 90% of the non-SMS receiving farmers in both districts was interested in receiving the service. In addition, Table 3.30 shows that only 8% of the non-SMS-receiving farmers in Munshiganj and 28% in Rangpur had heard about the service.

Table 3.30 The percentage of non-SMS-farmers that heard of, would like to receive and is willing to pay for the service in Munshiganj (n=300) and Rangpur (n=450).

	Heard about the service		Like to receive		Willing to pay	
District	Yes	No	Yes	No	Yes	No
Munshiganj	8	92	92	8	9	91
Rangpur	28	72	98	2	79	21

Table 3.31 shows the reasons of non-SMS receiving farmers in both Munshiganj and Rangpur that were not interested in receiving the SMS alerts. The majority of these farmers had other reasons than distrust in the service and other information sources such as fellow farmers and DAE staff. Note that the percentages in Table 3.31 are based on very few farmers.

Table 3.31 Remarks of non-SMS-farmers in Munshiganj and Rangpur on the question 'why don't you want to receive the SMS?' expressed as percentage of total remarks per district.

Remarks	Munshiganj	Rangpur
Other	79	60
I do not trust	8	40
I will hear from fellow farmer / DAE	13	
# of farmers	24	10

3.2.8. Costs of late blight control

The costs for late blight control varied between 9,575 BDT/ha for non-SMS-receiving farmers in Munshiganj to 12,185 BDT/ha for SMS-receiving farmers in Rangpur (*Table 3.32*). There is no difference in costs per ha between SMS and non-SMS-receiving farmers, the only difference is between districts. Costs per ha for late blight control in Rangpur are just higher than in Munshiganj. The cost per ton potato show the same differences as the costs per ha: 398 BDT/t in Munshiganj is lower than 581 BDT/t in Rangpur and no differences between SMS and non-SMS-receiving farmers were found.

Table 3.32 The total cost for fungicide products per ha and per ton potatoes of farmers in Munshiganj and Rangpur divided in non-SMS (No) and SMS-receiving (Yes) farmers.

		Total cost	
District	SMS	BDT/ha	BDT/t potatoes
Munshiganj	No	9,575	404
	Yes	9,655	390
	All	9,610	398
Rangpur	No	12,033	572
	Yes	12,185	591
	All	12,109	581
All data	No	11,050	505
	Yes	11,326	523
	All	11,182	513
District		***	***
SMS or not		n.s.	n.s.
District * SMS or not		n.s.	n.s.

3.3. Outcome indicators evaluation

3.3.1. Late blight control demonstrations

Improvement in sustainable food production

Yields of DSS$^+$, DSS and FP in Munshiganj were on average 30 t/ha and did not differ where yields in Rangpur of DSS$^+$ were the highest of all, explaining the interactive effect between district and support service (Table 3.3). In Rangpur, the sustainable food production is improved with 8.9 t/ha when using the service. Food production in Munshiganj was not increased due to the service, most likely because the late blight pressure was neglectable or low.

Improvement in efficiency

The N-fertiliser use of the decision support demonstration plots (DDS$^+$ and DDS) ranged from 3.8 to 5.1 kg N/t product (potatoes produced) where the farmer plots applied 4.9 kg N/t (Table 3.33). The difference between the three different plots is significant at the 1% level. All plots have lower N-fertiliser use efficiencies than found in the baseline surveys of 8.9 kg N/t product in Munshiganj (Pronk, et al. 2017a) and 7.5 kg N/t product in Rangpur (Pronk, et al. 2017c), and in the evaluation study of 9.5 kg N/t product in Munshiganj (Pronk, et al. 2017b) and in the farmers survey of 9.5 kg/t product for the non- and SMS-receiving farmers (*Table 3.34*). But, the decision support demonstrations in Munshiganj season 2016-17 showed N-fertiliser use efficiencies of 2.5 kg N/t product for the DDS$^+$ and DDS treatments and 6.9 kg N/t product for the FP treatment (Pronk, et al. 2017b), being respectively lower and higher than the N-use efficiencies found in this study.

Table 3.33 The N-use efficiency (per t product) and the fungicide use efficiency (kg fungicide product and kg active ingredients) of the demonstration plots of the Decision Support Service using (DSS+), Decision Support Service using Dithane (DSS) and Farmers Practice (FP) in Munshiganj and Rangpur

			Fungicide use	
District	sub-district	N- fertiliser use (kg N/t product)	kg product/ha	kg active ingredients/ha
Munshiganj	DSS+	4.9	13.2	9.2
	DSS	5.1	8.3	4.7
	FP	4.9	14.5	10.7
Rangpur	DSS+	3.8	14.3	9.9
	DSS	4.3	8.6	5.0
	FP	4.9	15.1	10.7
All		4.5	12.4	8.4
District		***	n.s.	n.s.
Support service		***	***	***
District * Support service		***	n.s.	n.s.

The fungicide use expressed as kg product per ha ranged from 8.3 to 14.3 kg/ha for the DSS and DSS+ to 14.5 and 15.1 kg/ha for the FP (Table 3.33). There are two components contributing to the differences in kg product used per ha: the number of applications between the three systems is different (Table 2.2) and the type of used fungicides is different (Annex II). The dominant factor in reduced product use per ha is the use of the fungicide Revus. The recommended and used application rate of the product is very low compared to other fungicide products.
The same difference is found for the use of active ingredient (A.I.) per ha, on average 10.7 kg A.I./ha is used in the FP whereas only 4.7 and 5.0 kg/ha were used in the DSS.

Improvement in income

The improvement of income is estimated through changes in costs for late blight control per ton product, i.e. the marketable amount of potatoes produced. The costs for fungicide applications per ton product are higher in Munshiganj, 448 BDT/t compared to 410 BDT/t in Rangpur (Table 3.3, Figure 3.6 left) and no differences were found between the support services. However, evaluating Rangpur only, the DSS+ had the lowest costs per t potatoes and therefore increased income (Table 3.3, Figure 3.6 right).

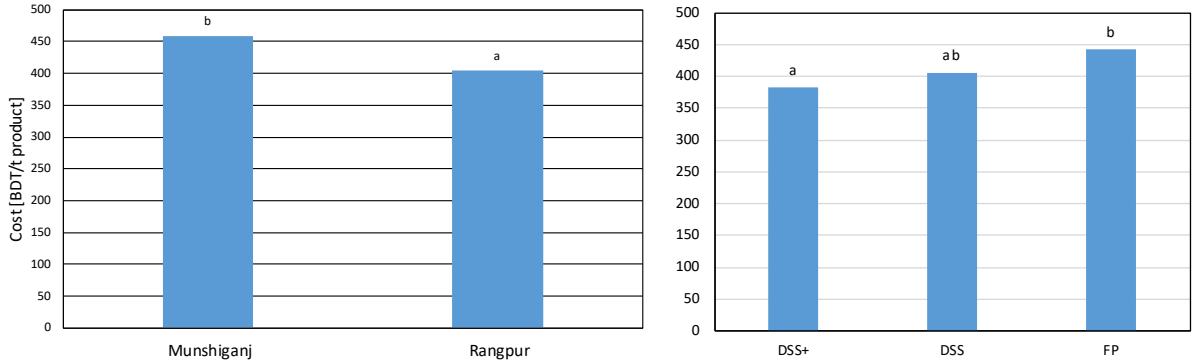

Figure 3.6 *The cost for fungicide applications in Munshiganj and Rangpur (left) and for the different support services in Rangpur (right). Bars with different letters are significant different*

Other outcome

Indicators for other outcomes are included for reference purposes only in the summary table (Table 4.1), as most are predetermined by the setup of the demonstrations.
The first indicator is number of fungicide products with curative active ingredients mentioned to be used in FP, which was four in Munshiganj as well as in Rangpur, although different products were used. Of those product and in both districts, one contained the curative component Metalaxyl, which has no effect on late blight due to resistance of the Blue 13 late blight strain. Thus, 25% of the curative products did contain Metalaxyl.
The second indicator concerning the use of curative fungicides is on the percentage of applications that contained Metalaxyl. In Munshiganj in FP, 25 curative applications were applied of which six contained Metalaxyl, thus 29% of all curative applications contained Metalaxyl. In Rangpur in the FP, 22 curative applications were applied of which 10 with Metalaxyl, thus 45% of all curative applications contained Metalaxyl. No metalaxyl containing products were used in the DSS or DSS^{+}.

