WAGENINGEN UR
For quality of life

Annual Report Topsector Potato India and Ethiopia 2014

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Preface

The Agricultural Counsellor of the Netherlands Embassy in Delhi initiated a BOCI project 'Overview of the potato chain in India' in early 2011. In September 2012 this initiative has been adopted by the Dutch and Indian stakeholders and the Pubic Private Partnership (PPS) was established to facilitate the intensification of collaboration between Dutch and Indian stakeholders of the potato chain. A team of Wageningen UR researchers was commissioned to carry out this project.

In 2011, the team collected information from reports, personal files, internet and some Dutch companies and reported the information in "An overview of the potato sector in India and prospects of Indo & Dutch cooperation". The team also participated in the Netherlands Trade mission to India (5 & 11 June 2011) and visited the Central Potato Research Institute at Shimla. Furthermore jointly with the Agricultural Counsellor we organized a potato seminar to present our findings on 5 October 2011 in Delhi. Major potato stakeholders both from India and from The Netherlands attended the seminar; total number of participants was about 60 persons.

In 2012, 2013 and 2014 the team carried out different tasks such as presenting information on various subjects of the Dutch and Indian potato chain to exchange knowledge. In addition, subjects for further investigation were identified. All actions and activities aimed to facilitate collaboration between Dutch and Indian stakeholders. Visits to different locations of India accompanied by Dutch stakeholders, meetings with experts of the Indian potato production chain both stakeholders and researchers, and yield gap analysis were successfully accomplished.

The WUR team was steered by the Netherlands Agro Food Technology Centre (NAFTC) in Delhi. The NAFTC was in charge of facilitating the collaboration between the NAFTC DPC (Dutch Potato Centre) members and the WUR researchers. The collaboration with NAFTC is appreciated.

This report focuses on India as well as on Ethiopia.

Corné Kempenaar
Coordinator Wageningen UR research team.

Executive summary

The potato production analysis of Gujarat and Punjab continued in 2014. In the winter project meeting it was decided which topics needed to be investigated in 2014. Several topics of 2013 are investigated in more depth and new topics are included. Short abstracts of each topic are presented below. Further details are found in the subsequent chapters.

Possible benefits of mechanization in potato production and handling

The only mechanized operations in a standard potato production in India are ploughing, seed bed preparation before planting, ridging, spraying for disease and pest control (tractor driven with hose or occasional boom spraying), windrowing at harvest and collecting and transporting of bagged potatoes by tractor after harvest. Manual operations consist of planting, weeding/hilling, furrow irrigation, knap sack insecticide and fungicide applications, defoliation, hand picking of tubers after lifting, bagging, loading of trucks or wagons and store filling.
Labour costs are expected to rise in the near future. Possible solutions are the replacements of manual operations by less labour consuming solutions like (semi-) automatic operations.

The purpose of chapter 2 was to investigate economic effects of replacing manual operations by less labour consuming solutions from harvest to delivery to the end user. Therefore, a model is set up to investigate costs of manual operations to estimate costs of (semi-)automatic operations. The model includes actual technical and economic data (plus investments) of operations in the Indian potato production from harvest (field operations) and storage (handling). Three production systems are considered: traditional, upgraded and advanced. From traditional to advanced production system the degree of mechanisation is increased. The first step of model development was develop the model and gather the data for a first economic analysis. The first economic analysis of the example storage of ware potatoes show that fixed costs and operations costs increase from traditional to upgraded to advanced through increased investments and use of electricity, respectively. In Addition, the storage period of potatoes with high quality increases from 6 to 8 to approximately 10 months.

Market study into the developments of 1) the Quick Service Restaurant business and 2) the potato snack (chips) business in India

India has a young and rapidly growing population which has a huge demographic impact. First, the scale of India's urbanization will be immense. It is projected that over the next 20 years the urban population is 40% of India's total population. Second, the poor at the bottom of the pyramid having average earnings of € 1.60 ($ 1.80) a day is expected to decrease from 86% to 64% in favour of the lower middle class income which increases from 11% in 2010 to 29% in 2020. These two major changes in society are accompanied by a rapid change in food consumption habits and a large increase is spending power.

Chapter 3 describes the expected effects of these changes on the developments of Quick Service Restaurant business and the potato snack business.

