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WAGENINGEN UR
For quality of life

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Photo cover: Annette Pronk

Contents

Preface and acknowledgement

This baseline survey on the potato cultivation practises in Southern Shan State, the major potato growing area Myanmar, is one of a number of assignments commissioned by the Embassy of the Kingdom of Netherlands in close cooperation with the Netherlands Enterprise Agency (Rijksdienst van Ondernemend Nederland (RVO) to initiate, develop and give a head start to the potato value chain in preparation of the Public Private Partnership "*Potato value chain development to secure healthy diverse food in Myanmar*". We like to thank the Myanmar's Agricultural Counsellor of the Netherlands, Mr. G. Westenbrink, for initiating this survey, his interest in the ongoing survey and his support for the field day.

The present survey would not have been possible without the great support of Mr. K. Jackson who made himself available to Dutch delegates travelling to Myanmar and was instrumental in establishing the necessary contacts with representatives of the Department of Agriculture (DOA) in Taunggyi, local township officers, and the Paoh and Danu communities. It was through his efforts that the long term visit of the students Koen Minderhoud and Machiel Goosen in the region turned out that well. In particular we thank the Paoh leader Khun Sun OO for providing housing, transport, cooking and translating by assigning Khun Chit Leal to the project. Koen and Machiel appreciated his help and they enjoyed the welcome cultural experiences he and Khun Sun OO offered. Furthermore, the Danu representative and chairman of the Heho Potato Association U Chan Htwe helped selecting farmers for the project in the Heho region. His involvement shows as he ordered seed potatoes already from the Netherlands. Thanks to the care of May Thazin Phoo and Nangphungengehtun Nang of the DOA, the survey includes the final harvest of farmers in Heho despite planting and thus harvest was later than initial anticipated. Their investment and expert knowledge on the potato cultivation in the region gave the project a head start which enormously enriched the results.

Finally, we thank all farmers offering us opportunities to collect information and making time to answer so many questions. Their cooperative attitude to share insights in their potato cultivation both successes and bottlenecks, their patience with the translation, misunderstandings and many clarifying questions, were heart-warming. The large turn-out on the field day showed their involvement and eagerness to learn from displayed activities.

This baseline survey undoubtable contributes to a prosperous development for all who are active in the Myanmar potato value chain. We believe this survey offers significant opportunities to the development of a successful potato sector in Myanmar.

Summary

In August 2015 – April 2016 a baseline survey on potato production in Myanmar has been carried out by 2 experts of Wageningen UR and 2 students of the Aeres Group Dronten, together with many stakeholders in the potato sector in Myanmar. The objectives of the baseline study are:

- To provide detailed information on all aspects of potato production, in 2 regions in Southern Shan State, by intensive monitoring of local production practices of 30-40 potato farmers, from seed quality and soil preparation until harvest and marketing.
- To demonstrate the importance of seed quality in a field experiment where small plots of seed potatoes, gathered from each participating farmer, have been planted and grown on one demo field under equal conditions.
- To perform a yield gap analysis for actual yields of potatoes in both regions, giving insight in attainable yields based on good practices and local climate conditions.
- To identify so called "Quick Wins" for potato farmers; practical advices for easily improvement of different aspects of potato production, leading to a better performance on yield and quality.

This baseline survey is one of the so called fast track activities proposed during the Netherlands potato mission to Myanmar early 2015. The mission's main objective was to scope the possibility of a Myanmar – Netherlands Public Private Partnership Programme that aims to support the development of a strong, sustainable and competitive potato sector in Myanmar. This public-private potato program has been worked out and approved and is expected to start in the second half of 2016 and end in December 2020. Meanwhile it was decided to start with a number of fast track activities to keep things going and to facilitate the preparation and establishing of a long term public-private Netherlands-Myanmar potato program. In the course of 2015-2016 the following potato projects have been carried out:

- Organizing a mission of Myanmar delegates to study the potato production chain in the Netherlands.
- Preparing a proposal for a 4-year PPP potato program for the Dutch Topsector Agri&Food.
- Providing a baseline survey / quick wins of potato production in Myanmar (this report).
- Setting up a capacity building program to train 1000 potato farmers.
- Organizing a mission on developing a small scale processing unit in Myanmar by a Dutch expert.

The results of the baseline survey are of great importance for the other potato projects, as they provide detailed information on existing, local potato production practices, making clear from where to start.

The baseline survey was carried out in 2 regions in Southern Shan State by 2 students of CAH Dronten, who stayed in Myanmar from August – November, under supervision of 2 experts of Wageningen UR. In Heho 9 potato growers and in Naung Ta Yar 24 growers were selected to participate in the survey. Each farmer was visited up to six times during the growing season and farmers were interviewed using a detailed potato production questionnaire. Besides gathering data through interviews, additional data were gathered by performing field observations. In this way a lot of basic information became available on seed quality, soil preparation, planting density, fertilization, crop protection, irrigation, harvesting methods, etc. From the field observations we learned about differences in growth vigour, pests and diseases infestations and yield performances.

From earlier visits to Myanmar, poor seed quality and limited availability of modern varieties were mentioned as most important areas of interest. On the demonstration field on seed quality different varieties of seed stock from farmers of both regions were compared under equal field conditions. Before planting the seed quality of each origin was classified. Many seed stocks were infected to a certain extend with pests (tuber moth) and diseases like Silver scurf. The variation in yield performance was high, for instance yields of the most grown variety Kurfi Jyoti varied between 3 and 24 tons per ha, with an average of 11 tons per ha.

Based on the number of growth days, climate conditions and local production circumstances, model calculations have been carried out to estimate yield performances in both regions in comparison to the actual yields. In Naung Ta Yar the actual average yield was 18 tons/ha, whereas the modelling results indicate that 42 tons/ha can be obtained. In Heho 15 tons/ha fresh potatoes was measured. The obtainable yield was calculated at 54 tons/ha.

The baseline survey produced many recommendations for the short term (quick wins) and the longer term. The most important Quick wins are:

- Making an open air, moth-free seed storage facility and using appropriate sized seeds (28-45 mm).
- Raise awareness on different aspects of potato production and yield performance, such as origin and quality of seed potatoes, crop rotation, seed preparation, chemicals and pesticides.
- Improving seed bed preparation by conducting a deeper soil tillage with a tractor.
- Anticipating the development of fertilizer guidelines, N- and K_2O-application rates can be reduced, P_2O_5-application rates need to be optimized.
- Farmers need to recognise diseases and pests, and select chemicals accordingly and use the right dosage of chemical products.
- Haulm killing needs to be introduced to control late blight infection of tubers, followed by a strategy for late blight control after haulm killing.

In addition to the quick wins the following investigations should be carried out to improve knowledge and performance of potato production:

- Develop optimal guidelines for seed size and planting densities,
- Develop fertilization guidelines for nitrogen, potassium and phosphorus, because inputs exceed crop need substantially (nitrogen and potassium); in the case of phosphorus application rates soil phosphorus status should be included to optimize application rates.
- Investigate the effects of mixing chemical products in one application/tank mix, because this may compromise effects of the pesticides.
- Investigate the life cycle of tuber moth and develop an adequate strategy to control this pest.

Besides the quick wins and proposed investigations, there are other needs for improving the performance of the potato chain in Myanmar, hence they require more efforts from different organizations.

It is recommended to develop a strong seed sector to provide certified, good quality seed of different varieties. In support of the seed sector development, a seed certification system should be established.

Cultivation guidelines for Good Agricultural Practices (GAP) should be developed. Tools for GAP would be decision support services (DSS) on soil fertility, fertilizer use and disease control. For DSS on soil fertility and fertilizer use, a soil laboratory to analyse soils is needed. For DSS on diseases control, diagnostic tools are needed so an integrated pest management strategy can be developed and implemented.

GAP require improved soil tillage practises as well as adequate planting and harvesting techniques, which all need availability of appropriate mechanization. A programme to develop and introduce mechanisation for soil tillage, planting, spraying and harvesting should be initiated to support GAP.

Ware potatoes can be stored in open air facilities up to three to four months when all guidelines are carried out correctly. However the market for crisps potatoes is growing, as is the demand for good quality potatoes for processing. Maintaining adequate processing quality of potatoes is of great importance for further development and professionalizing of the processing industry. Opportunities of modern cold storage facilities for potato processing and a market outlook for further development of the potato processing industry should be investigated.

In Myanmar consumable inputs such as fertilizers and pesticides are provided to farmers through AgriShops. AgriShops also advise on what to use and how and when. This makes the advisor not fully independent. Unbiased advice is important in building a strong potato sector. It would therefore be good when the Farmers Organisation in cooperation with the Ministry of Agriculture, Livestock and Irrigation and/or private extension agencies would take a more leading role in aiding farmers on the cultivation, storage and marketing of potatoes.

This baseline survey shows an enormous amount of data on the farming practices of potato production in Naung Ta Yar and Heho, Southern Shan State, Myanmar. The findings related to the collected data reveal that the potato in these regions is a most profitable cash crop. It also indicated that farmers sometimes had limited knowledge on Good Agricultural Practices and that the potato cultivation was not always prioritised compared to other crops, mostly maize for their animals and/or rice for feeding their own family. But, farmers participating in the survey were all very much engaged and eager to learn from the Dutch visitors. The students who stayed almost three months in the area, developed a good relationship with farmers in both regions and paved the way for a long lasting and beneficial collaboration. Several farmers participating in the survey were full of future plans that contribute to a strong and valuable potato chain: from seed, to ware, to cold storage and market expansion to processing.

1 Introduction

1.1 Background

The Union of Myanmar borders Bangladesh, India, China, Laos and Thailand (Figure 1, left). The potato production areas (Figure 1, middle) and systems have the irrigated winter crops as dominate in India and Bangladesh and the highland monsoon rain fed system in Yunnan-China in common. Combining Figure 1 middle and Figure 1 right shows that Shan state is one of the most important potato production areas.

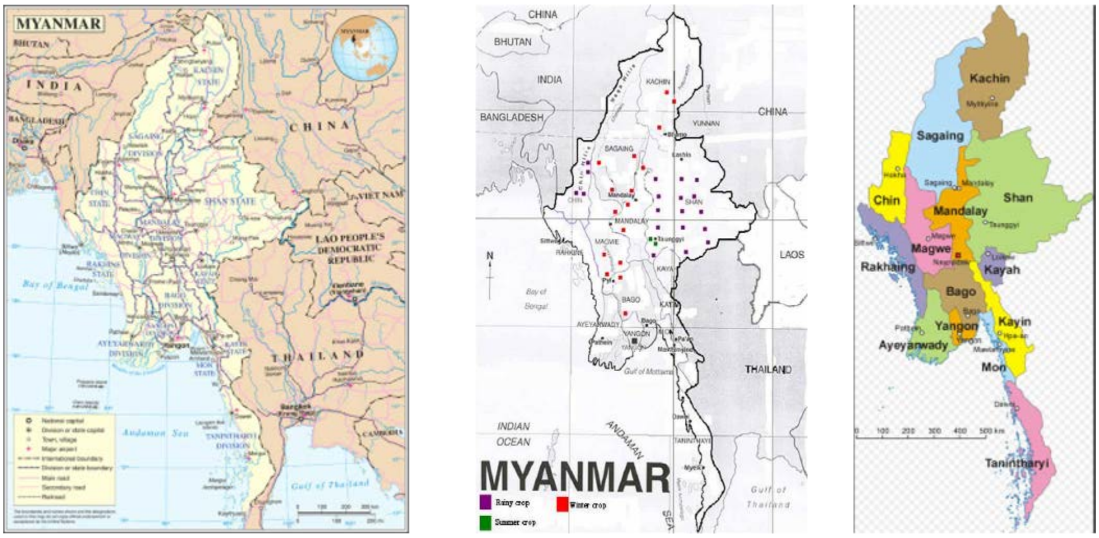

Figure 1 *Geographical location of Myanmar (left, source: Wikipedia) and potato production areas (right, source: CIP World Potato Atlas): centre irrigated winter crops, east Shan plateau, irrigated too but mainly rain fed crops: States of Myanmar (right, source: Wikipedia).*

Myanmar has a population of about 60 mil. inhabitants of which 65% is engaged in the agricultural sector (Myint 2015). The total area is 676,578 km^2. The country has three destined seasons: a rainy season, a winter season and a summer season. The potato has been introduced in the mid-19th century in Myanmar.

Recently, a number of activities were initiated in Myanmar to support agricultural development of small holders (farmers, Joosten 2014), to support the Myanmar government on the development of a framework for Good Agricultural Practices (Peeters *et al.* 2015), an economic analysis to identify opportunities for investment for Dutch Businesses (Wijnands *et al.* 2014) as well as to support Dutch businesses to participate in the development of different agricultural disciplines. The foundation of a Public Private Partnership (PPP) to develop of a potato value chain to secure healthy diverse food in Myanmar became an important objective of the Myanmar's Agricultural Counsellor of the Netherlands Mr. G. Westenbrink. In preparation of this PPP, a mission to Myanmar was organised for the members of the Netherlands potato industry and knowledge institutions in March 2015 (Pronk *et al.* 2015b) with a return mission of the Myanmar potato industry and Myanmar government representatives (Haverkort *et al.* 2015b). These activities resulted in an application for a PPP titled: "Potato value chain development to secure healthy diverse food in Myanmar" (Pronk *et al.* 2015c). Awaiting the decision for funding the PPP, the Netherlands Enterprise Agency (Rijksdienst van Ondernemend Nederland (RVO) commissioned a baseline survey titled: "Baseline potato cultivation in Myanmar" to facilitate a head start of the PPP to build a strong potato value chain. The results of the baseline survey are presented in this report. Additionally, RVO also commissioned a capacity building program "Myanmar Potato Value Chain – capacity building" and the PPP funding was approved. Furthermore, initiatives to develop potato processing are in preparation.

1.2 General aspects of the potato cultivation

At present potato is already an important cash crop for many farmers in Myanmar and especially in Shan State. With the expected growth of the economy and income/capita the consumption of potatoes (in curries and processed: Crisps, French fries) will increase substantial in the coming years. This offers opportunities for employment and income, especially of smallholder farmers. The overriding bottleneck at present and in particular for further growth is the lack of a seed potato system. At present farmers use the small potatoes of the previous harvest as seed potato, resulting in heavy diseased low yielding crops. There is no basic knowledge and experience in the field of organized seed potato production chain. A rapid multiplication in-vitro lab was set up by 2 Korean volunteers in 2004-2006 in Heho. There was however, no adequate transfer of technology but through national capacity in 2009 rapid multiplication was restarted with the then available varieties L11 of CIP and Up-to-Date. Emphasis was on L11 as that variety yielded higher due to late blight resistance. Up till today, the rapid multiplication system is not functioning at its best performance despite a training programme (Holdinga *et al.* 2014).
There are additional constrains in the potato cultivation in Shan State such as: no evidence based recommendations for use of fertilizers and pesticides, lack of credit system and 'appropriate' mechanization, lack of farmers organisation, a transparent marketing chain and lack of professional processing capacity. This offers a lot of opportunities to improve the potato value chain.

Potato in Myanmar is grown year round in 4 distinct seasons/regions (Haverkort 2013):

- An irrigated spring crop in rice paddies from January through April. This crop is irrigated and grows on peaty and clay soils in river plains in Southern Shan State and Shan State. This is a major crop with relatively high yields of 25 t/ha. The seed is derived from the August harvest of the pre-monsoon crop kept (Figure 2) or purchased from wholesalers.
- An early monsoon crop from April through August in the higher valleys (1000-1500 m above sea level) in the hilly regions of Shan States. This crop is rain fed and is a minor crop during this season. The seed is kept from a previous crop but usually purchased from wholesalers at 1.5 x the price of ware potatoes.
- A late monsoon crop from August through November in Southern Shan State and Shan State. This is a major potato cropping season. The seed is derived from the April harvest in the paddy fields.
- A (minor) winter crop from November through February in the alluvial plains, irrigated crops in central Myanmar.

Figure 2 *A schedule of the seed tuber flow of the informal seed system (left) and the production systems (right) in Myanmar (redrawn from Myint 2015).*

This baseline survey focuses on the late monsoon or post monsoon crop from August through November/December which is the major potato cropping season in the two regions Naung Ta Yar and Heho, both in Southern Shan State.

Over the past period, the average potato yields in Myanmar have steadily increased up to 15 tons/ha but seem to stabilize for recent years (Figure 3a). On the other hand, production costs continue to increase (Figure 3b).
Eventually production costs will meet financial yields and profits reduce. It is so far not clear which improvements can be made in the potato cultivation in order to secure high yields, low input costs, efficient use of inputs and thus improve income of smallholder potato farmers in Shan State Myanmar.

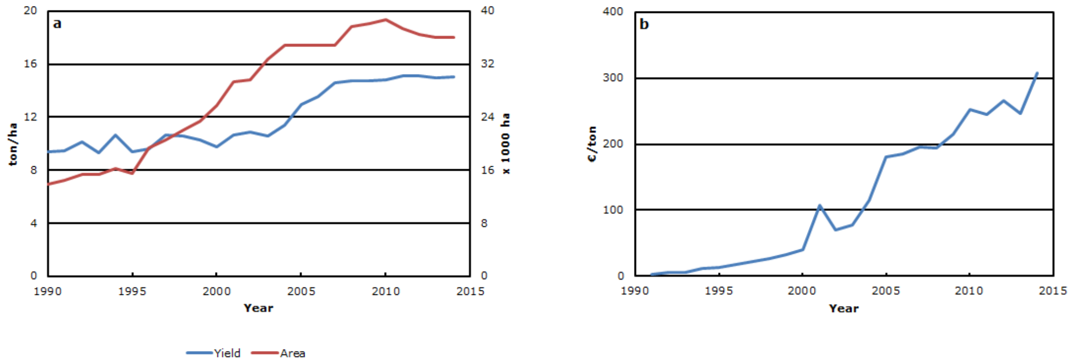

Figure 3 *Potato yield and production area (a) and the production costs for potatoes (b) in Myanmar over the past 20 - 25 years (FAOSTAT, accessed 30 November 2015).*

1.3 The baseline survey layout

1.3.1 Regions

The baseline survey is conducted in the Southern Shan State production regions in the surroundings of Naung Ta Yar and Heho (Figure 4). Naung Ta Yar is located at approximately 1400 m above sea level at a hilly area some 40 km south of Kalaw. Heho is a town with an airport and located at approximately 1100 m above sea level on a flat plateau some 30 km west of Taunggyi. Heho used to be near a lake that has dried out over the years. Most farmers participating in the survey (90%) had fields on the former lake. The differences between the soils in the two regions is illustrated in Figure 5.

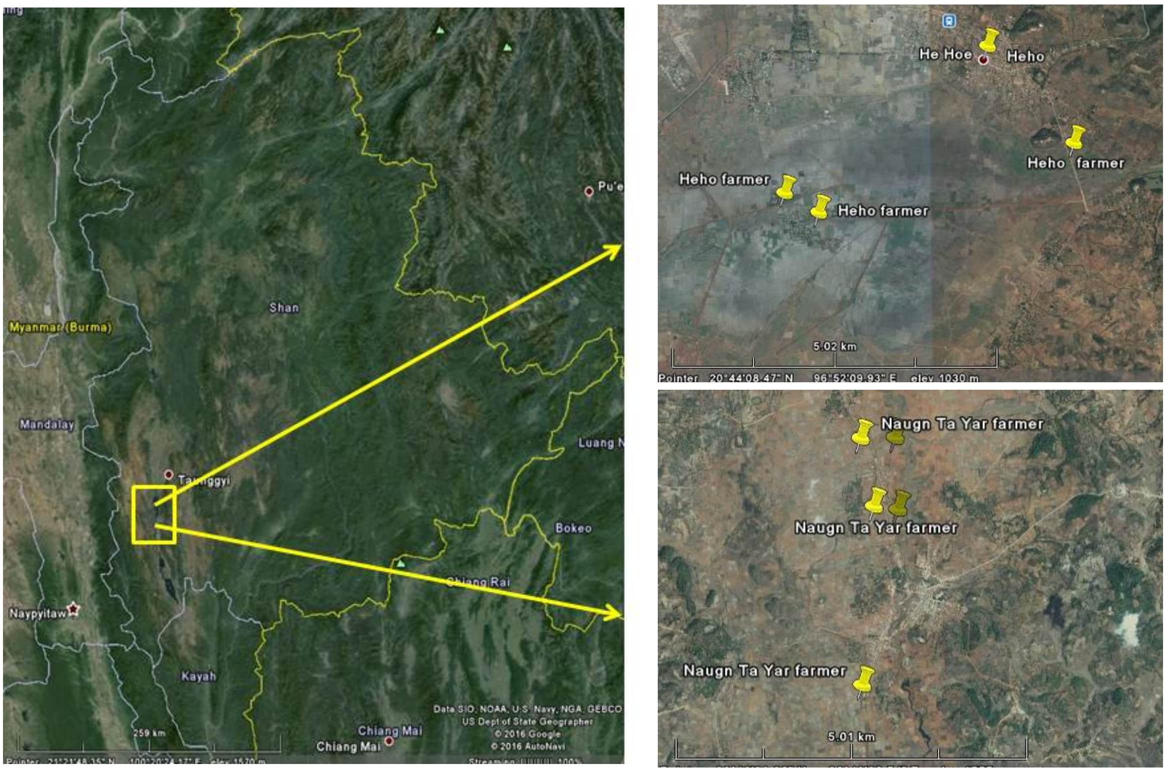

Figure 4 *Overview of the location of the Southern Shan State production regions (Google Earth).*

Both regions have potato growers on small plots. Potatoes are grown as a valuable cash crop.
In Naung Ta Yar the most cultivated variety is Kufri Jyoti (90%). Kufri Jyoti came into the country early 90's as a late blight tolerant variety (Thun *et al.* 2006) and hasn't been refreshed after that. In addition to Kufri Jyoti, varieties are Up To Date, CIP-24 and Atlantic.
In Heho more varieties are cultivated but Kufri Jyoti is still the major variety with more than 50%. Other varieties are Atlantic, Carolus, Markies, Chinese variety. And to a lesser extent L-11.

