Baseline study GEOPOTATO

Annette Pronk, Nazrul Islam, Hasib Ahsan, Md. Masudur Rahman, Geert Kessel, Huib Hengsdijk

GEOPOTATO

External Report 2

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).

Agricultural Information Services, Ministry of Agriculture, Bangladesh

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Summary

GEOPOTATO is one of the projects funded within the Geodata for Water and Agriculture (G4AW) facility, which improves food security in developing countries by using satellite data. 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.

The objective of the GEOPOTATO project is to reach 100,000 potato farmers with such the decision-support service after three years. The GEOPOTATO project has selected the major potato producing region Munshiganj, close to Dhaka, as the region to introduce the service in the season 2016/2017 after a baseline study was done to evaluate the state of the art of the potato production in the Munshiganj district of Bangladesh for the introduction of the late blight alert service to potato farmers.

The objective of this baseline study is:

- To better understand the behaviour of farmers, their needs, bottlenecks and barriers of late blight control,
- To collect information on the fungicides (pesticides) used and,
- To quantify indicators which are used to assess the performance of the GEOPOTATO service, i.e. (baseline values for outcome indicators).

The baseline study comprises information from different project activities in 2016 ranging from field trips, characterisation of the late blight genotypes prevailing in Munshiganj, a dedicated baseline survey carried out under potato farmers in Munshiganj, information from literature and from stakeholders in the potato value chain.

The conclusions of the baseline study with respect to the methodology used are:

- The baseline survey was performed in between the potato growing seasons and used the farmers' memory to answer questions which may therefore be considered to have a more general character than answers for a specific potato production. This should be kept in mind when reading the results and conclusions.
- Using open questions on the fungicide products applied by farmers leads to difficulties and it is concluded that an appropriate drop down list must be used.
- The chosen methodology of interviewing farmers on their behaviour, needs, bottlenecks and barriers with respect to late blight control yielded very useful information which is a solid starting point to introduce the late blight alert service.

The conclusions of the baseline study with respect to the survey are:

- Farmers have a great need to improved control of late blight.
- Farmers are eager to learn about improved strategies to control late blight.

- Late blight pressure may differ between sub-districts of Munshiganj.
- Farmers control practices differ between sub-districts of Munshiganj.
- The untimely spraying of preventive fungicides most likely contributes to yield losses although farmers are not aware of their malpractice.
- Farmers mainly apply Metalaxyl containing fungicides as curatives which have little/no effect on the control of the found Metalaxyl resistant strain of late blight.
- Other options to reduce late blight related yield losses might be included as a package to reduce losses.
- The increasing costs for pesticide products stimulate farmers' interest in the effective use of fungicides.

The conclusion of the baseline study with respect to the outcome indicators are:

- The starting point for the different indicators shows high potential to be improved when the late blight alert service is introduced.

The need for the late blight alert service was clearly identified in this study. However, some potential bottlenecks have also been identified and which may be difficult to change or improve during the project period. The two most important pitfalls are:

- The availability and subsequently use of counterfeit fungicides may lead to disappointments by farmers when using the alert service with insufficient late blight control. As the service is costing money and not working due to counterfeit fungicides trust may be lost resulting in dis-adoption.
- The unavailability of an adequate fungicide package to control preventively and curatively late blight including the Metalaxyl resistant strain Blue 13, might compromise an effective introduction and effective use of the GEOPOTATO alert service.

1 General introduction

1.1 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. 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. Through development of a decision-support service (DSS) based on a combination of satellite information and models infection periods late blight can be forecasted. A timely advice through mobile phone for the application of an appropriate fungicide can help farmers to prevent the infection of the potato crop with late blight.

Bangladesh is area-wise the third largest potato producer in Asia after China and India and among the top 10 of the potato producing countries in the world. The harvested potato area in Bangladesh is 445,000 ha (average 2011-2013; FAOSTAT) making it the second major food crop in Bangladesh after rice, which is mainly grown for subsistence. In contrast, potato is grown as the major cash crop during the dry winter season of Bangladesh (December - March). It is estimated that over 750,000 small farmers in Bangladesh produce a potato crop (Egger 2012). Because of the short growing cycle (approximately 90 days) the returns on investment for farmers are quick and also potentially high compared to other crops that can be grown in the winter season.

The objective of the GEOPOTATO project is to reach 100,000 potato farmers with the DSS after three years. Major potato production areas are in the district Munshiganj and the area surrounding Rangpur. The GEOPOTATO project has selected Munshiganj as region to develop and introduce the service in the season 2016/2017. Upscaling of the service to the Rangpur region is foreseen in the season 2017/2018. Baseline studies are carried out in both Munshiganj and Rangpur to better understand the needs, practices and performance of farmers, and the context of potato farming in these regions. Results of the baseline studies will also be used as benchmark to assess the change in management and performance of farmers after the introduction of the DSS.

The objective of this baseline study is:

- To better understand the behaviour of farmers, their needs, bottlenecks and barriers of late blight control,
- To collect information on the fungicides used and
- To quantify the baseline values for the outcome indicators of the GEOPOTATO DSS.

The report comprises information from different project activities in 2016 ranging from field trips, characterisation of the late blight genotypes prevailing in Munshiganj, a dedicated baseline survey carried out under potato farmers in Munshiganj, information from literature and from stakeholders in the potato value chain. The bulk of this report describes the results of the baseline survey in

Munshiganj carried out in the fall of 2016 and of which most of the information refers to the potato season 2015/2016. During 2016 the Munshiganj district was visited frequently by local and international partners of GEOPOTATO. These field visits provided considerable information about the (context of) potato production in Munshiganj. The information was obtained from the local agents of the Department of Agricultural Extension (DAE) as well as potato farmers in Munshiganj. Although much of this information was qualitative and sometimes anecdotic, throughout this report information of the field visits is used to deepen understanding of more quantitative information which has been collected through other means.

In the rest of this Chapter, first general information on Munshiganj is given and second, a general overview of potato production in Munshiganj based on field visits and discussions with local potato specialists, extension agents and farmers. In Chapter 2 the various data and information sources are described. Chapter 3 gives a compilation of the major findings and characteristics of potato production in Munshiganj. The majority of the information provided in Chapter 3 is based on the dedicated survey carried out under 250 potato farmers in Munshiganj. Finally, in Chapter 4 major conclusions of this study are summarized and the main outcome indicators are discussed that will be used to assess the effects of the GEOPOTATO DSS in the future.

1.2 Munshiganj district

Munshiganj measures about 100,000 ha and is located at about a two hour drive south of the Capital Dhaka (Figure 1.1). The district is surrounded by rivers in the extensive delta of Bangladesh. The district is flat and intersected by dikes that are used for transport and housing. Because of its location in the delta the lower parts are inundated during a large part of the year in the rainy season. The annual flooding provides a major contribution to the soil fertility. Predominant soil types are calcareous dark grey floodplain soils and calcareous brown floodplain soils.

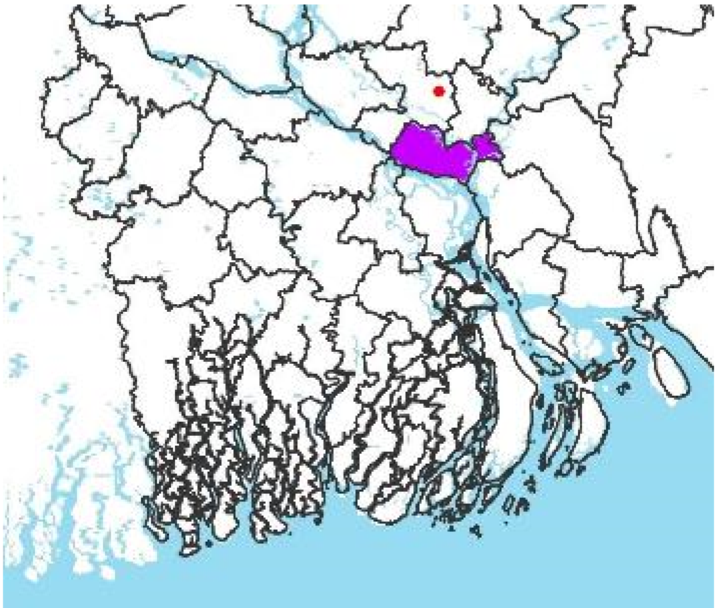

Figure 1.1 *The location of the Munshiganj district (purple) in Bangladesh and the Capital Dhaka (red dot).*

The Munshiganj district is divided into 6 sub-districts (upazila's), namely Gazaria, Lahajang, Munshiganj Sadar, Sreenagar, Serajdikhan and Tongibari (Figure 1.2).

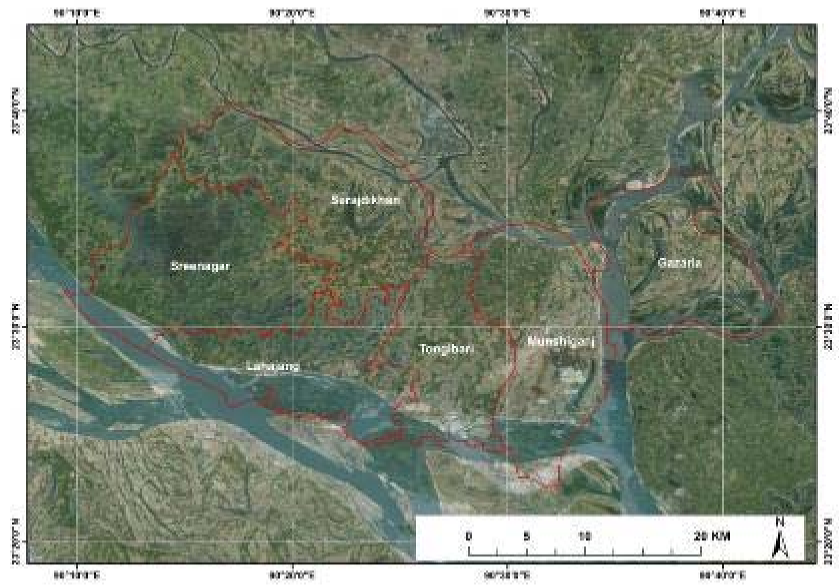

Figure 1.2 *Munshiganj district with its six sub-districts (upazila's).*

1.3 Potato production in Munshiganj

The total potato production in Munshiganj is estimated at 1.3 million tonnes, with an average yield of 35 tonnes/ha. This is much higher than the average potato yield in Bangladesh which was approximately 19 tonnes/ha in 2013 according FAOSTAT.

Farmers produce potatoes on 2-3 ha which is often divided in several fields. Farmers own the land, but also rent land with lease prices of about 550 BDT[1] per decimal[2] per season. Potato is an important cash crop for Munshiganj farmers in the dry winter season from November to March. Potato is alternated with deep water/floating rice, jute or Sesbania (for fire wood) in the wet season. Water levels can be as high as 2 meters above the soil surface in the wet season.

Mechanised ploughing / power tiller up to 10 - 15 cm (4 – 6 inches) deep is common before planting. and very well possible because of the flat production area (Figure 1.3).

The predominant potato variety used by farmers is Diamant from Agrico, 95% of all potatoes are Diamant. About 5-10% of the potato seed is new to the farmer, i.e. bought from outside his farm each year, the remainder is graded from last year's harvest and cold stored till the next potato season starts in November. Commonly, potato seeds are cut in pieces to reduce seed costs. The cut seed pieces are not treated with a pesticide before planting. Planting is done manually without ridges with a row distance of approximately 35 cm and plant distances of 10 cm in the row are common, totalling over 250,000 plants per ha. This number of plants is extremely high compared to planting densities of potatoes in the Netherlands, which typically range between 30,000 and 50,000 plants/ha. However, where the cut seed potato pieces in Bangladesh usually produce one healthy potato main stem per planted cutting, a non-cut but well sprouted potato can have up to 6 potato main stems depending on the size of the planted seed potato. Stems originating from the potato are the so-called main stems and they are tuber bearing stems. As the number of main stems is best related to yield, the Dutch target value varies between 15 to 22 main stems for ware potatoes in the Netherlands. Plant densities of 50,000 plants per ha with 5 or 6 main stems per potato are therefore comparable to densities in Bangladesh but differently obtained. Rice straw is commonly used in Bangladesh as mulch to reduce evaporation losses.

[1] One Bangladesh Taka (BDT) equals 0.0119 Euro; 1 Euro = 84 BDT (November 22, 2016)

[2] One decimal is a unit of area used in Bangladesh and equals approximately 1/100 acre (= 40.46 m^2). 100 decimal is 4046 m^2 and 250 decimal is about 1 ha which unit will be used throughout the report.

Figure 1.3 Landscape in Munshiganj with extensive potato fields.

Common fertilizer practices are 350 - 600 kg Urea/ha, while the recommendation is 400 kg Urea/ha depending on soil fertility (Annex II). Phosphate is applied as Triple Super Phosphate (TSP) at a rate of 700 kg/ha, while the recommend rate is 500 kg/ha. Potassium is applied as Potash at a rate of 600 kg/ha, while the recommendation is 400 kg/ha. Fertilizers are subsidized and average costs in 2016 were 16 BDT per kg Urea, 22 BDT per kg TSP and 15 BDT per kg of Potash.

Major crop protection problems are late blight, scab and viruses. Late blight periodically destroys the potato crop with the last major incident reported in the potato growing season of 2006-2007 when between 50% to almost 80% of the yield was destroyed nationwide (Dey *et al.* 2010). According to farmers not all crop protection agents are working properly. Some 40 days after planting farmers start to spray against late blight. The spray strategy starts with Mancozeb, 3-5 kg/ha at an interval of 10 days. Later in the season also Ridomil Gold MZ 68 WG (Mancozeb (64%) + Metalaxyl (4%), Annex I), 2 kg/ha is used. Other available fungicides are Acrobat MZ (500 g/l Mancozeb (60%) + Dimethomorph (9%)) and Melody duo 66.8 WP (Iprovalicarb + Propineb 6675 WP (5.5% + 61.25% w/w).

The potato crop is commonly irrigated 2 to 3 times per growing season using a hose and surface water. Commonly, the harvest starts in the last week of February. By that time potato haulms have died because of the rapidly increasing daily temperature. Around harvesting average daily temperatures range from 27 to 30°C. Potatoes are manually harvested and after 2 to 3 days field drying temporarily stored at the field in piles covered with dead potato haulms (Figure 1.4).

Figure 1.4 Piles with potatoes after the harvest covered with potato haulms (March, 2016).

After some time being stored in the field the potatoes are sold or brought to one of the 69 cold stores in Munshiganj (Figure 1.5). Farmers rent storage for 360 BDT per bag of 80 kg for the entire year. Farmers prefer to store potatoes and to benefit from higher prices later in the year: At harvest prices for potatoes are around 10 BDT/kg while prices increase to 20 BDT/kg later in the season.

Figure 1.5 Bags with potatoes along the road ready to be transported.

2 Materials and methods

2.1 Weather data

Weather data were made available by the Bangladesh Meteorological Department (BMD). Because there is no meteorological station in Munshiganj we used data from meteorological stations in adjacent districts, Dhaka which is Northwest of Munshiganj and of Chandpur which is Southeast of Munshiganj (Figure 2.1). Chandpur meteorological station is more closely located to large surface water areas than the Dhaka station.

Figure 2.1 The location of the meteorological stations Dhaka and Chandpur used to characterize the weather conditions in Munshiganj.

The data included three hourly rainfall measurements (period January 2003 to December 2015), three hourly dry bulb temperature (period January 2006 to January 2016), three hourly relative humidity (period January 2006 to January 2016).

Based on these data we calculated 13-years average monthly rainfall and related standard deviations, 10-years average daily minimum and maximum temperatures, 10-years average daily minima and maxima relative humidity throughout the year.