The Indian middle upper class consumers visit QSR's and buy frozen potato products in supermarkets for home preparation as well. Supermarkets are the second important selling channel for a wide range of frozen potato products. All retail stores sell frozen products of McCain and they offer one or two other brands. Smileys and letters are popular to families with young children. At home Indian's prepare fried products in oil heated on gas or electric. We did not find the electric French fries pan in supermarkets (mission 2014). But Indians are used to bake several dishes in oil and use this way of preparation for French fries or other frozen potato products as well.
Experts indicate that QSR restaurants sell 60% of frozen potato products and retail (mainly supermarkets) 40%. They expect that the sales of frozen potato products via the retail chain (including smaller grocery shops) will increase faster than via QSR's in the future.

Most QSR's are located in Tier I, II and III cities. At this moment the product availability of frozen (potato) products is nil to very poor in smaller cities and villages. An important development in the future is the increasing availability of frozen potato products in traditional grocery stores in these smaller towns and villages. These stores already invest in (small) freezers for selling frozen products like ice-cream, frozen vegetables and also potato products. In the future this trend will continue and subsequently lead to an increase in volumes as well.

The chips market is part of a competitive snack market. In a strongly competitive market new suppliers offer more chips for the same price (€ 0.07 and € 0. 14 /5 and 10 Rs. packages). This means that the growth of the chips volume (and potato need) is expected to grow faster than the turnover. The unorganized sector dominates the market but this is changing.
The need and demand for raw material (potatoes) of perfect quality will increase. Processors of Indian origin increase their market share; after being successful on regional markets these Indian processors will open up markets in new neighbouring regions. Middle sized processors (about >10 MT; organized sector) focus on regional markets and use 3rd-party models.

Potato storage experiments in Gujarat 2014

The Indian potato processing companies require raw material throughout the year. The raw material is supplied freshly from the field during February through March and from cold stores from April through January. The raw material quality of about 300,000 tonnes (40%) during August-January is insufficient due to poor storage management. At the workshop held at Ahmedabad (Gujarat, India) on 29 November 2013 it was decided to the experiment in Gujarat state as some major potato processors get most of their raw material supply from this state.

Chapter 4 describes the experiment, which focused on the conditions in the cold store during storage and the effects on the processing quality of the potatoes. Different varieties and lots were stored in the stores involved. This makes it difficult to determine exactly the effects of the different storage systems on quality parameters. Nevertheless the data provide a first impression of the performances of the stores. Data analysing has started and is ongoing (December 2014). Results however, are such that a second experiment will be started in 2015.

Chain solutions and introduction of innovations, new products and approaches

Chapter 5 deals with the visit paid to IlanBio to investigate a novel and undisclosed propagation method of mini-tubers of potatoes. The propagation method was found promising. Several decisions were taken:

- HZPC will carry out a test at its laboratory and greenhouse in the Netherlands to assess the added value of micro-tubers from IlanBio.
- HZPC, in cooperation with WUR will carry out a replicated trial producing mini-tubers (from in-vitro plants and micro tubers).
- Based on results HZPC and NAFTC (H&P) may decide to develop a business plan to exploit the potential of the micro-tuber approach.

Improved transparency in seed potato certification and transparency in potato varietal testing for DUS and VCU

At the request of NAFTC the Wageningen UR team carried out an investigation with the following aims:

- Increase transparency in DUS (registration) and VCU (commercialisation) of Dutch potato cultivars in India.
- Introduction of a licence based seed potato certification scheme in Punjab.

The started dialog is summarised in Chapter 6 and will be continued in 2016.

Centre of Potato Expertise in Punjab

Results of the February 16 - 19, 2014 major Agricultural Summit at Chandigarh Punjab are described in Chapter 7.

During this Summit the Punjab Agricultural University (PAU) in India and Wageningen University and Research centre (WUR) in the Netherlands expressed an intention to set up a University to University (U2U) cooperation to facilitate a Business to Business (B2B) model. The business partner of PAU is the Confederation of Potato Seed Farmers (POSCON) and that of WUR is the Netherlands Agro, Food & Technology Centre (NAFTC-India). This endeavour was supported by the Government of Punjab, India. The aim of the formal cooperation among the five partners is to establish a Centre of Expertise of the potato value chain in Punjab. The Centre of Potato Expertise (CPE) will be established under the auspices of PAU and the following areas were as areas of cooperation: Propagation material, field production, post-harvest handling and storage, processing and knowledge transfer. Executive arrangements and financial arrangements were made and signed by all parties involved.