Figure 5 *The red soil in Naung Ta Yar (left) and the grey soil in Heho (right).*

In Shan State, 26,000 ha potatoes are cultivated yearly, which resembles about 75% of the total countries area cultivated with potatoes. The average yield in Southern Shan State is estimated at 18 - 19 tons/ha (Thun *et al.* 2006). In Shan State 60% of the country's total production takes place (Haverkort 2013).

1.3.2 Collaborators

The baseline survey was a collaboration between Wageningen UR, Aeres Group (CAH Vilentum, location Dronten), two graduates of the University of Yezin currently working at the Department of Agriculture (DOA) in Taunggyi, local officials and farmers in Shan State, Myanmar.

1.3.3 Objectives

The objectives of the baseline survey are:

- To perform a baseline survey on the potato cultivation in two regions in Southern Shan State Myanmar, Naung Ta Yar and Heho,
- To demonstrate effects of seed potato quality on growth and yield,
- To perform a yield gap analysis for actual yields of potato in both regions and
- To identify evidence based “Quick Wins” for good agricultural practices and which bridge the identified yield gap.

The objectives were carried out through interviews of farmers on their activities, registration of the data, and processing and evaluating the collected data. The findings were shortly compared to literature and reported in this document.

2 Materials and methods

2.1 The baseline survey

2.1.1 Data collection

In Heho 9 growers and in Naung Ta Yar 24 growers were selected to participate in the survey. Each grower was visited up to six times (see Annex 1) to register how and what he had done in the potato cultivation. In Naung Ta Yar the planting of the potatoes had taken place when the data registration started whereas in Heho the potatoes were to be planted.
Seven farmers of Naung Ta Yar had their potato field in a neighbouring town at approximately 15 minutes' drive from Naung Ta Yar. The other farmers fields were close to Naung Ta Yar. The fields in Heho were close together at some distance from the town, 10 minute drive.
Data collection took place by visits at either the farm house and or the fields. The questions asked are listed in Annex 2. The value chain of the potato production was investigated.
During the visits a large number of questions were asked on seed potatoes, soil management and tillage, fertilization, crop protection, harvest, storage, marketing, labour and prices of input products and selling prices of the potatoes. Not only questions were asked. The potato fields were measured, the row distance and the in row planting distances were measured, the number of stems were counted, the planting depth, and height of plants was determined. Finally, a harvest was carried out to determine yields. Minderhoud and Goosen (2016) provide additional information on the baseline survey.

2.1.2 Data processing

2.1.2.1 Farm registrations

The farm registration has been checked for errors and missing data. Where possible, additional data were provided by farmers and stakeholders. Units were standardized to SI units to allow comparison with known other data.

2.1.2.2 General data

The information on the size of the fields was obtained from the farmers and in most cases also measured with GPS. There were some small differences between the GPS data and the size farmers said but on average farmers had a good estimate of the size of their fields.

2.1.2.3 Seed potatoes

The weight of the seed potatoes is calculated from the number of seeds planted and the planting distance. Most farmers know how many seeds were planted but have less knowledge on the mass that is planted. The indicated seed weight by the farmer is used to calculate the mass of potatoes planted (kg/ha) and compared with the mass calculated with the measurement weight of the seeds from the demonstration on seeds, see additional actions described in paragraph 2.2.

2.1.2.4 Soil management and tillage

The percentage of farmers who used soil preparation, ploughing, harrowing and/or ridging was calculated as the number of farmers indicated to use the technique divided by the total number of farmers.

2.1.2.5 Fertilization

Different aspects of fertilization were calculated from the registered data: application rates; percentage wise use of products; and product types and frequency of product use per type.

Application rates
After unit standardization the total amounts of mineral nitrogen, phosphate and potassium per ha were calculated for each potato field. Additionally, the nutrient supply by organic products was calculated and included into the total nutrient supply calculations for which the mineral content of organic products provided by the two collaborators from DAO from literature (Table 1) was used.

Percentage wise use of products and product types
The percentage of farmers who used chemical, organic and/or foliar fertilizer products was calculated as well as the percentage of farmers who used specific types of products.

Frequency of product use per type
Details on how, when and frequency of different fertilizer product use was calculated as times of occurrences.

Table 1
Nutrient content of dried organic products (based on standard nutrient contents from literature of Myanmar, % dry weight).

Manure type	N (%)	P (%)	K (%)
Sheep	2.70	1.90	1.93
Chicken	1.46	1.50	0.50
Horse	1.56	1.72	1.20
Cow	1.40	0.92	1.08
Worm compost	1.60	0.70	0.80
Straw of rice	1.57	0.35	0.81
Chaff of rice	0.59	0.17	0.16

2.1.2.6 Crop protection
Different aspects of crop protection were calculated from the registered data: the percentage wise use of products and product types for fungicides, insecticides, and herbicides, plant growth regulators and antibiotics; the average spraying volume applied per application and number of applications; the number of days between planting and first application, between first and last application and between last application and harvest; the average application interval; and the total amount of active ingredients applied of fungicides, insecticides and herbicides. In addition, chemicals used were classified according to the World Health Organization (WHO) data presented in Table 2.

Table 2
Pesticide classification system of the World health organisation (WHO).

Class	Description
Ia	Extremely hazardous
Ib	Highly hazardous
II	Moderately hazardous
III	Slightly hazardous
U	Unlikely to pose an acute hazard in normal use
NL	Not listed (mostly related to new pesticides of which no or limited information is available)

The percentage wise use of products and product types for fungicides, insecticides, and herbicides, plant growth regulators and antibiotics
This percentage was calculated as the total number of farmers that use the chemical divided by the total number of farmers of which data on pesticide use was registered.

The average spraying volume applied per application and number of applications
The average spraying volume per application was calculated as the mean of all volumes applied. The number of applications in one growing season were calculated for fungicides and insecticides separately as the average of the total number of applications per farmer.

The number of days between planting and first application, between first and last application and between last application and harvest
The number of days between applications were calculated as the average number of days per farmer.

The average application interval and the total amount of active ingredients applied of fungicides, insecticides and herbicides
The intervals were calculated as the average intervals per farmer.

The total amount of active ingredients applied of fungicides, insecticides and herbicides
The total amount of active ingredients were calculated using the Profile of Pesticides Registered in Myanmar (Phone Kyaw *et al.* 2012). The registration did not always provided detailed information on formulations of the chemicals used. In cases information was not available, registered formulations from the Profile of Pesticides Registered were used. When multiple formulations were available from the Profile the product with a minimum of active ingredient was selected.

2.1.2.7 Irrigation
In this baseline survey the late monsoon crop was evaluated. This cropping season runs from August through November/December in Southern Shan State and is the major potato cultivation period in the area (Haverkort 2013). The cultivation is not irrigated and irrigation is therefore not further addressed in this survey.

2.1.2.8 Harvest
All farmers' fields were harvested by the interviewers close to the expected harvest date of the farmer. In Naung Ta Yar that was in the first half of November whereas this was on 15 December in Heho. Yields were therefore representative to the farmers yields. Two samples of each farmers' field of 2 rows 3 meter row (≈ 2.5 to 3 m^2/plot depending on row distance) were sampled. Fresh weight and number of tubers were determined per sample and per size distribution <28 mm, 28-35 mm, 35-50 mm, 50-60 mm and 60 > mm. The Weight In tab Water (W.I.W.; weight of 5050 g dry potatoes in tap water) (Ludwig 1972) of a representative sample was measured and used to calculated dry matter concentration and specific gravity. A visual assessment was done on insect damage, nematode damage, green potatoes etc.

2.1.2.9 Storage
Farmers were asked where and how they store the potatoes after harvest and if they use chemicals during harvest.

2.1.2.10 Marketing
Farmers were asked if and when yes where they buy the seed potatoes and where they sell there produce.

2.2 Additional non-funded activities

2.2.1 Collection of *Phytophthora* DNA samples

During the visit in November (14 - 22 November) *Phytophthora infestans* DNA samples were collected on 9 locations of 8 infected potato fields and 1 tomato field. The samples were analysed by WUR and the *Phytophthora infestans* type was identified.

2.2.2 Demonstration on seed tuber quality

Layout of the demonstration

A demonstration on seed tuber quality was performed at a field close to Naung Ta Yar. The main purpose of the demonstration was to show effects of different seed origins on production and yield to farmers. Each plot had 4 rows of 6 m (Figure 6). Seeds were planted on 28 August at 0.22 m distance in the row. The soil was a silt loam. Crop care was done by the farmer, often initiated by Frank ter Beke through the students. The growth performance of the potatoes was evaluated on a regular basis. The potatoes were harvested on 12 and 13 November 2015. The fresh tuber mass was determined, the Weight In tap Water (W.I.W.) and the size distribution (weight and number) of the tubers in classes of <28, 28 - 35, 35 – 50, 50 – 60, 60> mm. More details are provided by Minderhoud (in prep. 2016).

Table 3

Overview of the seed demonstration and trials.

Trial	Treatments	Explanation
Seed tuber quality	Different seed stocks	7 varieties of 25 farmers were compared
Ridging	Early ridging: immediately after planting Standard ridging: three weeks after planting	2 replicates
Nitrogen	100, 200, 300 kg/ha	4 replicates
Potassium	100, 200, 300 kg/ha	no replicates
Planting distances	row distance: 0.45 m in row distance: 0.40, 0.60 and 0.80 m	2 replicates. Small (<25 mm) and large (>45 mm) seeds were used
Best Practices Trial	row distance: 0.65 m in row distance: 0.30 m Soil cultivation depth: 0.20 to 0.25 m deep ridging: 3 to 5 weeks after planting fertilization: 250-150-220 kg/ha of N, P_2O_5 and K_2O respectively	one treatment, one replicate

Seed stocks used

In this demonstration 2 different varieties of seed stocks of 10 farmers from Naung Ta Yar and 5 different varieties of seed stocks of 15 farmers from Heho were compared. Varieties included L-11, CIP-24, a Chinese variety, Markies, Atlantic, Kufri Jyoti and Carolus. A sample of approximately 200 tubers was collected and evaluated. The general impression, physiological age, skin curing index, *Phoma* infection (%), *Rhizoctonia* infection index, *Fusarium* infection (%), Blackleg infection (%), Mel. *Chitwoodi* infection (%), damage index, common Scap index, Silver scurf index, tuber moth infection (%), tuber weight (based on 50 tubers) and size classes of 50 ad random selected seeds was evaluated. Size classes were <28 mm, 28 - 35 mm, 35 - 45 mm, 45 - 55 mm and >55. Additionally, a visual evaluation of the seeds was given as good (G), moderate (M) and bad (B).

Definitions for the evaluation of seed tuber quality

General impression: the first impression is valued with a number between 0, not good, and 10, good.
Physiological age: the number of tubers not germinated or hardly germinated is evaluated with a high number, 10; tubers that are too much germinated and shrinking are evaluated with a low number, 0.
Rhizoctonia infection index; common Scap index; Silver scurf index: the extent of the occurrence of the infection on tubers is categorized into no occurrence, light, moderate and heavy occurrence. The index is calculated as: (# of tubers class no * 0 + # of tubers class light * 1 + # of tubers class moderate * 2 + # of tubers class heavy * 3) / 3.
Skin curing index; Rhizoctonia infection index; common Scap index; Silver scurf index: tubers are categorized into no peeling, light, moderate and heavy peeling. The index is calculated as: (# of tubers class no * 0 + # of tubers class light * 1 + # of tubers class moderate * 2 + # of tubers class heavy * 3) / 3.

Phoma infection (%); Fusarium infection (%), Blackleg infection (%), root know nematode infection (%); tuber moth infection (%): the percentage of tubers infected with the specified disease, bacteria or pest.

Table 4

Applied fertilizers (kg/ha) in the different trials at planting and ridging, and the total amount applied.

	Basal dressing			Ridging			Total		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Seed	150	150	150	50	0	50	200	150	200
Ridging	150	150	200	50	0	0	200	150	200
N-fertilizer	100/150 /225	150	200	0/50 /75	0	100/200 /300	100/200 /300	150	200
Distances	150	150	200	50	0	0	200	150	200
K_2O-fertilizer	150	150	100/150 /225	50	0	50/75	200	150	100/200 /300
Best Practices	150	150	120	100	0	100	250	150	220

2.2.3 Trials

Layout of the trials

Five trials were performed at a field close to Naung Ta Yar. The main purpose of the trials was to show effects of different treatments to farmers; farmers can see the effects of ridging time, fertilizers (N and potassium), planting distances and best practices on production and yield. Each plot had 4 rows of 6 m (Figure 6). The number of treatments is indicated between brackets in Figure 6. The variety Kufri Jyoti was used. Seeds were planted on 28 August at 0.22 m distance in the row, except for the trials on planting distances and the 'Best Practices'. The soil was a silt loam. Crop care was done by the farmer, often initiated by Frank ter Beke through the students. The growth performance of the potatoes was evaluated on a regular basis. The potatoes were harvested on 12 and 13 November 2015. A second harvest was done for all trials on 10 December 2015 except for the planting distance trial. The fresh tuber mass was determined, the Weight In tap Water (W.I.W.) and the size distribution (weight and number) of the tubers in classes of <28, 28 - 35, 35 – 50, 50 – 60, 60> mm. When possible, a standard analysis of variance (anova) was done with GENSTAT version 17.

Ridging trial

In this trial ridging was done immediately after planting in two fields and compared with the traditional practice of ridging three weeks after planting (Table 3). Earlier riding keeps potatoes cooler which we think is beneficial for growth. Fertilization was 200 kg N/ha, 150 kg P_2O_5/ha and 200 kg Potassium K_2O/ha (Table 4). The row distance was 0.30 to 0.40 m and the potatoes were spaced at 0.25 m in the row.

Nitrogen application trial

In this trial we compared three N levels: 100, 200, 300 kg/ha in four replicates. Seventy five percent of the dose was broadcasted just before planting; the remaining amount was applied at ridging (Table 4).

Potassium application trial

In this trial we compared three potassium K_2O_5 levels: 100, 200 and 300 kg/ha. The N and P_2O_5 applications were 150 and 200 kg/ha, respectively (Table 4).

Planting distance trial

In this trial small (<28 mm) and big (>45 mm) seed tubers were planted at 0.25, 0.33 and 0.51 m distance in the row, leading to 4.4, 6.7 and 8.7 seeds/m^2. The treatments were done in replicate leading to 12 plots. All treatments had the same row distance of 0.45 m. The fertilization was the same as in the ridging trial (Table 4).

Best Practice trial
In this trial potatoes were cultivated to the best expertise and knowledge of the students. The planting distance was 0.30 m in the row and row distance was 0.60 to 0.65 m. Soil cultivation was approximately 4 to 5 cm deeper than traditional to provide more loose soil for the roots to grow and take up water and nutrients. The fertilization was 250 kg N/ha, 150 kg P_2O_5/ha and 220 kg K_2O/ha. After three and five weeks ridging was done. Larger row distances allowed bigger rows to be formed which was intended to provide more loose soil for potatoes to grow in.

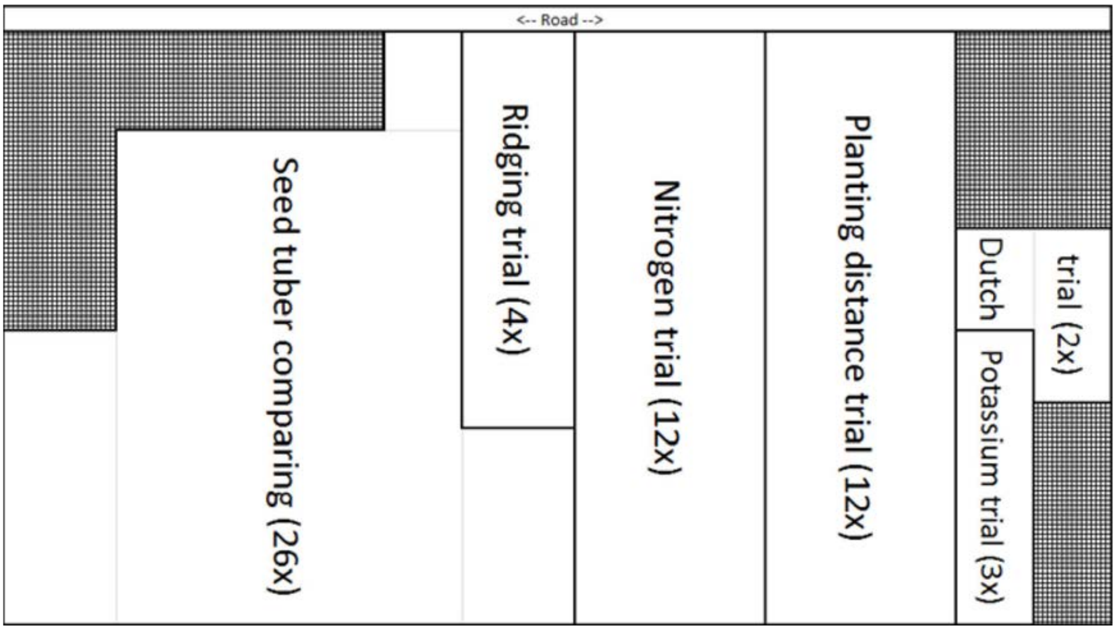

Figure 6 *The layout of the field for the demonstration and the trials in Naung Ta Yar.*

2.2.4 Field meeting with farmers and suppliers mid-term potato cultivation

A field day was organized by the visiting WUR scientist and the students on 24 October 2015 on site for farmers and local suppliers.

2.2.5 Short communication: Quick win gap and baseline study of potato cultivation practices in Myanmar

A the special request of the Agricultural Counsellor of the Embassy of the Kingdom of the Netherlands in Bangkok Mr. G. Westenbrink an early in between short communication was prepared.

2.3 Yield gap analysis

2.3.1 Introduction

The average yield of potatoes in Myanmar is approximately 15 tons fresh weight/ha (Figure 3a). The average yield in Southern Shan State is approximately 25% higher than the countries average, 18 - 19 tons/ha (Thun *et al.* 2006). But, these actual yields may still be lower than attainable yields. In practise, the economic attainable yield is approximately 2/3 of the modelled attainable yield (pers. comm. A.J. Haverkort). At this point, costs for additional inputs are balanced with profits raised by increased yields.

Improving yields may improve recourse use efficiency of inputs and land. To explore the possibility of improved yields, a yield gap analysis was done. In this yield gap analysis, the attainable yield was calculated and compared with data on actual yield of all interviewed farmers in Naung Ta Yar and Heho.

2.3.2 Materials and methods

2.3.2.1 The LINTUL-DSS model

The simple crop growth model LINTUL-DSS (Haverkort *et al.* 2015a) is used to calculate the attainable yield. This simple model calculates dry mass production through the interception of radiation by green leaves. Sprout growth and canopy closure are temperature driven and when the canopy is closed maximum radiation interception occurs with maximum dry mass production as a result. Distribution of dry mass between the various organs is also temperature driven. Approximately 75% of total dry mass production is distributed to the tubers by the end of the growing period. Subsequently, fresh tuber weight is calculated from total tuber dry weight. The input data required are weather data (average daily temperature, total daily radiation and precipitation), cultivation data (date of planting, planting depth and data of haulm killing) and data on soil type. These cultivation data and actual yield were taken from the registration data. A summary of the input data is presented in Table 38.
The weather data were provided by the project partner of the DAO when available. When data were not available, they were derived from the PRI-database containing weather data of the Climatic Research Unit (CRU) (Jones & Harris 2008).

In this baseline survey the measured fresh yield of farmers is recalculated to dry mass based on the determined weigh in tap water (W.I.W; weight of 5050 g dry potatoes in tap water) and the corresponding dry matter concentration related to the W.I.W. (Ludwig 1972). The modelled and actual dry mass yields are compared.

2.3.2.2 Weather data

The weather data were provided by the collaborating researchers from the DAO in Taungi for Naung Ta Yar and Heho. The collected data were on precipitation and on temperature for NTY and in Heho also relative humidity was available (Table 5). For the yield gap analysis the daily radiation and the evapotranspiration is needed which was extracted from the database containing long term weather data of the Climatic Research Unit (CRU, Table 6) (Jones & Harris 2008).

Table 5

Measured data of 2015 on precipitation (PREC; mm), number of days with rain (# rain), the average maximum temperature (Tmax; ◦C), average minimum temperature (Tmin; ◦C) and the average humidity (AH) during the potato cropping season in Naung Ta Yar and Heho.