3.3.2. Late blight control service

Improvement in sustainable food production

Yields of SMS-receiving farmers were significantly higher, 0.5 t/ha, than non-SMS-receiving farmers (Table 3.15). More interesting is the difference between farmers that followed the SMS advice and SMS farmers that neglected the advice. SMS-receiving farmers that neglected the SMS alerts had significantly lower yields than farmers that followed the advice, 23.1 t/ha and 25.0 t/ha, respectively (Table 3.16). In Munshiganj, the difference between these two types of farmers was 1.3 t/ha and in Rangpur it was even 3.7 t/ha. Therefore, in both districts sustainable food production was increased when farmers received a SMS and even more when SMS-receiving farmers followed the SMS advice.

Improvement in resource use efficiency

N use efficiency between SMS-receiving farmers and non-SMS-receiving farmers was not much different between the support services but was different between districts: in Munshiganj, this was

14.2 kg N/t product and about twice as high as in Rangpur which was 7.2 kg N/t product (*Table 3.34*). More nitrogen was used per ton product in this study than previously found in the baseline study if 8.9 kg N/t product and evaluation study of 9.3 kg N/t product in Munshiganj and the baseline study of Rangpur of 7.5 kg N/t product (Table 4.2).

Fungicide use between SMS-receiving farmers and non-SMS-receiving farmers was not much different, 8.3 and 8.5 kg product/ha (*Table 3.34*) but lower than found in the baseline surveys of Munshiganj and Rangpur of 11.8 and 11.3 kg product/ha and higher compared to the evaluation study of Munshiganj of 2016/17 of 7.5 and 7.4 for non-SMS-receiving and SMS receiving farmers (Table 4.2).

Table 3.34 Outcome indicators of N-use efficiency and fungicide use efficiency of non-SMS-receiving (No) and SMS-receiving (Yes) farmers in Munshiganj and Rangpur.

		N-fertiliser use	Fungicide use	
Sub-district	SMS	kg N/t product	kg product/ha	kg AI/ha
Munshiganj	No	14.5	8.0	5.1
	Yes	13.8	8.2	5.2
	All	14.2	8.1	5.2
Rangpur	No	7.1	8.5	5.4
	Yes	7.2	8.6	5.7
	All	7.2	8.6	5.6
All data	No	10.1	8.3	5.3
	Yes	9.5	8.5	5.5
	All	9.8	8.4	5.4
District		***	n.s.	n.s.
Support service		n.s.	n.s.	n.s.
District * Support service		n.s.	n.s.	n.s.

Improvement in income

The improvement of income is estimated through changes in costs for late blight control per ton product, that is marketable potatoes produced.
There were no differences in costs for late blight control per t potatoes produced between the SMS- and non-SMS-receiving farmers (*Table 3.32*). However, there was a difference between SMS-receiving farmers that did act upon the SMS alert or not: farmers that said to act upon the SMS alert had lower costs per t potatoes than farmers that said not to act upon the alert see *Table 3.35*. Results presented in *Table 3.35* may seem confusing as farmers that said "Sometimes" have higher costs as farmers that said "Yes". The results here are of log-transformed data to ensure a normal distribution in combination with an unbalanced design (farmers in different categories differs). Lower costs per t potatoes increases income of farmers. Therefore, following the SMS alert increased farmers' income.

Table 3.35 Statistical analysis of costs [BDT/t product] of SMS-receiving farmers that said to act upon the received SMS in Munshiganj and Rangpur. A log transfer was done on cost to ensure a normal distribution.

	Acted upon							
District	No		Sometimes		Yes		Total	
Munshiganj	386		417		388		397	a
Rangpur	576		576		548		563	b
Total[1]	497	A	507	ab	501	b	502	

[1] This analysis was done on data of SMS-receiving farmers that said to have received the SMS. Total average costs/t may therefore differ from other data presented in other tables

Other outcomes

The number of fungicide products with curative active ingredients mentioned to be used by farmers is shown in T*able 3.36*. More than 75% of these products contained metalaxyl, which was almost the same as in Munshiganj in the 2016/17 season (Pronk, et al. 2017b) and in the baseline study of Rangpur (Pronk, et al. 2017c). There were no differences between SMS-receiving farmers and non-SMS-receiving farmers.

The average number of applications per farmer with products containing curative active ingredients was 1.4, which was much lower than in Munshiganj in the 2016/17 season and the baseline study of Rangpur where on average respectively 3.9 and 4.3 curative applications were applied. The share of metalaxyl in these curative applications was 19%, much lower than in Munshiganj in the 2016/17 season where it was 64% and in Rangpur where it was 56%.

This shows that farmers reduced the number of curative applications although the number of products that contained metalaxyl remained the same. This is a major benefit for farmers as metalaxyl has lost its effect on the resistant late blight strain Blue 13.

T*able 3.36* Products with curative active ingredients (Products, #) or Metalaxyl (#) and applications with products with curative active ingredients or Metalaxyl of the baseline survey and the evaluation of non-SMS-receiving (No) and SMS-receiving (Yes) farmers in Munshiganj and Rangpur.

		Products	Metalaxyl		Curative applications	Metalaxyl	
District	SMS	#	#	%	#	#	%
Munshiganj	No	31	24	77	1.2	0.3	23
	Yes	24	18	75	1.1	0.4	40
	All	38	30	79	1.2	0.4	30
Rangpur	No	42	32	76	1.5	0.2	12
	Yes	42	32	76	1.5	0.3	18
	All	55	43	78	1.5	0.2	15
All data	No	56	43	77	1.2	0.4	30
	Yes	50	40	80	1.5	0.2	15
	All	65	52	80	1.4	0.3	19

3.4. Customized SMS service of Bayer in Mithapukur

3.4.1. Interviewed farmers

In total, nine SMS alerts have been send to the 200 farmers and subsequently nine calls were made to the group of 60 farmers of the Regular group and 60 farmers each round randomly selected from the remaining 140 farmers, called Random group. It was noticed that farmers of the Regular group became a bit tired being called each time a SMS was send.

3.4.2. General characteristics of interviewed farmers

Farmers of the Regular group had twice as much available area and seven times larger potato area than farmers of the Random group (T*able 3.37*), suggesting that farmers of the Regular group were larger potato farmers than farmers of the Random group.

T*able 3.37* The area available for and planted with potato and the number of farmers answering this question (#) of the regular and random farmer group.

	Area available		Area planted	
Farmer group	Ha	#	ha	#
Regular	1.692	60	3.711	60
Random	0.865	140	0.593	60

Additionally, farmers of the Regular group cultivated predominantly the variety Granola, which is a high yielding ware potato variety, and farmers of the Random group mainly cultivated Deshi Sada, a local, low yielding variety.

T*able 3.38* The area available for and planted with potato and the number of farmers answering this question (#) of the regular and random farmer group.

Farmer Group	Potato variety	#
Regular (60)	Asterix	2
	Cardinal	3
	Diamant	11
	Granola	39
	Granola, Sheel Bilatee	1
	Sheel Bilatee	4
Random (140)	Deshi Sada	127
	Granola	2
	Sheel Bilatee	11

Farmers were asked what type of products they were accustomed to use, a non-mandatory question. About 33 and 50% of the farmers of the Regular and Random farmer group respectively did not answer this question (T*able 3.39*). Furthermore, most farmers used preventive fungicides first and secondly again preventive fungicides. In addition, products were mentioned that have no effect on late blight.

T*able 3.39* Efficacy of products (#) previously used by Regular and Random farmer groups.