Rhizoctonia solani in potatoes and its control

Chapter 8 presents solutions to control *Rhizoctonia* in potatoes in Punjab. Symptoms of *Rhizoctonia solani* are described and a control strategy in seed potato production was developed. Tuber inoculum was found more important than soil inoculum as the primary cause of *Rhizoctonia* damage. Options to control *Rhizoctonia solani* at all stages of the production of seed potatoes are discussed and summarised. This includes the appropriate use of chemicals like Moncereen. The following recommendations were presented (incomplete):

- Planting seed potatoes free from sclerotia,
- Selecting *Rhizoctonia* free fields,
- Optimizing treatments of seed potatoes with fungicides,
- Investigated if the higher Dutch dose rate (250 g pencycuron per 1000 kg) gives better results than the recommended Punjabi dose rates (25 – 80 g pencycuron per 1000 kg).
- Moncerene should not be applied by means of a drip treatment

Visits to Ethiopia

In 2014 three missions took place to Ethiopia to assist the potato Platform of the Addis Ababa Chamber of Commerce in realizing its goals, chapter 9. In November 2014, the Platform, Solagrow and WUR were approached to assist in an FDOV tender to establish a potato processing factory in Addis funded by Veris Investments.

Communication

Knowledge dissemination described in chapter 10, is a major topic within the India – Ethiopia project. In years 2014, a training in Utter Pradesh and Gujarat was performed as the first Knowledge Transfer activity following the signing of an memorandum of Understanding between the NAFTC and the government of Utter Pradesh in the presence of the Ambassador of the Netherlands Embassy.
Furthermore, the project yielded 12 missions, 14 presentations and 4 publications.

1. Introduction

India holds third position in potato area and second position in total potato production in the world (NHB 2011). About 90% of the crops are grown in the plains during the cooler autumn, winter and early spring seasons; the remaining is grown in summertime at higher elevations most in the lower Himalayas and some in Karnataka. The average national yield is around 23 tonnes per hectare (Vanitha *et al.* 2013); the yield level in better performing states varies from 25 – 29 tonnes per hectare for Punjab and West Bengal in 2012 - 2013 respectively (www.nhrdf.com). Potato has the third position in per capita availability of food crops after rice (1th) and wheat (2nd).

About 3% of the national seed requirement originates from the national seed potato multiplication scheme; implying that 97% of the acreage is planted which more or less degenerated seed. Cold storage capacity covers about 50% of the national production, leading to high levels of post-harvest losses after the winter crop harvests. About 1% of the national production is processed into potato chips. The cost of potato production is rather low which provides great future for processing. India is not exporting its potatoes to other countries.

The Central Potato Research Institute (CPRI) has a monopoly on variety development and seed production. Imports of foreign varieties and seed is banned although processing companies may negotiate exemptions.

Several opportunities for cooperation between Indian and Netherlands companies and institutions were identified. The themes for cooperation are: varietal development; seed production; introduction of Good Agricultural Practices (GAP); improving storage, storage management and processing qualities; yield gap analysis and yield increase goals; production of high quality raw material for potato processing factories. It is suggested that the implementation is to be carried out in a Public Private Partnerships (PPS). More information on the background of India is provided by Wustman et al. (2011). That study proved that a PPS would significantly stimulate the stakeholders market opportunities throughout the potato production chain. As from 2012 the PPS was established and the tasks are being executed.

The Netherlands Agro Food Technology Centre (NAFTC) was established to facilitate the collaboration between its (potato) members and the WUR researchers. The WUR team informed NAFTC on all its activities such as visits and workshops.

The purpose of the visits and workshops is:

- To exchange information and knowledge on the Indian potato production chain,
- To investigate possible benefits of mechanization in potato production and handling,
- To perform a market study into the developments of
  1) the Quick Service Restaurant business and
  2) the potato snack (chips) business in India,
- To evaluate potato storage experiments in Gujarat,
- To present chain solutions and introduction of innovations, new products and approaches,
- To improve transparency in seed potato certification and transparency in potato varietal testing for DUS and VCU,
- To facilitate the establishment of the Centre of Potato Expertise in Punjab,
- To investigate *Rhizoctonia solani* in potatoes and its control,
- To assist the potato Platform of the Addis Ababa Chamber of Commerce in Ethiopia in realizing its goals.

A team of Dutch potato specialists was composed to carry out the above presented tasks. Contacts in India were established with McCain, POSCON and Punjab Agricultural University (PAU). After the field trial of the yielding performance of potatoes from different storage facilities in Punjab 2013, a study was initiated of the storage systems of Gujarat. Farmers interviews were done to investigate economic aspects of the potato production in

Punjab and Gujarat. The interviews were also used to collect information to identify possibilities to introduce mechanization in the potato production. The results were shared with stakeholders and farmers.