	Naung Ta Yar				Heho				
	PREC	# rain	Tmax	Tmin	PREC	# rain	Tmax	Tmin	AH
July	286	24	23.7	16.2	-	-	-	-	-
August	145	16	23.8	16.5	155	16	27.6	19.4	77
September	92	10	24.6	16.5	90	11	29.3	19.0	70
October	55	9	22.6	15.5	102	17	27.0	16.2	74
November	-	-	-	-	34	5	25.8	14.9	83

Table 6
The long term maximum temperature (Tmax; ◦C), minimum temperature (Tmin; ◦C), the daily radiation (DRAD; MJ m^2 day^{-1}), precipitation (PREC; mm) and evapotranspiration (PET; mm) for Naung Ta Yar and Heho, extracted from the PRI-database containing weather data of the Climatic Research Unit (CRU) (Jones & Harris 2008).

	Naung Ta Yar					Heho				
	Tmax	Tmin	DRAD	PREC	PET	Tmax	Tmin	DRAD	PREC	PET
January	24.9	9.7	15.0	2	81	24.2	9.3	14.9	2	78
February	27	11.1	17.9	4	99	26.1	11	17.6	5	99
March	29.8	14.4	20.3	8	136	29.2	14.5	20.0	7	136
April	31.6	18.1	19.9	52	144	31.1	18	19.5	52	147
May	29	18.9	15.7	179	115	28.7	18.7	15.7	169	118
June	26.7	18.9	10.1	251	84	26.5	18.8	10.2	216	84
July	25.8	18.6	8.6	262	78	25.7	18.6	8.7	228	81
August	25.6	18.3	8.3	329	78	25.5	18.3	8.5	303	78
September	26.4	18.6	10.8	281	78	26.2	18.6	10.9	280	78
October	26.4	17.7	13.0	180	81	26	17.6	13.0	188	81
November	25.2	14.3	13.7	73	75	24.5	13.9	13.6	77	75
December	23.5	10.7	13.9	5	71	22.6	10.1	13.8	5	68

The year 2015 was somewhat cooler during July through October in Naung Ta Yar than long term data (Figure 7a). July had more precipitation whereas August, September, and October were drier than the long term data (Figure 7a). The opposite was found for Heho, where 2015 was warmer and drier than the long term data (Figure 7b).

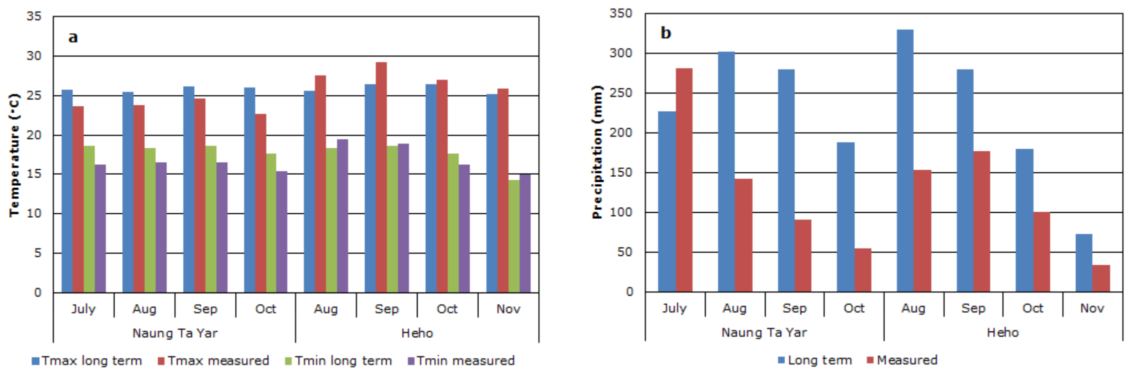

Figure 7 *Comparison between the measured and long term weather data Tmax and Tmin (a) and precipitation (b) for the growing season in Naung Ta Yar and Heho.*

2.4 Economy

2.4.1 Operational costs

The operational costs were costs for seed, fertilizers, crop protection products, machinery (fuel and repairs), hired labour, costs for land rent and cost for renting a tractor. Costs for seed are scarcely available as most farmers use farm saved seed. Costs for machinery (fuel and repairs) were not available.
Costs for labour were occasionally registered and when registered is was most often on contract jobs. This applied mostly to planting, pesticide applications (specialized spaying teams that did fields for a fixed price), ridging and harvesting. It was difficult to get a clear picture on labour costs as several tasks were not separately identifiable and farmers had no clear picture of those jobs. An example was

planting. Planting and the application of the basal dressing was done as one job and it was not possible to separate on tasks. Another fact was that man and women were rewarded equally for their work and not separated further in this survey.

Labour data on harvest were not available for Heho and only very limited for Naung Ta Yar. The data on labour and subsequently total cost of the production for potatoes in both regions were therefore a rough indication of actual costs.

2.4.2 Fixed costs

The fixed costs were costs for tractors, equipment and own land costs. Three types of tractors were distinguished in the survey, small, normal and big tractors. A small tractor was a hand driven machine with two wheels (Figure 8), a normal and big tractor had 4 wheels.
Costs for own land were not collected. Costs for tractors were collected but were for rented tractors. Therefore, these costs were included by the operational costs.

Figure 8 *Small tractor that is becoming very popular.*

Other fixed costs are costs for depreciation and investments. Both were not included in the data collection.

2.5 Communication

2.5.1 Visits by WUR scientist to Southern Shan State

Three visits by WUR scientists were conducted.

1. The purpose of the first visit (23 - 28 August) was to select farmers to participate in the base survey and to support the students to settle in,
2. The purpose of the second visit (20 - 30 October) was to monitor the on-going activities mid-term the potato cultivation,
3. The purpose of the third visit (14 – 22 November) was to ensure appropriate completion of the baseline survey and to organize a field day for farmers, stakeholders, officials and government representatives. This visit took place at the end of the cultivation period in Naung Ta Yar.

2.5.2 Field day

During the third visit a field day was organized on site for farmers, stakeholders, officials, government representatives and interested people. The field day took place on 18 November 2015. In preparation of the field day an invitation (Annex 3) and a handout were made (Annex 4).

3 Results and discussion

3.1 Baseline survey

3.1.1 Data collection

Farmers were visited several times during the growing season (Annex 1). In Naung Ta Yar almost the entire cultivation period was covered by the visits. In Heho, the production started later and subsequently was not followed through till the end. Registration on pesticide use in Heho is therefore not complete but nevertheless included in the results.
Some farmers dropped out from the survey after a while. Starting with 34 farmers in Naung Ta Yar and 10 in Heho resulted in complete registrations with departure of the students of 33 farmers in Naung Ta Yar and 8 in Heho.

Naung Ta Yar
All farmers in Naung Ta Yar cultivated ware potatoes, Kufri Jyoti except for one grower who cultivated Atlantic for processing in addition to Kufri Jyoti as well. The varieties are therefore not distinguished. The number of growing days of potatoes was almost 90 days (Table 7).

Table 7
Growing days, planting and harvest date, average field size and altitude (m above sea level) of recorded potato fields.

	Naung Ta Yar			Heho		
	Average	Max	Min	Average	Max	Min
Growing days	88	109	69	91	134	76
Planting date	12-Aug-15	01-Sep-15	17-Jul-15	15-Sep-15	30-Sep-15	03-Aug-15
Harvest date	07-Nov-15	11-Nov-15	17-Jul-15	15-Dec-15	15-Dec-15	15-Dec-15
Field size (m^2)	4,984	8,766	2,235	9,676	36,414	2,031
Altitude (m ASL)	1500			1100		

Heho
The farmers in Heho cultivated different varieties such as Kufri Jyoti, Atlantic, Carolus, Chinese var. and Canada. The number of farmers was small, only 8 so no differences between varieties were made. The number of growing days was the same as for Naung Ta Yar, about 90 days (Table 7). The planting date was one month later in Heho compared to Naung Ta Yar but as the harvest date was also later, the growing days are comparable. The field size in Heho is almost 1 ha and somewhat larger than that of Naung Ta Yar.

3.1.2 Seed potatoes

In Myanmar farmers frequently save their small potatoes to be used as seed for the next cultivation, the so called farm saved seed. In this survey, 91% and 54% of the farmers Naung Ta Yar and Heho respectively indicated to use farm saved seeds. Otherwise, seeds were bought at the local market of Aungbun. Farmers had no knowledge of the origin of the seeds bought at Aungban market. It was very well possible that seeds were imported from neighbouring countries like China and Thailand. No seed certification system is in place.
The general informal seed system is that the irrigated summer crop (growing season January/February till April/May produces seeds for the late/post monsoon crop (growing season August/September till December/January, Figure 2). The rainy season crop (growing season April/May till August/

September) provides seeds for the winter crop (growing season October/November till January/February.

Naung Ta Yar

The amount of seed potatoes planted in NTY as indicated by farmers was approximately 4,000 kg/ha (Table 8) but varied greatly between farmers. Based on the planting distances the average seed tuber weight was 40 grams/tuber. Farmers had no idea on the generation of potatoes they grew. Seed potatoes were not cut before planting.

Table 8

Seed potato use (kg/ha), generation of planting material, seed potato tuber weight and number of farmers cutting seed potatoes for planting.

	Seed potatoes	S.E.	Generation	Tuber weight	S.E.	Cutting
Naung Ta Yar	3,949	1,178	Not known	40	13	No
Heho	3,125	2,703	Not known	25	10	No

Heho

The amount of seed potatoes planted was slightly more than 3,000 kg/ha and lower than of Naung Ta Yar. Also, the variation of the amount of planted seed potatoes was larger than in Naung Ta Yar. Based on the planting distances the average seed tuber weight was 25 grams/tuber. Farmers had no idea on the generation of potatoes they grew. As in Naung Ta Yar, seeds were not cut before planting.

Table 9

Planting density (# m^{-2}) and planting distances (m).

	Naung Ta Yar			Heho			
	Average	Max	Min	Average	Max	Min	Average
Plants/m^2	11	20	6	16	28	8	13
Between row (m)	0.45	0.56	0.33	0.64	0.75	0.40	0.55
In row (m)	0.22	0.30	0.15	0.11	0.17	0.06	0.17

The amount of seed potatoes and the planting systems indicated that there was not yet a standard seeding rate or planting system developed. The variation among farmers practices was high. The small row distance resulted in low ridges and subsequently limited loose soil for the potatoes to grow in. This was all connected to shallow soil cultivation, as that was done by hand or by ox/buffalo/cow and therefore not very deep. The standard Dutch depth of 0.25 to 0.3 m was not reached, 0.10 to 0.15 m was maximum at most in Naung Ta Yar. Loose soil to form ridges was limited which allows row distances to be smaller.

The amount of seed planted was indicated by the farmer and estimated by the row distance and in row planting distance. The two methods yielded substantial different results due to lack of knowledge of the farmer on the actual seed weight planted and the manual planting system. Although farmers instruct their workers to make rows at a certain distance and plant potatoes in these rows at specified intervals, this was rarely found in the field. This mismatch in instructed planting densities and actual planting densities contributes considerable to the gap found in seed size weight for the seed potato trial and calculated seed weights based on provided data by the farmers. The measured tuber weight of 10 growers in NTY was 44 gram/tuber where the calculated tuber weight differed by 46%.

Figure 9 *An example of salt residue in a chunk of soil in Heho.*

3.1.3 Soil management and tillage

There are many differences between the soil cultivation systems in Naung Ta Yar and Heho to prepare the land for potato production. The main factor to contribute to the differences is the soil type. The general procedure is to plough (either tractor driven, cow or manual) the soil followed by harrowing to crumble the seed bed after ploughing.
The registration indicates the following main soil treatments: soil preparation, and ploughing and harrowing, all pre planting. All indicated soil treatments could have been done by hand, cow (1 or 2), and tractor (small or big). Soil preparation was likely to include the loosening of the soil pre planting (similar to a ploughing treatment) and crumbling the soil so the planting could be done.

Chemical soil properties
The chemical properties of the soils indicated that both soil samples had a very low phosphorus available for plant growth (Table 10). The Dutch standard level for Pw for plant growth has a minimum value of 21. Potassium levels were high in both soil samples and the pH was somewhat low in Naung Ta Yar. The salt content, measured by the Department of Agriculture in Taunggyi, was 0.18 and 0.41 mS/cm in Naung Ta Yar and Heho respectively. The higher content in the Heho soil was in agreement with the history of a dried out lake. This content is not yet a yield reducing factor as potato is classified to be a moderately sensitive crop (Shannon & Grieve 1998) and will suffer from yield losses when EC values increase till 1.7 mS/cm (Blom-Zandstra *et al.* 2014; Wolters *et al.* in press). Residual salts were visible during the visit where a salt deposit layer in the soil profile was noticed (Figure 9). The C:N ratio of the soils was within the range recommended by the Dutch Advisory standards indicating that nitrogen will not immobilize into the soil organic matter and that mineralisation of organic matter will release nitrogen.

Table 10
The chemical properties of one field in Naung Ta Yar and one field in Heho analysed by the Dutch Laboratory Zeeuws-Vlaanderen (% o.m. = organic matter content, N-total = total Nitrogen, C: N = ration carbon to nitrogen, Pw = water extractable phosphorus, P-Al, phosphorus extracted in an aluminium extract, K-HCl = potassium extracted in a chloride solution, pH-KCL = acidity in a potassium chloride solution.

	% o.m.	N-total (mg/kg)	C:N	Pw	P-Al	K-HCL	pH-KCL	pH-H_2O
Naung Ta Yar	4.4	2370	11	3	4	26	5.6	6.4
Heho	6.9	3060	13	16	8	69	7.8	8.5
Recommended[1]			12-18	21-30	19-27	13-15	6.6-7.5	5.7-7.5

[1] Recommended chemical properties according to the Dutch Advisory standard (Van Dijk 2003)

Physical soil properties
The particle analysis showed that the soils were silty loam (Table 11).

Table 11

The soil texture of one field in Naung Ta Yar and one field Heho analysed by the Department of Agriculture in Myanmar and the soil texture class (SSSA 1997).

	Clay	Silt	Sand	Total	Soil texture class
Naung Ta Yar	26.7	66.1	5.7	98.4	silt loam
Heho	25.8	56.0	16.7	98.5	silt loam

Naung Ta Yar

The depth of ploughing in Naung Ta Yar was between 0.05 to 0.10 m and did not differ between ploughing by hand (17% of farmers), with animals (50% of the farmers) or tractor (33% of the farmers, Table 12). Ploughing depth was not increasing when done by tractor as disk plough were used (Figure 10 left). The costs of ploughing by cow was approximately 50 €/ha (Table 13) and by tractor it was more than 72 €/ha. After ploughing, soils were treated with a disk harrow as presented in Figure 10 right.

Table 12

The number of farmers (#) and the percentage of farmers indicating to use soil preparation, ploughing, harrowing or making rows by hand, cow or tractor.

	Naung Ta Yar				Heho			
Treatment	#	Hand	Cow	Tractor	#	Hand	Cow	Tractor
Soil preparation	6	17	50	33				
Ploughing	15	0	60	40	10	0	0	100
Harrowing	12	0	83	17	12	0	25	75
Making rows					8	0	88	13

Table 13

The number of farmers (#) and the costs of different equipment used to plough the soils (1€ = 1,393 Kyats).

	Naung Ta Yar		Heho	
Method	#	€/ha	#	€/ha
Cow	5	50	-	-
Tractor	2	73	2	9
Big tractor	4	77	3	13
Small tractor	-	-	4	15

Figure 10 *A disk plough (left) and a disk harrow (right) as used in Naung Ta Yar.*

Heho
The soil cultivation in Heho was much more mechanized than in Naung Ta Yar, which allows a deeper soil treatment. Every participating farmer used a tractor of approximately 70 pk for soil preparation which was done with a disk plough. This allowed the cultivation depth to increase to 0.25 to 0.30 m. Harrowing was also tractor driven. The registration indicated that soil cultivation in Heho by tractor was much cheaper than in Naung Ta Yar, only 9 to 15 €/ha (Table 13). A reason may be that less labour is involved when ploughing and that no fuel costs or depreciation on the investments are included in the costs.

3.1.4 Crop rotation

The farming systems in Myanmar were characterized by several crops per year per field, on fields scattered throughout the region and divided at convenience for each crop. It was therefore difficult to get a clear picture on the crop rotation within each farming system. The most common farming systems in Southern Shan State that include potato were (Thun *et al.* 2006):
- Potato – Niger / Upland Rice – Niger
- Potato – Niger
- Potato - Upland Rice
- Potato - Vegetables (cabbage, cauliflower, garlic, ...)
- Lowland Rice – Potato (irrigated area only)

Rice was the main crop in the both research regions and provided the main food for families and locals. Other crop, such as vegetables and potatoes were grown as valuable cash crops.
There are some differences between the two regions in crops grown. It appeared that towns have their own speciality, as in Naung Ta Yar tomatoes were grown and not/hardly seen in Heho, and in Heho garlic was grown and not/hardly seen in Naung Ta Yar. Potato was considered to be a vegetable in both regions.

Naung Ta Yar
The most common crop rotation within the farming system of the participating farmers in Naung Ta Yar was fallow – fallow - potatoes (Table 14). The potato cultivation in Naung Ta Yar is from the end of August till the end of November, a post monsoon crop. Most farmers, 52%, have the same crop rotation each year. In Naung Ta Yar, potatoes are mostly cultivated as the only crop per year or in rotation with rice. In the potato – rice rotation weeds are better controlled. Also, rice is expected to be good for soils in terms of controlling soil-borne pathogens such as nematodes. Farmers have little to no awareness of potential nematode problems and only minor indications of such problems during the survey were found.

Heho
The most common crop rotation within the farming system of the participating farmers in Heho was cabbage – fallow – potatoes (Table 14). The potato cultivation in Heho starts later than in Naung Ta Yar, mid-September and ends mid-December (Table 7). Farmers have in general only two crops of which one is potatoes. But, also in the region, farmers have little to no awareness of potential threats of frequently cultivating potatoes on the same fields.

Table 14
Crop rotation of one field in one year in Naung Ta Yar and Heho (number of farmers between brackets) and the percentage of farmers practising the rotation.

	Crop 1	Crop 2	Crop 3	% of farmers
Naung Ta Yar (23)	Fallow	Fallow	Potatoes	30
	Cabbage	Fallow	Potatoes	22
	Fallow	Rice	Potatoes	17
	Rice	Rice	Potatoes	13
	Rice	Cabbage	Potatoes	4
	Fallow	Potatoes	Potatoes	4
	Beans	Fallow	Potatoes	4
	Mustard	Fallow	Potatoes	4
Heho (7)	Cabbage	Fallow	Potatoes	43
	Garlic	Fallow	Potatoes	29
	Corn	Fallow	Potatoes	14
	garlic	Corn	Potatoes	14

3.1.5 Fertilization

The organic products used in Myanmar are dried organic products, sold in bags of 50 kg. Fresh organic products are not used by the farmers in this survey. The nutrient content of the dried products is presented in Table 1.
All products (chemical and organic) are applied as close to the potatoes at planting as possible. Farmers believe that this will increase the efficiency but have no knowledge on possible salt damage and subsequently delay of germination. As some application rates of for instance K_2O are rather high, a delayed germination may be expected. A second application of fertilizers is applied at ridging. The general procedure is that fertilizers are spread and ridging takes place. The moment of this ridging is chosen when the crop is approximately 0.15 m tall.

Figure 11 *An example of two fertilizer blends used in Naung Ta Yar.*

Naung Ta Yar
Half of the farmers in Naung Ta Yar used these dried organic products to fertilize the potatoes. Except for one occasion, the organic products were applied at planting or close before planting. One farmer applied the organic product and chemical fertilizer more than 1 month before planting. All farmers applied chemical fertilizers shortly before or at planting and 71% of the farmers applied a second application of chemical fertilizers, again mostly a blend, at ridging.
The total amount of nitrogen fertilizers applied varied between 70 and 512 kg/ha (Table 16). Most of the total N, P_2O_5 and K_2O is applied with chemical fertilizers, 89%, 94% and 89% on average, respectively. The majority of the chemical nutrients are applied with fertilizer blends (Table 16). It is striking that different fertilizer blends are applied at planting. This may be because some blends contain additional nutrients to NPK (Figure 11). Farmers may get advice from the AgroShops to apply these enriched blends but as they may be more expensive, farmers most likely do not apply the total amount of NPK with these relative expensive fertilizer products and use products without these

additional nutrients. Furthermore, it appeared that farmers cannot calculate the total amount of a specific nutrient that is applied with the different products. Each 50 kg bag contains the same amount of N, P and K as far as the farmers are concerned. The favourite products are 10-10-05 and 15-15-15 blends. In addition, it is remarkable that 21% of the farmers use foliage sprays with nutrients (Table 16).

The total amount of nutrients applied are relatively high compared to the expected removal with the (low) yield, even when general efficiency losses are taken into account. Crop demand in general, is higher for N than for P_2O_5. But, because the soil in Naung Ta Yar has very low P-levels (Table 10), these high application rates contribute to meet crops demand.

Table 15

The amount of organic products used (ton/ha) and the amount of N, P_2O_5 and K_2O (kg/ha) from organic fertilizers and chemical fertilizers applied in potato.

	Naung Ta Yar			Heho		
	Average	Max	Min	Average	Max	Min
Organic products	**3.6**	**7.2**	**0.9**	**15**	**25**	**5**
N-organic	51	101	13	194	263	70
P_2O_5-organic	28	56	7	118	173	11
K_2O-organic	39	78	10	150	203	54
N-chemical	196	443	70	79	149	19
P_2O_5-chemical	222	483	66	126	200	56
K_2O-chemical	165	430	61	95	200	19
Total N	221	512	70	274	411	89
Total P_2O_5	237	483	83	244	373	68
Total K_2O	184	461	62	245	403	73

Table 16

Fertilizer products and types applied in potato by farmers (% of farmers).