2.2 Genotyping late blight

Mid-January 2016 ten late blight infected plants from eight different potato fields in Munshiganj have been sampled to characterize the genotype of late blight pathogen prevailing in the region (Table 2.1). For sampling, the so-called FTA cards were used, which consist of specially treated paper to bind and protect the nucleic acids from pathogen and plant tissue from degradation. The nucleic acids bound to the FTA cards have been further analysed in a laboratory of Wageningen Plant Research, the Netherlands, to determine the late blight genotype. Genetic fingerprints were generated using the standardized Euroblight 12plex set of SSR’s (www.euroblight.net, Li et al., 2013) for identification and comparison of pathogen genotypes.

Table 2.1 GPS coordinates of the locations for the FTA cards.

FTA code	North	East
BD 16005	23.515837	90.508156
BD 16006	23.482026	90.492769
BD 16007	23.49987	90.458891
BD 16008	23.500355	90.459047
BD 16009	23.499511	90.461453
BD 16010	23.513328	90.470197
BD 16011	23.517844	90.470644
BD 16012	23.518234	90.471159
BD 16013	23.519713	90.470973
BD 16014	23.523514	90.471224

2.3 Farmer’s survey

2.3.1 Questionnaire

A questionnaire was developed that focused at the major characteristics of potato production and specifically of current late blight control by farmers, outcome indicators (Table 2.2), and that required relatively little time and effort from the farmers to answer.

All questions refer to last potato season 2015-2016 and refer to one potato plot (largest or best performing) of the interviewed farmer.

Table 2.2 Questionnaire of the Baseline survey in Munshiganj.

nr	Question	Unit / response option
1	Sub-district	Name sub-district
2	Gender	Male / Female
3	Farmer's mobile number	Number
4	Land size of the potato plot	Decimal (= 1/100 ha)
5	Crop preceding potato	Yes / No
6	If answer is 'Yes' to question 8: Name crop preceding potato	Crop type
7	Potato variety	Variety name
8	Seed origin	Farm saved / certified / uncertified
9	Date of planting	Date
10	Entire tuber or cut tuber used as potato seed	Whole / cut
11	Row distance	Cm
12	In-row distance	Cm
13	Amount of urea applied	Kg/acre
14	Amount of TSP applied	Kg/acre
15	What is your biggest problem in potato cultivation?	Labour availability / potato seeds / late blight / irrigation / storage / sales price / other
16	Are you satisfied with current options to protect your crop from late blight	Yes / No
17	If answer is to question 16 is 'No': Why are you not happy using existing options to protect your crop from late blight	It takes too long time to detect late blight in the crop / fungicide availability / high cost of treatment / neighbours do not care about treating their crop properly / no late blight resistant variety / no information on late blight / Other
18	Where do you get information on late blight currently?	Experienced local farmers / service providers / input suppliers / Sub Assistant Agricultural Officer or DAE / buyers / newspaper / radio / TV / other
19	First day that disease was observed	Days after planting
20	Number of fungicide applications	Number
21	Names of used fungicides	Fungicide name
22	Fungicide dose	Gm, ml/L water
23	Fungicide application interval	Days
24	Fungicide application method used	knapsack sprayer / power sprayer / both
25	Intensity of infection	Low (*few plants infected*) / medium (*majority of plants infected*) / high (*severe damage all over the field*)
26	Time of harvest	Date
27	Yield (ton/acre)	Number
28	Selling price (BDT/ton)	Number
29	Location of interview	GPS coordinates

The original survey contained one question about the generation of seed potatoes used but this question was not well-translated into Bengal and did not render sensible information. Quantitative information was collected using local units (decimal, acre) but converted into and reported as hectares in the remainder of the report.
In the result section questions nrs 1 to 12 are reported in paragraph 3.3.1, nrs 13 and 14 in paragraph 3.3.2, nrs 16 to 25 in paragraph 3.3.3 and nrs 26 to 28 in paragraph 3.3.4.
From question nos. 9, 20, 23 and 26 the day after planting on which the first fungicide application was applied, was estimated. First, the total growing season was calculated (nr 26 – nr 9), and reduced with 14 days as this is the moment farmers do not apply any fungicide any more before harvest. The period fungicides are applied was calculated by multiplying the number of fungicide applications indicated by the farmers (nr 20) with nr 23, the fungicide application interval. This time period was subtracted from the period fungicides are applied. The so estimated number of days after planting that the first fungicide application was applied, is compared with the first day late blight is observed, question nr 19.

2.3.2 Selection of farmers

In total 253 potato farmers were selected by the local Department of Agricultural Extension (DAE) in Munshiganj. A selection criterion was that the farmers had a mobile telephone number, and to have a representative sample of farmers from Munshiganj they were selected from the six sub-districts, namely Gazaria (20 farmers), Lahajang (20 farmers), Munshiganj Sadar (60 farmers), Sreenagar (20 farmers), Serajdikhan (73 farmers) and Tongibari (60 farmers) (Table 3.1).

Figure 2.2 shows the six sub-districts and the location of the interviewed farmers in Munshiganj. Some of the 253 farmers appear to live outside the Munshiganj district or in water (Figure 2.2), which is related to inaccuracies in GPS and GIS information. The two locations outside Munshiganj were excluded from the data processing, leaving 251 farmers as sample size. In addition, the GPS coordinates refer to the place of interview, which was not necessarily the homestead of farmers but may have been outside Munshiganj or the district where they lived.

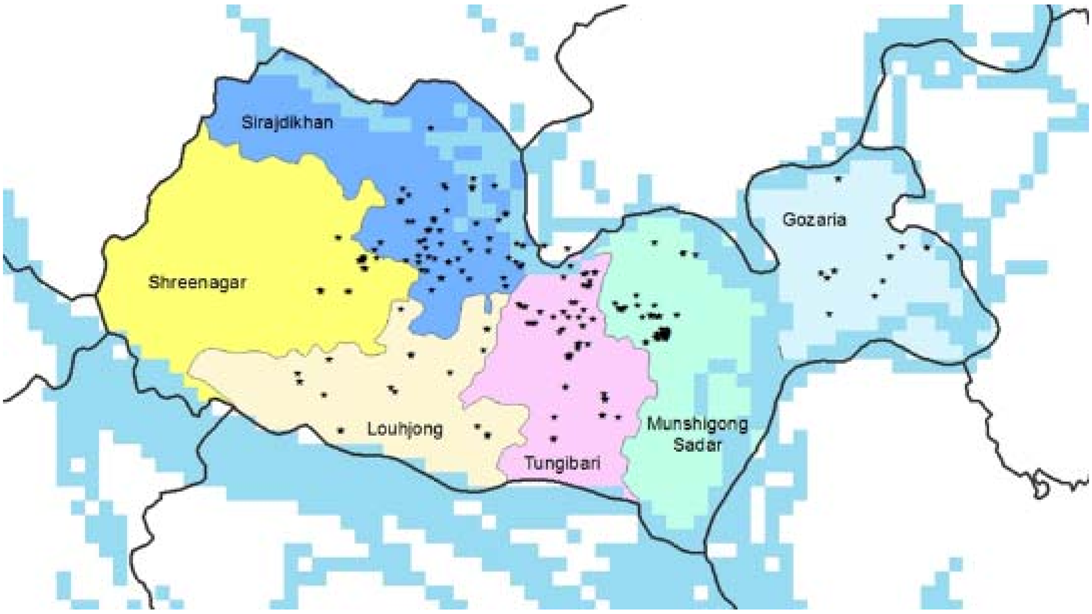

Figure 2.2 *The six sub-districts (upazila's) and locations of the 251 interviewed farmers and 2 farmers just outside Munshiganj district in Bangladesh. The blue blocked structure indicates surface water.*

2.3.3 Enumerators and survey implementation

The survey was implemented by nine enumerators, three quality control staff and one team leader of the Development Research Institute in Dhaka. The survey was carried out from October 12 – 16, 2016.

The questionnaire was translated from English into Bengal and programmed for a mobile application by mPower. This application was installed on tablets, which were used by the enumerators to interview farmers. See Figure 2.3 for some screenshots of the mobile application.

The digital survey system consisted of three different parts:

- Data input form (through the smartphone application)

- Data view (through web dashboard)

- Data extract and output (through excel/csv file system)

During the interview, the enumerators used the digital questionnaire form of their tablets. Also the GPS location of the interview location was recorded. After the interview the questionnaire was sent (through internet connection) to a server. The web dashboard allowed to view the data and to carry out a first data quality control. Finally, all the data were downloaded from the web into a CSV/Excel file, which was further used to control data entries before reporting the results.

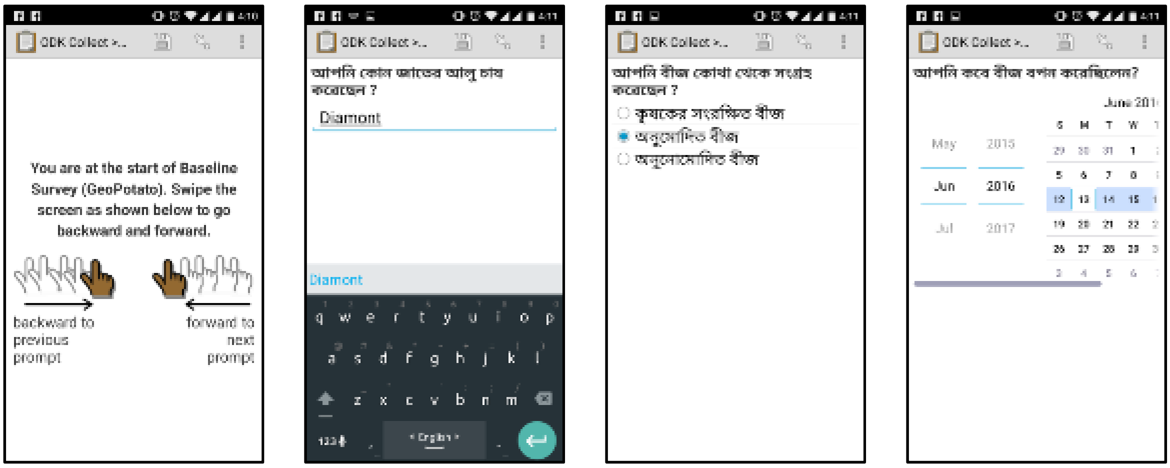

Figure 2.3 Screenshots of the mobile survey application.

2.3.4 Data processing

Data were cleaned from missing values and some unreliable recordings. Names of fungicides were phonetically written and as much as possible traced back to fungicides listed in the Registered Pesticide List (www.bcpabd.com/pdf/RegisteredPesticidesList.pdf). 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 5 categories:

1. only use of preventive fungicides,
2. use of preventive and curative fungicides,
3. only use of curative fungicides,
4. use of preventive and curative resistance fungicides,
5. 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.
Data on yield, the first day late blight was observed, the number of fungicide applications and the fungicide application interval, questions 27, 19, 20 and 23 respectively (Table 2.2) were subjected to an analysis of variance (unbalanced) with sub-district and farmers grouped as factors.

2.4 Costs of late blight control

The costs of late blight control were calculated based on market prices for used fungicides in Munshiganj, the advised spraying volume of 500 L/ha (pers. comm. AIS and DAE.) and the recommended dosage for the fungicide used according to the Registered Pesticide List (www.bcpabd.com/pdf/RegisteredPesticidesList.pdf). The estimated labour costs to apply one pesticide spray are 800 BDT/ha. Additional costs calculations were done to explore effects of increased spraying volumes, 2 and 3 times the recommended spraying volume and increased dosages, 1.5 and 2 times the recommended dosage. The increased spraying volumes equal to 1000 and 1500 L/ha are chosen as it is difficult to apply 500 L/ha to a full grown crop with a knapsack sprayer (De Putter *et al.* 2014; Pronk *et al.* 2017; Van den Brink *et al.* 2015).

The application schedule used for the calculations is based on the results of the farmer's review. This includes the average number of applications of a fungicide (six applications, Table 3.15) and the products most frequently used (Table 3.17). No differences regarding regions are included.

2.5 Baseline outcome indicators

The late blight alert service of GEOPOTATO is evaluated based on different indicators. Following the annual progress report the baseline study is used to calculate outcome indicators on different aspects of the project results. The outcome indicators are on sustainable food production, input use efficiencies, income and other outcomes.

The outcome indicator on sustainable food production is:

- Crop yield, ton/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/ton product). The use of fungicides is expressed as fungicides applied as kg or L product/ha and as active ingredient as 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 in the standard scenario

The costs calculated for the standard scenario is used as the baseline costs for fungicide use (section 2.4). The range in costs due to increased spray volume or dosages are also indicated.

The indicator on other outcome is:

- The reduction in the use of curative fungicides containing Metalaxyl.

The expected change by the introduction of the service is twofold: 1) the use of different curative active ingredients, that is a change towards those active ingredients which do have an adequate curative effect on late blight, or 2) less curative fungicide applications are needed as the service helps to adequately apply preventive fungicides, thus curative applications are less needed.
The reduction in the use of curative fungicides containing Metalaxyl is therefore expressed in two ways. First, the % of curative fungicide products used by the farmers containing Metalaxyl is used as the starting point to evaluate changes following the introduction of the service when it comes to

type of curative products. Second, the number of times a spray application containing Metalaxyl is identified, is used as an indicator to evaluate changes on the number of Metalaxyl containing curative applications.

3 Results

3.1 Weather data

Figure 3.1 shows the average monthly rainfall and average monthly minimum and maximum temperatures in districts nearby Munshiganj. Total average annual rainfall is about 1950 mm per year with little difference between both districts. However, the rainfall distribution is somewhat different, i.e. rainfall in Dhaka is higher in the first half of the year, while rainfall in Chandpur is higher in the second part of the year. The wettest period is from May to July in Dhaka and from June to August in Chandpur. The winter period from November to March is extremely dry in both districts.
The pattern in minimum and maximum temperature throughout the year in both districts hardly differs. Lowest temperatures are recorded mid of January after which the temperature increases to average daily temperatures of almost 35°C and average daily minimum temperatures above 25°C in April. These high temperatures last till October when temperature minima and maxima gradually decrease till the end of the year.

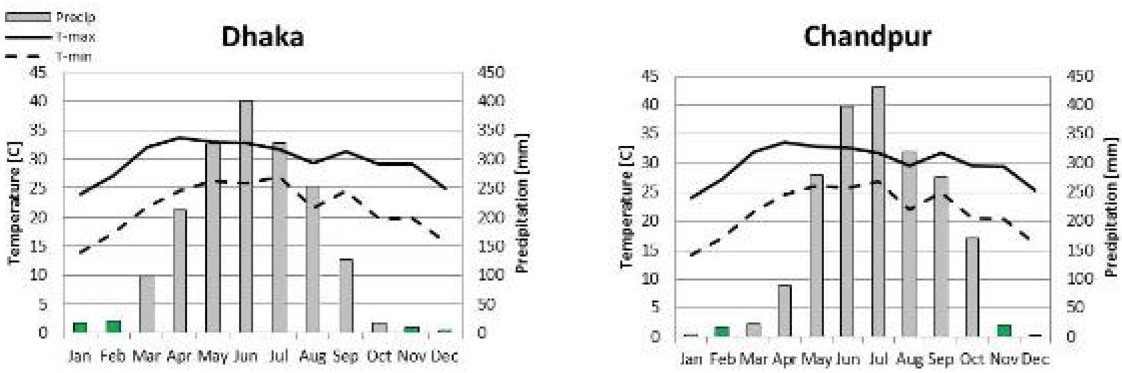

Figure 3.1 The average minimum (T-min; ℃) and average maximum (T-max; ℃) temperature and average total precipitation per month (Precip.; mm) for Dhaka and Chandpur (period 2006-2015). Green bars indicate the potato growing season. Source: BMD.