		Product		
Farmer Group	Efficacy	First	Second	Third
Regular	no answer	21	45	56
	Preventive	26	6	0
	Preventive + curative	4	3	2
	Preventive + curative resistance	2	1	0
	Preventive + slightly curative	0	3	1
	Curative resistance	0	0	0
	No late blight	7	2	1
Random	no answer	31	42	53
	Preventive	20	10	1
	Preventive + curative	2	2	1
	Preventive + curative resistance	1	1	0
	Preventive + slightly curative	0	1	2
	Curative resistance	2	2	0
	No late blight	4	2	3

More than 60% of the farmers with no differences between the farmers groups, indicated to have ever used advised branded fungicides (T*able 3.40*).

T*able 3.40* Advised Branded fungicides used by Regular and Random farmer groups.

Farmer Group	Advised Branded fungicides	%
Regular	Yes	65
	No	22
	no answer	13
Random	Yes	64
	No	19
	no answer	17

3.4.3. Service evaluation

The majority of the farmers received the SMS, on average 57 and 54 out of 60 farmers for the regular and random farmer group, respectively (*Table 3.41*).

Table 3.41 Times (#) answers were given by farmers of the Regular and Random farmer groups on the question asked after each SMS was sent: did you receive the SMS?

	Regular				Random			
SMS	No	Yes	Not seen	Not interested/ ignored	No	Yes	Not seen	Not interested/ ignored
1	3	56	0	1	4	54	0	2
2	3	55	2	0	5	51	1	3
3	0	59	0	1	7	53	0	0
4	3	55	2	0	6	52	1	1
5	1	58	0	1	4	52	1	3
6	0	59	0	1	0	59	1	0
7	3	55	2	0	5	51	1	3
8	1	58	0	1	3	55	1	1
9	0	59	0	1	3	51	2	4
Total	14	514	6	6	37	478	8	17

T*able 3.42* shows that farmers did understand the message and that there were no differences between groups. On average about 10% of the sent SMS were not understood by farmers.

T*able 3.42* Times (#) answers were given by farmers of the Regular and Random farmer groups on the question asked after each SMS was sent: did you understand the SMS?

	Regular		Random	
SMS	No	Yes	No	Yes
1	11	46	11	45
2	10	47	4	46
3	4	55	10	45
4	10	47	5	47
5	3	56	3	50
6	4	55	3	56
7	10	47	4	44
8	3	56	4	50
9	4	55	6	45
Total	59	464	50	428

The majority of farmers said to spray at the advised moment (T*able 3.43*) and this did not change over time. Twenty-two and 15% of the farmers for respectively the Regular and Random group did not use the product advised in the SMS. There was no change over time for either of these answers.

T*able 3.43* Times (#) answers were given by farmers of the Regular and Random farmer groups on the question asked after each SMS was sent: did you spray at the advised moment/ with the product advised in the SMS?

	At the advised moment				With the product advised in the SMS			
	Regular		Random		Regular		Random	
SMS	No	Yes	No	Yes	No	Yes	No	Yes
1	7	43	17	35	4	41	10	33
2	8	44	9	39	14	39	6	39
3	11	47	4	45	9	43	4	43
4	8	44	11	39	14	39	7	39
5	5	53	3	48	12	46	6	44
6	11	47	10	50	9	43	13	43
7	8	44	5	45	22	31	3	43
8	5	53	10	42	12	46	10	39
9	11	47	6	41	9	43	5	39
Total	74	422	75	384	105	371	64	362

Farmers did not take the SMS alert seriously in about half of the 149 times that farmers said not to have sprayed at the advised moments (T*able 3.44*), followed by not trusting the service or having sprayed before the alert already. These answers were evenly distributed over the number of SMS's so farmers did not get more serious on the alerts or more trust in the service during the potato-cultivating period.

T*able 3.44* Reasons why and times mentioned by farmers 'not to spray at the advised moment'.

Answer	Regular	Random	Total
I did not take it seriously	33	41	74
Because I do not trust the service	18	0	18
Spray before SMS	0	15	15
My potato field is good condition/not infested	0	7	7
Field already infected	2	3	5
Other	22	13	35
Total	73	76	149

About one third of the farmers that said not to spray with the advised product in the SMS did find the price of the advised product relatively to high (T*able 3.45*). Most interesting is also the answer that the quality of the advised product is not available and of low quality. The unavailability of the advised product was analysed per village. Melody Duo was not available according to farmers in 17; Secure not in eight and Dithane not in six out of the 20 villages.

T*able 3.45* Reasons why and times mentioned by farmers 'not sprayed with the product advised in the SMS'.

Answers	Regular	Random	Total
Price of advised product is relatively high	32	19	51
Advised product not available	28	8	36
Do not take it seriously	3	9	12
Used another fungicide or Melody duo or Monostar	2	7	9
Quality of the advised product is low	8	0	8
Not interested using this product/ignored the message	6	1	7
Other	12	8	20
Total	91	52	143

4. Discussion and conclusions

4.1. Late blight control demonstrations

As in in the 2016/17 season (Pronk, et al. 2017b), performance of late blight demonstrations and comparison of the spraying strategy with farmer's strategy was challenging for multiple reasons. Therefore, results of the demo fields should be interpreted and used with care.

The DSS alerts indicated when to apply the fungicide and which fungicide to apply for both DSS treatments. Understandably, demo managers applied fungicides to all treatments in various cases, including the farmer's practice. On average, the timing between farmer's practice and both DSS treatments was different (Table 2.2). However, the detailed spray schemes of the different demo sites shows that the spray timing was in many cases at the same day, for example, in most demonstrations of Munshiganj. Most demonstration sites in Rangpur showed a larger difference in the timing between farmer's practice and DSS treatments (Annex III). Both in Munshiganj and in Rangpur, the first spray was applied on average earlier in farmer's practice than in both DSS treatments. In addition, the total number of sprays in farmer's practice was often higher than in the DSS treatments in Rangpur. Remarkable and unexplained is that the timing of both DSS treatments at the same demonstration sites also differed in various cases (Annex III). Similarly, the DSS treatments received unintentionally one spray less than the DSS$^+$ treatments in some cases. The small difference in the application time of all treatments in the Munshiganj demonstrations may explain the small yield difference between on the one hand farmer's practice and on the hand the two DSS treatments. A disturbing factor in Munshiganj was the flooding of some demonstration fields early in the season due to unexpected rainfall. Therefore, two demonstration sites in Munshiganj were replanted but we do not know whether and how severely (parts of) other demonstration sites have been affected by the flooding. Especially the results of Shreenagar-2 are suspicious in this respect because of the extreme yield difference between farmer's practice and both DSS treatments, and the fact that the demonstration at Shreenagar-1 was replanted because of flood damage.

Both DSS treatments differed in the used fungicides types, DSS$^+$ comprised relatively new and mostly more expensive fungicides while DSS was based on commonly used fungicides by farmers in Bangladesh. For both treatments, a well-defined sequence of fungicide types was proposed (paragraph 2.1.1). However, this prescribed sequence was not always followed up correctly (Annex II). In some cases, the curative fungicides were used before preventive fungicides were applied, for example, in Pirgaccha 2 (Annex II).

A disturbing factor in the interpretation of the demonstrations carried out in 2016/17 was the much higher nitrogen application in farmer's practice treatment than in both DSS treatments. The higher nitrogen application in the farmer's treatment could have delayed tuber bulking and thus reduced potato yield (Pronk, et al. 2017b). In the late blight demonstrations of 2017/18 nitrogen application among the three treatments differed about 10%, except in Shreenagar 1 and 2 (Munshiganj) where Farmer's practice received up to 30% more nitrogen (Annex I).

4.2. Late blight control service: farmer survey

The survey results characterizing the non-SMS-receiving and SMS-receiving farmers indicated some differences in both Munshiganj and Rangpur. On average, SMS-receiving farmers had significantly larger land sizes than non-SMS-receiving farmers (par. 3.2.2 & *Table 3.5*). In addition, SMS-receiving farmers were better off based on the ownership of smartphones, which was also significantly higher in this group (Table 3.7). This can be a result of the inherent biased selection procedure of SMS-receiving farmers: Mobile ownership is the decisive factor for service subscription. Poor farmers that do not have a mobile phone cannot subscribe to the GEOPOTATO service. Hence, this wealth bias in SMS-receiving and non-SMS-receiving farmers as coming to the fore in land size and smartphone ownership should be born in mind while analysing and using the evaluation data.