		% of farmers	
Product	**Type**	**Naung Ta Yar**	**Heho**
Chemical fertilizers	NPK 9-25-25	-	20
	NPK 10-05-05	8.3	-
	NPK 10-10-05	70.8	10
	NPK 15-05-05	12.5	-
	NPK 15-07-08	-	20
	NPK 15-10-05	4.2	-
	NPK 15-15-10	4.2	-
	NPK 15-15-15	62.5	100
	NPK 15-15-20	8.3	-
	NPK 15-43-20	-	10
	NPK 16-16-08	4.2	-
	NPK 16-16-16	-	10
	NPK 17-10-10	4.2	-
	P_2O_5 46%	37.5	50
	Urea 46%	25	20
	K_2O 60%	42	30
Organic fertilizers	Compost	50	-
	Cow manure		100
Foliar applications	Armo 2(15-15-15+6 micro elements)	21	
	Inca (4,8%N, 7%CaO, 1% Zn)		
	NPK 0-40-40		
	NPK 20-20-20		
	NPK 25-05-05		
	NPK 38-05-05		
	Soil Plus organic carbon		
	NPK 00-52-43	-	30
	NPK 15-43-20	-	
	NPK 20-10-10	-	

Heho

In Heho, all farmers used organic products before or at planting (Table 16). As a consequence, the total N, P_2O_5 and K_2O applied are high with 274, 244 and 245 kg/ha respectively.
All farmers applied chemical fertilizers shortly before or at planting. Besides different NKP blends, 50% of the farmers also applied additional phosphate fertilizers and 33% of the farmers applied additional potassium fertilizers at planting (Table 16). One farmer applied a second application of chemical fertilizers, two blends, at ridging.
The total amount of nitrogen fertilizers applied varied between 89 and 411 kg/ha (Table 16). Most of the total N, is applied with the organic products, 71% where most of the P_2O_5 and K_2O are applied with the chemical fertilizers, 54% and 50% on average, respectively. The majority of the chemical nutrients are applied with fertilizer blends (Table 16). As in Naung Ta Yar, the different fertilizer blends are applied at planting for the same reasons. Furthermore, it appeared that farmers cannot calculate the total amount of a specific nutrient that is applied with the different products. Each 50 kg bag contains the same amount of N, P and K as far as the farmers are concerned. The favourite product is 15-15-15 blend which they all use. Foliar sprays are only used by one farmer, although he applied three different blends at three different moments during the growing season (Table 17).

The total amount of nutrients applied are relatively high compared to the expected removal with the (low) yield, even when general efficiency losses are taken into account. Crop demand in general, is higher for N than for P_2O_5. Considering the suboptimal phosphate levels in the soil, a high P_2O_5 in beneficial for the production. But, the potassium application levels are high and may potentially cause salt stress on top of the already salty soils (Table 10). This is promoted by the application close to the seeds in the row.

Table 17
Details on how, when and frequency of the use of different fertilizer products.

	Naung Ta Yar	Heho
Number of foliar sprays when applied[1]	1.6	3[3]
Number of chemical N fertilizer applications[1]	2.4	1.1
Chemical N applied before planting (% of farmers)	96	100
Percentage of total N applied pre planting (% of total amount)[2]	75	98
Second N application after planting (DAP)	29	29
Third N application after planting (DAP)	68	-
Number of chemical P_2O_5 fertilizer applications[1]	3.0	1.1
Chemical P_2O_5 applied before planting (% of farmers)	96	100
Percentage of P_2O_5 applied pre planting (% of total amount)	75	97
Second P_2O_5 application after planting (DAP)	30	29
Number of chemical K_2O fertilizer applications[1]	2.1	1
Chemical K_2O applied before planting (% of farmers)	88	100
Percentage of K_2O applied pre planting (% of total amount)	79	97
Second K_2O application after planting (DAP)	26	29
Organic product application (days before planting)	0.1	0.0

1 per season

2 including N applied with organic products

3 One grower sprayed three times

4 One grower applied a fertilizer blend of NKP 29 days after planting

3.1.6 Crop protection

The most important fungal disease in the potato production in both regions was late blight (caused by *Phytophthora infestans*) especially in this, the post monsoon season. Most fungicides were therefor used to control late blight (Table 18). Pesticides were in general applied with a knap sack sprayer and occasionally as a powder at planting with the fertilizers. No protective closing or other safety precautions were taken (Figure 12 top). Package materials of pesticides were left on the fields or in the gutters or in the small man made ponds for the collection of rain water for spraying (Figure 12 bottom).

Most fungicides used belonged to the WHO class III or U (Table 18), corresponding with slightly hazardous and unlikely to pose an acute hazard in normal use. Most insecticides used belonged to class II, moderate hazardous, but occasionally to class Ib, highly hazardous (Table 19). Most herbicides and other chemicals were classified as slightly hazardous or unlikely to pose an acute hazard although paraquat was use and that is considered highly hazardous (Table 20).

Table 18
Overview of different fungicides used in Naung Ta Yar and Heho. Number of farmers interviewed between brackets.

Type of fungicide for late blight control			% of farmers applying the fungicides		
		WHO[1]	Naung Ta Yar (24)	Heho (10)	All farmers (34)
Contact	Chlorothalonil	U	42	10	32
	Mancozeb	III	75	70	74
	Copperchloride	III	8	-	6
Local systemic	Cymoxanil	III	38	20	32
	Dimethomorph	U	92	70	85
Systemic	Metalaxyl	III	25	20	24
Controlling other diseases than late blight	Azoxystrobin	III	50	-	35
	Carbendazim	U	13	10	12
	Difeconazole	III	67	10	50
	Hexaconazole	U	4	-	3
	Hymexazol	-	4	-	3
	Propineb	U	-	20	6
	Propiconazole	U	29	20	27
	Thiophanate Methyl	III	4	-	4
	Thiram	III	4	-	4

[1] see Table 2 for explanation of the pesticide classification system by the World Health Organisation

Figure 12 *An example of weighing chemicals (top left), adding water collected from the nearby gutter (top middle), applying pesticides without protection (top right)and an example of disposed pesticide packaging in the field (bottom left) or in the (gutter (bottom right).*

Naung Ta Yar

Most farmers used contact fungicides to control late blight (Table 18). In addition, the local systemic fungicide dimethomorph was used by almost all farmers. Beside these fungicides they also applied a large number of other fungicides to control early blight or other fungal diseases. It was not always clear for what purpose the fungicides are used.
When looking at the insecticides (Table 19) also a large number of different products were applied of which imidacloprid was used by almost half of the farmers. Also, the purpose for use was not clear. Paraquat was used by 71% of the farmers for weed control (Table 20) and 21% of the farmers used a plant growth regulator on their potatoes. This product was normally used in rice. Furthermore, almost half of the farmers used an antibiotic on their crop.

Table 19

Overview of different insecticides used in Naung Ta Yar and Heho. Number of farmers interviewed between brackets.

		% of farmers applying the insecticides		
Chemical compound	**WHO[1]**	**Naung Ta Yar (24)**	**Heho (10)**	**All farmers (34)**
Acephate	II	-	10	3
Acetamiprid	II	8	-	6
Carbofuran	II	17	50	27
Carbosulfan	-	4	-	3
Cartap	II	21	-	15
Chlorpyrifos	II	29	10	24
Cypermethrin	II	17	50	27
Diazinon	III	8	-	6
Imidacloprid	II	46	20	38
Lambda Cyhalothrin	II	21	-	15
Methomyl	Ib	8	-	6
Profenofos	II	13	-	9
Prolam	-	4	-	3

[1] see Table 2 for explanation of the pesticide classification system by the World Health Organisation

Table 20

Overview of other chemicals used in Naung Ta Yar and Heho. Number of farmers interviewed between brackets.

			% of farmers applying the chemicals		
		WHO[1]	**Naung Ta Yar (24)**	**Heho (10)**	**All farmers (34)**
Herbicides	Paraquat	Ib	71	10	53
	Glyphosate	U	8	10	3
	Pendimethalin	III	-	10	3
	Oxadiazon	-	-	20	6
	Delete	-	-	10	3
Plant growth regulators	Mepiquat chloride	II	21	-	-
Antibiotics	Abamectin	III	42	20	35

[1] see Table 2 for explanation of the pesticide classification system by the World Health Organisation

The average spray volume was approximately 500 l/ha and the average number of fungicide applications was 11 where insecticides were applied 7 times on average (Table 21). The large number of applications of both fungicides and insecticides indicates that tank mixes were made frequently. On average, farmers combined 2.6 fungicide products when spraying, up to a maximum of 6 products in one application (Table 22). The first fungicide application was 24 days after planting and spraying continued for the next 47 days (Table 23). After the last spray, harvest took place after 18 days on average. The interval between fungicide sprays was 4.5 days. This interval was very short as chlorothalonil and or mancozeb were found to effectively control late bight at intervals of 6 to 8 days (Myint 2007). Insecticides were sprayed less frequently, 7 sprays per season resulting in an application every 6.3 days. Insecticides were less frequently combined than fungicides, 1.3 products on average up to a maximum of 2 products. The foliar fertilizer products were when used, combined with the pesticides as well.

The total kg active ingredients applied with fungicides varied between 2.2 up to 74 kg/ha with an average of 17.8 kg/ha (Table 24). The total kg active ingredients applied with insecticides ranged from 0 to 25 kg/ha with an average of 2.0 kg/ha.

Table 21

The average spray volume applied per application, and total number of applications with a fungicide and with an insecticide in one growing season.

	Naung Ta Yar			Heho		
	Average	Max	Min	Average	Max	Min
Spray volume per application (l/ha)	491	1028	279	598	2167	45
Nr. of fungicide applications	11	18	7	10	20	2
Nr. of insecticide applications	7	16	1	7	12	2

Heho

The average spray volume was approximately 600 l/ha and the average number of fungicide applications was 10 as insecticides were applied 7 times on average (Table 21). As described above, the large number of applications of both fungicides and insecticides indicated that tank mixes were made frequently. The foliar fertilizer products were, when used, combined with the pesticides as well.

On average, farmers combined 1.9 fungicide products when spraying, up to a maximum of 2.5 products in one application (Table 22). The first fungicide application was 18 days after planting and spraying continued for the next 25 days (Table 23), or in this survey, till the visits were no longer preformed. No information was available for the time between the last spray and harvest.

The interval between fungicide sprays was 3.4 days.
On average, farmers used 1 insecticide product when spraying, although sometimes more products were combines (Table 22). Insecticides were sprayed less frequently, 7 sprays per season resulting in an application every 8 days.

The total kg active ingredients applied with fungicides varied between 0.6 up to 57 kg/ha with an average of 13.7 kg/ha (Table 24). The total kg active ingredients with insecticides ranged from 0 to 1.6 kg/ha with an average of 1.1 kg/ha.

Table 22

Application interval (days) of fungicides or insecticides, and average number of fungicide or insecticide products used per single application.

	Naung Ta Yar			Heho			
	Average	Max	Min	Average	Max	Min	Mean
Fungicide application interval	4.5	6.6	3.1	3.4	5.0	2.0	3.9
Nr. of fungicide products per application	2.6	6.0	1.0	1.9	2.5	1.0	2.3
Insecticide application interval	6.3	25	0.0	8.1	11.0	3.3	7.2
Nr. of insecticide products per application	1.3	2.0	1.0	1.0	1.2	1.0	1.1

Table 23

Number of days between planting and first fungicide application, between first and last application and between last application and harvest.

	Naung Ta Yar			Heho		
	Average	Max	Min	Average	Max	Min
Days between planting and first application	24	69	47	18	10	20
Days between first and last application	47	22	69	25	2	57
Days between last application and harvest	18	0	40	-	-	-

Table 24

Total amount of active ingredients applied with fungicides, insecticides or herbicides (kg/ha).

	Naung Ta Yar			Heho			
	Average	Max	Min	Average	Max	Min	Mean
Fungicides	17.8	73.7	2.2	16.2	52.7	0.6	17.0
Insecticides	2.0	25.0	0.1	0.9	1.6	0.5	1.4
Herbicides	0.6	3.1	0.1	1.0	2.4	0.0	0.8

3.1.7 Harvest

The yield of the potato production ranged from 18 tons/ha in Naung Ta Yar till 15 tons/ha in Heho (Table 25), which was comparable to the average yields estimated for Southern Shan State of 18 - 19 tons/ha (par. 2.3.1) and to the countries average of 15 tons/ha (par. 1.2). In Naung Ta Yar, one field had an excellent yield of 40 tons/ha, for one repetition, and 25 tons for the second repetition, with an average of 33 tons/ha. Diamond star (processing company) started importing the variety Atlantic from 2010 onwards (Myint 2015), has the import rights and imports seed through the Dutch seed company Agrico. The variety Atlantic has good processing qualities but is very susceptible to late blight.

The estimated dry matter concentration (by W.I.W) was low, 15% indicating that either the crop was immature when harvested or that high amounts of N and potassium applications reduced dry matter concentration. One field in Naung Ta Yar and one field in Heho had a dry matter concentration of 21 and 22% respectively, due to the variety Atlantic.

Table 25

Potato fresh yield (ton/ha), weight in tap water (W.I.W.; weight of 5050 g dry potatoes in tap water) estimated percentage of dry matter concentration (%, D.M.) and specific gravity (mg/cm^3, S.G.).

	Naung Ta Yar			Heho			
	Average	Max	Min	Average	Max	Min	Mean
Fresh tuber yield	18.2	33.3	7.3	14.8	20.0	10.3	16.5
W.I.W.	261	394	211	269	415	180	265
D.M.	14.8	21.4	12.4	15.2	22.4	10.9	15.0
S.G.	1,055	1,086	1,043	1,056	1,056	1,036	1,056

The tuber weight in the different size classes did hardly differ between Naung Ta Yar and Heho (Table 26).

Table 26

Tuber weight (g/tuber) in the different size classes (< 28 mm, 35 - 50 mm, 50 - 60 mm and >60 mm).

	Size class (mm)				
	<28	28 – 35	35 – 50	50 – 60	>60
Naung Ta Yar	9	18	55	116	200
Heho	7	22	57	115	210

3.1.8 Storage

When seeds are farm saved, they are kept under their house. Myanmar houses have storage capacity at the ground level and living quarters at the first floor. Storage time was usually 3.5 to 4.5 months (Table 27) as most farmers had more than one potato cultivation per year. The storage time showed that farmers from this baseline survey had an irrigated winter crop additionally to the post monsoon crop. The average harvest time of the seed was late April in Naung Ta Yar (approximately 113 days before planting on 12 August) and mid-May in Heho (approximately 130 days before planting on 15 September).

Potatoes and also seed potatoes, are kept in bags, baskets and bulk under their houses or in diffuse light storages (Figure 13). Potatoes as well as seed potatoes were frequently treated with pesticides, mostly with insecticides to control tuber moth infections. In Naung Ta Yar seeds were treated mostly just before bagging, (87% of farmers), whereas in Heho all farmers sprayed the pesticides over the free laying potatoes in bulk or diffuse light storage. Chemicals used were Cartap, Abamectin, Parzon (Cypermethrin + Phosalone) and Awdrin (Chlorpyrifos). But on some occasions, Mancozeb and Dimethomorf were used as well. In the diffuse light storage in Heho, fresh air can circulate around the potatoes at any time to properly dry the potatoes and to prevent increasing temperatures due to self-heating. The main reason to store potatoes in diffuse light storages was to keep the sprouts green and firm allowing early emergence.

Table 27

The storage methods and storage time (days) of seed potatoes in Naung Ta Yar and Heho.

	Method				Storage time		
Region	Bags	Baskets	Bulk	Diffuse light storage	Average	Max	Min
Naung Ta Yar	87	4	9	0	113	120	90
Heho	0	0	43	57	130	150	120

Figure 13 *Storage in bags (left) and bulk (middle) at the ground floor under a house, and in a diffuse light storage (right). Pesticides are used to control tuber moth during storage.*

3.1.9 Marketing

Most farmers sell their potatoes to the local market of Aungban through a middleman. They store the potatoes under their houses and wait for good prices to deliver to Aungban. Only a few farmers indicated that they sell the potatoes this way but it is common practice in the region.

3.2 Additional non-funded activities

3.2.1 Collection of *Phytophthora* DNA samples

Seven of the collected samples contained DNA of *Phytophthora*. The metalaxyl resistant A2 type of *Phytophthora infestans* was found of all of the 7 samples (Figure 14). Two samples did not contain DNA of *Phytophthora*.

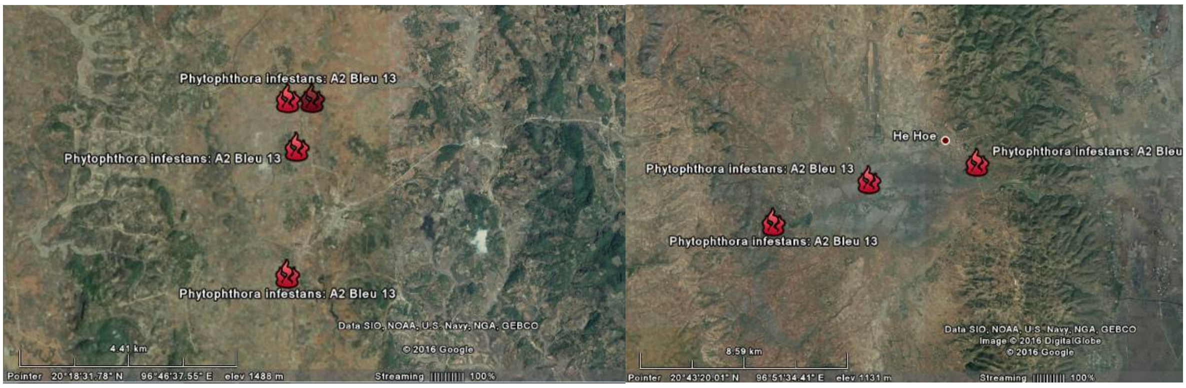

Figure 14 *Locations where Bleu 13 was found in Naung Ta Yar (left) and Heho (right) plotted in google Earth.*

3.2.2 Demonstration on seed tuber quality

Seed stock

The general impressions of the seed was sufficient and ranged from 3.5 for Atlantic to 7.5 for Carolus and Markies (Table 28). The physiological age of most varieties was sufficient, 6, although the physiological age of Atlantic with a 2.5 was very low and inadequate compared to the other varieties (Table 28). CIP-24 had the highest value, an 8 for physiological age, followed by a 7.5 for Carolus and a 7 for Markies. Kufri Jyoti yielded 5.9 in both regions and the Chinese variety was found inadequate with a 5.

The skin curing index showed that Atlantic had the highest index and was therefore the most sensitive seed for damage by peeling due to the less cured skin. The Chinese variety had no peeling and a totally cured skin, resulting in a 0. The other varieties had skin curing indexes in between these two extremes. The index for physical damage indicated that L11 suffered the most from mechanical damage where Markies hardly suffered. Kufri Jyoti was more damaged in Naung Ta Yar than in Heho.

Table 28

Results of the demonstration on seed tuber quality.

Region	Variety	# of samples	General impression	Physiological age	Skin curing index	Physical damage index
Naung Ta Yar	CIP-24	1	6	8	12	7.0
	Kufri Jyoti	9	6	5.9	7.9	8.3
Heho	Atlantic	2	3.5	2.5	21.5	4
	Carolus	2	7.5	7.5	1	7
	Chinese var.	1	6.5	5	0	6
	Kufri Jyoti	7	5.6	5.9	9.3	4.4
	L11	1	6	6.5	8	10
	Markies	2	7.5	7	9	1.5
Average			6.1	6.0	8.6	6.0

Seeds were not infected with *Fusarium* and only a low infection percentage was found for Blackleg (Table 29). The largest infection was found for tuber moths: all seed stocks except one were infected and the average infection rate of the infected seed stocks was 25%. Markies was not infected and L11 was the most infected seed stock with 80% infection. Tuber moth infection is one of Myanmar's major pests (Thun *et al.* 2006) and mostly occurs during storage. Although farmers intensively use pesticides to control tuber moths, apparently most seed stocks do suffer from it.

Table 29

The disease infections found on different seed tuber samples.

Region	Variety	# of samples	*Phoma* infection (%)	*Rhizoctonia* infection index	*Fusarium* infection %	Blackleg infection (%)	Common scab index	Silver scurf Index	Tuber moth infection (%)
Naung Ta Yar	CIP-24	1	4.0	0.0	0.0	0.0	0.0	6.0	42.0
	Kufri Jyoti	9	4.3	0.6	0.2	0.0	0.4	5.1	24.4
Heho	Atlantic	2	0.0	11.5	0.0	0.0	0.0	2.5	21.0
	Carolus	2	0.0	0.0	0.0	0.0	0.0	1.5	5.0
	Chinese var.	1	0.0	3.0	0.0	0.0	0.0	4.0	6.0
	Kufri Jyoti	7	5.6	0.0	0.0	1.3	0.0	9.3	22.0
	L11	1	0.0	0.0	0.0	0.0	0.0	0.0	80.0
	Markies	2	0.0	0.0	0.0	0.0	0.0	2.5	0.0
Average			1.7	1.9	0.0	0.2	0.1	3.9	25.1

The infection of diseases and pests differed between the two regions (Table 31 and Table 30). A higher *Phoma* infection percentage was found in Heho and black leg infections were only found in Naung Ta Yar. Almost all seed stocks were infected by Silver scurf, 76%, but the infection index was low, 3.9 showing that the infection was mild.