Figure 3.2 shows the average daily minimum and maximum relative humidity (RH) in Dhaka and Chandpur. The general pattern is the same in both districts, i.e. consistently high maxima and a more changing minima levels throughout the year. However, absolute levels in minimum and maximum RH are somewhat different. The maximum RH in Chandpur is above 90% throughout the year, while Dhaka shows a little dip in RH maxima into the 80's in February and March. Also the minimum RH in Chandpur is higher than in Dhaka throughout the year. This difference is probably related to the location of the meteorological station of Chandpur which is relatively nearby large open surface waters. The red line indicates the threshold level above which late blight develops. Both locations show RH values favourable for late blight development throughout the growing season (November - March).

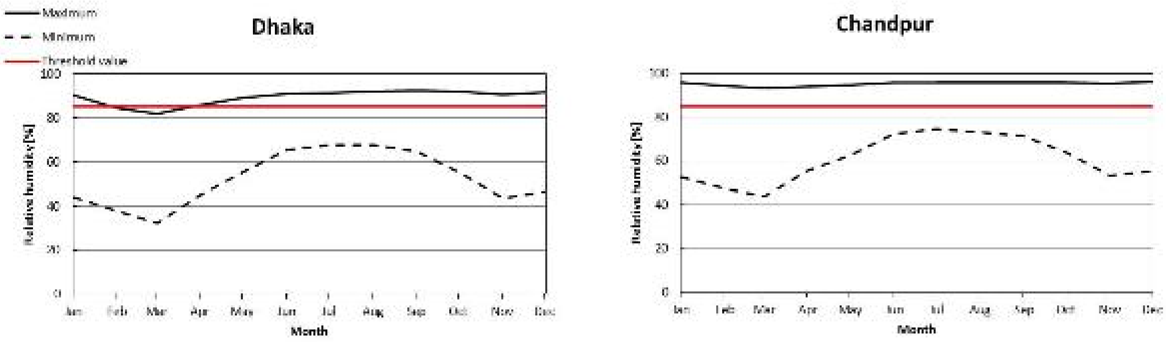

Figure 3.2 The average minimum (Minimum) and maximum (Maximum) relative humidity for Dhaka (left) and Chandpur for the period 2006-2015 (right, source: BMD) and the threshold relative humidity (Threshold value) for late blight development (red line)

3.2 Genotyping late blight

Results from the late blight sampling in Munshiganj showed that all ten samples belonged to the so called *Phytophthora infestans* EU_13_A2 (Blue13) genotype. This *P. infestans* genotype is of European origin (Cooke *et al.* 2012) first found in 2004 and dominant in the North Western *P. infestans* population since then. It is well known for its aggressiveness and resistance to Metalaxyl. This genotype is e.g. also found in other Asian countries like China, Myanmar and India.

3.3 Farmer's survey

3.3.1 General information of interviewed farmers

Table 3.1 gives an overview of the number of farmers in each sub-district, the area of each sub-district (calculated with ArcMap) and the UserID's of the enumerators in each sub-district. In few cases the number of farmers in a sub-district according DAE data was not the same as the number of farmers tagged during the interview (using a shapefile of the sub-district and a point shapefile of the location of interview). This is related to inaccuracies in GPS and GIS information and because farmers may have been interviewed in another sub-district than where their homestead is (see also section 2.3.2).

Table 3.1 Total area of each sub-district and number of interviewed farmers per sub-district. The value between brackets is the number of farmers found using ArcMap.

District	Sub-district	Area (ha)	# farmers
Munshiganj	Gazaria	14,247	20 *(20)*
Munshiganj	Lahajang	13,468	20 *(20)*
Munshiganj	Munshiganj Sadar	16,773	60 *(62)*
Munshiganj	Sreenagar	20,702	20 *(21)*
Munshiganj	Serajdikhan	17,388	71 *(69)*
Munshiganj	Tongibari	11,262	60 *(57)*

Table 3.1 shows that the number of interviewed farmers in Serajdikhan, Tongibari and Munshiganj Sadar were much higher than in Lahajang, Gazaria and Sreenagar (approximately a factor 3). All interviewed farmers were male.

In the Table 3.2 the minimum, average and maximum land area with potato are presented in decimals and hectares. Gazaria sub-district has the largest average land size (5.3 ha), Tongibari the smallest (1.4 ha).

Table 3.2 Minimum, average and maximum land sizes with potato in decimal and hectares of interviewed farmers.

	Land size (decimal)			Land size (ha)		
Sub-district	Minimum	Average	Maximum	Minimum	Average	Maximum
Gazaria	60	1299	4000	0.2	5.3	16.2
Lahajang	28	823	3640	0.1	3.3	14.7
Munshiganj Sadar	14	387	2100	0.1	1.6	8.5
Sreenagar	70	528	1680	0.3	2.1	6.8
Serajdikhan	70	723	4000	0.3	2.9	16.2
Tongibari	14	336	1680	0.1	1.4	6.8
Average	14	589	4000	0.1	2.4	16.2

Figure 3.3 shows a frequency distribution of the plot size planted with potato in Munshiganj.

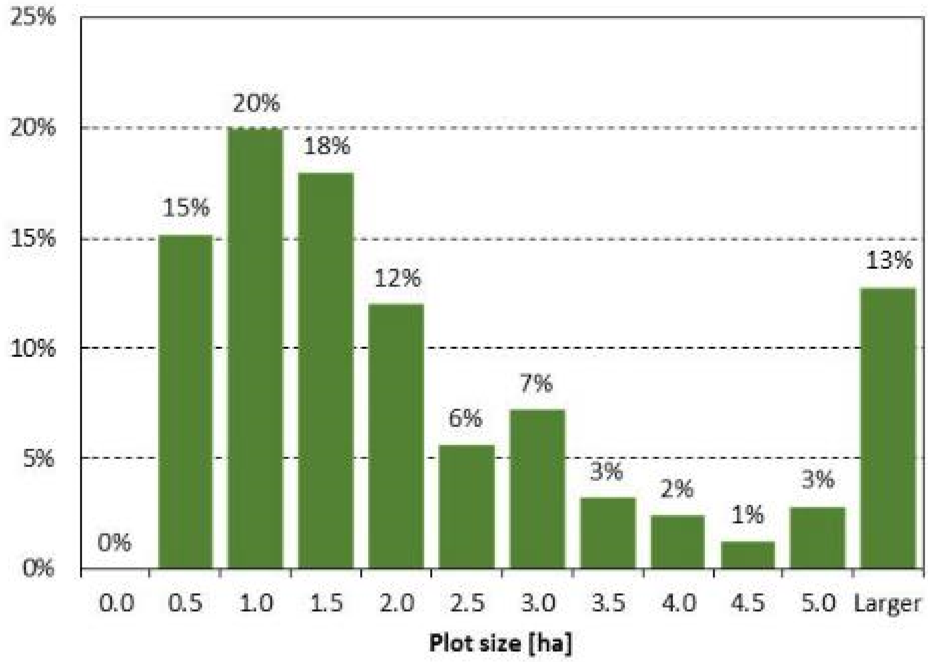

Figure 3.3 Frequency distribution of the plot sizes (ha) planted with potato in Munshiganj.

Table 3.3 gives an overview of the number of other crops (besides potatoes) that were grown by the interviewed farmers before potato. Mostly the other crop was rice or jute. Note that farmers can have grown more than one other crop, and therefore the number of crops in Table 3.3 is not the same as the number of farmers per sub-district. In the sub-district Munshiganj Sadar the percentage of farmers without other crops (40%) is highest suggesting that these potato farmers are most specialised in potato production.

Table 3.3 Number (n) and percentage (%) of interviewed farmers with other crops (other; beside potatoes) and without other crops (non), and the number of farmers per type of crop grown per sub-district.

	Other		Non		Type of crop							
Sub-district	n	%	n	%	Rice	Jute	Sesame	Sesbania	Maize	Amaranth	Vegetable	other crop
Gazaria	14	70	6	30	8	7	6	1	9	0	0	0
Lahajang	19	95	1	5	9	8	4	4	0	0	0	0
Munshiganj Sadar	36	60	24	40	19	18	0	1	0	0	7	0
Sreenagar	16	80	4	20	10	10	2	4	0	2	1	0
Serajdikhan	65	92	6	8	59	16	2	7	0	2	5	1
Tongibari	56	93	4	7	44	28	2	6	0	0	2	3

3.3.2 Planting

Table 3.4 gives an overview of the used potato varieties by the interviewed farmers. Variety 'Diamant' is by far the most used potato variety. Diamant is a so called High Yielding Variety (HYV) in contrast to local varieties which have in general lower yields. Diamant is a common HYV and covered 63% of the potato area in Gorizia in 2008-09 (Uddin *et al.* 2010).

Table 3.4 Number of potato varieties used in the different sub-districts of Munshiganj by interviewed farmers.

	Name of potato variety						
Sub-district	Diamant	Cardinal	Other	Rosa Gold	Granola	Alga	Asterix
Gazaria	20	0	0	0	1	1	0
Lahajang	19	1	0	0	0	0	0
Munshiganj Sadar	59	0	1	0	0	0	0
Sreenagar	19	0	1	0	0	0	0
Serajdikhan	69	0	3	1	1	0	2
Tongibari	60	0	0	0	0	0	0
Total	246	1	5	1	2	1	2

Table 3.5 gives an overview of the number of farmers that used an authorized dealer as seed source and those that used farmer-saved seed. On nearly all farms (98%) the seed source is from an authorized dealer.

Table 3.5 Overview of seed source and percentage of total bought as the seed source.

Sub-district	Authorized dealer	Farm-saved seed
Gazaria	20	0
Lahajang	20	0
Munshiganj Sadar	58	2
Sreenagar	20	0
Serajdikhan	71	0
Tongibari	58	2
Total	247 (98%)	4 (2%)

Table 3.6 gives an overview of the earliest, average and latest planting date in 2015.
All potato seeds were cut before planting and not further treated with a pesticide. Figure 3.4 shows the weekly frequency distribution of planting dates and indicates that more than 50% of the potato fields were planted in the second half of November.

Table 3.6 Overview of earliest, average and latest planting date in Munshiganj and its sub-districts in the 2015/16 growing season.

	Planting date		
Sub-district	Earliest	Average	Latest
Gazaria	10 November	29 November	15 December
Lahajang	26 October	22 November	6 December
Munshiganj Sadar	7 October	21 November	20 December
Sreenagar	10 November	24 November	10 December
Serajdikhan	15 October	21 November	15 December
Tongibari	5 November	24 November	25 December
Average	7 October	23 November	25 December

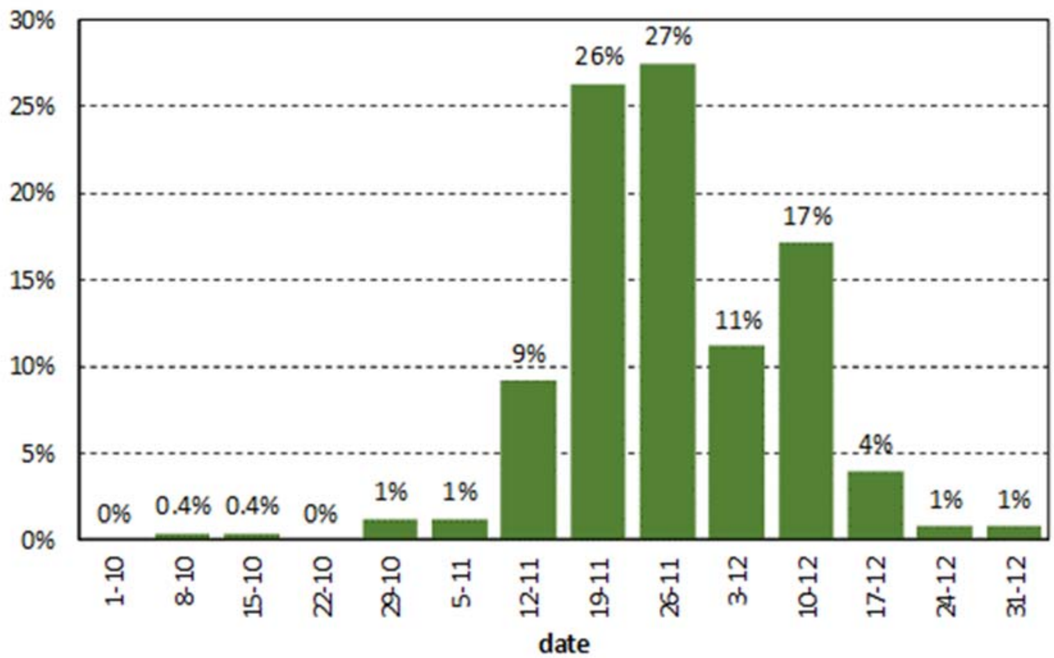

Figure 3.4 *Weekly frequency distribution of the potato planting dates in Munshiganj in the 2015/16 season.*

Table 3.7 gives an overview of the minimum, average and maximum row and intra-row distance and the calculated plant density.

Table 3.7 *Minimum (min), average (avg) and maximum (max) row and intra-row distance (cm), and the calculated plant density (plants/ha).*

	Row distance			Intra-row distance			Plant density		
Sub-district	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max
Gazaria	15	35.4	45	9	12.7	20	111,111	252,246	555,556
Lahajang	30	35.4	45	9	9.8	13	202,020	299,340	370,370
Munshiganj Sadar	25	39.0	55	8	11.3	20	111,111	241,829	416,667
Sreenagar	30	36.6	55	6	11.3	15	148,148	269,523	555,556
Serajdikhan	20	38.5	50	9	10.4	23	100,000	264,603	454,545
Tongibari	25	36.9	50	6	12.9	25	133,333	236,527	416,667
Munshiganj district	15	37.6	55	6	11.4	25	100,000	254,623	555,556

3.3.3 Fertilisation

Table 3.8 shows the minimum, average and maximum doses of applied urea and TSP fertiliser. The application doses have been converted to hectares instead of acres as in the questionnaire. The minimum, average and maximum applied amounts of urea and TSP have also been converted into the amounts of applied N and P_2O_5 at district level, respectively.

The advised doses of fertilisers for potato in Bangladesh for a yield goal of 30 tons/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) (Annex II). From Table 3.8 it becomes clear that the current average application rates for N (277 kg/ha) and P_2O_5 (304 kg/ha) are much higher than the recommendations but in agreement with application rates found in Munshiganj in 2009 (Rabbani *et al.* 2010).
The subsidised fertiliser costs contribute approximate 8 to 10% to the variable costs (Hossain *et al.* 2008).

Table 3.8 *Minimum, average and maximum applied urea and triple superphosphate (TSP, kg/ha) in the sub-districts of Munshiganj, and the minimum, average and maximum applied N and P_2O_5 (kg/ha) in Munshiganj.*

	Urea (kg/ha)			TSP (kg/ha)		
Sub-district	Minimum	Average	Maximum	Minimum	Average	Maximum
Gazaria	353	679	941	353	743	1175
Lahajang	514	729	864	494	738	988
Munshiganj Sadar	351	590	1230	395	657	1111
Sreenagar	346	633	988	257	701	1114
Serajdikhan	175	532	864	328	588	988
Tongibari	494	604	706	494	659	822
Munshiganj district	175	602	1230	257	661	1175
average kg N / P_2O_5 /ha	81	277	566	118	304	541

3.3.4 Production

Table 3.9 shows the harvest time and number of growing days, i.e. the difference between harvest and planting date. Figure 3.5 shows the weekly frequency distribution of harvesting dates.

Table 3.9 Minimum, average and maximum harvest time and number of growing days in Munshiganj and its sub-districts.