In general, yield differences between Munshiganj and Rangpur were small in the 2017/18 season, because yields in Munshiganj (25.2 t/ha) lacked behind the long-term average yield (about 31 t/ha in the baseline, see Pronk et al, 2017a). Probably, the unexpected extreme rainfall event mid-December, resulting in flooding of various parts of Munshiganj, reduced yield levels in Munshiganj. Based on the opinion of both the SMS-receiving farmers and non-SMS-receiving farmers, late blight pressure in the 2017/18 season was higher in Rangpur than in Munshiganj. In both districts, yields of SMS-receiving farmers were significantly higher than the yields of non-SMS-receiving farmers. Despite the lower perceived late blight pressure the yield difference was larger in Munshiganj than in Rangpur, 1.4 t/ha *vs.* 0.3 t/ha, respectively. Within the group of SMS-receiving farmers yield differences between farmers that acted upon the SMS were on average 1.9 t/ha higher than farmers that did not act upon the SMS. In Rangpur, the difference was even 3.7 t/ha, which may be associated with the higher late blight pressure compared to Munshiganj: Farmers that sprayed according the SMS alerts were better able to control late blight and thus achieving better yields. Remarkable difference between Munshiganj and Rangpur is the high use of urea in Munshiganj, on average twice as much as in Rangpur and with little difference between SMS-receiving farmers and non-SMS receiving farmers in both districts.

In both districts, farmers said to apply the first fungicide spray to control late blight after observing the first disease symptoms (Table 3.19). Most farmers, 86 and 65% in Munshiganj and Rangpur respectively (Table 3.20), used a preventive fungicide for this first application, which has no curative effects. This may suggest that the first alert was send to late, that is after late blight was already in the area, but also that farmers have mixed recollection on first notice of the disease and first application date or that disease symptoms are misinterpreted, e.g. other symptoms than late blight are seen. Hence, disease management can be improved when farmers have a proper understanding of the disease symptoms as well as the working mechanism of preventive fungicides, such as mancozeb.

As reported in the first evaluation of the service in Munshiganj, the majority of the farmers shares the content of the SMS with other farmers. In the evaluation of the 2017/18 the messages were shared with on average 10 other farmers. We do not know whether these indirect beneficiaries of the service of the SMS indeed have used the information, but this is a potential confounding factor in the survey data analysis as the non-SMS-receiving farmers may have adopted the GEOPOTATO advised spray strategy.

In Munshiganj, satisfaction of farmers with the service provision was somewhat lower than in evaluation of the first season, 84 (Table 3.28) *vs*. 94% (Pronk, et al. 2017b). The reason for the lower satisfaction remains unclear, as the majority of the surveyed people that was not satisfied did not give a reason. Maybe the low late blight pressure in Munshiganj played a role, i.e. the urgency for a

decision support service was felt less this season. In contrast, in Rangpur, late blight pressure was higher and the percentage of farmers satisfied with the service was high, 92%.

4.3. Outcome indicators evaluation

4.3.1. Late blight control demonstrations

The results of the outcome indicators of the late blight control remonstrations are presented in Table 4.1. This table shows that yields in Munshiganj in 2017/18 were low compared to 2016/17 and Rangpur 2017/18. Other reasons than late blight control contributed to these low yields (par. 3.1.2).

Table 4.1 Outcome indicators of the demonstrations in Munshiganj and Rangpur.

			Munshiganj		Rangpur
Indicator	Unit	Service	2016/17	2017/18	2017/18
Yield	t/ha	DSS+	46	29.9	37.2
		DSS	44	29.1	32.2
		FP	48	32.0	28.2
N-fertiliser use	kg N/t product	DSS+	2.5	5.1	3.9
		DSS	6.9	5.2	4.4
		FP	2.5	4.9	5.1
Fungicide use	kg product/ha	DSS+	7.7	13.2	14.3
		DSS	16.0	8.3	8.6
		FP	16.8	14.5	15.1
	kg AI/ha	DSS+	3.9	9.2	9.9
		DSS	12.5	4.7	5.0
		FP	12.8	10.7	10.7
Costs fungicide applications	BDT/ha	DSS+	13,658	12,712	14,040
		DSS	9,941	13,306	12,797
		FP	8,445	13,636	12,265
	BDT/t product	DSS+	285	442	383
		DSS	214	471	405
		FP	191	431	443
Curative products with Metalaxyl	%	DSS+	0	0	0
		DSS	0	0	0
		FP	100	25	25
Curative applications with Metalaxyl	%	DSS+	0	0	0
		DSS	0	0	0
		FP	100	29	45

4.3.2. Late blight control service: farmer survey

Table 4.2 shows the outcome indicators of the farmer surveys over time.
Yields did not improve in the potato season 2017/18 compared to the baseline, due to flooding in Munshiganj and unfavourable growing conditions and heavy rains in Rangpur. Yields of SMS-receiving

farmers decreased less compared to the baseline surveys than the yields of non-SMS-receiving farmers and this was certainly true for SMS-receiving farmers that followed the advice, compare yields of Table 3.16 with yields of the baseline surveys.

Table 4.2 Outcome indicators of the baseline surveys and the evaluation surveys in Munshiganj and Rangpur.

				Baseline survey		Evaluation 16/17	Evaluation 17/18	
Category	Indicator	Unit	SMS	Munshiganj 15/16	Rangpur 16/17	Munshiganj	Munshiganj	Rangpur
Improvement in sustainable food production	Yield	t/ha	No	31	25	30	25	23
			Yes	-	-	30	26	24
Improvement in efficiency	N- fertiliser use	kg N/t product	No	8.9	7.5	9.6	14.5	7.1
			Yes	-	-	9.0	13.8	7.2
	Fungicide use	kg product /ha	No	7.7	11.3	7.6	8.0	8.5
			Yes	-	-	7.4	8.2	8.6
		kg AI/ha	No	5.7	6.8	5.0	5.2	5.5
			Yes	-	-	4.9	5.3	5.7
Improvement in income	Costs fungicide applications	BDT/ha	No	6,960	14,193	9,954	9,575	12,033
			Yes	-	-	10,224	9,655	12,185
		BDT/t product	No	225	596	348	390	572
			Yes	-	-	355	398	591
Other outcome	Curative Metalaxyl products	%	No	50	78	66	77	76
			Yes	-	-	74	75	76
	Curative Metalaxyl applications	%	No	78	58	58	23	12
			Yes	-	-	74	40	18

The N-fertiliser use efficiency of Munshiganj has worsened compared to the baseline and the evaluation survey. This is directly related to the low yields and is likely to improve when yields increase to their regular levels. In Rangpur, there is a small improvement in N-fertiliser use efficiency of 7.1 and 7.2 kg N/t product compared to the baseline of 7.5 kg N/t.

Cost per ha as well as per t product did not improve. In Munshiganj costs per ha increased compared to the baseline but stabilized compared to the evaluation survey 2016/17. Again, due to the low yields the costs per t product did also increase in this survey. In Rangpur, costs per ha were lower in this survey than in the baseline but costs per t product were comparable and hardly improved.

The percentage of products with metalaxyl as curative active ingredients used by farmers did not change over time but the percentage of applications with Metalaxyl as curative component did, in Munshiganj from 78% in the baseline to inly 23 and 40% and in Rangpur from 74% in the baseline to 12 and 18% in this survey. This is a large improvement and contributes to an improved efficacy of late blight fungicides.

4.4. Customized SMS service in Mithapukur

The differences between the two farmer groups, Regular and Random on the response of the customized service were small although the groups had different characteristics. The Regular group had larger fields with potatoes and cultivated high yielding potato varieties. These farmers may be characterized as more advanced and/or having more money to buy inputs such as seeds. The Random group had smaller fields and cultivated local and low yielding varieties, although those are preferred by local families for their taste and may yield better prices. However, with respect to a customized SMS alert service for late blight control, the response between the two groups was small, that is little difference on 'spray at the advised moment' and 'use product advised in SMS'.