Table 30

The percentage of seed samples infected with diseases or pests.

	Naung Ta Yar	Heho	Total
Phoma infection (%)	27	80	48
Rhizoctonia infection index	20	20	20
Fusarium infection (%)	0	10	4
Blackleg infection (%)	13	0	8
Common scab index	0	10	4
Silver scurf index	80	70	76
Tuber moth infection (%)	60	90	29

Yield

Kurfi Jyoti was the most delivered variety by farmers although it was with its 11 tons/ha average fresh tuber yield a variety with one of the lowest yields in the demonstration (Table 32). Yields of Kufri Jyoti varied between 2.6 and 24 tons/ha demonstrating the large variability in seed quality and performance. Kufri Jyoti seeds from Naung Ta Yar yielded much better than those from Heho. The low yields were predominantly caused by a low number of stems per tuber as a result of one dominant top sprout. Kufri Jyoti has been introduced in Myanmar in 1992 as a late blight resistant variety (Myint 2004) which was one of the main reasons for farmers to cultivate this variety. Other varieties that participated were CIP 24, imported from Bhutan and L11 imported from Vietnam by Dr. Maung Maung Myint. Variety L11 has a good yield and is LB resistant, but it is a late variety and therefore difficult to cultivate in Heho and Naung Ta Yar.

The lesson learned here is, that farmers have no or very limited knowledge on how to prepare seeds for planting. Removal of the dominant top sprout and dormancy breaking are unknown to them as processes that can greatly improve seed performance.

Furthermore, seeds of Kufri Jyoti were on average small, <35 mm (Table 31).

Table 31

The average number of tubers in the different size classes (mm), the average weight of 50 tubers (g) and the average tuber weight of seed samples from Naung Ta Yar (NTY) and Heho.

		Number of tubers					
		<28	28-35	35-45	45-55	>55	g/tuber
NTY	CIP-24	2	46	2	0	0	21
	Kufri Jyoti	39	10	28	13	2	44
Heho	Atlantic	10	27	14	0	0	25
	Carolus	13	30	10	8	0	31
	Chinese variety	2	17	31	0	0	29
	Kufri Jyoti	17	31	15	2	0	21
	L11	0	0	35	15	0	60
	Markies	0	3	11	33	3	43
All samples		8	19	16	5	0	34

Table 32

Fresh and dry tuber yield, the dry matter concentration (D.M., %) and weight in tap Water (W.I.W.; weight of 5050 g dry potatoes in tap water) of different varieties in the seed demonstration from Naung Ta Yar (NTY) and Heho.

			Yield (ton/ha)			
Region	Variety	# of plots	Fresh	Dry	D.M.	W.I.W.
NTY	CIP-24	1	11.3	2.2	19.1	348
	Kufri Jyoti	9	14.1	2.3	16.9	302
Average			12.7	2.2	18.0	325
Heho	Atlantic	2	12.7	3.0	23.8	443
	Carolus	2	7.9	1.3	16.3	291
	Chinese variety	1	14.9	2.6	17.8	320
	Kufri Jyoti	7	6.0	1.1	18.9	343
	L11	1	20.3	4.3	21.2	390
	Markies	3	17.3	3.0	17.2	309
Average			13.1	2.5	19.0	346
Average			13.0	2.5	18.8	341

3.2.3 Trials

Ridging trial

The yield of the plots in the ridging trial varied between 18 to 25 tons/ha (Table 33). Early or late ridging has a small and non-significant effect on fresh and dry tuber yields or on W.I.W. Also, the second harvest did not increase yields, it significantly reduced fresh tuber yields at the 10% significant level. Early ridging might be beneficial as temperature is cooler when early ridging takes place and thus cool air is stored within the ridge and stimulates a better development of the crop. Although early ridging increased yields t the first harvest with approximately 3 tons/ha this is within the variation of yields measured.

Table 33

Effect of early and late ridging on fresh and dry tuber yield (ton/ha), the dry matter concentration (D.M., %) and weight in tap water (W.I.W.; weight of 5050 g dry potatoes in tap water).

		Yield (ton/ha)			
Harvest time	Ridging time	Fresh	Dry	D.M.	W.I.W.
15 November	Early	24.3 (b)	4.2	17.1	308
15 November	Late	21.1 (b)	3.5	16.7	299
15 December	Early	18.6 (a)	3.0	16.2	287
15 December	Late	18.1 (a)	3.1	17.1	307
Harvest time		*[1]	n.s.[2]	n.s.	n.s.
Ridging time		n.s.	n.s.	n.s.	n.s.
Harvest time x Ridging time		n.s.	n.s.	n.s.	n.s.
LSD (p = 0.1)		4.31			

1 * meaning p = 0.1

2 n.s. meaning not significant

Nitrogen application trial

Harvest time nor nitrogen application level had an effect on yield or W.I.W. (Table 34). A difference of approximately 3 tons/ha fresh yield increase may seem substantial between an application of 100 kg/ha and 200 kg/ha but is within the variation of the measurements and not significant. This trial indicates that an application of 100 kg/ha was just as good for production as 200 or 300 kg/ha. At the time of the first harvest, the crop was still green and expected to increase in yield in the next few weeks. However, this increase was not substantiated with the measurements of the second harvest one month later.

Table 34

Effect of nitrogen application of 100, 200 and 300 kg/ha on fresh and dry tuber yield (ton/ha), the dry matter concentration (D.M., %) and Weight In tap Water (W.I.W; weight 5050 g dry potatoes in tap water). No significant effects are found for harvest time or nitrogen application.

		Yield (ton/ha)			
Harvest time	N-application	Fresh	Dry	D.M.	W.I.W.
15 November	100	18.6	3.0	16.4	293
15 November	200	21.4	3.5	16.2	288
15 November	300	19.7	3.3	17.2	310
15 December	100	19.6	3.6	18.2	329
15 December	200	22.1	3.5	15.7	278
15 December	300	22.0	3.8	17.3	312
Average		20.6	3.5	16.8	301

Potassium application trial

Fresh tuber yield varied between 20 and 31 tons/ha (Table 35). Compared to all other trials, this yield is high. Also, dry tuber yield is high 5.2 tons/ha maximum with an overall average of 4.3 tons/ha.

Table 35

Effect of potassium application of 100, 200 and 300 K_2O/ha on fresh and dry tuber yield (ton/ha), the dry matter concentration (D.M., %) and Weight In tap Water (W.I.W; weight 5050 g dry potatoes in tap water).

		Yield (ton/ha)			
Harvest time	K_2O-application	Fresh	Dry	D.M.	W.I.W.
15 November	100	27.7	4.4	15.8	280
15 November	200	27.9	4.7	16.8	300
15 November	300	20.4	3.6	17.6	317
Average		25.3	4.2	16.7	299
15 December	100	22.3	4.1	18.5	335
15 December	200	30.7	5.2	16.8	300
15 December	300	26.2	4.1	15.8	280
Average		26.4	4.5	17.0	305
Average		25.9	4.3	16.9	302

Planting distance trial

Yields of fresh potatoes from large seed varied between 16 to 24 tons/ha and was mostly higher than fresh yields of small potatoes (Table 36). The interaction showed that planting small seeds at large distance can yield as much as large seeds planted at small distances. The dry tuber yield showed similar effects of both seed size and row distance. Small seeds yielded lower but at large distances dry yield was the same as from large seeds at small distances, compare 2.56 and 2.41 tons/ha. Large seeds planted at large distances had the highest dry tuber yield. The Weight in tap Water (W.I.W.) was only affected by row distance: a larger row distance increased the W.I.W. of both small and large seeds.

Table 36

Effect of seed tuber size and planting distances on fresh and dry tuber yield (ton/ha), the dry matter concentration (D.M., %) and Weight In tap Water (W.I.W; weight of 5050 g dry potatoes in tap water).

		Yield (ton/ha)			
Seed size	Distance	Fresh	Dry	D.M.	W.I.W.
Small	40	10.0 (a)	1.49 (a)	14.9 (a)	262 (a)
	60	10.1 (a)	1.43 (a)	14.2 (a)	247 (a)
	80	14.2 (ab)	2.56 (b)	18.2 (bc)	328 (b)
Large	40	16.0 (b)	2.41 (b)	15.3 (a)	269 (a)
	60	26.0 (cd)	4.17 (c)	16.0 (ab)	285 (a)
	80	24.2 (d)	4.54 (d)	18.7 (c)	340 (b)
Size		***[1]	***	n.s.[1]	n.s.[1]
Distance		**	***	*	*
Size x Distance		*	***	n.s.	n.s.
LSD (p = 0.05)		4.65	0.346	2.57	74.2

[1] ***, ** and * are for p <0.01; 0.01 < p < 0.05; 0.05 < p < 0.1

[2] n.s. meaning not significant

Best Practices

Yield from fields with an increased soil cultivation and larger rows of the treatment best practices was good (Table 37) and in agreement with the yields of several other treatments, see Table 33, Table 34 and Table 35. The intension to loosen the soil was promising but blisters on hands made clear that it was not an easy job to do.

Table 37
Effect of Best Practices on fresh and dry tuber yield (ton/ha), the dry matter concentration (D.M., %) and Weight In tap Water (W.I.W; weight 5050 g dry potatoes in tap water).

	Yield (ton/ha)			
Best Practices	Fresh	Dry	D.M.	W.I.W.
Average	23.2	3.3	14.4	251
Standard deviation	3.2	0.3	3.4	68.7

3.2.4 Field day mid-term potato cultivation on 24 October 2015

The main purpose of this field day was to show stakeholders (farmers, local suppliers, officials etc.) the cultivation up till this point, and evaluate and discuss crop performance. Later on, at the end of the cultivation period, a second field day was organized (see par. 3.5.2).

Almost 20 visitors attended the field day and engaged in lively discussions on seed quality, fertilizer use and all that came to mind. Differences between treatments showed clearly and the meeting fulfilled its educational intended effects. Participants were critical on some treatments and most interested in the yields to come. Farmers indicated that it is not guaranteed that a nicely looking crop yields good. Therefore, they will return when yields are shown.

Figure 15 *The field day organizing team (left) and visiting stakeholders (right).*

3.2.5 Short communication: Quick win gap and baseline study of potato cultivation practices in Myanmar

The short communication 'Quick win gap and baseline study of potato cultivation practices in Myanmar' is listed in Annex 5.

3.3 Yield gap analysis

3.3.1 Attainable yields according to model calculations

The average input data are presented in Table 38. As the variation in planting dates was large, the yield gap analysis was done on the data of each individual farm. Irrigation is not needed in this post monsoon cultivation as natural precipitation is sufficient for crop growth and not further included (see also par. 2.1.2.7).

Naung Ta Yar
The measured yield in Naung Ta Yar was 18 tons/ha fresh potatoes. The weight in tap water was used to determine the dry yield, which was 2.7 tons/ha. The average dry matter concentration was low, only 15%. The dry matter concentration of Atlantic was high, 21%, but an exception. The modelling results indicated that 4.9 tons/ha dry yield and 42 tons/ha fresh yield can be obtained.

Heho
The measured yield in Heho was 15 tons/ha fresh potatoes. The weight in tap water was used to determine the dry yield, which was 2.1 tons/ha. The average dry matter concentration was low, only 15%. Again, Atlantic had a higher dry matter concentration, 22%. The modelling results indicated that 7.9 tons/ha dry yield and 54 tons/ha fresh yield can be obtained.

Table 38
The measured input data for the yield gap analysis compared with model results.

	Naung Ta Yar		Heho	
Measured input data	**Mean**	**SE**	**Mean**	**SE**
Planting date	10-Aug-15	12	15-Sep-15	17
Harvesting date	07-Nov-15	3	15-Dec-15	-
Planting depth (cm)	9.7	1.8	12.2	4.0
Yield (ton fresh/ha)	18.2	6.4	14.9	3.5
Yield (ton dry/ha)	2.7	0.9	2.1	0.1
# of growing days	89	11	91	17
Model results				
Yield (ton dry/ha)	4.9	1.2	7.9	1.50
# days with 100% ground cover	57	11	54	18
Ratio Actual : Attainable	0.55	0.20	0.27	0.07

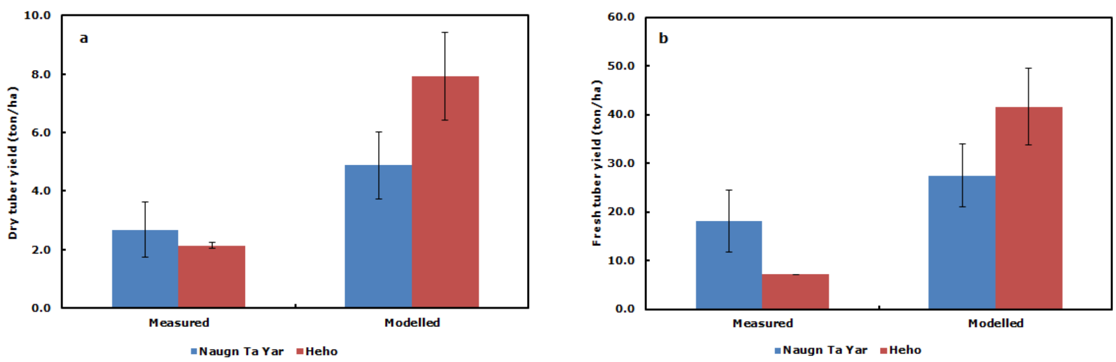

Figure 16 *Results of the yield gap estimates on dry (a) and fresh yields (b).*

3.4 Economics

3.4.1 Operational costs

Seeds
One farmer in Naung Ta Yar and 4 farmers in Heho indicated the costs of seed (Table 39).

Table 39

Cost of seed (€/ha, 1€ = 1,393 Kyats).

	Naung Ta Yar				Heho				
	#	Average	Max	Min	#	Average	Max	Min	Mean
Seed	1	999	-	-	4	1,036	1,564	621	1,018

Fertilizers

The costs for mineral fertilizers (Table 40) ranged from 406 to 571 €/ha in Heho and Naung Ta Yar respectively. When organic products were used additionally to the mineral fertilizers, costs for fertilization increased substantially. All farmers in Heho used organic fertilizers which considerable contributes to the product costs. The money spend on organic fertilizers in Heho per farmer was higher than in Naung Ta Yar as the average application rate in Heho was 25 tons/ha compared to an average application rate in Naung Ta Yar of 3.6 tons/ha (Table 16).

Table 40

Cost of applied fertilizer products (€/ha) and number of farmers (#) on which the costs are calculated (1€ = 1,393 Kyats).

	Naung Ta Yar				Heho				
Fertilizer products	#	Average	Max	Min	#	Average	Max	Min	Mean
Mineral	24	571	1,449	62	10	406	947	181	488
Organic	10	272	1,235	49	10	600	1,484	135	436
Foliar	4	28	82	7	1	20	20	20	24
Total[1]		689	1,710	62		1,008	2,432	532	848

[1] The average of total costs is calculated for individual farmers and may differ from the total average calculated as the sum of column average. This because not all farmers used all pesticide products.

Crop protection

Most money was spend on fungicides, ± 500 €/ha in both regions and was followed closely in Naung Ta Yar by costs for insecticides (Table 41).

Table 41

Cost of applied pesticide products (€/ha) and number of farmers (#) on which the costs are calculated (1€ = 1,393 Kyats).

	Naung Ta Yar				Heho				
Pesticide product	#	Average	Max	Min	#	Average	Max	Min	Mean
Fungicides	24	478	1,485	142	8	544	1,876	8	511
Insecticides	24	313	4,981	9	4	140	402	21	226
Herbicides	21	10	49	2	5	37	58	17	24
Total[1]		777	6,087	191		549	2,191	1[2]	663

[1] The average of total costs is calculated for individual farmers and may differ from the total average calculated as the sum of column average. This because not all farmers used all pesticide products.

[2] One farmer in Heho did use very limited amounts of pesticides, most likely due to an incomplete registration.

Machinery (fuel and repairs)

Information on fuels and repairs were not registered in the data collected and therefore not included in the operational costs.

Marketing costs

Cost for marketing were not collected.

Labour

As mentioned before (par. 2.4.1) information on labour was difficult to collect. It is therefore not clear if the labour mentioned was for contract jobs or by permanent employs. Furthermore, not all field operations were included due to missing data.

Table 42

Cost of labour (€/ha) for different field operations and number of farmers (#) on which the costs are calculated (1€ = 1,393 Kyats).

	Naung Ta Yar				Heho			
	#	Average	Max	Min	#	Average	Max	Min
Land preparation	1	39	-	-	9	24	65	6
Planting	20	106	169	53	9	97	260	35
Ridging	15	88	191	25	4	71	106	35
Fertilization	2	10	10	9		-	-	-
Crop protection	15	80	188	4	9	138	645	19
Harvesting	4	165	222	85		-	-	-
Total labour costs		487	780	176		330	1,076	96

Land rent

When land is rented this was often just for the potato cultivation. Three crops are usually grown per year on one field. Potato being the most profitable cultivation, was charged more than would be charged for the other two crops. Farmers here only rented the land for the potato cultivation.
In Naung Ta Yar, 21% of the farmers had potatoes grown on rented land. One farmer rented the land for one year on which two potato productions were produced, the other farmers rented land for one potato production period. The cost for renting land for one potato production was on average 22 €/ha.
In Heho, one farmer rented land for 32 €/ha, for a potato cultivation.

Rented equipment for soil cultivation

Equipment for soil cultivation were a cow or buffalo, and a small, normal or big tractor (Table 43). This equipment was mostly rented in Naung Ta Yar and in Heho tractors were owned. Costs for rented equipment included a person to run the equipment where costs for tractors owned in Heho were operational costs for the use only, including labour to operate the tractor.
Cow/buffalo and tractors were used for ploughing, harrowing and ridging although ploughing was mostly done by a big tractor and small tractors mostly used for ridging and harrowing.
The costs for renting a tractor varied between 33 and 77 €/ha (Table 43) and was on average 61 €/ha. The average costs for soil cultivation in Naung Ta Yar was 54 €/ha. The operational costs of owned tractors were only 12 €/ha.

Table 43

Costs for renting a cow/buffalo or a tractor and number of farmers (#) on which the costs are calculated in Nauyng Ta Yar and Heho (€, 1€ = 1,393 Kyats).

	Naung Ta Yar		Heho	
	#	€/ha	#	€/ha
Cow/buffalo	19	35	-	-
Small tractor	3	33	4	15
Tractor	4	73	2	9
Big tractor	4	77	3	13
Average		54		12

Total operational costs for the potato production

The total operation costs ranged from a minimum of 467 €/ha to a maximum of 8,682 €/ha both found in Naung Ta Yar (Table 44). The average total costs in both regions was approximately 3,000 €/ha. Seed costs contribution to the products cost was ≈ 33% and was the most costly product to be purchased (Table 44), followed by cost of pesticides in Naung Ta Yar and closely followed by the cost of fertilizer in Heho. The cultivation of potato showed to be a capital intensive crop and farmers needed to have cash or other means (credit for example) to pay for these investments.
These data should, however, be treated carefully as they were not totally complete and based on farmers view of prices and labour costs.
Although it was clear that this estimated production costs did not include all costs, it was in agreement with the official estimate production costs of the FAO for the potato cultivation in Myanmar (Figure 17).

Table 44
Total operational costs for potato cultivation and the percentage wise contribution of different field operations to the total operational production costs (€/ha, 1€ = 1,393 Kyats).

	Naung Ta Yar				Heho			
	Average	Max	Min	%[1]	Average	Max	Min	%[1]
Seed	999	-	-	33	1,036	1,564	621	35
Fertilization	689	1,710	62	23	1,008	2,432	532	34
Crop protection	777	6,087	191	26	549	2,191	1	19
Land rent	21	33	13	1	35	-	-	1
Tractor rent	54	73	35	2	12	15	9	-
Labour	487	780	176	16	330	1,076	96	11
Total	3,027	8,682	476		2,970	7,277	1,258	

[1] Column results in 100%

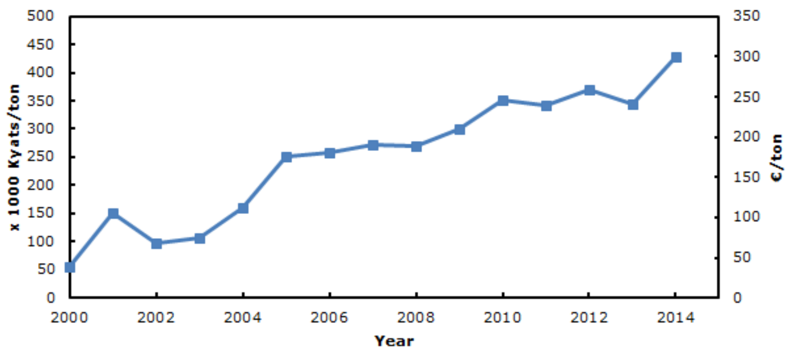

Figure 17 *Development of the official estimated production costs for potato production in Myanmar (FAOSTAT, accessed 30 November 2015).*

3.4.2 Fixed costs

Fixed costs were not included as data on own land costs were not collected and data on tractors were for rented tractors for soil cultivation operations. Depreciating and investments were also not included.