	Harvest date			Number of growing days		
Sub-district	Minimum	Average	Maximum	Minimum	Average	Maximum
Gazaria	15 February	07 March	25 March	67	98	121
Lahajang	02 March	11 March	25 March	94	109	151
Munshiganj Sadar	08 February	05 March	15 April	78	105	155
Sreenagar	20 February	07 March	30 March	82	104	123
Serajdikhan	15 February	06 March	30 March	82	105	141
Tongibari	10 February	03 March	25 March	57	99	120
Munshiganj district	08 February	05 March	15 April	57	104	155

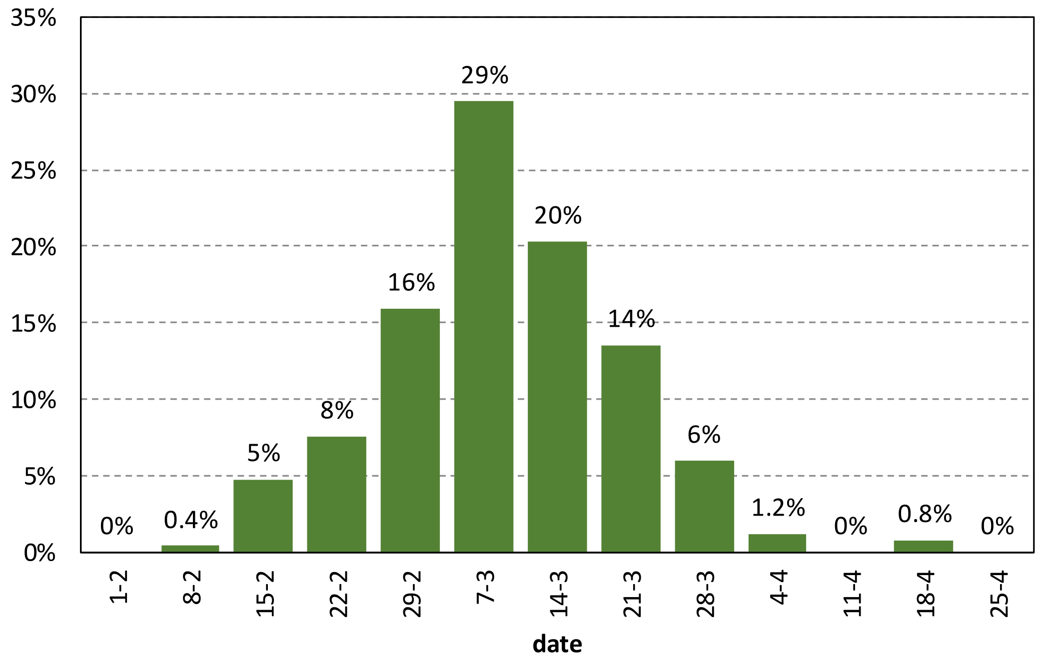

Figure 3.5 Weekly frequency distribution of the harvesting date in Munshiganj in the 2015/16 season.

Figure 3.6 shows the five-days frequency distribution of the length of the growing period in Munshiganj in the 2015/16 season. This figure suggests that the difference in growing period between minimum and maximum duration was about 25 days for the majority of farmers.

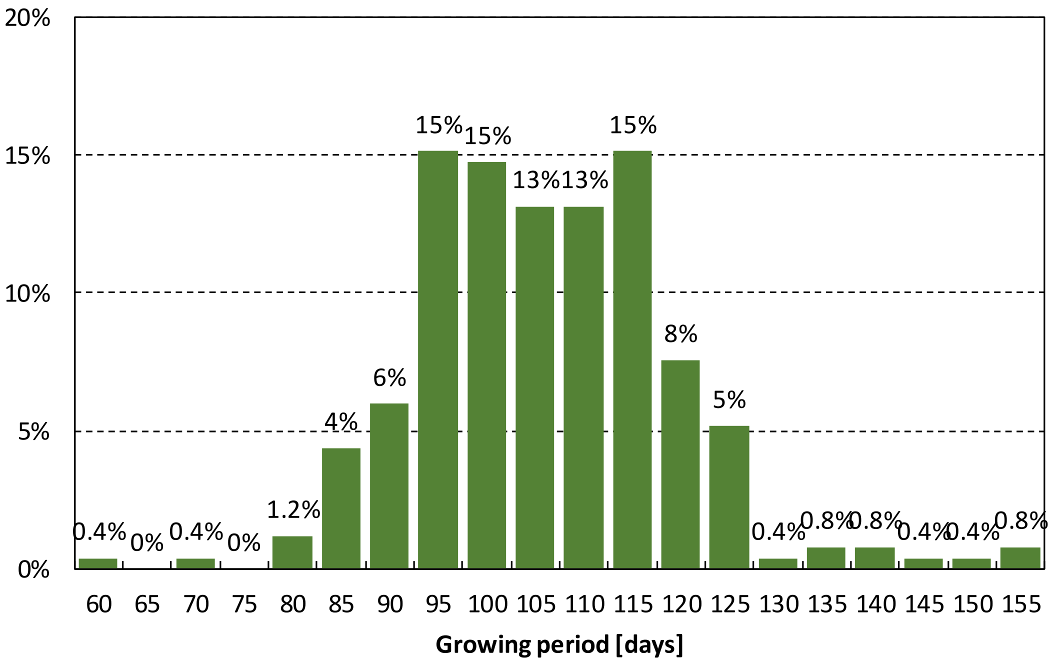

Figure 3.6 The five-days frequency distribution of the growing period of potatoes in Munshiganj in the season 2015/16.

The potato yields varied between 9.9 and 56.8 tons/ha (Table 3.10) with an average yield of 31 tons/ha. This yield is considerable higher than the national average of only 19 tons/ha. A survey of 2008 on potato for food security in Bangladesh found an average yield in Munshiganj of 25 tons/ha (Azimuddin *et al.* 2009), a survey of 2009 investigating the challenges of potato production, found that yields in Gazaria were slightly more than 24 tons/ha (Uddin *et al.* 2010) and a survey of 2010 of Adhara sub-district in Munshiganj on resource use efficiencies found yields of 28 ton/ha. Our finding of an average yield of 31 ton/ha suggests that yields increased during the past years. The study of 2009 showed a price of potatoes in Gazaria of 11.64 BDT/kg which is just slightly higher than prices presented in Table 3.11.

Table 3.10 Potato yields (in ton/ha) in different sub-districts and in Munshiganj in the 2015/16 season.

Sub-district	Minimum	Average	Maximum
Gazaria	17.3	29.0	37.0
Lahajang	22.2	30.2	44.4
Munshiganj Sadar	22.2	34.1	56.8
Sreenagar	19.8	30.5	42.0
Serajdikhan	17.3	30.3	39.5
Tongibari	9.9	29.7	49.4
Munshiganj district	9.9	31.0	56.8
Sub-district		***	
Type of active ingredients		n.s.	
Sub-district * Type of active ingredients		n.s.	

Figure 3.7 shows the frequency distribution of potato yields in Munshiganj in the season 2015/16.

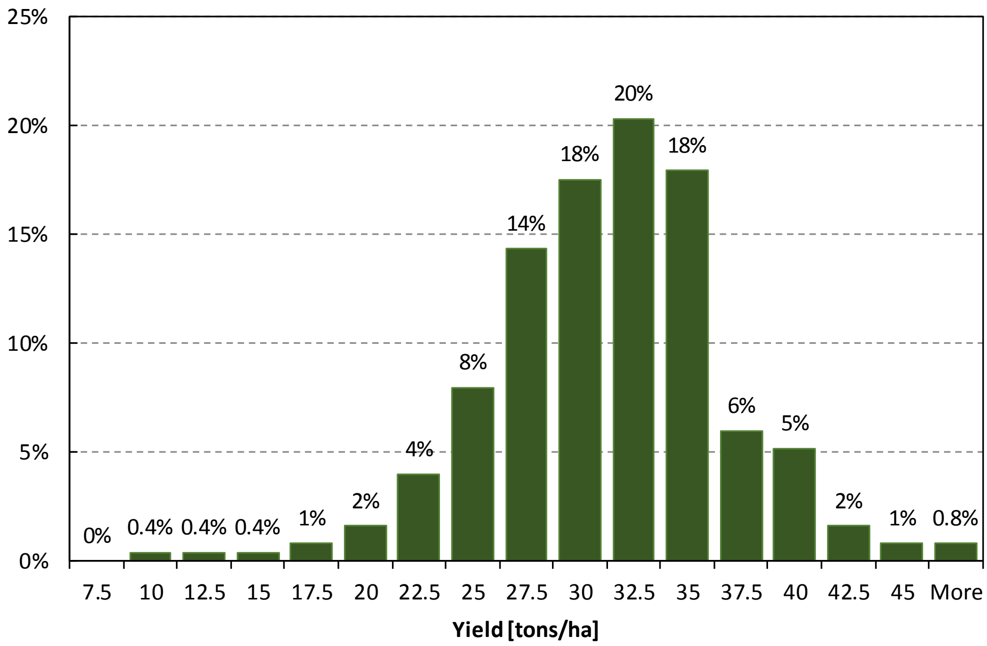

Figure 3.7 Frequency distribution of potato yields in Munshiganj.

Because of the variation in length of growing period (Figure 3.6) in theory one would expect a relationship between length of growing period and yield, i.e. higher yields with longer growing periods. However, Figure 3.8 (left) shows that there is no relationship between the number of growing days and potato yield. This relationship may not be found as the day of harvest is not the day dry mass productions ends, the so called haulm killing day. Depending on practical issues, time between haulm killing and harvest differs between farmers. Also, sometimes crops die due to late blight infections and the day dry mass production ends is difficult to indicate.

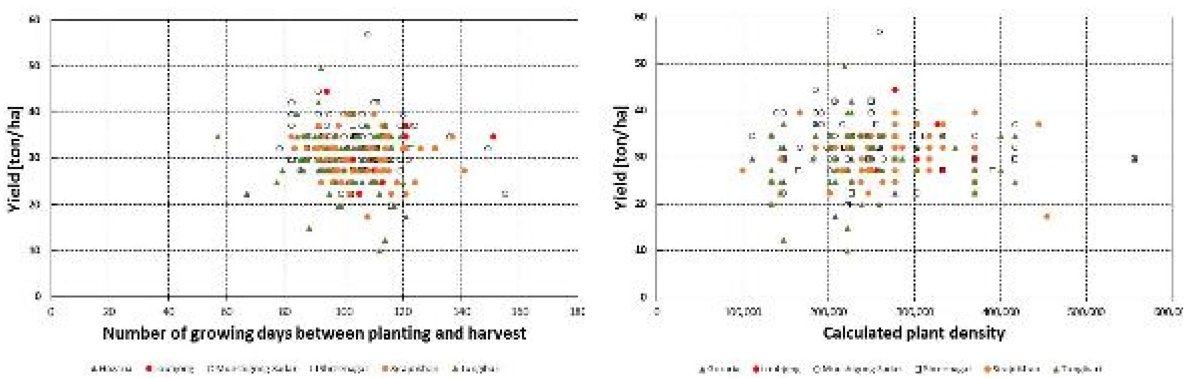

Figure 3.8 Relationship between the number of growing days (left) and the calculated plant density (plants/ha, right) and potato yield.

Because of the high variation in planting density (Table 3.7) we also studied the relationship between plant density and yield (Figure 3.8, right). This plant density - yield relationship however, did not show a clear trend either.

Table 3.11 shows the price at which farmers sold their potatoes after the harvest.

Table 3.11 Sales prices of potatoes (BDT/ton).

Sub-district	Minimum	Average	Maximum
Gazaria	9,000	12,350	17,000
Lahajang	10,150	11,295	18,000
Munshiganj Sadar	9,000	11,425	16,000
Sreenagar	10,000	12,025	15,000
Serajdikhan	9,500	12,222	16,000
Tongibari	10,000	12,174	16,000
Munshiganj district	10,150	11,940	18,000

3.3.5 Control of late blight

The majority of the farmers, 76%, indicated that late blight is the major problem (Table 3.12). The minor problems mentioned were sales price and potato seed issues, both mentioned by 6% of the farmers and other problems, 7%. Although late blight was the largest identified problem, most farmers, 60%, indicated to be satisfied with the current options to control late blight in the potato crop.

Table 3.12 Major problems identified by farmers in Munshiganj.

Problem	Count	%
Labour availability	3	1
Potato seed	14	6
Late blight	191	76
Storage	10	4
Sales price of potato	15	6
Other	18	7
Total	251	100

Despite the relevance of late blight for farmers in Munshiganj only 10% indicated to have faced serious late blight infection problems, 21% medium infection and the far majority assessed the infection as low (few plants).

Table 3.13 shows the reasons why farmers were not satisfied with the current options to control late blight. Only 40% of the farmers provided a reason, which may be related to the fact that only 76% of the farmers considered late blight as the major problem and only 10% faced serious late blight problems. About 70% of the farmers pointed at the low quality of fungicides for controlling late blight. Counterfeit pesticide products on the market are a major problem in many developing countries and resistance of the prevailing late blight genotype in Munshiganj against Metalaxyl (section 3.2) may add to understanding the reasoning of farmers. Earlier findings indicated that insect-pests and disease problems were identified before as being the largest problem in potato production (Uddin *et al.* 2010).

Table 3.13 Reasons why farmers are not satisfied with the current options to control late blight.

Reason	Count	%
High cost of treatment	7	7
No late blight disease resistant potato variety	10	10
Fungicide availability	4	4
Other (low quality of fungicides)	67	66
Lack of adequate information available	7	7
Too late identification of late blight for sufficient control	2	2
Other	5	5
Total	102	100

Most farmers, ≈ 50%, use the sub assistant agricultural officer for information on late blight control (Table 3.14). Farmers also follow experienced local farmers, 26% and input sellers, product providers, are also used for information to control late blight. Service providers are only used by 4% of the farmers.

Table 3.14 Times (#) and percentage (%) that different information sources (SAAO=Sub Assistant Agricultural Officer) are mentioned by farmers to control late blight in the sub-districts.

	SAAO		Input seller		Experienced local farmer		Service provider		Television	
Sub-district	#	%	#	%	#	%	#	%	#	%
Gazaria	13	65	2	10	5	25	0	0	0	0
Lahajang	8	40	5	25	7	35	0	0	0	0
Munshiganj Sadar	34	57	9	15	13	22	4	7	0	0
Sreenagar	9	45	2	10	9	45	0	0	0	0
Serajdikhan	38	54	16	23	14	20	2	3	1	1
Tongibari	21	35	16	27	18	30	5	8	0	0
Munshiganj district	123	49	50	20	66	26	11	4	1	0

Table 3.15 shows the number of days after planting that late blight was first observed by farmers, the number of fungicide applications in the growing season and the interval time of fungicide applications.

The average number of days after planting that late blight was first observed was 43 days and varied between 7 and 75 days. Between sub-districts there was a significant difference. Late blight was first

observed later in Lahajang and Sreenagar than in Gazaria and Munshiganj Sadar.
The average number of applications was 6.3 times per potato growing season and varied between 3 and 16 times. Again, differences were found between sub-districts, in Sreenagar only 5.2 times a fungicide was applied compared to 7.3 times in Gazaria. The number of applications of fungicides (pesticides) in Munshiganj has increased since 2008 from 2 to 3 applications (Hossain *et al.* 2008) to more than 6 in this baseline study. The field survey of the potato growing season 2008-2009 in the Munshiganj district showed that almost 7 fungicide applications were performed (Rabbani *et al.* 2010).
The average application interval between fungicide sprays was 8 days and varied between 2 and 40 days. The statistical analysis shows that the interval in the sub-district Sreenagar is significantly larger than the interval in Gazaria.

Table 3.15 The minimum (min), average (avg) and maximum (max) number of days after planting (DAP) that late blight was observed by farmers, the number of fungicide applications per season (times per season) and the application interval time (days) for the different sub-districts and Munshiganj district, and the results of the statistical analysis.

	DAP			# of applications			Application Interval		
Sub-district	min	avg	max	min	avg	max	min	avg	max
Gazaria	15	37.0	60	3	7.3	15	3	5.9	12
Lahajang	20	49.5	70	4	7.1	16	2	7.1	10
Munshiganj Sadar	7	37.1	60	3	6.4	11	3	8.6	15
Sreenagar	35	49.5	75	4	5.2	9	4	9.6	15
Serajdikhan	21	47.4	65	3	5.9	12	3	7.9	15
Tongibari	15	40.8	60	3	6.6	12	3	8.0	40
Munshiganj district	7	42.8	75	3	6.3	16	2	8.0	40
Sub-district		***			**			**	
DAP		n.s.			*			*	
Sub-district * DAP		n.s.			*			n.s.	