There are some messages from the evaluation to improve a customized service. First, the product advised in the SMS must be available; otherwise, farmers are not able to use the product. Second, it is most important that the Agro Shop is also part of the service and is able to facilitate the farmers. That is with the availability of the advised product but also with supporting information to mitigate the distrust that farmers still have, considering the answer 'did not trust the service'.

4.5. Highlights summarized

4.5.1. Late blight demonstrations

With respect to the late blight demonstrations, it is concluded that:

- It is difficult to realise a demonstration, which compares a DSS for late blight control with a control according to farmers' practice.
- The demonstrations included a number of factors that contributed to the yield differences. This makes it particularly difficult to relate yield differences to treatments.
- The treatments in Munshiganj suffered from unexpected flooding and heavy rainfall. Some plots were partly replanted with reduced yields consequently.
- Fungicide costs per t product for DSS^{+} in Rangpur were lower compared to FP and DSS and thus the income was improved.

4.5.2. The late blight alert service for farmers

Based on the survey results it is concluded that:

- Interviewed farmers in Munshiganj cultivate more land with potatoes compared to Rangpur and SMS-receiving farmers in Munshiganj cultivate more land with potatoes compared to the non-SMS receiving farmers. No difference in land cultivated with potato was found between non-SMS and SMS-receiving farmers in Rangpur.
- According to farmers in Munshiganj, late blight pressure was low (65%) and medium (34%) and in Rangpur low (50%), medium (31%) and high (19%) in the potato season 2017-2018.
- Possibly related to the low late blight pressure in Munshiganj, yield benefit of SMS-receiving farmers was, although significant, modest compared to the control group. In Rangpur, yield benefits were larger.

- Yield benefit for SMS-receiving farmers who followed the advice was 1.3 and 3.7 t/ha in Munshiganj and Rangpur respectively.
- Nearly all SMS receiving farmers, 84 and 92% in Munshiganj and Rangpur respectively, were satisfied with the SMS-alert service.
- The SMS-alert service was 'good and helpful' according to more than 65% of the SMS receiving farmers.
- In Munshiganj 29% and in Rangpur 88% of the SMS receiving farmers is willing to pay for the service.
- On average, 78% of the SMS receiving farmers shared the SMS information with 11 other farmers.
- About 8 and 29% of the non-SMS-receiving farmers in Munshiganj and Rangpur respectively, heard about the service and 92 and 72% of these farmers would like to receive the service. The willingness to pay for the service was 9% in Munshiganj and 79% on Rangpur.
- The cost for late blight control in Munshiganj were lower than in Rangpur but no differences were found for non-SMS and SMS-receiving farmers.

4.5.3. Outcome indicators

With respect to the outcome indicators, it is concluded that:

- Crop yield was lower in Munshiganj and did not change in Rangpur compared to the baseline survey.
- SMS-receiving farmers in both districts following the advice had higher yields than farmers who did not follow the advice.
- N-fertiliser use efficiency in Munshiganj was much higher than in the baseline and evaluation survey, due to the low yields. N-fertiliser use efficiency in Rangpur did not change compared to the baseline survey.
- In Munshiganj, the fungicide use efficiency in terms of kg product per hectare and A.I. per hectare of the participating farmers as well as the farmers in the control group varied in time with no clear direction in improvement or worsening. In Rangpur, the fungicide use efficiency in terms of kg product per hectare and A.I. per hectare of the participating farmers as well as the farmers in the control group improved compared to the baseline survey.
- The percentage of curative products used with metalaxyl did not differ between districts of non-SMS and SMS-receiving farmers and did not change compared to the baseline survey.
- The percentage of curative applications with metalaxyl decreased in both districts compared to the baseline survey.

References

Hossain M., T. Dey, M. Iqbal Hossain, S. Begum and M. Kadian, 2008. Research experience on potato late blight disease management in bangladesh. *In* III International Late Blight Conference 834, 2008. pp. 175-186.

Pronk A.A., N. Islam, H. Ahsan, M.M. Rahman, G.J.T. Kessel and H. Hengsdijk, 2017a. Baseline study GEOPOTATO, Wageningen University and Research Centre, Wageningen, 59 pp.

Pronk A.A., H. Ahsan, M.M. Rahman, G. Kessel and H. Hengsdijk, 2017b. Geo data for late blight control in potato : evaluation of decision support service in Bangladesh, 2016-2017.

Pronk A., G. Kessel, H. Ahsan, M.M. Rahman, S. Abdulla Hil, N. Islam, J.-M. Michielsen and H. Hengsdijk, 2017c. Baseline study Rangpur GEOPOTATO. Wageningen University & Research, Wageningen.

FRG, 2012. Fertilizer Recommendation Guide. Bangladesh Agricultural Research Council (BARC), Farmgate, Dhaka 1215. 274 p.

Rabbani M.G., M.A. Siddique, M.M. Islam and M.S. Islam, 2010. The potato sector in Bangladesh: its challenges and opportunities. Katalyst, Dhaka, Bangladesh. 144 p.

Annex I Details of the demonstration plots in each sub-district

Munshiganj - Treatment Farmer Practice (FP)

	Unit	Gozaria	Louhazang	Munshiganj Sadar	Sreenagar-1	Sreenagar-2	Sirajdikhan	Tungibari
Planting date	date	03-12-17	02-12-17	02-12-17	05-12-17	13/12/17	02-12-17	02-12-17
Seed planted	kg/ha		2000	2000	2125	2000	2000	2000
Tubers planted	#/ha		111105	111105	1111105	111105	111105	111105
Organic fertiliser	date				03-12-17			
Amount	Kg/ha				466			
Basel dressing	date	31/11/17	30/11/17	30/11/17	03-12-17	11-12-17	30/11/17	30/11/17
N-applied	kg/ha	77	92	92	130	122	77	92
P2O5-applied	kg/ha	233	217	217	200	233	233	233
K2O-applied	kg/ha	180	160	160	240	160	180	180
Costs MOP	BDT/ha							
Gypsum	kg/ha	133	100	100	100	100	133	100
Boron	kg/ha	23	22	22	17	22	22	22
Side dressing	date	25/12/17	25/12/17	27/12/17	08-01-18	20/2/18	26/1/18	07-02-18
N-applied	kg/ha	61	61	61	54	61	61	61
Harvesting date		12-03-18	07-03-18	10-03-18	10-03-18	15/3/18	09-03-18	07-03-18
Growing period	days	99	95	98	95	92	97	95

Munshiganj - Treatment DSS

	Unit	Gozaria	Louhazang	Munshiganj Sadar	Sreenagar-1	Sreenagar-2	Sirajdikhan	Tungibari
Planting date	Date	3/12/2017	2/12/2017	2/12/2017	5/12/2017	13/12/17	2/12/2017	2/12/2017
Seed planted	kg/ha		2000	2000	2125	2000	2000	2000
Tubers planted	#/ha		111,105	111,105	1,111,105	111,105	111,105	111,105
Organic fertiliser	date				3/12/2017			
Amount	Kg/ha				466			
Basel dressing	Date	31/11/17	30/11/17	30/11/17	3/12/2017	11/12/2017	30/11/17	30/11/17
N-applied	kg/ha	92	92	92	100	92	77	92
P2O5-applied	kg/ha	217	217	217	200	217	217	217
K2O-applied	kg/ha	170	160	160	180	180	160	180
Gypsum	kg/ha	133	100	100	100	100	100	100
Boron	kg/ha	22	22	22	22	22	22	22
Side dressing	Date	25/12/17	25/12/17	27/12/17	8/1/2018	20/2/18	26/1/18	7/2/2018
N-applied	kg/ha	54	61	61	38	61	69	61
Harvesting date		12/3/2018	7/3/2018	10/3/2018	10/3/2018	15/3/18	9/3/2018	7/3/2018
Growing period	Days	99	95	98	95	92	97	95