3.4.3 Economic return

The balance calculation showed that profits ranged from slightly more than 600 €/ha to more than 6,000 €/ha (Table 45).

Table 45
A balance calculation for the average yield of Naung Ta Yar and Heho at a selling price of 0.27 and 0.57 €/kg (1€ = 1,393 Kyats).

	Naung Ta Yar			Heho		
	kg/ha	€/ha		kg/ha	€/ha	
Yield	18,200[1]	4,411	9,410	14,800[1]	3,587	7,652
Seed		999	999		1,036	1,036
Fertilizers		689	689		1,008	1,008
Crop protection		777	777		549	549
Land rent		21	21		35	35
Tractor rent		454	47		-	-
Labour		487	487		330	330
Total operational costs		3,027	3,020		2,970	2,970
Profit		1,384	6,390		617	4,682

[1] A 10% loss was included between harvest and selling

[2] 0.27 €/kg corresponds with 370 Kyats/kg, 0.57 with 800 Kyats/kg

Exploring the range of farmers yields (15,000 to 20,000 kg/ha) and market prices (between 370 and 800 Kyats/kg), the financial yields were estimated between 700 €/ha and 7,500 €/ha (Table 46). Labour costs were not complete and for Heho the disease control was not monitored throughout the entire cultivation period. This estimate is therefore an optimistic view of the profit.

Table 46
A simple profit calculation for the potato cultivation in Naung Ta Yar and Heho at a selling price of 0.27 or 0.57 €/kg (1€ = 1,393 Kyats).

		€/ha	
Region	Yield[1] (kg/ha)	0.27[2]	0.57
Naung Ta Yar	15,000	616	4,736
	20,000	1,828	7,321
Heho	15,000	677	4,797
	20,000	1,889	7,382

[1] A 10% loss was included between harvest and selling

[2] 0.27 €/kg corresponds with 370 Kyats/kg, 0.57 with 800 Kyats/kg

3.5 Communication

3.5.1 Visits by WUR scientist to Southern Shan State

The three visits were carried s planned. Trip reports are made

Trip report of the first visit (23 – 28 August)
Departure Schiphol for Bangkok on 23 August at 17.15 hrs. with Koen Minderhout and Machiel Goosen
Arrival at Bangkok on 24 August at 10.05 hrs.
Departure for Yangon on 24 August at 13.40 hrs.
Arrival at Yangon on 24 August at 14.40 hrs, met with Mr. Jackson Kalipo, night stop at M-hotel.
Departure to Heho on 25 August at 6.30 hrs from Yangon domestic airport.
Arrival at Heho on 25 August at 7.45 hrs.

25 – 27 August 2015
This period was used to organize housing, select farmers and prepare the seed demonstration and field trials. Contacts were made with the leader of the Paoh community Khun Sun OO and Khun Chit Leal, May and Pooh and U Chan Htwe leader of the Potato Association in Heho.

27 August 2015
Departure to Heho at 18.30 hrs for flight to Yangon at 19.45 hrs.

28 August 2015
Departure Yangon to Bangkok at 4.15 hrs.
Departure Bangkok to Schiphol at 12.20 hrs. arrival at 18.30 hrs.

Figure 18 *Evaluation of seed potatoes (left) and discussion potato diseases in the field (right).*

Trip report of the second visit (20 - 30 October)
Departure Schiphol for Bangkok on 20 October at 17.15 hrs.
Arrival at Bangkok on 21 October at 10.05 hrs.
Departure for Yangon on 21 October at 13.40 hrs.
Arrival at Yangon on 21 October at 14.40 hrs, met with Mr. Jackson Kalipo, night stop at M-hotel.
Departure to Heho on 22 October at 7.00 hrs from Yangon domestic airport.
Arrival at Heho on 22 October at 8.15 hrs. Met with Koen Minderhoud and Machiel Goosen.

22 October 2015
Afternoon: field day preparation at home students.

23 October 2015
Leaving at 8.45 hrs to the field. Field day meeting starts at 9.00 hrs.
Field meeting finished at 11.00 hrs.

30 October 2015
Departure Yangon to Bangkok at 4.15 hrs.
Departure Bangkok to Schiphol at 12.20 hrs. arrival at 18.30 hrs.

Trip report of the third visit (14 – 22 November)
Departure Schiphol for Bangkok on 14 November at 17.15 hrs.
Arrival at Bangkok on 15 November at 10.05 hrs.
Departure for Yangon on 15 November at 13.40 hrs.
Arrival at Yangon on 15 November at 14.40 hrs, met with Mr. Jackson Kalipo, night stop at M-hotel.
Departure to Heho on 16 November at 9.30 hrs from Yangon domestic airport.
Arrival at Heho on 16 November at 10.45 hrs. Met with Koen Minderhoud and Machiel Goosen.

16 November 2015
Visit potato field in Heho area, farmer nr. 14.
Visit potato field in Heho area, farmer nr. 3.
Visit a trial on pesticides seen on the way to the field of farmer nr. 3.
The Golden Key Company demonstrates the effects of chemicals on late blight in potato. Not that much differences although the control has late blight.

Travel to Naung Ta Yar, pass by the whole sale market of vegetables in Aungban. Arrival at 18.30 hrs, diner. Night stay at Hotel at Pin Laung.

17 November 2015
Morning: field day preparation at home students.
Skype meeting with Frank ter Beke on ongoing things.
Visit field trial in afternoon. Trial is in good shape for local standards. Weeds are controlled and half the plots still show crop performance. Demo on seed is harvested totally, trials are harvested half for demonstration purposes at the field day, second harvest will be in a few weeks. Differences in foliage are less obvious as at the field meeting mid-term. However, yield is being presented so farmers can have a look on quantity and quality of the potatoes.
Visit to Agrishop on Naung Ta Yar. Shop sells pesticides and fertilizers. Shop also provides loans to farmers. Payback time is 1 year. No interest asked. Shop sells on commission. Shop owner indicates that it is sometimes difficult for farmers to pay back the loan.

18 November 2015
Pickup at 7.00 hrs in Pin Laung. Drive to Demo and trial location to prepare for the field meeting at 9.15 hrs. At 8.00 hrs field was prepared and leaving for breakfast at the house of the students.
Leaving at 8.45 hrs to the field. Field day meeting starts at 9.15 hrs.
Field meeting finished at 11.15 hrs and is followed by a round table discussion.
Late afternoon; visit to Taunggyi to the opening of the Balloon Festival.
Night stop at Khin Maung Thein, staff officer (Farm) Heho, Seed Division.

19 November 2015
Visit to house of Chan Htwe (Chairman Potato Cluster Heho).
Visit Heho Multiplication Farm, Ministry of Agriculture and Irrigation, Department of Agriculture, meeting with Aye Cho Cho Soe, responsible for the multiplication. Accompanied by U Chan Htwe.
Visit Department of Agriculture, State Agricultural Institute Heho.
Visit to Ministry of Agriculture and Irrigation, Department of Agriculture, State Agricultural Institute Heho. We met with U Khin Maung Than, assistant director. Head of the department is U Min Thit who was not available at the time.
Field visit Heho area, three fields close together
Field 1: Variety Kufri Jyoti, farmer nr. 16.
Field 2: Variety Atlantic, farmer nr. 5.
Field 3: Variety Kufri Jyoti, farmer nr. 12.
Drive back to Naung Ta Yar, arriving at 16.30 hrs after a very beautiful drive through the mountains. Stop for a visit on the way and we saw bathing cows.

20 November 2015
Morning:
Last meeting with May and Phoo on work to be done when Dutch delegation is leaving.
Visit three fields in the vicinity of Naung Ta Yar.
Field 1: Kufri Jyoti, farmer nr. 8.
Field 2: Atlantic and Kufri Jyoti next to each other, farmer 6.
Field 3: Kufri Jyoti, farmer 17.
After noon:
Reporting and packing

21 November 2015
Departure to Heho at 7.30 hrs for flight to Yangon at 10.30 hrs.
Arrival Yangon International airport at 12.00 hrs.
Meeting with Emeritus Prof. Dr. Maung Maung Myint and his wife Dr. Mar Mar Kyu at his home residence. Dr. Maung Maung Myint is an expert on late blight in potatoes in Myanmar and Dr. Mar Mar Kyu is an agronomist working at the moment for the FAO.
Farewell dinner with Mr. G. Westenbrink and evaluation of the mission and the long term stay of the two students.

22 November 2015
Departure Yangon to Bangkok at 4.15 hrs.
Departure Bangkok to Schiphol at 12.20 hrs. arrival at 18.30 hrs.

3.5.2 Field day 18 November 2015

Activities in the field
Following the invitation (Annex 3) the field day was well attended. Government representatives from the Netherlands and Myanmar, local suppliers, farmers and interested people listened to short presentations, received a handout of the activities (Annex 4) and evaluated the displayed results of the seed quality demonstration and the trials (Figure 19). The field day was attended by 60 to 70 people.

Figure 19 *Preparation of the field day and early arrivals (top left), Attention by visitors on presentations of work (top right) and farmers and stakeholders discussion the results of the field trials (bottom).*

Round table discussion
After the field visit a round table meeting was held with Myanmar stakeholders and Dutch Government representatives to discuss upcoming plans and events and to discus and answer the questions presented below.

How can the cultivation of potato be improved?
- Develop seed production system is most important.
- Late blight resistant variety/varieties are needed.
- Solution for bacterial wilt is needed.

What is the biggest problem you have in the cultivation of potatoes?
- There is no good seed available, quality of the available seed is poor.
- Storage of seed potatoes is not yet well organized.
- It is necessary to further develop diffuse light storage and develop/ make a user guide.
- We need alternatives for potato use/selling during times prices are very low, during glut season.

- What do you suggest?
  One possible solution could be processing of potatoes into different products. Potato flakes can be made of potatoes of any size, and most quality is accepted. The need for potato flakes must be investigated in a market study.
- Potato growers need to specialize into seed potato growers by learning, training and support from experts. Also additional aspects must be taken care of like storage, transport and disease control. There must be done a study on what needs to be done to develop a seed potato system. The certification system should be developed and farmers need to specialise.
- If we import seeds, we would like to know how it should be treated and what we need to do to maintain good quality of the imported seeds.

Training programme.
Introduction: the upcoming project on training allows 25 persons to be trained. These persons need to be local speaking representatives of the potato farmers and must be able to train farmers themselves. A list of quality demands for the persons to be trained will be provided by the project leader of the training project.

Question of Myanmar representatives:
- we need to have the time frame of the dates the trainings will be. These dates need to be in agreement with the holidays and dates of festivals in Myanmar. The following points is agreed upon:
  - WUR will formulate criteria where persons to be trained must qualify for,
  - WUR will provide a time frame of the trainings, how many days and when. Suggestion: 2 days training, two days off, 1 day training. This can be something like: Heho 2 days, Naung Ta Yar 2 days, Heho 1 day, Naung Ta Yar 1 day. This schedule is to be repeated after some weeks, three to four times in total.
  - Training must be during the potato cultivation.
  - Training must be close to the farmers, so in Heho and in Naung Ta Yar.

Question to Myanmar representatives:
Do you want suppliers to be included as persons to be trained?
- Yes, suppliers need to be included as persons to be trained.

Proposal for participants of the training:
- private companies, 5 to 6 township officials, and 15 farmers.
- Private companies might have to pay to participate in the training.
- Proposal of private companies to include: Awba, Diamond Star, Bayer, Prime, Kaung Thuka, Armo.

Proposal of persons to include:
- May Thazin Phoo (DAO) & Nangphungengehtun (DAO),
- Khun Chit Lael (Paoh).

These persons have a background in Agriculture, are already involved in the baseline study and have experience with the potatoes and working with the Dutch. Also, they speak sufficient English.

Question form the PA-O representative:
- Is it possible to send a person to work in the Dutch potato cultivation for a season to be trained? This question is not answered immediately but will be discussed with our colleagues shortly.

Advice from students based on their experience and expertise on farming potatoes in Myanmar, the cultural situation and local social structures:
- Include the Paoh and Danu communities in the training.
  When the Paoh / Danu send a representative to be trained they make sure that the knowledge will be shared with potato cultivating community. The social structure is such that knowledge transfer to farmers is guaranteed. For selection of the persons to be trained the Paoh representative Khun Sun OO and the Danu representative U Chan Htwe can be asked.
- Include Dr. Maung Maung Myint into the organization of the training as he is head of the Danu organisation in the Taunggyi region of Shan State.

4 Evaluation and recommendations

This baseline survey was assigned to identify "evidence" based Quick wins. After evaluating different aspects of the potato production (par. 4.1), the identified Quick wins are summarized in par. 4.2.1. Quick wins were defined as returns being made in one year or one cultivation. It should be noted that the Quick wins here apply to the post-monsoon potato cultivation only. When Quick wins are implemented common sense is needed because one of the a major taps of quick wins is jumping to implementation too quickly (Van Buren & Safferstone 2009).

Furthermore, this baseline survey identified strategic recommendations for improvements in the potato value chain, summarized in par. 4.2.2. For these strategic recommendations the evidence based results of this survey were combined with expert knowledge for professionalizing the potato production and the potato value chain.

Finally, concluding remarks are presented in par 4.3.

4.1 Evaluation

4.1.1 Baseline survey

4.1.1.1 Seed potatoes

Current practices
The common seed potato system encountered in this baseline survey was an informal seed system of farm saved seeds or buying at local markets.
Most farmers used farm saved seeds (par. 3.1.2). The largest problem with farm saved seeds was the quality. Quality degraded by pests (tuber moth infection) because seeds were stored in open air storage facilities under their houses and easily infected. Chemical control was used but in most cases not sufficiently. Here, a moth free storage, developed in a simple way, would be very helpful.
When fresh seeds were used farmers bought small potatoes (15 to 30 mm) as seed from the local market in Aungban. Farmers had no knowledge of the origin and the physiological age of the bought seed.

Preparation of seeds for planting such as pre sprouting and/or removal of the dominant top sprout, was not practised. Farmers lacked knowledge and skills to adequately prepare seeds for planting. Furthermore, farmers lacked information on the relationship between seed size and optimal planting densities.

The strongest weakness of the seed potato system in Southern Shan State was related to the informal seed system (Myint 2015) and confirmed by the results described above. It is not a quick win but developing an official seed certification system with the private sector and improve availability of certified seeds will significantly contribute to bridge the yield gap. The import of certified seeds from foreign acknowledged seed suppliers however, gives a head start on the benefits of a formal seed certification system.

Quick wins
- Building a simple moth free open air storage facility for seed storage (such as well screened diffuse light storage).
- Use larger sized seeds: > 45 mm.
- Awareness raising on quality aspects of seed potatoes, of farm saved seed and bought seed from markets,
- Knowledge transfer on seed preparation for fast and good germination,

- Develop optimal guidelines for seed size and planting densities,
- Use certified seeds from trustworthy seed suppliers from abroad.

4.1.1.2 Soil management and tillage

Current practices
Almost all soil cultivation is done manually or by cow, from loosening the soil to crumbling, making rows and ridging. As a consequence, seed bed preparation is shallow and rows are low as not enough soil is available to make rows. Potatoes are often planted in small furrows to increase the volume potatoes can develop in.

In a crop rotation with rice soils are often compacted to form a non-permeable soil layer to be able to flood the rice crop. The compacted soil layer needs to be broken for the potato cultivation, which is difficult even with a tractor. This needs attention and several passing's with a deep cultivator are needed. Most probably soil cultivation by hand or cow is insufficient to sufficiently break this layer.

Soil cultivation by hand or cow can be replaced by tractor driven soil cultivations on most fields as slopes are in general not too steep and which has already taken place in the Heho area (Table 12). Tractor driven soil cultivation allows a deeper soil preparation and therefore larger rows and thus more volume for potato plants to form tubers in.

No soil samples are taken and thus no information on soil fertility is available to farmers. But, all farmers in Heho and 50% of the farmers in Naung Ta Yar used organic products (see par. 3.1.5). So farmers are aware that the potato cultivation profits from organic products application. The application levels need to optimized to maximize efficiency.

Quick wins
- Seed bed preparation needs to be improved by a deeper soil cultivation, by tractor.
- When potatoes are cropped in rotation with rice the impermeable soil layer must be broken. A moldboard plough is advisable.
- Optimize organic products application.

4.1.1.3 Crop rotation

Current practices
Potatoes were cropped once or sometimes twice a year in rotation with rice or other vegetables, including tomatoes (Table 14). Fallow is also part of the crop rotation. Although bacterial wilting is frequently mentioned to be a major threat (Thun *et al.* 2006) and farmers are aware of this disease, this baseline survey did not encounter problems related to this disease.

Farmers have little knowledge of crop rotations and its effects on crop production, soil quality, survival of pests and diseases or weeds. This lack of knowledge is a weakness in the potato cultivation as crop rotation issues may become relevant in the near future because the potato production area is steadily increasing in Southern Shan State.

Quick wins
No immediately crop rotation yield reducing factors were identified in the baseline survey.
However, as many related to a crop rotations exists, including some very important yield reducing factors directly related to potato, knowledge on crop rotation needs to be provided to farmers.

- Awareness training on effects of crop rotations on the performance and yield of potato

4.1.1.4 Fertilization

Current practices
The soil samples taken in this baseline survey indicated that soils had limited phosphorus available for plant growth (Table 10). This needs attention when fertilization plans are developed. The potassium

status of these two soils was adequate to high. Standard levels for potassium fertilizer will therefore be sufficient for a good yield. This means that application levels for potassium can be reduced. Fertilizer plans are not yet developed. A good fertilizer plan however, will contribute to bridge the yield gap.

The total amount of nitrogen applied of 221 kg/ha in Naung Ta Yar and 275 kg/ha in Heho (Table 15) is most likely to too much compared to the relative low yields of 15 to 20 tons/ha (Table 25). In general, a N application of 3 to 6 kg N per ton harvested potato yield sufficives for optimal production accounting for a nutrient use efficiency of the fertilizer of only 50%. Applications of 45 to 90 kg N/ha will therefore be sufficient for 15 tons fresh yield/ha and 60 to 120 kg N/ha will be sufficient for 20 tons fresh yield/ha. N-fertilizer trials need to substantiate these reduced application rates. Reduced application rates of N increases profits with no yield losses to be expected.

The potassium application is high compared to the status of the soils, the soils are rather rich of potassium (Table 10). The current application levels (Table 15) exceed the Dutch recommendations for potatoes on soils with an adequate potassium status. In Heho the high levels of potassium in the soil indicate that no potassium is needed for optimal yield, in Naung Ta Yar only small applications up to 90 kg/ha are needed. The applied applications of on average 184 and 245 kg K_2O/ha are high (Table 15).

No soil sampling was done to evaluate soil fertility status and no recommendations to improve soil fertility and or provide fertilizers were available. Introducing soil sampling will not immediately increase yields as guidelines need to be developed.

The phosphorus fertilization is high and efficiently applied close to the potatoes. As soils have low phosphorus available for potatoes (Table 10) this high application is needed for optimal growth.

Quick wins
- Provide fertilizer plans to farmers.
- Nitrogen fertilization guidelines need to be developed as inputs exceed crop need substantially.
- Anticipating N-fertilizer guidelines development, N-application rates can be reduced, improving profits.
- Potassium fertilization guidelines need to be developed as inputs exceed crop need substantially.
- Anticipating potassium fertilizer guidelines development, K_2O-application rates can be reduced, improving profits.
- Phosphorus fertilization must be investigated because the plant available phosphorus is low and should improve, be optimized.

4.1.1.5 Crop protection

Current practices
Farmer use many chemicals (Table 18 to 24) mostly without knowing for what particular disease or problem. To improve the efficacy of their pesticide package farmers need to identify the problem and select pesticides accordingly. Awareness that some applications may results in reduced growth is very low. Using the plant growth regulator Mepiquat chloride reduces growth and is likely to reduce yields subsequently. It looks like farmers have adopted the spraying strategies from the rice cultivation and only modified it to include late blight fungicides.

Farmers in Naung Ta Yar combine up to 6 different products when spraying (Table 22). The combination of so many different products in one spray may complicate and/or compromise the application and its efficacy. Farmers in Heho tend to combine less products in one pesticide application. This may suggest that farmers focus more on the control of specific pests and use active ingredients that control this specific pest. The water quality has also a possible effect on the efficacy of the pesticides. This needs to be investigated further.

Besides the use of many products, Figure 12 top left clearly illustrates that overuse of chemicals is likely to occur when such spoons are used. Training in right dosages increases at least financial yields.

Additionally, many Chinese produced chemicals are used. It is uncertain if the products contain the active ingredients as indicated on the package. This may greatly impair the efficacy of the products to control pests and diseases.

The use of fungicides is large. There is no specific plan to treat late blight effectively. It seems that farmers have little knowledge on diseases and how to combat them. This lack of knowledge is in agreement with previous studies (Phoo 2013). The common practise initiated metalaxyl resistance in late blight (par 3.2.1) so products containing this active ingredient have no effect on late blight. A better control strategy is most needed with less but more effective active ingredients and application strategies.

There is no professional independent extension agency that is able to adequately advise farmers on crop protection. That is the largest weakness concerning crop protection. Advice on crop protection is done by AgriShops which benefit from selling pesticide products. AgriShops cannot be expected to be independent in the advice and they may not be skilled sufficiently in potato pest control management.