Late blight was on average first seen on 4 January. However, the very first observation was in Munshiganj Sadar at the end of December and latest observation in Sreenagar on 12 January (Table 3.16). The day that the first fungicide spray was applied was on average 2 January which was just before late blight was found. In total, 50% of the farmers applied the first fungicide spray later than the day late blight was first observed. In Gazaria, 60% of the farmers applied the first fungicide application after late blight was seen, which is too late to spray a preventive fungicide. In Lahajang 45% of the farmers applied the first fungicide after late blight was seen.

Table 3.16 The average day that late blight (LB) was first observed, the average day the first fungicide spray was applied and the percentage of farmers that applied the first spray after LB was observed

Sub-district	LB was first observed	First fungicide spray	% farmers first spray after LB observed
Gazaria	05/Jan/16	10/Jan/16	60
Lahajang	11/Jan/16	09/Jan/16	45
Munshiganj Sadar	28/Dec/15	29/Dec/15	50
Sreenagar	12/Jan/16	06/Jan/16	50
Serajdikhan	06/Jan/16	06/Jan/16	49
Tongibari	03/Jan/16	26/Dec/15	50
Munshiganj district	04/Jan/16	02/Jan/16	50
Sub-district	**	n.s.	n.s.

In total, more than 500 recordings concerning fungicide use were recorded (Table 3.17). Farmers indicated to use different products, on average approximately two per farmer. Of all recordings, 472 were identified, which was about 90% of all recordings. Not all reported recordings (48) could be identified and thus related to the list of Registered Products of Bangladesh (Annex I) because of spelling errors in the mobile survey application by enumerators or because unknown substances/products were mentioned by farmers.

Products containing only Mancozeb were mentioned most, 196 times (≈ 38%) and followed with 147 recordings of products containing Mancozeb + Metalaxyl (≈ 28%). More than 80% of all recordings were fungicide types containing Mancozeb. Mancozeb is a preventive fungicide which works well when applied before late blight infects. Metalaxyl is a curative fungicide which controls late blight when the crop is infected. However, some late blight strains have developed resistance to Metalaxyl and this type of late blight is known to be in Bangladesh (Dey *et al.* 2010) and found in Munshiganj (section 3.2). Farmers indicated before that they mainly use Dithane M 45 (Mancozeb) as a preventive fungicide and Ridomil MZ (Mancozeb plus Metalaxyl) as a curative fungicide to control late blight (Rabbani *et al.* 2010). Especially Ridomil MZ is insufficient to control the late blight Metalaxyl resistant strain.

Table 3.17 The number and percentage of growers that mentioned to use a specific fungicide active ingredient of total recordings and the type of active ingredient.

Active ingredient	Number of Recordings	% of total recordings	Type of active ingredient
Chlorothalonil	1	0.19	Preventive
Cymoxanil + Tri Basic Copper Sulphate	1	0.19	Curative
Dimethomorph + Mancozeb	23	4.41	Preventive + curative
Mancozeb	196	37.55	Preventive
Mancozeb + Fenamidone	34	6.51	Preventive
Mancozeb + Carbendazim	2	0.38	Preventive
Mancozeb + Cymoxanil	21	4.02	Preventive + curative
Mancozeb + Metalaxyl	147	28.16	Preventive + curative, resistance
Metalaxyl	13	2.49	Curative, resistance
Propineb	12	2.30	Preventive
Propineb + Iprovalicarb	2	0.38	Preventive
Pyraclostrobin + Metiram	5	0.96	Preventive
Sulphur	8	1.53	Other than late blight
Iprodione	3	0.57	Other than late blight
Azoxystrobin + Difeconazole	1	0.19	Other than late blight
Carbendazim	5	0.96	Other than late blight
Total identified active ingredients	474	90.80	
Not identified	48	9.20	

Table 3.18 shows the type of sprayer used by farmers in Munshiganj to apply fungicides. About 82% of the farmers uses a manual knapsack sprayer. The rest of the farmers used (also) a power sprayer to apply the fungicides.

Table 3.18 The number of Munshiganj farmers and the percentage of Munshiganj farmers that used a specific type of sprayer to apply fungicides.

Sprayer type	Number	%
Knapsack sprayer	206	82
Power sprayer	35	14
Both	10	4

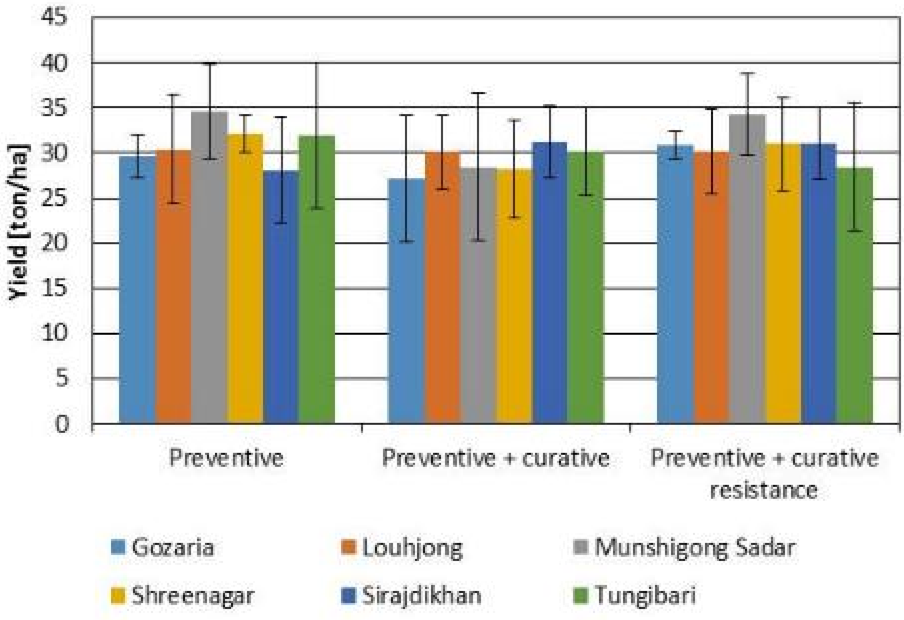

Figure 3.9 The effect of different types of active ingredient on yield of the interviewed farmers in different sub-districts.

3.4 Costs of late blight control

The standard scenario defined in Chapter 2 included six fungicide applications; three of the preventive fungicide Dithane M 45 and three fungicide applications of the fungicide Ridomil Gold MZ 68 WG. The latter fungicide contains Metalaxyl which is not effective as a curative chemical (active ingredient) to specific late blight types. However, this fungicide was used most as a curative fungicide by the interviewed farmers (Table 3.17).

The costs of fungicide products in this standard scenario are estimated at almost 7,000 BDT/ha per season (Table 3.19).

Table 3.19 The standard schedule of fungicide application for late blight control and costs.

Spraying nr.	Product	Active ingredient	Price (BDT/kg)	Recommended dosage		Spray volume	Costs (BDT/ha)
1	Dithane M 45	Mancozeb	600	2.2	kg/ha	500	1320
2	Dithane M 45	Mancozeb	600	2.2	kg/ha	500	1320
3	Dithane M 45	Mancozeb	600	2.2	kg/ha	500	1320
4	Ridomil Gold MZ 68 WG	Mancozeb + Metalaxyl	1000	2	g/l	500	1000
5	Ridomil Gold MZ 68 WG	Mancozeb + Metalaxyl	1000	2	g/l	500	1000
6	Ridomil Gold MZ 68 WG	Mancozeb + Metalaxyl	1000	2	g/l	500	1000
Total costs							6960

Table 3.20 shows the effect of increased spray volume and a higher than recommended fungicide dose on the costs for fungicides in one season. Compared to the standard schedule the costs can increase almost four-fold up to a maximum of 25,920 BDT/ha. Higher costs than the standard schedule are likely as most farmers tend to use higher than recommended spray volumes and dosages.

Table 3.20 The effect of increased spraying volumes and increased recommended dosages on costs for fungicides used (BDT/ha).

	Dosage		
Spray volume (L/ha)	Recommended	1.5 times recommended	2 times recommended
500	6,960	10,440	13,920
1000	9,960	14,940	19,920
1500	12,960	19,440	25,920

3.5 Baseline outcome indicators

The average yield of this baseline study is 31 tons/ha (Table 3.10) and is used as the baseline indicator value for improvement in sustainable food production (Table 3.21). The N-fertiliser use is 8.9 kg N/ton potatoes produced. The efficiency of fungicide use is 7.7 kg product/ha or 5.6 kg AI/ha. The baseline outcome indicator for costs of fungicide applications following the standard scenario was almost 7000 BDT/ha (Table 3.20, Table 3.21) and subsequently 0.225 BDT/kg potato produced. Of all the identified curative fungicide products used by farmers half of them (50%) contained the active ingredient Metalaxyl. But, the majority of curative fungicide applications contained Metalaxyl, 78%. This shows that farmers spray curative active ingredients abundantly which are most likely not very effective in Munshiganj as the Metalaxyl resistant strain of late blight is found frequently (section 2.2).

Table 3.21 Baseline values for outcome evaluation.

Objective	Indicator	Unit	Value
Improvement in sustainable food production	Yield	ton/ha	31
Improvement in resource use efficiency	N-fertiliser use	kg N/ton product	8.9
	Fungicide use	kg product/ha	7.7
		kg AI/ha	5.6
Improvement in income	Costs fungicide applications, standard scenario	BDT/ha	6960
		BDT/kg product	0.225
Other outcome improvements	Curative fungicides with Metalaxyl[1]	%	50
	Curative applications containing Metalaxyl[2]	%	78

[1] As percentage of total number of curative fungicides used
[2] As percentage of total number of curative applications

4 Discussion and Conclusions

4.6 Discussion

Methodology

The utmost attention has been paid to the baseline study questionnaire, i.e. the formulation of the questions and the number of questions. The questionnaire should not require too much time of the farmer and only provide information needed to assess and understand the impact of the GEOPOTATO service.

However, during the interviews it became clear that several questions were either not correctly translated or asked wrongly due to misperception of the context of potato production in Munshiganj.. Additionally, the survey implementers were not potato specialist which complicated matters further.

The baseline study was performed in between the potato growing seasons and used the farmer's memory to answer questions. This may have had an effect on the accuracy of some answers, especially those related to the time of operations. These answers may have a more general character in the sense of what the farmer is usually doing and less of the specific potato growing season 2015-16. Hence, these data should be used with care.

The survey of the baseline study had a number of open questions. With respect to the use of fungicides, this resulted in a list of fungicides that was phonetically written down and almost 10% of the mentioned products could be identified (Table 3.17). The Bangladesh Crop Protection Association has released a long list of Registered Agricultural Pesticides, Bio Pesticides and Public Health Pesticides Approved (www.bcpabd.com/list-of-pesticide.php) and it is advised to use this list to include the appropriate fungicides in a drop down to choose from which undoubtable will reduce the number of non-traceable products used.

The methodology of asking farmers questions however, served the purpose of understanding behaviour of farmers, their needs, bottlenecks and barriers of late blight control and provided information on the pesticides/fungicides used. These all support this baseline to be a solid starting point to introduce the late blight alert service.

Potato production

The average yield found in the baseline study was 31 tons/ha (Table 3.10). This yield was higher than the countries average of 19 tons/ha (2013; FAOSTAT) but somewhat below the expected 35 tons/ha for the Munshiganj district although sub-district Munshiganj Sadar had the highest yields, 34 tons/ha which was close to the expected yield. The Munshiganj district is known to have high yields which is suggested to be related to the good quality of seed potatoes used by farmers and the awareness of farmers to buy good quality of seed (Hoque & Sultana 2012).
Farmers in Munshiganj tend to cultivate more land with potato (3.4 ha/farmer) than other potato farmers in Bangladesh such as in the Rangpur area (1.6 ha/farmer) (Rabbani *et al.* 2010), but further study also in Rangpur is needed to quantify the difference. Farmers in Munshiganj also appear

relatively rich. Typically, seed potatoes make up 30 to 60% of the variable production costs (Azimuddin *et al.* 2009; Hossain *et al.* 2008; Rabbani *et al.* 2010) and such high costs at the start of the season are generally difficult to bear for small resource-poor farmers. However, farmers in Munshiganj indicated in informal discussions that they do not need credit for purchasing seed potatoes to start the potato production. A possible reason might be that Munshiganj is very close to the major market Dhaka so that the costs for transport are low and the sales of potatoes are less problematic than in more remote areas such as around Rangpur.

Control of late blight

Farmers considered late blight as the major problem but uncertain is whether this opinion has been motivated by the context of the survey (Table 3.12). However, this finding agrees with findings of Uddin *et al*. (2010). Only 10% of the farmers indicated to have faced serious infected fields and 21% medium infected fields with late blight. Late blight in Munshiganj is in general a mild disease compared to the Northern regions of Bangladesh (Figure 4.1). But, severe yield losses occur periodically with high incidences reported in the potato growing season of 2006-2007 when between 50% to almost 80% of the yield nationwide was lost (Dey *et al.* 2010). Field visits of Dutch participants in January 2016 identified late blight infections in all visited fields which certainly have resulted in yield loss. Lack of information on late blight is not considered a major obstacle for late blight control by Munshiganj farmers, but rather the quality of fungicides (Table 3.13). This is understandable because of three reasons. First, counterfeiting fungicides is a major problem in developing countries also in Bangladesh, where various generic, cheap but not-tested products from surrounding countries are on the market. Second, the genotyping study (section 3.2) showed that the prevailing late blight genotype in Munshiganj is the Metalaxyl resistant strain Blue 13. Metalaxyl containing products such as Ridomil MZ and Zhe Metalex are still preferentially used by farmers (Table 3.17) but little effective in controlling the prevailing Blue 13 late blight genotype. Third, a substantial number of farmers (50%) applied the Mancozeb containing preventive fungicide too late that is after late blight had been observed (Table 3.16). Subsequently, farmers see no or limited effects of the spray and relate that to, may be, the wrong reasons, such as low quality of fungicides for instance. We expect the effect of the Mancozeb containing preventive fungicide spay to improve when farmers follow the alert service.

Late blight was observed later in Sreenagar than in Gazaria or Munshiganj Sadar (Table 3.15) and in Sreenagar the least fungicide sprays were applied. These findings are in agreement with each other: the larger time span between planting and late blight observed in Sreenagar, the fewer times fungicides are applied and the larger time interval between sprays indicate that late blight pressure was lower in Sreenagar than the late blight pressure in Gazaria for instance. In Gazaria late blight pressure was the highest: late blight was on average observed earliest of all sub-districts, the highest number of applications was applied and the average spraying interval was the shortages of all sub-districts. The majority of the farmers in Gazaria also started with late blight control after the disease was observed (Table 3.16) and most farmers used preventive fungicides for control (Table 3.17). In the sub-district Gazaria, yields were also the lowest (Table 3.10). These findings indicate that late blight pressure differs between sub-districts but also that farmers' awareness on timely spraying fungicides differs per district which is reflected in yield differences between sub-districts.

The total number of growing days or the estimated number of late blight free growing days did not correlate with yield although one would expect that there is a relationship as a longer and disease free growing would increase yields. Early planting, that is before or around 15 November, is found to increase yield (Haque *et al.* 2013) as the number of late blight free growing days is increased. However, that result is not substantiated with findings of this baseline study.