Munshiganj - Treatment DSS+

	Unit	Gozaria	Louhazang	Munshiganj Sadar	Sreenagar-1	Sreenagar-2	Sirajdikhan	Tungibari
Planting date	date	3/12/2017	2/12/2017	2/12/2017	5/12/2017	13/12/17	2/12/2017	2/12/2017
Seed planted	kg/ha		2000	2000	2125	2000	2000	2000
Tubers planted	#/ha		111,105	111,105	1,111,105	111,105	111,105	111,105
Organic fertiliser	date				3/12/2017			
Amount	Kg/ha				466			
Basel dressing	date	31/11/17	30/11/17	30/11/17	3/12/2017	11/12/2017	30/11/17	30/11/17
N-applied	kg/ha	92	92	92	100	92	77	92
P2O5-applied	kg/ha	217	217	217	200	217	217	217
K2O-applied	kg/ha	170	160	160	170	180	160	180
Gypsum	kg/ha	133	100	100	100	100	100	100
Boron	kg/ha	22	22	22	22	22	22	22
Side dressing	date	25/12/17	25/12/17	27/12/17	8/1/2018	20/2/18	26/1/18	7/2/2018
N-applied	kg/ha	54	61	61	37	61	69	61
Harvesting date		12/3/2018	7/3/2018	10/3/2018	10/3/2018	15/3/18	9/3/2018	7/3/2018
Growing period	days	99	95	98	95	92	97	95

Rangpur - Treatment Farmer Practice (FP)

	Unit	Sadar	Kaunia	Badarganj	Pirgachha-1	Pirgachha-2	Pirgonj-1	Pirgonj-2
Planting date	date	05/12/17	02/12/17	02/12/17	02/12/17	06/12/17	08/12/17	05/12/17
Seed planted	kg/ha	2000	2000	2000	2000	2000	2000	2000
Tubers planted	#/ha	111105	111105	111105	111105	111105	111105	111105
Organic fertiliser	date	03/12/17	01/12/17	30/11/17	30/11/17	04/12/17	05/12/17	03/12/17
Amount	kg/ha	433	467	467	467	467	433	433
Basel dressing	date	03/12/17	01/12/17	30/11/17	30/11/17	04/12/17	05/12/17	03/12/17
N-applied	kg/ha	77	61	92	92	77	77	77
P2O5-applied	kg/ha	233	233	233	233	233	233	233
K2O-applied	kg/ha		100	170	170	160	160	160
Gypsum	kg/ha	100	100	133	133	100	117	133
Zinc	kg/ha							
Boron	kg/ha	17	17	17	17	17	17	17
Side dressing	date	20/1/18	25/1/18	07/01/18	07/01/18	24/1/18	05/01/18	20/1/18
N-applied	kg/ha	61	77	54	54	61	61	61
Harvesting date		43284	43223	43254	43254	43254	43315	43223
Growing period	days	94	94	94	94	90	90	90

	Unit	Gangachara-1	Gangachara-2	Taragonj-1	Taragonj-2	Taraganj-3	Metro-1	Metro-2
Planting date	date	05/12/17	06/12/17	07/12/17	04/12/17	05/12/17	03/12/17	03/12/17
Seed planted	kg/ha	2000	2000	2000	2000	2000	2000	2000
Tubers planted	#/ha	111,105	111,105	111,105	111,105	111,105	111,105	111,105
Organic fertiliser	date	30/11/17	01/12/17	05/12/17	30/11/17	02/12/17	02/12/17	30/11/17
Amount	kg/ha	500	466	433	433	433	433	433
Basel dressing	date	30/11/17	01/12/17	05/12/17	30/11/17	02/12/17	02/12/17	30/11/17
N-applied	kg/ha	69	77	77	77	77	77	77
P2O5-applied	kg/ha	217	233	233	233	233	233	233
K2O-applied	kg/ha	160	170	160	140	160	160	160
Gypsum	kg/ha	117	133	133	100	133	100	100
Zinc	kg/ha							
Boron	kg/ha	17	17	17	17	17	17	17
Side dressing	date	05/12/17	3/1/2018	10/01/18	24/1/18	22/1/18	20/1/18	27/12/17
N-applied	kg/ha	69	77	61	61	61	61	61
Harvesting date		10/03/18	12/03/18	5/3/2018	7/3/2018	15/3/18	9/3/2018	5/3/2018
Growing period	days	95	96	88	93	100	96	92

Rangpur - Treatment DSS

	Unit	Sadar	Kaunia	Badarganj	Pirgachha-1	Pirgachha-2	Pirgonj-1	Pirgonj-2
Planting date	date	05/12/2017	01/12/2017	02/12/2017	02/12/2017	06/12/2017	08/12/2017	05/12/2017
Seed planted	kg/ha	2000	2000	2000	2000	2000	2000	2000
Tubers planted	#/ha	111,105	111,105	111,105	111,105	111,105	111,105	111,105
Organic fertiliser	date	3/12/2017	1/12/2017	30/11/17	30/11/17	2/12/2017	5/12/2017	3/12/2017
Amount	kg/ha	467	400	433	433	400	466	466
Basel dressing	date	3/12/2017	1/12/2017	30/11/17	30/11/17	2/12/2017	5/12/2017	3/12/2017
N-applied	kg/ha	92	77	92	92	77	77	92
P2O5-applied	kg/ha	233	217	217	217	200	184	233
K2O-applied	kg/ha	160	160	170	120	180	170	160
Gypsum	kg/ha	117	117	117	100	117	100	117
Zinc	kg/ha							
Boron	kg/ha	17	17	17	17	17	17	17
Side dressing	date	20/1/18	25/1/18	7/1/2018	7/1/2018	24/1/18	5/1/2018	20/1/18
N-applied	kg/ha	46	77	46	69	77	69	46
Harvesting date		7/3/2018	5/3/2018	6/3/2018	6/3/2018	6/3/2018	8/3/2018	5/3/2018
Growing period	days	94	94	94	94	90	90	90

	Unit	Gangachara-1	Gangachara-2	Taragonj-1	Taragonj-2	Taraganj-3	Metro-1	Metro-2
Planting date	date	05/12/17	06/12/17	07/12/17	04/12/17	05/12/17	03/12/17	03/12/17
Seed planted	kg/ha	2000	2000	2000	2000	2000	2000	2000
Tubers planted	#/ha	111,105	111,105	111,105	111,105	111,105	111,105	111,105
Organic fertiliser	date	30/11/17	30/11/17	30/11/17	03/12/17	02/12/17	02/12/17	30/11/17
Amount	kg/ha	400	433	433	466	433	400	400
Basel dressing	date	30/11/17	30/11/17	30/11/17	03/12/17	02/12/17	02/12/17	30/11/17
N-applied	kg/ha	69	92	92	92	92	77	92
P2O5-applied	kg/ha	217	217	200	200	233	200	200
K2O-applied	kg/ha	180	160	180	120	160	180	180
Gypsum	kg/ha	117	100	117	133	117	117	117
Zinc	kg/ha							
Boron	kg/ha	17	17	17	17	17	17	17
Side dressing	date	05/12/17	7/1/2018	10/01/18	20/1/18	22/1/18	24/1/18	27/12/17
N-applied	kg/ha	69	54	46	46	46	77	46
Harvesting date		10/03/18	12/03/18	5/3/2018	7/3/2018	15/3/18	9/3/2018	5/3/2018
Growing period	days	95	96	88	93	100	96	92

Rangpur - Treatment DSS+

	Unit	Sadar	Kaunia	Badarganj	Pirgachha-1	Pirgachha-2	Pirgonj-1	Pirgonj-2
Planting date	date	5/12/2017	1/12/2017	2/12/2017	2/12/2017	6/12/2017	8/12/2017	5/12/2017
Seed planted	kg/ha	2000	2000	2000	2000	2000	2000	2000
Tubers planted	#/ha	111,105	111,105	111,105	111,105	111,105	111,105	111,105
Organic fertiliser	date	3/12/2017	1/12/2017	30/11/17	30/11/17	4/12/2017	5/12/2017	03/12/2017
Amount	kg/ha	433	433	433	433	467	433	433
Basel dressing	date	3/12/2017	1/12/2017	30/11/17	30/11/17	4/12/2017	5/12/2017	3/12/2017
N-applied	kg/ha	92	61	92	92	77	77	92
P2O5-applied	kg/ha	200	233	217	217	233	217	200
K2O-applied	kg/ha	180	160	160	170	160	170	180
Gypsum	kg/ha	117	117	100	100	117	117	117
Zinc	kg/ha							
Boron	Kg/ha	17	17	17	17	17	17	17
Side dressing	date	20/1/18	25/1/18	7/1/2018	7/1/2018	24/1/18	5/1/2018	20/1/18
N-applied	kg/ha	46	77	54	54	61	69	46
Harvesting date		7/3/2018	5/3/2018	6/3/2018	6/3/2018	6/3/2018	8/3/2018	5/3/2018
Growing period	days	94	94	94	94	90	90	90