The November visit has not passed by unnoticed: the training in Utter Pradesh and Gujarat was covered by local newspapers and television (Figure 10.1) as the Minister and Director of Horticulture, the Chancellor of the C.S. Azad University, its vice chancellor (prof Munna Singh), Mr Marijn Leijten (Director NAFTC), prof Anton Haverkort (Wageningen UR) and the Chief Minister of the state of Uttar Pradesh were present.

Contacts in Ethiopia were established with IlanBio, potato Platform of the Addis Ababa Chamber of Commerce and Solagrow. These contacts provide ample opportunities to continue collaboration on new innovations and techniques.

2. Possible benefits of mechanization in potato production and handling

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2.1 Introduction

Usually the only mechanized operations in potato production in India are ploughing and seed bed preparation before planting, ridging, spraying (knap sack and tractor with hose) for disease and pest control, windrowing at harvest and hauling by tractor of the bags after harvest. Manual operations consist of planting, weeding/hilling, furrow irrigation, knap sack insecticide and fungicide applications, defoliation, hand picking of tubers after lifting, bagging and store filling. Small holders may do all this themselves with aid of family members, larger holdings employ (daily) labourers depending on need. There is a concern for the sustainability of the intense deployment of labour with urbanization leaving fewer people in the country side and rising labour costs, partly associated with legal minimum wage policies. A model will be set up to investigate economic effects of replacing manual operations by less labour consuming solutions like (semi-)automated operations.

2.2 Model

As a first step a model has been set up to collect actual technical and economic data of operations in Indian potato growing (field operations) and storage (handling) and to calculate costs of operations. Cost of investments in machines, equipment and storages are incorporated as well.
To compare the current degree of mechanization (field and handling) with an increased deployment of machinery the actual status in Indian potato growing (traditional) will be compared to two future-oriented scenarios (upgraded and advanced). These scenarios focus on improved handling. The advanced scenario will focus on 10 year in advance. Calculation of gross margins and cost prices is part of the model.

2.2.1 Fixed costs

Fixed cost enclose machinery and equipment costs and storage houses.

- Investment [A] in INR
- Interest [a%]
- Depreciation [b%]
- Maintenance and assurance [c%]
- Year costs investment = A * (a%+b%+c%)

Additional information to collect as well (if available): type machine or building, capacity, initial costs (new or second hand), life span.

2.2.2 Input cost

Operational costs include inputs including energy, labour and other costs. Make an inventory per scenario of inputs and yield:

- Product (yield, chemicals, energy, etc.)
- Volume: units per acre used or harvested
- Price per unit

Input costs (per season or crop) [B]: volume * price

2.2.3 Operational costs (labour)

Make inventories of all operations including:

- Description
- Carried out by own employees or hired labour
- Hours or pieces [d]
- Piece wages and time wages [e]

Costs of operations [C]: d * e

2.2.4 Total costs

Total year cost: [A+B+C]
Cost price (INR/kg) = total year costs (INR) / capacity or yield per acre (tonne)

2.3 Example of storage

In India potatoes are stored in specialized cold storages owned by cold store holders. Not farmers but wholesalers exploit these cold stores. Processors, wholesalers, or farmers pay a rent for storing products.

2.3.1 Ware potatoes (Gujarat)

Potatoes grown during rabi season, are harvested from January till the beginning of March. For adequate supply of quality potatoes during the whole year, storage is necessary. During the harvest period potatoes can be transported from land to the processing facilities or wholesale markets directly. Raw material need during the processing season prescribes the storage capacity needed. For long storage more advanced storage facilities are necessary; for shorter storage relatively simple storage facilities should be sufficient. Besides potatoes for processing, lots of potatoes for the wholesale markets have to be stored as well.

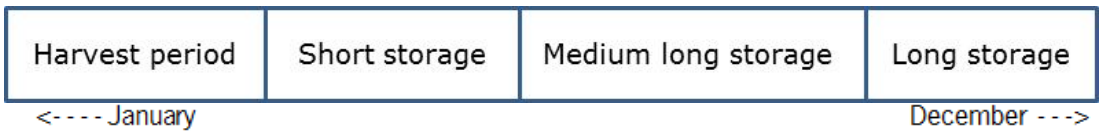

Figure 2.1. Ware potato storage January – December.