Figure 4.1 Distribution of late blight disease of potato in Bangladesh (from Dey et al., 2010)

Costs of late blight control

The costs of fungicide products in the standard scenario are estimated at almost 7,000 BDT/ha (Table 3.19). The costs for pesticide applications have hardly increased over the past 8 years compared to finding of Hossain *et al*. (2008), where pesticide applications (2 to 3 applications) were 3,070 BDT/ha and only 1.6% of total variable costs. A field survey of the potato growing season 2008-2009 however, indicated that costs for pesticide products with on average nearly 7 fungicidal and 1.48 insecticidal sprays were approximately 7% of total variable costs in the Munshiganj district (Rabbani *et al.* 2010).
The additional scenario's indicate that increased spray volumes increase costs accordingly, as does an increased dosage. In practice, a combination of these options is probably applied to some extent by farmers.

Baseline outcome indicators

The use efficiency of N-fertilisers in this baseline study is slightly better (lower value) than previously found by Shahriar (2001) of 9.7 kg N/ton product. The N-fertiliser efficiency following the Fertilizer Recommendation Guide for potato (2012) varies between 1.5 to 6 depending on the soil fertility status according to the soil analysis (Table 4.1).

Table 4.1 The nitrogen fertiliser recommendations for different soil fertility statuses for a yield goal of 30 tons/ha ± 3.0 tons/ha (FRG 2012).

Soil analysis Interpretation	N-application (kg/ha)	N-fertilise use efficiency
Optimum	0-45	1.5
Medium	46-90	1.5 – 3
Low	91-135	3 – 4.5
Very low	136-180	4.5 – 6

The costs for pesticide applications (that is herbicides, insecticides and fungicides) by farmers were found to range from almost 2000 BDT/ha in 2007 (Hossain *et al.* 2008) to almost 3500 BDT/ha in 2009 (Azimuddin *et al.* 2009) to slightly more than 5000 BDT/ha in 2011 (Hoque & Sultana 2012), showing a steady increase in costs of pesticide use. The higher costs for fungicides found in the baseline survey are mainly related to the costs of an increased number of applications. The mentioned studies indicate that farmers applied pesticides 2 to 3 times, whereas the baseline study indicates 6 applications (Table 3.15) which number was subsequently used in the standard scenario. The costs for pesticides applied ranged from 1.5% (Hossain *et al.* 2008) to 1.9% (Azimuddin *et al.* 2009) to 5.3% (Hoque & Sultana 2012) of variable costs and are thus small compared to other costs components such as potato seed costs and labour costs (≈ 40% and 20% respectively). It may well be that the cost component “pesticide products” has increased as percentage of variable costs as farmers nowadays apply 6 fungicide sprays on average (Table 3.15).

The service to be introduced aims at the application of preventive active ingredients mainly and curative active ingredients only when farmers have inadequately followed the advice or when the service had some inaccuracies when weather data were not predicted adequately. When curative active ingredients are to be used they need to control late blight which means that in this region other curative active ingredients than Metalaxyl are needed.

4.7 Conclusions

The baseline study was done to describe and evaluate the state of the art of the potato production in the Munshiganj district of Bangladesh for the introduction of the late blight alert service to potato farmers. The study comprises information from different project activities in 2016 ranging from field trips, characterisation of the late blight genotypes prevailing in Munshiganj, a dedicated baseline survey carried out under potato farmers in Munshiganj, information from literature and from stakeholders in the potato value chain.

The conclusions of the baseline study with respect to the methodology used are:

- The baseline survey was performed in between the potato growing seasons and used the farmers' memory to answer the questions which may therefore be considered to have a more general character than answers for a specific potato production. This should be kept in mind when reading the results and conclusions.
- Using open questions on the fungicide products applied by farmers leads to difficulties and it is concluded that an appropriate drop down list must be used in surveys to come.
- The chosen methodology of interviewing farmers on their behaviour, needs, bottlenecks and barriers with respect to late blight control yielded very useful information which is a solid starting point to introduce the late blight alert service.

The conclusions of the baseline study with respect to the survey are that:

- Farmers have a great need to improved control of late blight.
- Farmers are eager to learn about improved strategies to control late blight.
- Late blight pressure may differ between sub-districts.
- Farmers' control practices slightly differ between sub-districts.
- The untimely spraying of preventive fungicides most likely contribute to yield losses although farmers are not aware of their malpractice.
- Farmers apply mainly curative Metalaxyl containing fungicides which have little/no effect on the control of the found Metalaxyl resistant strain of late blight in Munshiganj.
- Other options to reduce late blight related yield losses might be included as a package to reduce losses.
- The increasing costs for pesticide products stimulate farmers' interest in effective use of fungicides.

The conclusion of the baseline study with respect to the outcome indicators are that:

- The starting point for the different indicators shows high potential to be improved as the late blight alert service is introduced.

The need for the late blight alert service was clearly identified in this study. However, some potential bottlenecks have also been identified and which may be difficult to change or improve during the project period. The two most important pitfalls are:

- The availability and subsequently use of counterfeit fungicides may lead to disappointments by farmers when using the alert service with insufficient late blight control. As the service is costing money and not working due to counterfeit fungicides thrust is lost and adaption is stopped.
- The unavailability of an adequate fungicide package to control preventively and curatively late blight including the Metalaxyl resistant strain Blue 13, might compromise an effective introduction and effective use of the alert service.

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Annex I: List of Registered Agricultural Pesticides, Bio Pesticides & Public Health Pesticides in Bangladesh Approved

SL No	Common Name of Products	SL No	Trade Name of Products	Registration Number	Name of Registration Holder	Recommended Crops	Recommended Pests	Dosage rate/ha (ml/lt/gm/kg)
49	Mancozeb (64%) + Metalaxyl (8%)	103	AB Monoxil 72WP	AP-4624	ABS Agro Products	Potato	Late blight	2 g/L of water
43	Mancozeb	192	Acemezeb 80WP	AP-4706	Acme Pesticide Limited	Potato	Late blight	2 g/L of water
23	Dimethomorph (9%) + Mancozeb (60%)	1	Acrobat MZ	AP-353	BASF Bangladesh Limited	Potato, Tomato	Early, Late blight	2.00 kg
86	Phosphorous Acid	1	Actifos 400 SL	AP-2793	Active Crop Care Limited	Potato	Late blight	3 ml/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	74	Advance 72 WP	AP-2511	Advance Crop Care Limited	Potato	Late blight	2 g/L of water
43	Mancozeb	82	Afizeb 80 WP	AP-2154	Sundarban Agro Products	Potato	Late blight	2 g/L of water
43	Mancozeb	13	Agrizeb 80 WP	AP-603	Square Pharmaceuticals Limited	Potato	Late blight	2 g/L of water
43	Mancozeb	118	Agrofil M 45	AP-2487	Agro Business Support Limited	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	43	Agromil 72 WP	AP-1369	Agro Business Support Limited	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	86	Aidmeal 72 WP	AP-3116	Agro Aid International	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (4%)	51	Amagold 72 WP	AP-1682	Aama Green Care	Potato	Late blight	2 g/L of water
43	Mancozeb	187	Amazeb 80WP	AP-4701	Aman Enterprise	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	22	Amcomyl 72 WP	AP-808	Atherton Imbros Company Limited	Potato	Late blight	2 g/L of water
3	Azoxystrobin (20%) + Difenoconazole (12.5%)	1	Amistar Top	AP-2312	Syngenta Bangladesh Limited	Potato	Late blight	1 ml/L of water
43	Mancozeb	77	Ancozen 80 WP	AP-2149	A N Corporation	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (4%)	26	Antiblight MZ 72 WP	AP-969	National AgriCare Import & Export Ltd	Tomato, Potato	Early, Late blight	2 g/L of water
43	Mancozeb	151	Anto Zeb 80 WP	AP-3583	Antar Business International	Potato	Late blight	2 g/L of water
61	Propineb	1	Antracol 70 WP	AP-487	Bayer CropScience Limited	Potato	Late blight	2.47 kg
43	Mancozeb	113	Aqizeb 80 WP	AP-2482	Agri Business & Advisory Service	Potato	Late blight	2 g/L of water
43	Mancozeb	47	Ascozeb 80 WP	AP-1687	Assign Crop Care Limited	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (4%)	31	Ashameal 72 WP	AP-1030	Mimpex Agrochemicals Limited	Potato	Early, Late blight	2 g/L of water
43	Mancozeb	41	Ashazeb 80 WP	AP-1594	Asia Trade International	Potato	Late blight	2 g/L of water
55	Mancozeb (50%) + Fenamidone (10%)	2	Assurance 600 WG	AP-2532	Aranya Crop Care Limited	Potato	Late blight	2 g/L of water
43	Mancozeb	197	Astha 80WP	AP-4711	S T Trading Corporation	Potato	Late blight	2 g/L of water

43	Mancozeb	172	Autozeb 80WP	AP-4230	Auto Crop Care Limited	Potato	Late blight	2 g/L of water
43	Mancozeb	98	Avzeb 80 WP	AP-2467	Agrivision International	Potato	Late blight	2 g/L of water
43	Mancozeb	116	A-Zeb 80 WP	AP-2485	Aranya Crop Care Limited	Potato	Late blight	2 g/L of water
8	Bismerthiazol	1	Bactrol 20 WP	AP-2567	Surovi Agro Industries Limited	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	12	Baimyl 72 WP	AP-790	Bangladesh Agricultural Industries	Potato	Late blight	2 g/L of water
43	Mancozeb	25	Baizeb 80 WP	AP-859	Bangladesh Agricultural Industries	Potato	Late blight	2 g/L of water
46	Mancozeb (64%) + Cymoxanil (8%)	16	Baronto 72 WP	AP-3614	Cobra Land Care	Potato	Late blight	2 g/L of water
46	Mancozeb (64%) + Cymoxanil (8%)	10	Bentacyl 72 WP	AP-2519	Bengal Agro Chemicals Industries	Potato	Late blight	2 g/L of water
43	Mancozeb	46	BGM Special	AP-1685	Larsen Chemical Industries (Pvt) Ltd	Potato	Late blight	2 g/L of water
46	Mancozeb (64%) + Cymoxanil (8%)	5	Bicojan 72 WP	AP-1882	Bismillah Corporation Limited	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (4%)	56	Bicoril MZ 72 WP	AP-1686	Bismillah Corporation Limited	Potato	Late blight	2 g/L of water
43	Mancozeb	34	Bicozeb M-45 80 WP	AP-1076	Bismillah Corporation Limited	Potato	Late blight	2 g/L of water
43	Mancozeb	87	Blezeb 80 WP	AP-2159	Blessing Agrovet Industries Limited	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	88	B-Mil Glod 72 WP	AP-3118	Basic Agrovet	Potato	Late blight	2 g/L of water
43	Mancozeb	155	Bomdshell 80 WP	AP-3587	Sealand Agro Industries Limited	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	101	Boom 72WP	AP-4622	Lark International	Potato	Late blight	2 g/L of water
44	Mancozeb (63%) + Carbendazim (12%)	11	Bunker 75 WP	AP-2522	Marshal Agrovet Chemical Industries Ltd	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	61	Bycomil 72 WP	AP-1913	Byco Agro Chemicals	Potato	Late blight	2 g/L of water
43	Mancozeb	138	Byvin 80 WP	AP-3104	Krishan Agro Chemicals	Potato	Late blight	2 g/L of water
64	Pyraclostrobin (5%) + Metiram (55%)	1	Cabrio Top	AP-1770	BASF Bangladesh Limited	Potato	Late blight	1.50 g/L of water
44	Mancozeb (63%) + Carbendazim (12%)	9	Camamix 750 WP	AP-2167	ACI Limited	Potato	Late blight	2 g/L of water
44	Mancozeb (63%) + Carbendazim (12%)	6	Carbazeb 75 WP	AP-1931	Raven Aqua Agriculture Limited	Potato	Late blight	2 g/L of water
44	Mancozeb (63%) + Carbendazim (12%)	5	Carcozeb 75 WP	AP-1929	Sea Trade Fertilizer Limited	Potato	Late blight	2 g/L of water
44	Mancozeb (50%) + Carbendazim (25%)	30	Cash 75WS	AP-4712	Indofil Bangladesh Industries Private Ltd.	Potato	Late Blight	1.5 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	13	Censor MZ 72 WP	AP-795	Naboti Corporation Limited	Potato	Late blight	2 g/L of water
18	Copper hydroxide	1	Champion 77 WP	AP-354	Petrochem (Bangladesh) Limited	Potato, Tomato	Late blight	2 g/L of water
43	Mancozeb	110	Chemzeb 80 WP	AP-2479	Chemolimpex Agro Limited	Potato	Late blight	2 g/L of water
43	Mancozeb	104	Chotranash 80 WP	AP-2473	Sadik Agrochemicals Co.	Potato	Late blight	2 g/L of water
43	Mancozeb	105	Clorofil M 45	AP-2474	S M Agriculture Division	Potato	Late blight	2 g/L of water
44	Mancozeb (63%) + Carbendazim (12%)	12	Combine 75 WP	AP-2523	Cobra Land Care	Potato	Late blight	2 g/L of water
44	Mancozeb (63%) + Carbendazim (12%)	1	Companion	AP-664	Auto Crop Care Limited	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	4	Coromil MZ 72 WP	AP-446	Corbel International Limited	Potato	Late blight	2 g/L of water

43	Mancozeb	18	Corozeb 80 WP	AP-711	Corbel Chemical International Ltd.	Potato	Late blight	2 g/L of water
43	Mancozeb	7	Cozeb 80 WP	AP-448	Alpha Agro Limited	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	67	Crazy 72 WP	AP-2135	M S Agro Chemicals Company Ltd	Potato	Late blight	2 g/L of water
45	Mancozeb (12%) + Copper (30%)	1	Cuprofix 30 Dispers	AP-1887	Chens Crop-Science Bangladesh Ltd	Potato	Late blight	2 g/L of water
46	Mancozeb (64%) + Cymoxanil (8%)	2	Curzate M8	AP-1372	Petrochem Agro Industries Ltd.	Potato	Late blight	2 g/L of water
46	Mancozeb (64%) + Cymoxanil (8%)	19	Cycozeb Plus 72 WP	AP-3617	Digital Agricultural Industries Ltd	Potato	Late blight	2 g/L of water
16	Chlorothalonil	1	Deconil 500 EC	AP-2114	Haychem (Bangladesh) Limited	Potato	Late Blight	750 ml
19	Copper oxychloride (50%)	13	Delight 50 WP	AP-1675	ACI Formulations Limited	Potato	Late blight	2 g/L of water
43	Mancozeb	20	Dencozeb 80 WP	AP-718	Reximco Insecticides Limited	Potato	Late blight	2 g/L of water
46	Mancozeb (64%) + Cymoxanil (8%)	17	Dentacyl 72 WP	AP-3615	Sahjalal Agro Industries	Potato	Late blight	2 g/L of water
46	Mancozeb (64%) + Cymoxanil (8%)	25	Dentanil 72WP	AP-4250	Delta Agro Chemicals Limited	Potato	Late blight	2 g/L of water
46	Mancozeb (64%) + Cymoxanil (8%)	14	Desconil 72 WP	AP-3139	Desh Agro Services Co.	Potato	Late blight	2 g/L of water
43	Mancozeb	140	Deshzeb 80 WP	AP-3106	Desh Agro Services Co.	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	42	Dewmil 72 WP	AP-1368	D M International	Potato	Late blight	2 g/L of water
43	Mancozeb	157	Digicozeb 80 WP	AP-3589	Digital Crop Solution	Potato	Late blight	2 g/L of water
43	Mancozeb	133	Direl M 45	AP-3099	General Agro Chemicals Limited	Potato	Late blight	2 g/L of water
43	Mancozeb	12	Dithane M 45	AP-547	Bayer CropScience Limited	Potato	Early & Late blight	2.20 kg
49	Mancozeb (64%) + Metalaxyl (8%)	60	Doman 72 WP	AP-1766	Dreamland Agro Products	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	95	Easynet 80 WP	AP-3606	Nahar Agro International	Potato	Late blight	2 g/L of water
44	Mancozeb (63%) + Carbendazim (12%)	14	E-Carman 75 WP	AP-2525	Energy Agro Chemicals	Potato	Late blight	2 g/L of water
43	Mancozeb	42	Eco-M-45	AP-1596	Amco Agricultural Industries	Potato	Late blight	2 g/L of water
43	Mancozeb	186	EcoMan M-80WP	AP-4700	Eco Aid Limited	Potato	Late blight	2.00 kg
49	Mancozeb (64%) + Metalaxyl (4%)	52	Ecomyl 72 WP	AP-1595	Amco Agricultural Industries	Potato	Late blight	2 g/L of water
43	Mancozeb	4	Edcozeb 80 WP	AP-273	Sea Trade Fertilizer Limited	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	15	Edmeta 72 WP	AP-798	Nokon Limited	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	44	Emimix 72 WP	AP-1370	Eminence Chemical Industries Ltd	Potato	Late blight	2 g/L of water
61	Propineb	3	Etacol 70 WP	AP-2116	East West Crop Science Ltd	Potato	Late Blight	2 g/L of water
46	Mancozeb (64%) + Cymoxanil (8%)	4	Euromil 72 WP	AP-1867	Newlife Agro Chemicals	Potato	Late blight	2 g/L of water
43	Mancozeb	109	Eurozeb 80 WP	AP-2478	Euro Bangla Agricultural Ltd	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	17	Evamil 72 WP	AP-800	E H & Agrovet Limited	Potato	Late blight	2 g/L of water
43	Mancozeb	136	Everthane 80 WP	AP-3102	Evergreen Crop Care Limited	Potato	Late blight	2 g/L of water
43	Mancozeb	97	Exzeb 80 WP	AP-2466	Mary Gold Agro Science	Potato	Late blight	2 g/L of water