	Unit	Gangachara-1	Gangachara-2	Taragonj-1	Taragonj-2	Taraganj-3	Metro-1	Metro-2
Planting date	date	05/12/17	06/12/17	07/12/17	04/12/17	05/12/17	03/12/17	02/12/17
Seed planted	kg/ha	2000	2000	2000	2000	2000	2000	2000
Tubers planted	#/ha	111,105	111,105	111,105	111,105	111,105	111,105	111,105
Organic fertiliser	date	30/11/17	30/11/17	05/12/17	30/11/17	02/12/17	02/12/17	30/11/17
Amount	kg/ha	433	433	466	433	466	466	466
Basel dressing	date	30/11/17	30/11/17	05/12/17	30/11/17	02/12/17	02/12/17	30/11/17
N-applied	kg/ha	69	92	92	77	92	77	92
P2O5-applied	kg/ha	217	217	233	233	200	233	200
K2O-applied	kg/ha	160	170	160	240	180	160	160
Gypsum	kg/ha	117	117	117	117	117	117	117
Zinc	kg/ha							
Boron	kg/ha	17	17	17	17	17	17	17
Side dressing	date	05/12/17	7/1/2018	10/01/18	24/1/18	22/1/18	20/1/18	27/12/17
N-applied	kg/ha	77	46	61	61	46	61	61
Harvesting date		10/03/18	12/03/18	5/3/2018	7/3/2018	15/3/18	9/3/2018	5/3/2018
Growing period	days	95	96	88	93	100	96	92

Annex II Fungicides used in the different treatments of the field demonstrations on the late blight control service

Munshiganj

Sub-district	Treat-ment	Spray number							
		1	2	3	4	5	6	7	8
Gozaria	DSS+	Antracol	Dithane	Antracol	Secure	Secure	Secure		
	DSS	Revus	Melody Duo	Revus	Melody Duo	Melody Duo	Melody Duo		
	FP	Nuben	Nuben	Nuben	Nuben	Nuben	Nuben	Secure	Secure
Louhojong	DSS+	Antracol	Dithane	Dithane	Secure	Secure	Secure	Secure	Secure
	DSS	Revus	Melody Duo	Revus	Revus	Melody Duo	Revus	Melody Duo	Revus
	FP	Indofil	Indofil	Indofil	Indofil	Indofil	Indofil	Micra	Micra
Munshiganj Sadar	DSS+	Dithane	Dithane	Antracol	Antracol	Secure			
	DSS	Revus	Melody Duo	Revus	Melody Duo	Revus	Melody Duo		
	FP	Indofil	Indofil	Micra	Micra	Secure	Secure		
Serajdikhan	DSS+	Antracol	Dithane	Antracol	Dithane	Secure	Secure	Secure	
	DSS	Melody Duo	Melody Duo	Revus	Melody Duo	Revus	Melody Duo	Revus	
	FP	Golden	Golden	Micra	Micra	Secure	Folimin	Folimin	
Sreenagar 1	DSS+	Antracol	Antracol	Dithane	Dithane	Secure	Secure		
	DSS	Revus	Revus	Melody Duo	Melody Duo	Revus	Melody Duo		
	FP	Indofil	Indofil	Dithane	Dithane	Micra	Micra		
Sreenagar 2	DSS+	Antracol	Dithane	Antracol	Dithane	Secure			
	DSS	Revus	Melody Duo	Revus	Melody Duo	Revus			
	FP	Indofil	Indofil	Indofil	Micra	Micra	Nemispore		
Tungibari	DSS+	Dithane	Dithane	Antracol	Antracol	Secure	Secure		
	DSS	Revus	Melody Duo	Revus	Melody Duo	Revus	Melody Duo		
	FP	Indofil	Indofil	Micra	Micra	Secure	Secure		

Rangpur

Sub-district	Treat-ment	Spray number								
		1	2	3	4	5	6	7	8	9
Badarganj	DSS+	Antracol	Antracol	Dithane	Dithane	Secure	Secure	Secure		
	DSS	Revus	Revus	Melody Duo	Melody Duo	Melody Duo	Melody Duo			
	FP	Cozeb	Cozeb	Cozeb	Corzim	Corzim	Corzim	Cozeb	Cozeb	Cozeb
BADC Campus	DSS+	Antracol	Dithane	Antracol	Dithane	Secure	Secure	Secure		
	DSS	Revus	Melody Duo	Revus	Melody Duo	Melody Duo	Melody Duo			
	FP	Indofil	Indofil	Dithane	Dithane	Dithane	Dithane	Zaz	Zaz	Zaz
Gangachara-1	DSS+	Antracol	Dithane	Dithane	Secure	Secure	Secure			
	DSS	Melody Duo	Melody Duo	Revus	Revus	Melody Duo	Revus			
	FP	Indofil	Acrobat	Acrobat	Ecozim	Ecozim	Dithane	Dithane		
Gangachara-2	DSS+	Antracol	Secure	Dithane	Dithane	Secure	Secure	Secure		
	DSS	Revus	Revus	Melody Duo	Melody Duo	Melody Duo	Melody Duo			
	FP	Indofil	Cozeb	Cozeb	Corzim	Corzim	Corzim	Cozeb	Cozeb	Cozeb
Kaunia	DSS+	Antracol	Dithane	Antracol	Dithane	Secure	Secure	Secure		
	DSS	Revus	Revus	Melody Duo	Revus	Melody Duo	Revus			
	FP	Zaz	Zaz	Revus	Revus	Revus	Zaz	Zaz	Zaz	
Metro-1	DSS+	Dithane	Dithane	Antracol	Antracol	Secure	Secure	Secure		
	DSS	Melody Duo	Melody Duo	Revus	Revus	Revus	Revus			
	FP	Cozeb	Cozeb	Folimin	Folimin	Folimin	Metataf	Metataf		
Metro-2	DSS+	Dithane	Dithane	Antracol	Antracol	Secure	Secure	Secure		
	DSS	Melody Duo	Melody Duo	Melody Duo	Revus	Melody Duo	Revus			
	FP	Naczeb	Naczeb	Naczeb	Folimin	Folimin	Folimin	Folimin	Folimin	Folimin
Pirgaccha-1	DSS+	Melody Duo	Antracol	Antracol	Dithane	Dithane	Secure	Secure	Secure	
	DSS	Revus	Revus	Melody Duo	Melody Duo	Melody Duo				