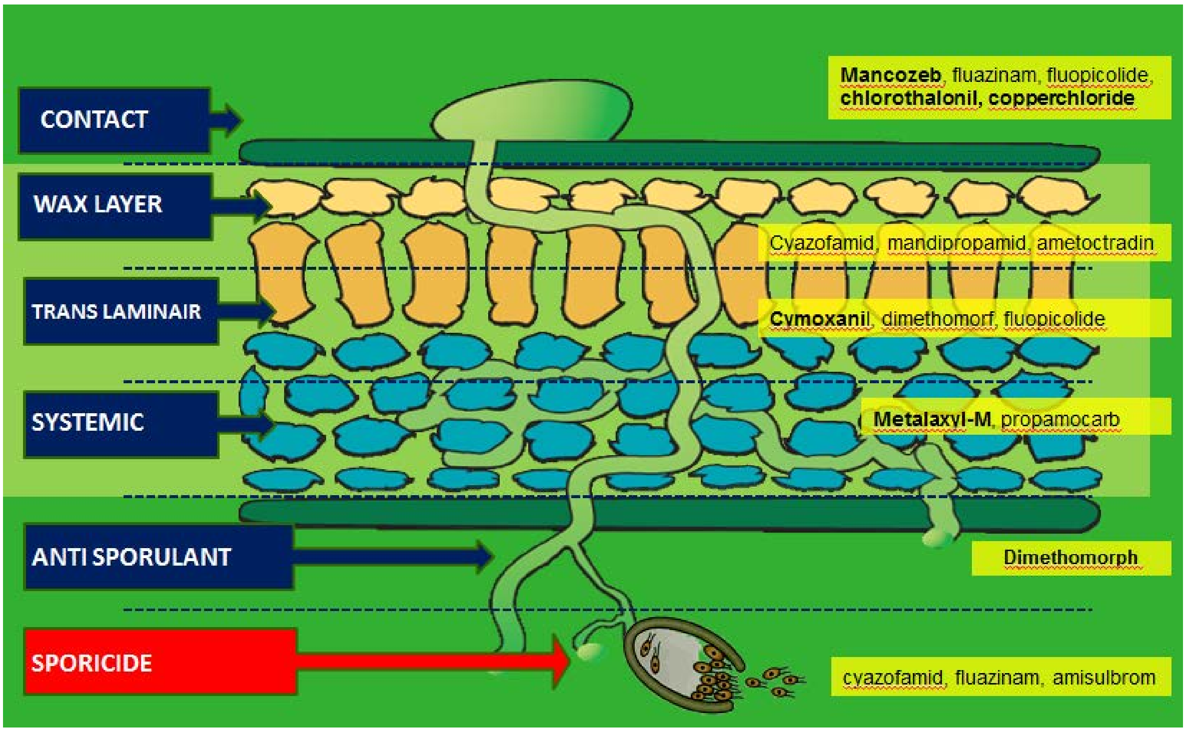

Figure 20 *Effects of different fungicides on late blight. Active ingredients in bold are currently used in Southern Shan State.*

Quick wins

- Farmers need to recognise diseases and pests, and select chemicals accordingly.
- Awareness training on effects of chemicals/pesticides on crop growth.
- Identify why some chemicals/pesticides are used, for example antibiotics and growth regulators.
- Use the right dosage of chemical products.
- Buy chemical products from reliable sources.
- Introduce that metalaxyl will not cure late blight.
- Investigate the effects of so many products in one application/tank mix, because this may compromise effects of the pesticides.
- Awareness training on hazardous effects of chemicals/pesticides for humans.
- Awareness training on Good Agricultural Practices: package waste collection and disposal.
- Introduction of a strategy for late blight control during cultivation.
- Introduction of a strategy for late blight control after haulm killing.
- Train AgriShops employees in potato pest control management.
- Introduce an independent extension agency.

4.1.1.6 Harvest

Current practices
Farmers simply stop the late blight control and leave the crop to die. It depends on the farmer when that moment is. The moment depends also on the weather conditions. The dry season is arriving and when natural precipitation runs short farmers stop late blight control. Tuber infection by late blight is likely to happen. This moment can also be initiated due to competition on labour to do the spraying because other crops like corn or rice need to be harvested. These crops are prioritised for labour because they feed the family and their animals.

The yield varied between 15 and almost 20 tons/ha (Table 25). With good seed, advanced soil cultivation techniques and a good disease control system yields can increase to 25 tons/ha, which some farmers produced and was found in the demonstration and trials (Table 32 till Table 37). It will be a challenge but feasible to increase yields in the near future. An important factor in the yield is the length of the growing season. The general practice is that farmers leave the crop to die as described above.

Sometimes the crop will stay in the soil for a long period, up to 1 to 2 months, until the farmer has time to harvest or prices are good. The dry season arrives at the end of this potato cultivation which allows potatoes to stay in the field and not rot. Shallow grown potatoes may get infected in that period with tuber moths and the infection is brought into the storage.

The potato harvest is done by hand which is time consuming and may damage a large proportion of the potatoes. Farmers have little or no knowledge on the relationship between damaged potatoes and storage problems such as rot. Where mechanical harvest may reduce damage, this is far beyond the possibilities to introduce at this moment. In Heho, where tractors are more common and soils are deeper cultivated, simple and small diggers may be introduced in the near future.

Quick wins
- Haulm killing needs to be introduced to control late blight infection of tubers.
- The introduction of an adequate disease control strategy to extend the growing season to its full potential. This will increase yields immediately.
- Investigate the life cycle of tuber moth and develop an adequate strategy to control this pest.
- Awareness raising on the relationship between damage and storage quality of potatoes.

4.1.1.7 Storage

Current practices
Farmers store potatoes (seed and ware) in open air under their houses in bags or bulk. Open air conditions follow weather patterns and storages under houses can get very humid during the rainy season. Additionally, tuber moth infections are likely to occur. Storage should therefore be improved by building simple and moth free facilities where wind flows are allowed to dry the potatoes. Or, for future developments, build cold storage facilities.

Quick wins
- Building a simple moth free open air storage facility for seed storage (such as well screened diffuse light storage) and ware storage.

4.1.1.8 Marketing

Current practices
Most farmers sell their potatoes to the local market of Aungban through a middleman. They store the potatoes under their houses and wait for good prices to deliver to Aungban.
The only problem that was indicated was during the glut season when prices go down. Farmers know the market, had access to it and did not indicate any bottlenecks. Quick wins are therefore not identified. An opportunity for farmers would be to identify other buyers than the middlemen of the market of Aungban.

4.1.2 Additional non-funded activities

4.1.2.1 Collection of *Phytophthora* DNA samples

Current practices
Late blight is abundantly available in the pre monsoon potato cultivation. In the Kawal township the *Phytophthora infestans* found was A2 type Bleu 13 which is resistant to the chemical active ingredient metalaxyl.

Quick wins
- Use of fungicides for late blight control with active ingredients other than metalaxyl.

4.1.2.2 Demonstration on seed tuber quality

Current practices
The quality of the seed stocks involved in the demonstration were of relative good quality. Seeds visual appearance was acceptable although some exceptions indicated that seeds were too old or too young. All seed stocks however, were infected by tuber moths. Tuber moth control in storage is a major problem.
Yields varied widely between the seed stocks (Table 32). However, no difference in yield between locations was found. Seeds from Naung Ta Yar yielded as good as the seeds from Heho.

Quick wins
- Building a simple moth free open air storage facility for seed storage (such as well screened diffuse light storage) and ware storage.

4.1.2.3 Trials

Current practices
The trials served their purpose as demonstration on different cultural practices. However, only small and indicative differences between treatments were found.
No effects of early or late ridging on yields were found (Table 33). No effects of N-application of 100, 200 or 300 kg/ha or potassium applications of 100, 200 and 300 kg/ha on yields were found (Table 34 and Table 35). To increase financial yields, these trials should be repeated to validate the results so that the average amount of N or K_2O applied in Naung Ta Yar and Heho may be reduced.
A significant effect of seed size and planting distance was found on yield (Table 36). Larger seeds yielded more than small seeds and a larger panting distance in the row increased yields. The aim was to have 4, 6 and 8 seeds per m^2, which effects the number of stems per m^2 and that is a good indicator for yield. Due to improper treatment of seeds, tubers do not always form the right and whished number of stems. Farmers compensate by planting more potatoes per m^2 but a better seed treatment and good size seed if far more effective to get the right number of stems than changing row width, in row planting distance or even more seeds per planting hole. The trial on best practices had comparable yields as the other treatments. Although the main objective to improve soil cultivation still stands as an important production increasing improvement, it did not show.

Quick wins
- N-application rates may be reduced to improve use efficiency and increase profits.
- Potassium application rates may be reduced to improve use efficiency and increase profits.
- Seed of a larger size (>45 mm) increases yields.

4.1.3 Yield gap analysis

Current practices
Yields in Naung Ta Yar and Heho showed a considerable gap to the attainable yields, 55% and 27%, respectively (Table 38). In practise, the economic attainable yield is approximately 2/3 of the modelled attainable yield (pers. comm. A.J. Haverkort). At this point, costs for additional inputs are balanced with profits raised by increased yields.

The yield gaps are comparable to yield gaps found in surrounding regions such as India (Pronk *et al.* 2014) and China (Kempenaar *et al.* 2015; Ruijter *et al.* 2013). The improvements needed to bridge the gap between actual and attainable yields will not be in increased use of inputs such as fertilizers and pesticides. For these inputs efficient use will improve at least the profit.

This yield gap analysis does not identify quick wins in particular but supports that yields can be improved by all the aspects for improvements identified under par. 4.1.1 and 4.1.2.

4.1.4 Economics

Current practices
The costs to cultivate potatoes is estimated at 3,000 €/ha (Table 44). In 2006, the costs for the cultivation of potatoes was almost 900 €/ha and high compared to costs for the cultivation of other crops (Table 47). In 2006, the profit of the potato cultivation was more than 1300 €/ha and high too compared to the profit of other crops. Ten years later, this situation is most likely not changed for potatoes. Potato cultivation is still a costly cultivation with large profits to be made.

Table 47
The cultivation costs of potato compared with other crops in Myanmar in 2006 (redrawn from Thun, 2006).

	Cost of cultivation per ha				Income	Profit (€/ha)
Crop	Land preparation	Inputs	Labour costs	Total costs	(€/ha)	
Rice (upland)	101	76	53	231	319	89
Rice (lowland)	77	90	70	236	373	137
Wheat	106	101	47	255	355	100
Maize	106	61	57	225	288	64
Soybean	106	79	42	228	319	92
Garlic	106	607	102	815	1596	782
Cabbage	96	291	148	534	887	352
Potato	101	697	98	896	2217	1321

Quick wins
- Input costs for crop protection can be reduced by optimizing pesticide use.
- Input costs for fertilization can be reduced by optimizing fertilizer use.
- Cost for bought seed at the local market is better spent at certified seed from abroad.

4.2 Recommendations

4.2.1 "Quick wins"

4.2.1.1 Baseline survey

Summarizing, the following Quick wins can be drawn from this baseline survey:
- Build a simple moth free open air storage facility for seed storage (such as well screened diffuse light storages).
- Use appropriate sized seeds: 28 to 45 mm.
- Raise awareness on:
  - Quality aspects of seed potatoes, of farm saved seed and bought seed from markets.
  - Effects of crop rotations on the performance and yield of potato.
  - Effects of chemicals/pesticides on crop growth.
  - Hazardous effects of chemicals/pesticides for humans.
  - Good Agricultural Practices: package waste collection and disposal.
  - The relationship between damage and storage quality of potatoes.
  - Seed preparation for good and fast germination.

- Use certified seeds, preferably from reliable suppliers.
- Seed bed preparation needs to be improved by a deeper soil cultivation, by tractor.
- When potatoes are cropped in rotation with rice the impermeable soil layer must be broken. A moldboard plough is advisable.
- Optimize organic products application.
- Provide fertilizer plans to farmers.
- Anticipating the development of N-fertilizer guidelines, N-application rates can be reduced, improving profits (see also next paragraph).
- Anticipating the development of phosphorus fertilizer guidelines, P_2O_5-application rates need to be optimized, improving profits (see also next paragraph).
- Anticipating the development of potassium fertilizer guidelines, K_2O-application rates can be reduced, improving profits (see also next paragraph).
- Farmers need to recognise diseases and pests, and select chemicals accordingly.
- Use the right dosage of chemical products.
- Buy chemical products from reliable sources.
- Introduce that metalaxyl will not cure late blight.
- Introduction of a strategy for late blight control during cultivation.
- Train AgriShops employees in potato pest control management.
- Haulm killing needs to be introduced to control late blight infection of tubers.
- Introduction of a strategy for late blight control after haulm killing.
- The introduction of an adequate disease control strategy to extend the growing season to its full potential.

Summarizing, the following investigations should be carried out to bridge the yield gap in 5 to 10 years' time:

- Develop optimal guidelines for seed size and planting densities.
- Develop nitrogen fertilization guidelines because inputs exceed crop need substantially.
- Develop potassium fertilization guidelines because inputs exceed crop need substantially.
- Develop phosphorus fertilization because the plant available phosphorus is low and should improve, be optimized.
- Investigate and identify why some chemicals/pesticides are used, for example antibiotics and growth regulators.
- Investigate the effects of so many products in one application/tank mix, because this may compromise effects of the pesticides.
- Investigate the life cycle of tuber moth and develop an adequate strategy to control this pest.

4.2.1.2 Additional non-funded activities

Summarizing, the following Quick wins can be drawn from the Additional non-funded activities:

- Use of fungicides for late blight control with active ingredients other than metalaxyl.
- Building a simple moth free open air storage facility for seed storage (such as well screened diffuse light storages) and ware storage.
- Reduce N-application rates to improve use efficiency and increase profits.
- Reduce potassium application rates to improve use efficiency and increase profits.
- Use larger seed, size >45 mm.

4.2.1.3 Economics

Summarizing, the following Quick wins can be drawn from the study on economics:

- Input costs for crop protection can be reduced by optimizing pesticide use.
- Input costs for fertilization can be reduced by optimizing fertilizer use.
- Cost for bought seed at the local market is better spent at certified seed from reliable suppliers.

4.2.2 Strategic recommendations

Seed sector

The Myanmar private sector is recommended to develop the seed sector to provide certified, good quality seed of different varieties. Variety diversification has opportunities as late blight varieties contribute to reduced pesticide use and in an emerging processing market processing quality potatoes will be in demand. Such varieties are not or only limited available at the moment.

In support of the private seed sector development, a seed certification system should be established by an independent government body. A certification protocol must be developed, practiced and most important, acted on in terms of degrading seed stocks when quality standards are not met. Degrading seed stock class is most important to maintain farmers trust in using certified seeds (Holdinga *et al.* 2014). A seed certification system is in place in India for Indian breeder varieties. The protocol is well described (Wustman *et al.* 2011) and carried out accordingly. However, the certification consist of "carrying out the protocol". When seed stocks become infected with viruses, pest and/or diseases, degeneration of seed class is not applied. In India, the private seed sector is well developed and quality aspects need constant attention, problems are relatively small compared to the seed sector in Indonesia. In Indonesia seed degeneration due to i.a. bacterial wilting problems make farmers ask for second generation seeds from seed providers where the 4^{th} generation seed was previously used. Bacterial wilting was not found to be a problem in the baseline survey but in Myanmar but it was identified as major threat (Thun *et al.* 2006). Developments as in Indonesia must be prevented.

It is recommended to develop a strong seed sector with a well maintained seed certification system in place to support the development of the potato production value chain.

Cultivation guidelines for Good Agricultural Practices (GAP)
Several Quick wins for GAP were identified. However, many aspects need to be further investigated to substantially contribute to GAP, reduce the yield gap and increase profits. At this moment, no fertilizer guidelines are available, integrated pest management does not exist, effects of current crop rotations on potato yields are not clear and farmers have no awareness nor knowledge on rotation effects on the potato cultivation. Many other aspects are hardly developed, such as, soil fertility, soil cultivation practises, planting and planting densities, spraying, haulm killing and harvesting techniques. It is most likely that the area with potato will increase in the near future in this regions which increases pressure on available land for cultivation. Short potato rotations (1 cultivation in two or three years) have high risks to develop a wide range of mostly soil born problems such as nematodes, fungal diseases, virus infections and bacterial diseases.
Tools for GAP would be decision support services (DSS) on soil fertility, fertilizer use and disease control. For DSS on soil fertility and fertilizer use, a soil laboratory to analyse soils is needed. For DSS on diseases control, diagnostic tools are needed so an integrated pest management strategy can be developed and implemented.

It is recommended that when Quick wins are "cashed" they are followed up with guidelines established in research on a wide range of cultivation practices to further implement GAP. This includes the foundation of a soil analysis laboratory and diagnostic tools.

Mechanization
GAP require improved soil cultivation practises as well as planting and harvest techniques and which all need availability of appropriate mechanization. At this moment, tractors are available in Heho and to lesser extent in Naung Ta Yar. With Myanmar developing fast, labour costs will increase due to employment outside agriculture. Additionally, improved mechanisation provides opportunities for precision agriculture which on its turns improves product quality (less damaged tubers by harvest) and reduces pesticide use. So in time, there is a need to develop mechanisation for soil cultivation, planting, spraying and harvesting. This trend provides opportunities for market development on machinery and on de development of precision agriculture.

It is recommended that a programme to develop and introduce mechanisation for soil cultivation, planting, spraying and harvesting is initiated to support GAP.

Storage
Storage of ware potatoes is in open air facilities and can be stored up to three to four months when all guidelines are carried out correctly. Seed storage up to this period in these open air facilities is more difficult and the Quick win is the build diffuse light storages for seed. However, the crisps market is

growing (Haverkort 2013) and needs good quality potatoes for processing. June 2015, Kentucky Fried Chicken opened the first fast food restaurant in Yangon (Fisher 2015). In time these companies need good quality processing potatoes for their French fries. Maintaining adequate processing quality of potatoes year round is challenging and greatly facilitated by modern cold storage facilities (Pronk *et al.* 2015a).

It is recommended that a feasibility study is initiated on opportunities of modern cold storage facilities in Southern Shan State.

Extension service
In Myanmar consumable inputs such as fertilizers and pesticides are provided to farmers through AgriShops. AgriSHops also advise on what to use and how and when. This makes the advisor not fully independent. Unbiased advice is important in building a strong potato sector. It would therefore be good when the Farmers Organisation in cooperation with the Ministry of Agriculture, Livestock and Irrigation and/or private extension agencies would take a more leading role in aiding farmers on the cultivation, storage and marketing of potatoes.

It is recommended that the Farmers Organisation in cooperation with the Ministry of Agriculture, Livestock and Irrigation and/or private extension agencies take a more leading role in aiding farmers on the cultivation, storage and marketing of potatoes.

4.3 Concluding remarks

This baseline survey shows an enormous amount of data on the farming practices of potato in Naung Ta Yar and Heho, Southern Shan State Myanmar. The findings related to the collected data reveal that the potato cultivation in the study area is a most profitable cash crop. It also indicated that farmers sometimes had limited knowledge on Good Agricultural Practices and that the potato cultivation was not always prioritised compared to other crops, mostly maize for their animals and/or rice for feeding their own family. But, farmers participating in the survey were all very much engaged and eager to learn from the Dutch visitors. The students who stayed almost three months in the area developed a good relationship with farmers in both regions and paved the way for a long lasting and beneficial collaboration. Several farmers participating in the survey were visionaries and full of future plans that contribute to a strong and valuable potato chain: from seed, to ware, to cold storage and market expansion to processing.