43	Mancozeb	40	E-Zeb 80 WP	AP-1500	Eon Agro Industries Limited	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	92	Fasal Gold 72 WP	AP-3603	Fasal Agro Formulations	Potato	Late blight	2 g/L of water
43	Mancozeb	84	Faulizeb 80 WP	AP-2156	Rajib Agro Chemicals Limited	Potato	Late blight	2 g/L of water
43	Mancozeb	90	Fetter 80 WP	AP-2162	Joary Agro	Potato	Late blight	2 g/L of water
78	Zineb	1	Fiesta Z-78	AP-805	Auto Crop Care Limited	Potato	Late blight	2 g/L of water
43	Mancozeb	10	Filthane M 45	AP-504	Agritech	Potato	Late blight	2 g/L of water
43	Mancozeb	19	Flowin HT	AP-712	Auto Crop Care Limited	Potato	Late blight	3.50 ml/L of water
43	Mancozeb	137	Forezeb 80 WP	AP-3103	Grow More Agro Science	Potato	Late blight	2 g/L of water
23	Dimethomorph (9%) + Mancozeb (60%)	2	Forum MZ	AP-2535	BASF Bangladesh Limited	Potato	Late blight	2 g/L of water
43	Mancozeb	50	Freshzeb 80 WP	AP-1691	Agro System Limited	Potato	Late blight	2 g/L of water
43	Mancozeb	131	F-Zeb 80 WP	AP-3097	FCI Agro Limited	Potato	Late blight	2 g/L of water
7	Benalaxyl (8%) + Mancozeb (64%)	1	Galben M	AP-374	FMC Chemical International AG	Potato, Tomato	Late blight	2 g/L of water
43	Mancozeb	128	Genezeb 80 WP	AP-2903	Genetica	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	91	Gilder 72 WP	AP-3602	T H Pesticide	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	94	Gmaxyl 72 WP	AP-3605	Gourab Industries Limited	Potato	Late blight	2 g/L of water
43	Mancozeb	8	Golden M 45	AP-464	Atherton Imbros Company Limited	Potato	Late blight	2 g/L of water
44	Mancozeb (63%) + Carbendazim (12%)	7	Goldhope 75 WP	AP-2165	Mimpex Agrochemicals Limited	Potato	Late blight	2 g/L of water
43	Mancozeb	86	Goldizem 80 WP	AP-2158	Golden Agro Chemicals	Potato	Late blight	2 g/L of water
43	Mancozeb	58	Goldman 80 WP	AP-1894	Mary Gold Agro Science	Potato	Late blight	2 g/L of water
43	Mancozeb	30	Goldzeb 80 WP	AP-975	Agrimax Bangladesh Limited	Potato	Early, Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	85	Green Mil 72 WP	AP-3115	Green Harvest Limited	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	7	Greenland 72 WP	AP-604	Vegan Agro Limited	Potato	Late blight	2 g/L of water
43	Mancozeb	106	Gulf MZ 80 WP	AP-2475	Gulf Fertilizer & Chemicals Limited	Potato	Late blight	2 g/L of water
19	Copper oxychloride (50%)	16	Gunner 50 WP	AP-1877	Global Agrovet Limited	Potato	Late blight	0.8-1.0 kg
43	Mancozeb	119	Happy 80 WP	AP-2488	Aama Green Care	Potato	Late blight	2 g/L of water
43	Mancozeb	15	Haymancozeb 80 WP	AP-610	Haychem (Bangladesh) Limited	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	8	Haymaxyl MZ 72 WP	AP-611	Haychem (Bangladesh) Limited	Potato	Late blight	2 g/L of water
26	Pyraclostrobin (6.7%) + Dimethomorph (12%)	1	Headline Team	AP-4188	BASF Bangladesh Limited	Potato	Late blight	2.5 g/L of water
49	Mancozeb (64%) + Metalaxyl (4%)	57	Helen 72 WP	AP-1692	Desh Pesticides	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	89	Hixyl 72 WP	AP-3019	Hazi Abdul Hakim Sawdagor	Potato	Late blight	2 g/L of water
43	Mancozeb	99	Hizeb 80 WP	AP-2468	Hazi Abdul Hakim Sawdagor	Potato	Late blight	2 g/L of water
18	Copper hydroxide	3	Hydrocob 77 WP	AP-792	Asia Trade International	Potato	Late blight	3.50 g/Lof water

43	Mancozeb	195	Impala 75WP	AP-4709	Auto Crop Care Limited	Potato	Late blight	2 g/L of water
43	Mancozeb	3	Indofil M 45	AP-272	Auto Crop Care Limited	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (4%)	30	Ipromil 72 WP	AP-977	A M Traders	Potato	Early, Late blight	2 g/L of water
43	Mancozeb	78	Iprothane M-45	AP-2150	A M Traders	Potato	Late blight	2 g/L of water
38	Iprodione (17.5%) + Carbendazim (8.5%)	1	Iprozim 26 WP	AP-1355	Oroni International Limited	Potato	Late blight	2 g/L of water
43	Mancozeb	59	I-Then M-45 80 WP	AP-1896	Bengal Agro Chemical Industries	Potato	Late blight	2 g/L of water
43	Mancozeb	51	I-Zeb 80 WP	AP-1693	Integrated Crop Solution Bangladesh	Potato	Late blight	2 g/L of water
43	Mancozeb	67	Jazz 80 WP	AP-2001	Syngenta Bangladesh Limited	Potato	Late blight	2 g/L of water
43	Mancozeb	36	Kafa 80 WP	AP-1362	Intefa	Potato	Late blight	2 g/L of water
43	Mancozeb	85	Kazizeb 80 WP	AP-2157	S K Agro Chemicals	Potato	Late blight	2 g/L of water
43	Mancozeb	37	Kencozeb M-45	AP-1373	S I Agro International	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	34	King Meal 72 WP	AP-1087	King Tech Corporation Bangladesh	Potato	Late blight	2 g/L of water
43	Mancozeb	29	Kinmazeb 80 WP	AP-973	Omnichem Limited	Potato	Early, Late blight	2 g/L of water
43	Mancozeb	38	Kusum 80 WP	AP-1374	Crop Protection & Care Center	Potato	Late blight	2 g/L of water
46	Mancozeb (64%) + Cymoxanil (8%)	8	Larconil 72 WP	AP-2169	Larsen Chemicals Industries (Pvt) Ltd	Potato	Late blight	2 g/L of water
61	Propineb	4	Larneb 70 WP	AP-2117	Larsen Chemical Industries (Pvt) Ltd	Potato	Late Blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	96	Laxoma 72 WP	AP-3607	Runner Agro Products Ltd	Potato	Late blight	2 g/L of water
50	Mancozeb (48%) + Metalaxyl (6%) + Chlorathalonil (18%)	1	Laxyl 72 WP	AP-3577	Avino Trading	Potato	Late blight	2 g/L of water
64	Pyraclostrobin (5%) + Metiram (55%)	2	Legasus 60 WG	AP-3140	BASF Bangladesh Limited	Potato	Late blight	3 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	87	Lias 72 WP	AP-3117	Surjo Products	Potato	Late blight	2 g/L of water
43	Mancozeb	156	Lilizeb 80 WP	AP-3588	Lily Traders	Potato	Late blight	2 g/L of water
43	Mancozeb	11	LM 45	AP-526	The Limit Agroproducts Limited	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	41	Logon 72 WP	AP-1367	Crop Protection & Care Center	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	93	M K Best 72 WP	AP-3604	K E Bangladesh Limited	Potato	Late blight	2 g/L of water
43	Mancozeb	63	Magnate 80 WP	AP-1922	Rahman Pesticide & Chemicals Co.	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	84	Majurmil 72 WP	AP-3114	New Sonali Bandar	Potato	Late blight	2 g/L of water
43	Mancozeb	134	Mamcoz 80 WP	AP-3100	Aartessa Trading	Potato	Late blight	2 g/L of water
44	Mancozeb (63%) + Carbendazim (12%)	8	Mancarb 72 WP	AP-2166	East West Crop Science Limited	Potato	Late blight	2 g/L of water
44	Mancozeb (63%) + Carbendazim (12%)	13	Mancodazim Plus 75 WP	AP-2524	Unique Agro Technology Limited	Potato	Late blight	2 g/L of water
46	Mancozeb (64%) + Cymoxanil (8%)	18	Manconil 72 WP	AP-3616	Runner Agro Products Ltd	Potato	Late blight	2 g/L of water
44	Mancozeb (63%) + Carbendazim (12%)	15	Mancor 75 WP	AP-2526	Corbel Chemical International Ltd.	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	38	Mancosil 72 WP	AP-1363	Square Pharmaceuticals Limited	Potato	Late blight	2 g/L of water

43	Mancozeb	31	Mancothane 80 WP	AP-1037	Agribusiness International	Potato	Late blight	2 g/L of water
43	Mancozeb	23	Mancovit 80 WP	AP-787	Haychem (Bangladesh) Limited	Potato	Late blight	2 g/L of water
43	Mancozeb	52	Mancoz 80 WP	AP-1694	Unicrop Protection Limited	Potato	Late blight	2 g/L of water
43	Mancozeb	102	Mancozim 80 WP	AP-2471	Agrinet Crop Care Bangladesh	Potato	Late blight	2 g/L of water
43	Mancozeb	22	Manner M-45	AP-786	SAMP Limited	Potato	Late blight	2 g/L of water
43	Mancozeb	183	Manostar 80WP	AP-4241	Pace Import Export Limited	Potato	Late blight	2 g/L of water
43	Mancozeb	79	Mansis 80 WP	AP-2151	Symbiosis Technology	Potato	Late blight	2 g/L of water
43	Mancozeb	135	Maricozeb 80 WP	AP-3101	Mary Gold Agro Science	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	40	Matco 72 WP	AP-1366	Auto Crop Care Limited	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	98	Max Gold 72 WP	AP-3609	Avino Trading	Potato	Late blight	2 g/L of water
43	Mancozeb	111	Mcozeb 80 WP	AP-2480	M H Crop Care	Potato	Late blight	2 g/L of water
43	Mancozeb	9	McZidan 80 WP	AP-465	McDonald Bangladesh (Pvt) Limited	Potato	Late blight	2 g/L of water
43	Mancozeb	33	Media 80 WP	AP-1054	Global Agrovet Limited	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (4%)	54	Medumyl 72 WP	AP-1628	Marshal Agrovet Chemical Industries Ltd	Potato	Late blight	2 g/L of water
43	Mancozeb	32	Meena 80 WP	AP-1053	East West Chemicals Limited	Potato	Late blight	2 g/L of water
63	Propineb (70%) + Iprovalicarb	1	Melody Duo 66.8 WP	AP-501	Bayer CropScience Limited	Potato	Late blight	2 g/L of water
43	Mancozeb	190	Mend M-45	AP-4704	Miya Enterprise	Potato	Late blight	2 g/L of water
43	Mancozeb	103	Mentor 80 WP	AP-2472	Classic Agrovet Limited	Potato	Late blight	2 g/L of water
43	Mancozeb	45	Merry 80 WP	AP-1683	Valent Tech Limited	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	72	Meta Phyto 72 WP	AP-2509	S S Vision Limited	Potato	Late blight	2 g/L of water
43	Mancozeb	149	Metador 80 WP	AP-3581	Great Agro Care	Potato	Late blight	2 g/L of water
53	Metalaxyl	3	Metagold 25 WP	AP-1695	Blessing Agrovet Industries Limited	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (4%)	28	Metalman 72 WP	AP-972	MAP Agro Industries Limited	Potato	Early, Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (4%)	27	Metamil Special 72 WP	AP-971	Aranya Crop Care Limited	Potato	Early, Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	24	Metaplus 72 WP	AP-919	Rahman Pesticide & Chemicals Co.	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	5	Metaril 72 WP	AP-447	Auto Crop Care Limited	Potato	Late blight	2 g/L of water
53	Metalaxyl	1	Metataf 25 WP	AP-417	Auto Crop Care Limited	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	16	Metazeb 72 WP	AP-799	Mamun Agro Products Limited	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	20	Mexzil 72 WP	AP-803	Eon Agro Industries Limited	Potato, Tomato	Early, Late blight	2 g/L of water
46	Mancozeb (64%) + Cymoxanil (8%)	27	Micra 72WP	AP-4714	Auto Crop Care Limited	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	90	Mita Gold 72 WP	AP-3120	Tasin Agro Science	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	70	M-Metalaxyl 72 WP	AP-2138	M H Crop Care	Potato	Late blight	2 g/L of water