	FP	Cozeb	Cozeb	Cozeb	Corzim	Corzim	Corzim	Cozeb	Cozeb	Cozeb
Pirgaccha-2	DSS+	Antracol	Antracol	Dithane	Dithane	Secure	Secure	Secure		
	DSS	Melody Duo	Melody Duo	Revus	Revus	Revus	Revus			
	FP	Folimin	Folimin	Folimin	Metataf	Metataf	Folimin	Folimin		
Pirganj-1	DSS+	Dithane	Dithane	Antracol	Antracol	Secure	Secure	Secure		
	DSS	Revus	Melody Duo	Revus	Melody Duo	Revus	Melody Duo	Melody Duo		
	FP	Indofil	Indofil	Indofil	Indofil	Indofil	Dithane	Dithane		
Pirganj-2	DSS+	Antracol	Dithane	Antracol	Dithane	Secure	Secure	Secure		
	DSS	Revus	Melody Duo	Revus	Melody Duo	Melody Duo	Melody Duo			
	FP	Dithane	Dithane	Dithane	Dithane	Dithane	Dithane	Zaz	Zaz	Zaz
Sadar	DSS+	Antracol	Antracol	Dithane	Dithane	Secure	Secure	Secure		
	DSS	Melody Duo	Melody Duo	Revus	Revus	Revus	Revus			
	FP	Hasim	Metataf	Metataf	Metataf	Metataf	Metataf	Metataf	Cozeb	
Taraganj-1	DSS+	Antracol	Dithane	Antracol	Dithane	Secure	Secure	Secure		
	DSS	Melody Duo	Revus	Melody Duo	Revus	Melody Duo	Melody Duo			
	FP	Indofil	Indofil	Indofil	Indofil	Indofil	Indofil	Secure	Secure	Secure
Taraganj-2	DSS+	Dithane	Dithane	Antracol	Antracol	Secure	Secure	Secure		
	DSS	Revus	Revus	Melody Duo	Melody Duo	Melody Duo	Melody Duo			
	FP	Indofil	Indofil	Indofil	Indofil	Indofil	Indofil	Secure	Secure	Secure

Annex III Timing of fungicide applications (in Days after planting)

			Fungicide application								
District	Sub-district	Treatment	1	2	3	4	5	6	7	8	9
Munshiganj	Gozaria	DSS+	32	47	57	66	73	81			
		DSS	32	47	57	66	73	81			
		FP	19	27	32	47	57	66	73	81	
	Louhojong	DSS+	23	33	43	53	67	71	78	85	
		DSS	23	33	43	53	67	71	78	85	
		FP	23	33	43	53	67	71	78	85	
	Munshiganj Sadar	DSS+	18	31	44	52	68				
		DSS	18	31	44	52	68	83			
		FP	18	31	44	52	68	83			
	Serajdikhan	DSS+	21	26	39	51	61	72	80		
		DSS	21	26	39	51	61	72	80		
		FP	21	26	39	51	61	72	80		
	Sreenagar-1	DSS+	26	35	45	55	67	77			
		DSS	26	35	45	55	67	77			
		FP	26	35	45	55	67	77			
	Sreenagar-2	DSS+	28	38	54	61	69				
		DSS	28	38	54	61	69				
		FP	28	38	54	61	69	77			
	Tungibari	DSS+	23	36	44	54	66	80			
		DSS	23	36	44	54	66	80			
		FP	23	36	44	54	66	80			
Rangpur	Badarganj	DSS+	30	36	44	54	65	75	88		
		DSS	23	30	36	44	51	59			
		FP	23	30	36	44	51	59	65	75	88
	BADC Campus	DSS+	34	41	46	51	60	67	75		
		DSS	34	41	46	51	60	67			
		FP	30	34	41	46	51	60	67	75	82
	Gangachara-1	DSS+	31	38	45	57	69	82			
		DSS	31	38	45	57	69	82			
		FP	31	38	46	57	62	69	82		
	Gangachara-2	DSS+	32	40	47	55	61	71	81		
		DSS	32	40	47	55	61	71			
		FP	19	26	32	40	47	55	61	71	84
	Kaunia	DSS+	34	39	53	59	70	80	85		
		DSS	34	39	53	59	70	80			
		FP	27	39	46	50	55	61	68	80	
	Metro-1	DSS+	33	41	50	58	69	74	84		
		DSS	33	41	50	58	69	74			
		FP	33	40	48	58	65	74	86		
	Metro-2	DSS+	33	40	48	53	61	81	87		
		DSS	33	40	48	53	61	81			
		FP	22	27	35	45	51	55	64	69	79
	Pirgaccha-1	DSS+	23	30	36	44	51	59			
		DSS	30	36	44	51	61	72	82		
		FP	23	30	36	44	51	59	62	75	88
	Pirgaccha-2	DSS+	32	39	45	55	63	71	81		
		DSS	32	39	45	55	63	71			
		FP	32	39	45	55	63	71	83		
	Pirganj-1	DSS+	33	39	48	59	69	79	84		
		DSS	33	39	48	59	69	79	84		
		FP	20	33	39	48	59	69	79		
	Pirganj-2	DSS+	31	38	45	52	61	71	79		

		DSS	39	46	53	62	70	77			
		FP	29	33	39	46	53	62	70	77	85
	Sadar	DSS+	33	44	51	56	62	72	82		
		DSS	33	44	51	56	62	72			
		FP	22	33	44	51	56	62	72	82	
	Taraganj-1	DSS+	29	36	43	50	59	69	77		
		DSS	29	36	43	50	59	69			
		FP	25	29	36	43	50	59	69	77	85
	Taraganj-2	DSS+	38	45	56	62	68	76	86		
		DSS	38	45	56	62	68	86			
		FP	30	34	38	45	51	56	62	68	76
Average			35	37	45	53	62	67	76	77	83

Annex IV Post-season questionnaire 2017/18

Label
Select District
Select Upazilla
SMS Farmer 's/non-SMS Farmer 's
Write farmer’s name
Select farmer 's gender
Mobile number of interviewed person
Farmer uses smartphone
Farmer age younger than 35
Level of education
Land size of the potato plot (decimel)
Previous crop
Potato variety
Source (origin) of potato seed
Date of planting
Do you use whole potato seed of cut seed at planting
Planting distance in row (plant to plant distance in inch)
Planting distance between rows (row to row distance in inch)
How many Kg urea used per decimal
How many Kg MoP used per decimal
How many Kg TSP used per decimal
Number of fungicide treatments
1s Fungicide used name
1st Fungicide used how many times
2nd Fungicide used name
2nd Fungicide used how many times
3rd Fungicide used name
3rd Fungicide used how many times
4th Fungicide used name
4th Fungicide used how many times
5th Fungicide used name
5th Fungicide used how many times
First observation of late blight by farmer in his plot
First application against late blight
Average Late blight spray interval
Type of equipment used for spraying
Late blight infection level
Harvest date
Yield of plot (kg/decimal)
Selling price potato directly after harvest (BDT/kg)
How much of the yield will be stored (kg)
How many SMS did you receive
How many SMS received
Did you understand the SMS

Did you act according SMS message
If not, why not
Did you spray fungicides also at other moments than the message advised
Did you share the message with other farmers
If yes, with how many people approximately
Are you satisfied with the service
If not, why not
If yes, why
Are you willing to pay in the future to receive messages
If yes, how much TK would you be willing to pay
Any comments about the service
Did you hear about the SMS service
Did SMS farmers or DAE staff tell you about the message they had received
If yes, did you spray according the message you receive from the fellow farmer or DAE
If no, why not
Would you like to receive SMS on control of Late Blight spraying in the future
If no, why not
If yes, would you be willing to pay for it
If yes, how much
Interview place
Distance from residence (km)
GPS

Annex V Customized Bayer questionnaire Mithapukur

Q	Question	Unit/response option
1	Farmer Name	Input type
2	Village	Input type
3	Union	Input type
4	Upazilla	Mithapukur
5	District	Rangpur
6	Division	Rangpur
7	Contact No. (Mobile No.)	Input type-numeric
8	Potato Variety	Input type
9	Crop 1	Potato
10	Crop 1 Acreage (Acres)	Input type-numeric
11	Total Cultivated Acreage (Acres)	Input type-numeric
12	Registered for GEOPOTATO	Dropdown list: yes/no
13	Did You Receive GEOPOTATO SMS?	Dropdown list: yes/no
14	Did You Understand The Message?	Dropdown list: yes/no
15	If NO, Then Clarify Why?	Input type
16	Did You Spray At The Advised Moment?	Dropdown list: yes/no
17	If NO, Then Clarify Why?	Input type
18	If YES, Did You Spray With The Advised Product in SMS?	Input type
19	If NO, Then Clarify Why?	Input type
20	How did you get to know about this service?	Input type
21	What is your total cultivable land size for Potato this season? (in decimals)	Input type-numeric
22	What brand of fungicide did you use last season?	Input type
23	Did you ever use "Advised Branded" fungicide before?	Dropdown list: yes/no