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Annex 1 Overview of visits paid to the farmers in the two regions

Region	Farmers nr:	Total visits	26-Aug	28-Aug	29-Aug	31-Aug	02-Sep	03-Sep	04-Sep	07-Sep	08-Sep	10-Sep	11-Sep	14-Sep	15-Sep	16-Sep	17-Sep	21-Sep	22-Sep	23-Sep	24-Sep	28-Sep	30-Sep	07-Oct	08-Oct	09-Oct	12-Oct	14-Oct	15-Oct	19-Oct	20-Oct	21-Oct	02-Nov	03-Nov	04-Nov	06-Nov	11-Nov	12-Nov	13-Nov	14-Nov
NTY	1	6				x							x								x					x								x				x		
	3	5	x													x										x								x				x		
	4	6			x							x									x							x							x			x		
	5	5				x													x							x								x				x		
	6	6		x								x									x							x							x			x		
	7	6					x							x								x							x			x							x	
	8	6						x					x								x							x							x			x		
	9	6					x							x								x							x			x							x	
	10	6			x								x								x					x								x				x		
	11	6									x							x						x						x						x		x		
	16	5																		x					x						x				x					x
	17	6								x								x						x						x						x		x		
	23	5																	x						x						x				x					x
	25	6									x							x						x						x						x				x
	28	6								x								x						x						x						x				x
	29	5																		x					x						x				x					x
	30	6									x							x						x						x						x				x
	31	5															x					x							x			x							x	
	32	5															x					x							x			x							x	
	33	5															x					x							x			x							x	
	34	5															x					x							x			x							x	
	35	5															x					x							x			x							x	
	36	5																	x						x						x				x					x
	37	5																	x						x						x				x					x

Region	Farmers nr:	Total visits	26-Aug	28-Aug	29-Aug	31-Aug	02-Sep	03-Sep	04-Sep	07-Sep	08-Sep	10-Sep	11-Sep	14-Sep	15-Sep	16-Sep	17-Sep	21-Sep	22-Sep	23-Sep	24-Sep	28-Sep	30-Sep	07-Oct	08-Oct	09-Oct	12-Oct	14-Oct	15-Oct	19-Oct	20-Oct	21-Oct	02-Nov	03-Nov	04-Nov	06-Nov	11-Nov	12-Nov	13-Nov	14-Nov
He-ho	1	4							x																							x	x				x			
	2	4																					x				x						x				x			
	3	5							x						x												x						x				x			
	4	3							x																								x				x			
	5	4																					x				x						x				x			
	13	4																					x				x						x				x			
	14	6													x								x				x					x	x				x			
	15	3													x																		x				x			
	16	5																					x				x					x	x				x			
	17	4																					x				x						x				x			

Annex 2 Questionnaire

Name farmer:
Variety:
Number:
Storage:
How are the seed potatoes stored? And what time? (example: in bags on bamboo sticks, 2 months)
Which products you use in storage time? How it is used? (example: Cartap sprayed, before packaging)
When seed potatoes bought, how long is the storage time? And costs of seed?
Seed tubers:
If the farmer search for seed potatoes, does he look to the plant or to the tubers?
How is the decision made witch potatoes are used for seed tubers?
Size of seed tubers? (small= 25mm< (1 inch<), medium= 25-50mm (1-2inch), big= >50mm (>2inch))
Yield:
Size of field?
Expected Yield? (Estimate)
Yield of last year's? And size of that field? (Same season as now.)
(ex: 2014: 8.000 Viss, 1 acre. 2013: 5.000 Viss, 1acre. 2012: 10.000 Viss, 1.5acre)
2014:
2013:
2012:
Finances:
Fertilizers and pesticides bought directly or by loan?
By loan, how much interest?
Estimated price of potatoes? (this season)
Price of potatoes last year's? Estimate? (this season)
2014:
2013:
2012:
Where does the potatoes goes to? (market?) or company? Which?
Is there a different in the size of the tubers? Where they sold to?
If you rent land how much you pay? If you have to buy land, how much costs 1acre?
Other:
Crop rotation? Every year the same?
Fertilization? Every year the same?
Do you get advice? From who? Do you accept it?
Spraying, using motorized sprayer? Or electric?
When you decides to stop spraying against late blight?
Do you sometimes kill the leafs of the potato when you decide they grow enough? And how?

Annex 3 Invitation field day Naung Ta Yar 18 November

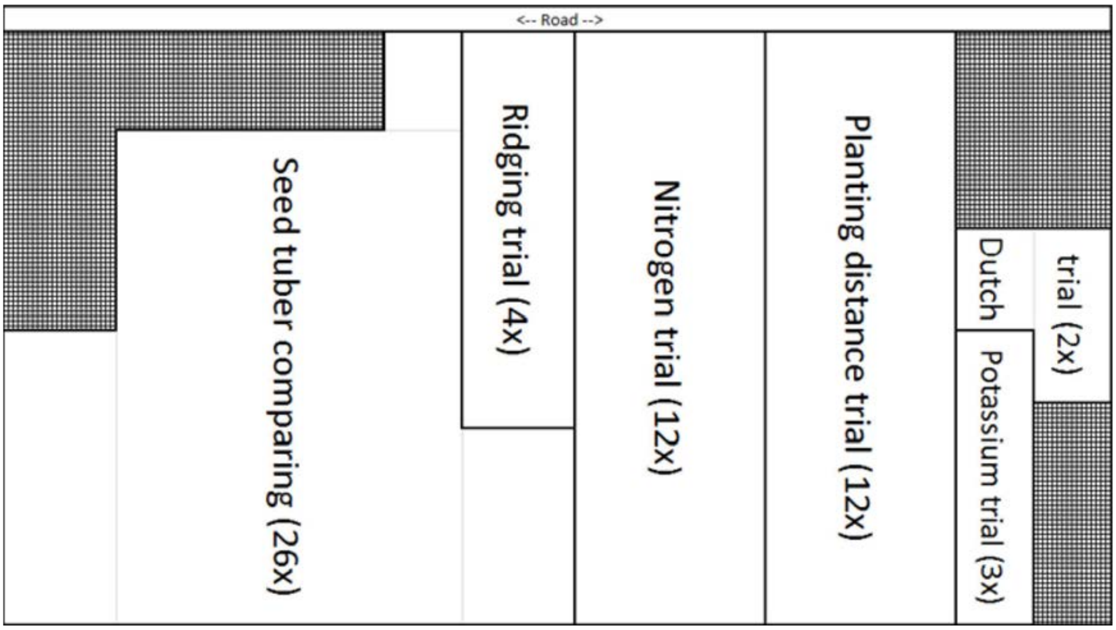
၂၀၁၅–၂၀၁၆ ခုနှစ် စကာအာလူးမျိုးသစ်ကွက် တောင်သူပညာပေး
Field Day ဖိတ်ကြားလွှာ

၂၀၁၅–၂၀၁၆ ခုနှစ် စကားအာလူးစိုက်ပျိုးရာသီတွင်
နောင်တရားမြို့နယ် နှင့် ကလောမြို့နယ်၊ ဟဲဟိုးမြို့မှ အာလူးစိုက်တောင်သူများ၏ မျိုးနမူနာများဖြင့်
နယ်သာလန်နိုင်ငံ CAH Vilentuim & Wageningen University တက္ကသိုလ်မှ
ကျောင်းသားနှစ်ဦး စမ်းသပ်စိုက်ပျိုးဆောင်ရွက်တွေ့ရှိမှု ရရှိသောအချက်အလက်များအား
လက်တွေ့ပညာပေးဆွေးနွေးပွဲ (Field Day)ကို
အောက်ပါအစီအစဉ်အတိုင်း ကျင်းပပြုလုပ်မည်ဖြစ်ပါ၍ ကြွရောက်ချီးမြှင့် (လေ့လာ) နိုင်ပါရန်
လေးစားစွာဖြင့် ဖိတ်ကြားအပ်ပါသည်။

အစီအစဉ်

နေ့ရက် ➢ ၁၈-၁၁-၂၀၁၅ (ဗုဒ္ဓဟူးနေ့)
အချိန် ➢ နံနက် (၉:၀၀) နာရီ
နေရာ ➢ အမှတ် (၃) ရပ်ကွက်၊ ကျောင်းကုန်း၊ ရွယ်တက်သွားလမ်း၊ နောင်တရားမြို့။

Annex 4 Handout field day Naung Ta Yar 18 November 2015



Six different trials are performed on this field. The main purpose of the trials is to demonstrate the effects of different treatments to farmers; farmers can see the effects of fertilizers, planting distances and seed tuber quality on production and yield. Each plot has 4 rows and is 6 m. Seeds are planted at 10 inch distance in the row, except for the trial on planting distances and the Dutch trial.

Seed tuber quality: In this trial we compare 26 different seed stocks of different farmers. Varieties included are L-11, CIP-24, a Chinese variety, Markies, Atlantic, Kufri Jyoti and Carolus. Fertilization is 80 kg Nitrogen N -acre, 60 kg Phosphate P_2O_5 -acre and 80 kg Potassium K_2O -acre.

Ridging trial: In this trial ridging is done immediately after planting in two fields and compared with the traditional practice of ridging three weeks after planting. Earlier riding keeps potatoes cooler which we think, is beneficial for grow. Fertilization is 80 kg N -acre, 60 kg P_2O_5 -acre and 80 kg Potassium K_2O -acre.

Nitrogen application trial: In this trial we compare 3 N levels: 40, 80, 120 kg -acre in four replicates. Seventy five % of the dose was broadcasted just before planting; the remaining amount was applied at ridging.

Planting distance trial: In this trial small and big seed tubers are planted at 10, 13 and 20 inch distance in the row. The treatments are done in replicate leading to 12 plots. All treatments have the same row distance of 0.45 m. The fertilization is the same as in the ridging trial.

Potassium application trial: In this trial we compare 3 Potassium K_2O_5 levels: 40, 80 and 120 kg -acre. The N and P_2O_5 applications are 80 and 60 kg -acre, respectively.

Dutch trial: In this trial potatoes are cultivated to the best expertise and knowledge of the students. The planting distance is 12 inch in the row and row distance is 20-24 inch. Soil cultivation was deeper than traditional to provide more loose soil for the roots to grow and take up water and nutrients. The fertilization is 100 kg N -acre, 60 kg P_2O_5 -acre and 90 kg K_2O -acre.

နောင်တရားမြို့နယ်တွင် စကအာလူးစမ်းသပ်ခြင်းသုတေသနလုပ်ငန်းဆိုင်ရာ လက်ကမ်းစာစောင် ဤသုတေသနလုပ်ငန်းတွင် စကအာလူးနှင့်ပတ်သတ်၍ စမ်းသပ်မှု (၆)မျိုးပြုလုပ်ခဲ့ပါသည်။ ဤသုတေသန လုပ်ငန်း၏ အဓိကရည်ရွယ်ချက်မှာ တောင်သူများကို မတူကွဲပြားသော စိုက်ပျိုးမှုပုံစံစနစ်၏ အကျိုးသက်ရောက်မှုအား လက်တွေ့သရုပ်ပြသလို၍ဖြစ်ပါသည်။ တောင်သူများအနေဖြင့် မြေဩဇာနှုန်းထား၊ မျိုးအာလူးအရည်အသွေး နှင့် ပင်ကြား တန်းကြားအကွာအဝေး စသည့်အချက်များသည် အာလူးသီးနှံထုတ်လုပ်မှုနှင့် အထွက်နှုန်းကို များစွာသက်ရောက် နိုင်ကြောင်း တွေ့ရှိနိုင်ပါသည်။ စမ်းသပ်ကွက်တစ်ကွက်တွင် စိုက်ကြောင်း(၄)ကြောင်းပါရှိပြီး တစ်ကြောင်းလျှင် (၆)မီတာ အကျယ်ရှိပါသည်။ ပင်ကြားတန်းကြား အကွာအဝေး စမ်းသပ်ကွက်နှင့် နယ်သာလန်နိုင်ငံတွင် စိုက်ပျိုးသော စိုက်နည်းစနစ် ပုံစံစမ်းသပ်ကွက်မှလွဲ၍ ကျန်စမ်းသပ်ကွက်များတွင် မျိုးအာလူးများကို ပင်ကြားအကွာအဝေး ၁၀လက်မ အကွာဖြင့် စိုက်ပျိုးထားပါသည်။

မျိုးအာလူးအရည်အသွေးစမ်းသပ်ကွက်။ । တောင်သူများမှရရှိထားသော အာလူးမျိုးများ အရည်အသွေး နှိုင်းယှဉ်ခြင်း စမ်းသပ်ကွက် (၂၆)ကွက်စမ်းသပ်ထားပါသည်။ ဤစမ်းသပ်ကွက်တွင် မျိုးကွဲ(၇)မျိုးပါရှိပြီး ၎င်းတို့မှာ L11၊ CIP-24၊ တရုတ်မျိုး၊ မာကီးစ်၊ အက်တလန်တစ်၊ ပွင့်ဖြူနှင့် ကာရိုးလပ်စ် မျိုးတို့ပါဝင်ပါသည်။ မြေဩဇာအနေဖြင့် နိုက်ထရိုဂျင် ၈၀ ကီလို -ဧက၊ ဖော့စဖော့ရပ်စ် ၆၀ ကီလို -ဧက နှင့် ပိုတက်ရှ် ၈၀ ကီလို -ဧက နှုန်းအသုံးပြုထားပါသည်။

ဘောင်တင်နည်းစနစ်စမ်းသပ်ခြင်း။ । ဤစမ်းသပ်ကွက်တွင် အာလူးစိုက်ပျိုးပြီး ချက်ချင်းဘောင်တင်ခြင်း(၂)ကွက် နှင့် စိုက်ပျိုးပြီးသုံးပတ်အကြာတွင် ဘောင်တင်ခြင်း(၂)ကွက်ကို နှိုင်းယှဉ် စမ်းသပ်ထားပါသည်။ စောစောဘောင်တင်ခြင်းသည် အာလူးကို အအေးဓါတ်ပိုမိုရရှိစေပြီး ကြီးထွားမှုအား ပိုမိုကောင်းမွန်စေပါသည်။ မြေဩဇာအနေဖြင့် နိုက်ထရိုဂျင် ၈၀ ကီလို -ဧက၊ ဖော့စဖော့ရပ်စ် ၆၀ ကီလို -ဧက နှင့် ပိုတက်ရှ် ၈၀ ကီလို -ဧက နှုန်းအသုံးပြုထားပါသည်။

နိုက်ထရိုဂျင်နှုန်းထားစမ်းသပ်ကွက်။ । ဤစမ်းသပ်ကွက်တွင် တစ်ဧကလျှင် နိုက်ထရိုဂျင်နှုန်းထား ၄၀ကီလို၊ ၈၀ကီလို နှင့် ၁၂၀ကီလို နှုန်းထားသုံးမျိုးဖြင့် တစ်မျိုးကို (၄)ကြိမ်နှုန်းစမ်းသပ်စိုက်ပျိုးထားပါသည်။ အာလူးစိုက်ပျိုးချိန်တွင် ၇၅%အသုံးပြုပြီး ကျန်ပမာနကို အာလူးဘောင်တင်ချိန်တွင် အသုံးပြုပါသည်။

ပင်ကြားအကွာအဝေးစမ်းသပ်ကွက်။ । ဤစမ်းသပ်ကွက်တွင် မျိုးအာလူးအရွယ် အသေး (၁လက်မအောက်)နှင့် အကြီး (၂လက်မခန့်) အရွယ်နှစ်မျိုးကို ၁၀လက်မ၊ ၁၃လက်မ နှင့် ၂၀လက်မ စသော အကွာအဝေးသုံးမျိုးဖြင့် စမ်းသပ်စိုက်ပျိုး ခဲ့ပါသည်။ စမ်းသပ်ကွက် အဖြေတိကျမှုရှိစေရန် စမ်းသပ်ချက် တစ်မျိုးကို (၂)ကြိမ်ပြုလုပ်သဖြင့် ဤစမ်းသပ်ကွက်တွင် စုစုပေါင်း (၁၂)ကွက်ပါရှိပြီး တန်းကြားအကွာအဝေး ၁၈လက်မအကွာဖြင့် စိုက်ပျိုးထားပါသည်။ မြေဩဇာအနေဖြင့် နိုက်ထရိုဂျင် ၈၀ ကီလို -ဧက၊ ဖော့စဖော့ရပ်စ် ၆၀ ကီလို -ဧက နှင့် ပိုတက်ရှ် ၈၀ ကီလို -ဧက နှုန်းအသုံးပြုထားပါသည်။

ပိုတက်ရှ်နှုန်းထားစမ်းသပ်ကွက်။ । ဤစမ်းသပ်ကွက်တွင် တစ်ဧကလျှင် နိုက်ထရိုဂျင်နှုန်းထား ၄၀ကီလို၊ ၈၀ကီလို နှင့် ၁၂၀ကီလို နှုန်းထားသုံးမျိုး စမ်းသပ်စိုက်ပျိုးခဲ့ပါသည်။ ထိုစမ်းသပ်ကွက်တွင် နိုက်ထရိုဂျင် ၈၀ကီလို -ဧက နှင့် ဖော့စဖိတ် ၆၀ကီလို -ဧကနှုန်း အသုံးပြုထားပါသည်။

နယ်သာလန်နိုင်ငံ၏စိုက်နည်းစနစ်ပုံစံစမ်းသပ်ကွက်။ ।ဤစမ်းသပ်ကွက်တွင် နယ်သာလန်ကျောင်းသား နှစ်ယောက်၏ ကျွမ်းကျင်မှုနှင့် ဗဟုသုတကို အခြေခံ၍စိုက်ပျိုးထားပါသည်။ ပင်ကြားတန်းကြားအကွာအဝေး အနေဖြင့် ၁၂လက်မx၂၀-၂၄လက်မ အကွာဖြင့် စိုက်ပျိုးထားပါသည်။ သမရိုးကျ စိုက်ပျိုးသောမြေသား အနက်ထက် ပို၍နက်နက်စိုက်ပျိုး ထားခြင်း သည် မြေသားကိုပိုမိုမွစေသောကြောင့် အမြစ်ကြီးထွားမှုအားကောင်းစေပြီး ရေနှင့် အာဟာရဓါတ် ပိုမိုရရှိစေနိုင်ပါသည်။ မြေဩဇာနှုန်းထားအနေဖြင့် တစ်ဧကလျှင် နိုက်ထရိုဂျင် ကီလို ၁၀၀၊ ဖော့စဖော့ရပ် ၈၀ကီလိုနှင့် ပိုတက်ရှ် ၉၀ကီလိုနှုန်း အသုံးပြုစိုက်ပျိုးထားပါသည်။

Annex 5 Quick win gap and baseline study of potato cultivation practices in Myanmar

Preliminary conclusions
Cultivation practices of potato production vary greatly among farmers. Farmers have many different views on what are the best cultivation practices for potatoes. Soil cultivation, planting systems, fertilization practices and postharvest handling differ substantially among farmers, moreover quality guidelines for seed tubers are not available. Contrarily to developed countries where cultivation practices are in accordance with climatic conditions and post-harvest produce use, the two areas included in the baseline study Naung Ta Yar and Heho seem to have no clear standards. Heho farmers are slightly more advanced compared to Naung Ta Yar farmers as they are looking into mechanisation and have larger fields. Farmers in both area's lack basic understanding of translation of the agri-shops advise and product information on application rates of pesticides and fertilizers to actual field application. Farmers organisations or farmers groups to stimulate democracy, economic growth and a better distribution of income hardly exist.
Cultivation guidelines highly depend on specific local conditions, only specific guidelines on seed treatment and aboveground pest control may be taken from comparable agro-ecological potato production areas with limited research adjustment as they mainly depend on climatic conditions. The majority of the cultivation guidelines, however, still need to be developed for this highly valuable cash crop. The demonstration field shows that local conditions are favourable for potato cultivation as yields are expected to vary between 5 to 35 tons per ha depending on seed quality. The field trial indicates that simple and small improvements boost yields considerable.

The main preliminarily conclusions of the study are that:
- both areas are highly suitable to cultivate potatoes in this season (August – December),
- capacity building of small and simple improvements show great potential for quick win yield increase,
- potato value chain is best improved:
  - by better seed quality,
  - by research on basic cultivation practices to develop local customized cultivation guidelines,
  - capacity building of farmers on basic understandings of application rates of inputs,
  - capacity building on developed local customized cultivation guidelines,
- development of farmers groups is needed to contribute to long term implementation of knowledge.

Purpose of the study
The purpose of this study is to perform a baseline study of the potato cultivation (including Yield Gap Analyses), to develop policy advice and investigate evidence based 'Quick Wins' Good Agricultural Practices.

Figure 5.1 *Farmers' fields: a young (left) and a full grown crop (right).*

Preliminarily provisional recommendations
Following the above mentioned conclusions, the main preliminarily recommendations are:
- A baseline study for remaining potato cultivation seasons,
- Continuation of field trials to develop customized cultivation guidelines,
- Continuation of demo's as they are highly valued for their educational effects,
- Improve seed tuber quality through:
- Introduction of virus free seed tubers,
- Include concept of farm saved seed & storage in development of cultivation guidelines,
  - Support development of simple (seed) storage facilities,
  - Introduce concept of the seed value chain,
  - Start the develop of the seed value chain through advice & coaching of farmers & intermediaries,
- Initiate introduction of new varieties,
- Start capacity building of basic & simple customized cultivation practices,
- Support capacity building through introduction of experimental farms & training of "trainers", extension agents, agri-shops representatives, etc.,
- Establishment of farmers groups and farmers organisations.

Figure 5.2 *An infection of late blight (Phytophthora infestans, left) and possibly secondary leaf roll virus through diseased seed (right).*

Baseline study in short
August 2015 a baseline study started on one of the three major potato cultivation seasons in Myanmar. The study is a collaboration between Wageningen UR, Aeres Group (CAH Vilentum, location Dronten), DOA, two graduates of the University of Yezin, local officials and farmers in Shan State, Myanmar. Nearly 40 farmers in the potato production area's Naung Ta Yar and Heho were visited and interviewed several times on their current potato cultivation practises between August and November 2015. Half way through the growing season, preliminary results mainly handle cultivation practices as yield data have to be collected as yet.
A demonstration of seed potato performance was supervised by students and staff of Wageningen UR. Seeds of 26 seed growers were collected, planted and treated equally to show differences in seed quality performance. Additionally and as part of their thesis students carried out a trial on the basics of the potato cultivation such as nitrogen and potassium fertilization, planting distances & depths, and soil cultivation practices. Farmers and local officials were informed of the first results on the field meeting, October 2015.

Figure 5.3 *Layout of the field trial (left) and stakeholders at the field meeting in October (right).*

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The mission of Wageningen UR (University & Research centre) is 'To explore the potential of nature to improve the quality of life'. Within Wageningen UR, nine specialised research institutes of the DLO Foundation have joined forces with Wageningen University to help answer the most important questions in the domain of healthy food and living environment. With approximately 30 locations, 6,000 members of staff and 10,000 students, Wageningen UR is one of the leading organisations in its domain worldwide. The integral approach to problems and the cooperation between the various disciplines are at the heart of the unique Wageningen Approach.

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