43	Mancozeb	154	Mohona 80 WP	AP-3586	CPC Trading	Potato	Late blight	2 g/L of water
73	Cymoxanil (2.74%) + Tri Basic Copper Sulphate (26.95%)	1	Moltovin 29.69SC	AP-3935	Petrochem Bangladesh Limited	Potato	Late blight	3 ml/L of water
49	Mancozeb (64%) + Metalaxyl (4%)	29	Monarch 72 WP	AP-976	MB Agro Products Limited	Potato	Early, Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	102	Monfil 72WP	AP-4623	Miya Enterprise	Potato	Late blight	2 g/L of water
43	Mancozeb	48	Monozeb 80 WP	AP-1689	Mosco Marketing Company	Potato	Late blight	2 g/L of water
46	Mancozeb (64%) + Cymoxanil (8%)	12	More 72 WP	AP-2521	McDonald Crop Care Limited	Potato	Late blight	2 g/L of water
43	Mancozeb	17	Mosum M 80 WP	AP-626	Axil Life Sciences Limited	Potato	Late blight	2 g/L of water
43	Mancozeb	83	Mouzeb 80 WP	AP-2155	Mou International	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	65	Mozar M 72 WP	AP-2133	Active Crop Care Limited	Potato	Late blight	2 g/L of water
43	Mancozeb	182	MuZeb 80WP	AP-4240	MU Trading Corporation	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	64	Mycoguard 72 WP	AP-2132	Star Particle Board Ltd	Potato	Late blight	2 g/L of water
43	Mancozeb	66	Naczeb 80 WP	AP-1928	National AgriCare Import & Export Ltd	Potato	Late blight	2 g/L of water
43	Mancozeb	188	Nasa 80WP	AP-4702	Imple	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	18	Nazah 72 WP	AP-801	Intefa	Potato	Late blight	2 g/L of water
43	Mancozeb	108	Netcozeb 80 WP	AP-2477	Agronet Crop Scence Limited	Potato	Late blight	2 g/L of water
43	Mancozeb	74	Nikizeb 80 WP	AP-2146	Anika Enterprise	Potato	Late blight	2 g/L of water
43	Mancozeb	160	Nishazeb 80 WP	AP-3592	National Green Care	Potato	Late blight	2 g/L of water
43	Mancozeb	100	Nokozeb 80 WP	AP-2469	Nokon Limited	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	9	Nuben 72 WP	AP- 612	ACI Formulations Limited	Potato	Late blight	2 g/L of water
43	Mancozeb	55	Onezeb 80 WP	AP-1700	One Agro Concern	Potato	Late blight	2 g/L of water
43	Mancozeb	27	Onthane 80 WP	AP-965	One Agro Concern	Potato, Tomato	Early, Late blight	2 g/L of water
43	Mancozeb	54	Oppose 80 WP	AP-1698	Agro Continent Bangladesh	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	23	Orion 72 WP	AP-863	Maitri Agro Industries	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	39	Oromil 72 WP	AP-1364	Oroni International Limited	Potato	Late blight	2 g/L of water
43	Mancozeb	35	Orozeb 80 WP	AP-1363	Oroni International Limited	Potato	Late blight	2 g/L of water
43	Mancozeb	88	Orzeb 80 WP	AP-2160	Orbit Agro Industries	Potato	Late blight	2 g/L of water
19	Copper oxychloride (50%)	7	Oxicob 50 WP	AP-791	Asia Trade International	Potato	Late blight	3.50 g/L of water
19	Copper oxychloride (50%)	3	Oxivit 50 WP	AP-616	SAM Agro Chemical	Potato	Late blight	3.50 kg
19	Copper oxychloride (50%)	21	Oxycol 50 WP	AP-3142	Lorota International	Potato	Late blight	2 g/L of water
44	Mancozeb (63%) + Carbendazim (12%)	20	Pafman 750 WP	AP-2531	PAFS Agro International Co.	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	63	Papa 72 WP	AP-2131	Supreme Seed Company	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	83	Paramil 72 WP	AP-3113	Pace Import Export Limited	Potato	Late blight	2 g/L of water

18	Copper hydroxide	5	Parasol 77 WP	AP-1360	Eminence Chemical Industries Ltd	Potato	Late blight	2 g/L of water
43	Mancozeb	2	Pencozeb 80 WP	AP-242	Shetu Pesticides Limited	Potato	Late blight	2.24 kg
43	Mancozeb	49	Percozeb 80 WP	AP-1690	Perfect Agro Care	Potato	Late blight	2 g/L of water
19	Copper oxychloride (50%)	11	Pipertox 50 WP	AP-1057	Agribusiness International	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	10	Polyman 72 WP	AP-613	Alpha Agro Limited	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	66	Polymer 72 WP	AP-2134	Siraj Agro International	Potato	Late blight	2 g/L of water
54	Metiram complex	1	Polyram DF	AP-206	BASF Bangladesh Limited	Potato	Late blight	2.00 kg
49	Mancozeb (64%) + Metalaxyl (8%)	11	Popular 72 WP	AP-614	Global Agrovet Limited	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (4%)	50	Pure Mil 72 WP	AP-1503	Pure Home	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	37	Putamil 72 WP	AP-1350	Prime Agro Limited	Potato	Late blight	2 g/L of water
43	Mancozeb	101	Putazeb 80 WP	AP-2470	Prime Agro Limited	Potato	Late blight	2 g/L of water
43	Mancozeb	107	Rafizeb 80 WP	AP-2476	Ashrafi Agro Science	Potato	Late blight	2 g/L of water
43	Mancozeb	125	Rainazeb 80 WP	AP-2494	Raina Associates	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	21	Rancozeb MZ 72 WP	AP-804	N S Group	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	35	Rapid 72 WP	AP-1092	SAMP Limited	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	76	Recometa 72 WP	AP-2513	Raina Associates	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	77	Redxyl Gold 72 WP	AP-2514	Bengal Agro Chemical Industries	Potato	Late blight	2 g/L of water
43	Mancozeb	68	Rekazeb 80 WP	AP-2140	T H Pesticides	Potato	Late blight	1.5 g/L of water
44	Mancozeb (63%) + Carbendazim (12%)	24	Rekazin 75 WP	AP-3254	T H Pesticides	Potato	Late blight	2 g/L of water
44	Mancozeb (63%) + Carbendazim (12%)	3	Relux 75 WP	AP-1696	Crop Protection & Care Center	Potato	Late blight	2 g/L of water
43	Mancozeb	184	Rescozeb 80WP	AP-4242	Rural Agro Science	Potato	Late blight	2 g/L of water
43	Mancozeb	53	Rexizeb 80 WP	AP-1697	Reximco Insecticides Limited	Potato	Late blight	2 g/L of water
46	Mancozeb (64%) + Cymoxanil (8%)	13	Ricomil 72 WP	AP-3138	Rico Agrovet	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (4%)	33	Ridomil Gold MZ 68 WG	AP-1075	Syngenta Bangladesh Limited	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	73	Rimeal 72 WP	AP-2510	Jony Enterprise	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	68	R-Metalix 72 WP	AP-2136	Bengal Agro Chemical Industries	Potato	Late blight	2 g/L of water
16	Chlorothalonil	2	Rotanil 500 SC	AP-2701	Agro Arena Associates	Potato	Late blight	2 g/L of water
43	Mancozeb	112	Rozeb 80 WP	AP-2481	Roza Agro	Potato	Late blight	2 g/L of water
43	Mancozeb	153	S N Zeb 80 WP	AP-3585	S N S Agro Tech	Potato	Late blight	2 g/L of water
43	Mancozeb	148	Sahzeb 80 WP	AP-3580	Sahjalal Agro Industries	Potato	Late blight	2 g/L of water
43	Mancozeb	130	Saila 80 WP	AP-3096	Swazis International	Potato	Late blight	2 g/L of water
3	Azoxystrobin (20%) + Difenoconazole (12.5%)	29	Salvation 32.5SC	AP-4654	Haychem (Bangladesh) Limited	Potato	Late blight	1 ml/L of water

46	Mancozeb (64%) + Cymoxanil (8%)	9	Sanil 72 WP	AP-2518	Sreejoni Agro Chemicals	Potato	Late blight	2 g/L of water
16	Chlorothalonil	3	Satez 50SC	AP-4719	Sonali Agro Crop care	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (4%)	32	Sazid 72 WP	AP-1049	Reximco Insecticides Limited	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	104	SB-Zeb 72WP	AP-4625	SB Crop Care Industries Ltd.	Potato	Late blight	2 g/L of water
43	Mancozeb	150	SB-Zeb 80 WP	AP-3582	S B Crop Care Industries Ltd	Potato	Late blight	2 g/L of water
19	Copper oxychloride (50%)	27	Seachloride 50WP	AP-4620	Sealand Agro Industries Ltd.	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (4%)	55	Seamodil 72 WP	AP-1684	Sealand Agro Industries Limited	Potato	Late blight	2 g/L of water
8	Sulphur	53	Seaovit 80 WG	AP-1267	Sea Trade Fertilizer Limited	Potato	Late blight	2 g/L of water
43	Mancozeb	152	Seazeb 80 WP	AP-3584	Sea Trade Fertilizer Limited	Potato	Late blight	2 g/L of water
43	Mancozeb	89	Secozeb 80 WP	AP-2161	Sun Seed Pesticides	Potato	Late blight	2 g/L of water
55	Mancozeb (50%) + Fenamidone (10%)	1	Secure 600 WG	AP-628	Bayer CropScience Limited	Potato	Late blight	1 g/L of water
43	Mancozeb	81	Security 80 WP	AP-2153	Croplife Agro Chemicals Ltd	Potato	Late blight	2 g/L of water
43	Mancozeb	139	Seedman 80 WP	AP-3105	Seed Link Enterprise	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (4%)	25	Seemland 68 WP	AP-968	Shetu Pesticides Limited	Tomato, Potato	Early, Late blight	2 g/L of water
78	Zineb	2	Sentra Z 78	AP-4725	Auto Crop Care Limited	Potato	Late blight	2 g/L of water
43	Mancozeb	80	Shield 75 WDG	AP-2152	Haychem (Bangladesh) Limited	Potato	Late blight	2 g/L of water
43	Mancozeb	16	Shinmazeb 80 WP	AP-615	Petrochem (Bangladesh) Limited	Potato	Late blight	2 g/L of water
43	Mancozeb	96	Siamzeb 80 WP	AP-2465	Siam Crop Care	Potato	Late blight	2 g/L of water
43	Mancozeb	64	Sinewzeb 80 WP	AP-1923	Safi Agro	Potato	Late blight	2 g/L of water
43	Mancozeb	61	Sinozeb 80 WP	AP-1903	Supreme Seed Company	Potato	Late blight	2 g/L of water
43	Mancozeb	158	Skyzeb 80 WP	AP-3590	New Sonali Krishi Sheba Industries	Potato	Late blight	2 g/L of water
43	Mancozeb	65	Smartzeb 80 WP	AP-1925	Smart Agrovet	Potato	Late blight	2 g/L of water
43	Mancozeb	147	Sonalizeb 80 WP	AP-3579	New Sonali Bhanar	Potato	Late blight	2 g/L of water
46	Mancozeb (64%) + Cymoxanil (8%)	23	Sondhi 72WP	AP-4248	Indofil Bangladesh Industries Private Ltd	Potato	Late blight	2 g/L of water
46	Mancozeb (64%) + Cymoxanil (8%)	7	Sprinter 72 WP	AP-1899	Mahin Enterprise Limited	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (4%)	58	Standard Gold 72 WP	AP-1699	Standard Yes Company	Potato	Late blight	2 g/L of water
43	Mancozeb	62	Sukria 80 WP	AP-1920	ACE Farming Solutions	Potato	Late blight	2 g/L of water
43	Mancozeb	6	Suncozeb 80 WP	AP-352	Shetu Corporation Limited	Potato, Tomato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (4%)	53	Sundari 72 WP	AP-1610	Smart Agrovet	Potato, Tomato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	1	Sundomil 72 WP	AP-394	Shetu Corporation Limited	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (4%)	45	Sundomil Plus 68 WP	AP-1375	Oroni International Limited	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	14	Sunmil MZ 72 WP	AP-797	Sun Seed Pesticides	Potato	Late blight	2 g/L of water

46	Mancozeb (64%) + Cymoxanil (8%)	1	Sunoxanil 72 WP	AP-796	McDonald Bangladesh (Pvt) Limited	Potato	Late blight	2 g/L of water
43	Mancozeb	141	Sur 80 WP	AP-3107	Surjo Products	Potato	Late blight	2 g/L of water
43	Mancozeb	161	T.Zeb 80 WP	AP-3593	Tajarat Agro Industries Ltd	Potato	Late blight	2 g/L of water
2	Azoxystrobin (20%) + Cyproconazole (8%)	2	Tared 280 SC	AP-3613	Intefa	Potato	Late blight	0.5 ml/L of water
62	Propineb (70%) + Cymoxanil (6%)	1	Temper M-76 WP	AP-1898	Mahin Enterprise Limited	Potato	Late blight	2 g/Lof water
43	Mancozeb	189	Ticozeb 80WP	AP-4703	Square Pharmaceuticals Limited	Potato	Late blight	2 g/L of water
65	Quardartary Ammonium	1	Timsen	AP-806	Eon Agro Industries Limited	Potato	Late blight	1 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	82	T-Max 72 WP	AP-3112	Green Cross Agro Chemicals	Potato	Late blight	2 g/L of water
43	Mancozeb	171	T-Mitra 80WP	AP-3911	Green Cross Agro Chemicals	Potato	Late blight	2 g/L of water
46	Mancozeb (64%) + Cymoxanil (8%)	22	T-Mughdha 72WP	AP-3909	H P Distribution	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	75	Topcil 72 WP	AP-2512	Agrivision International	Potato	Late blight	2 g/L of water
19	Copper oxychloride (50%)	9	Topgun 50 DF	AP-974	Global Agrochemicals Limited	Potato, Tomato	Early, Late blight	2 g/L of water
61	Propineb	2	Top-Notch 70 WP	AP-2115	Haychem (Bangladesh) Limited	Potato	Late Blight	2 g/L of water
43	Mancozeb	44	Tyzeb 80 WP	AP-1631	Sweet Agrovet Limited	Potato	Late blight	2 g/L of water
44	Mancozeb (63%) + Carbendazim (12%)	10	Tyzeb Gold 75 WP	AP-2168	Sweet Agrovet Limited	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	6	Unilux 72 WP	AP-452	United Phosphorus (Bangladesh) Ltd	Potato	Late blight	2 g/L of water
43	Mancozeb	21	Uthane 80 WP	AP-785	United Phosphorus (Bangladesh) Ltd	Potato	Late blight	2 g/L of water
43	Mancozeb	191	Vicozeb 80WP	AP-4705	Agro Vim Limited	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	3	Vitamyl 72 MZ	AP-445	Shetu Pesticides Limited	Potato	Late blight	2 g/L of water
43	Mancozeb	132	Vizeb 80 WP	AP-3098	Green View Bangladesh	Potato	Late blight	2 g/L of water
43	Mancozeb	14	Vondozeb 42 SC	AP-608	Naafco (Private) Limited	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	19	Way 72 WP	AP-802	Green View Bangladesh	Potato	Late blight	2 g/L of water
18	Copper hydroxide	4	Win 77 WP	AP-1119	Alpha Agro Limited	Potato	Late blight	2 g/L of water
43	Mancozeb	159	Winzeb 80 WP	AP-3591	Agro Winner Limited	Potato	Late blight	2 g/L of water
46	Mancozeb (64%) + Cymoxanil (8%)	6	Xtramil 720 WP	AP-1885	ACI Formulations Limited	Potato	Late blight	2 g/L of water
43	Mancozeb	43	Y-thene M 45	AP-1626	Marshal Agrovet Chemical Industries Ltd	Potato	Late blight	2 g/L of water
27	Ametoctradin (30%) + Dimethomorph (22.5%)	1	Zampro DM	AP-4189	BASF Bangladesh Limited	Potato	Late blight	1.6 ml/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	69	Zee-Mil 72 WP	AP-2137	Jareer Enterprise	Potato	Late blight	2 g/L of water
49	Mancozeb (64%) + Metalaxyl (8%)	2	Zhe Metalex 72 WP	AP-412	Sea Trade Fertilizer Limited	Potato	Late blight	2 g/L of water
53	Metalaxyl	2	Zhetalux 25 WP	AP-1371	Sea Trade Fertilizer Limited	Potato	Late blight	2 g/L of water
43	Mancozeb	1	Nemispore 80 WP	AP-166	ACI Formulations Limited	Potato	Late, Early blight	2.50 kg

Annex II: Fertilizer Recommendation Guide: Root and Tuber Crops: Potato (*Solanum tuberosum*) (FRG 2012)

	Nutrient recommendation (kg/ha)							Manure (ton/ha)	
Soil analysis Interpretation	N	P	K	S	Mg	Zn	B	Cowdung	Poultry manure
Optimum	0-45	0-10	0-45	0-5	-	-	-	5	3
Medium	46-90	11-20	46-90	6-10	0-5	0-2	0-0.5	5	3
Low	91-135	21-30	91-135	11-15	6-10	3-4	0.6-1.0	5	3
Very low	136-180	31-40	136-180	16-20	11-15	5-5	1.1-1.5	5	3

Method of application:

1. All of organic manure, phosphorus, sulphur, magnesium, zinc and boron and half of the nitrogen and potassium should be applied as basal during final preparation
2. Remaining half nitrogen and potassium should be applied as side dressing at 30-50 days after planting during earthing up operation.