In Gujarat three categories of potato cold stores are identified (Pronk *et al.* 2014):

- Traditional stores (short storage)
- Upgraded traditional stores (medium long storage)
- Advanced stores (bulk, boxes for long storage)

Investments

During the October 2014 mission investment figures have been collected. Table 2.1 shows the investments for store construction. The most common potato cold storage in India has a 5,000 tonnes capacity; as the state government provide a 30% subsidy for such capacity. Average investment for traditional storage: 9,000 INR per tonne; some storage holders indicated lower amounts (8,000 INR per tonne).

Table 2.1. Investments per store type (capacity 5,000 tonnes, in INR).

	Traditional store	Upgraded store	Advanced store (bulk storage)
Land (at least 2 acre)	8000000	8000000	8000000
Building	45000000	45000000	98000000
Equipment	8000000	22000000	56000000
Total (including land)	61000000	75000000	162000000
Building plus equipment (ex. subsidy)	53000000	67000000	154000000
Total investment (after subsidy)	37100000	46900000	107800000
Investment in INR per tonne	10600	13400	30800
Investment in euro per tonne[1]	132.5	167.5	385

[1] 1 euro = 80 INR

Land prices in India are high and comparable to Dutch land prices. At least 2 acre of land is needed for building a storage facility. Equipment includes cooling, elevators, etc.
The Government provides a 30% subsidy on the construction of (any) potato cold storage (has been 40% in the past). On innovation like advanced storages higher subsidies are possible. Beside this storage owners receive a 25% reduction on electrical energy for the initial three years of operation. Entrepreneurs in agriculture (including storage owners) also pay attractive (reduced) interest rates of 10-12% on loans; in other sectors: 24%. In some cases cold store owners pay interest rates below 10%.

Fixed costs

To calculate year costs normative figures are used for interest, depreciation and maintenance (Table 2.2).

Table 2.2. Percentages interest depreciation and maintenance

	Interest	Depreciation	Maintenance	Total
Building	5%	4%	2%	11%
Equipment	5%	10%	2%	17%

Based on average investment (residual value 0): 50% of 10% interest.
On base of investments and normative percentages year cost are calculated.

Table 2.3. Fixed year cost (INR).

	Traditional store	Upgraded store	Advanced store
Land	0	0	0
Building	4950000	4950000	10780000
Equipment	1360000	3740000	9520000
Total fixed costs	6310000	8690000	20300000
Total fixed cost after subsidy	4417000	6083000	14210000
Cost price INR per kg (ex. subsidy)	1.26	1.74	4.06
Cost price INR per kg (after subsidy)	0.88	1.22	2.84

Operational cost

Operational costs are electricity for cooling and labour (managers, operators, supervisors, loading and unloading storage).

Table 2.4. Operational cost potato storage (INR).

	Traditional store	Upgraded store	Advanced store
Electricity	1200000	3200000	4000000
Labour manager	120000	120000	300000
Labour operators	198000	198000	0
Labour supervisors (manage Loading/unloading)	198000	198000	0
Labour loading / unloading	1000000	1000000	0
Labour loading storage, sorting & grading	0	0	104000
Labour unloading, sorting & grading	0	0	135000
Total	2716000	4716000	4539000
Operational costs per kg	0.54	0.94	0.91

- Electricity cost 200,000 (traditional) - 400,000 (upgraded, advanced) INR per month; average storage period traditional 6 months, advanced 8 month, upgraded max. 10 month. 25% reduction on electrical energy for the initial three years of operation is not included in calculation.
- Managers (10,000 INR per month), operators and supervisors (5,500 INR per month); 2 managers on bulk storages earn more and are supervisor during loading/unloading;
- Labour loading and unloading storage: 10 INR per 50 kg bag (5 INR loading and 5 INR unloading). McCain offers workers 12 INR per bag in case of gently handling bags.
- Not included weight losses: traditional 10 - 12%, upgraded 8-10% and advanced 6 - 8%; risk of product owner.
- Cost for CIPC-treatments?

Cost prices

Table 2.5 and Table 2.6 show the cost prices of different storage systems before and after subsidy.

Table 2.5. Total costs per kg storage capacity.

	Traditional store	Upgraded store	Advanced store
Fixed cost	1.26	1.74	4.06
Operational costs	0.54	0.94	0.91
Total costs	1.81	2.68	4.97

Table 2.6. Total costs per kg storage capacity after subsidy.

	Traditional store	Upgraded store	Advanced store
Fixed cost	0.88	1.22	2.84
Operational costs	0.54	0.94	0.91
Total costs	1.43	2.16	3.75

Cost prices of upgraded and advanced storage systems are higher compared to traditional. Fixed cost depend on expand of investments. Higher operational costs is mainly connected with electricity.

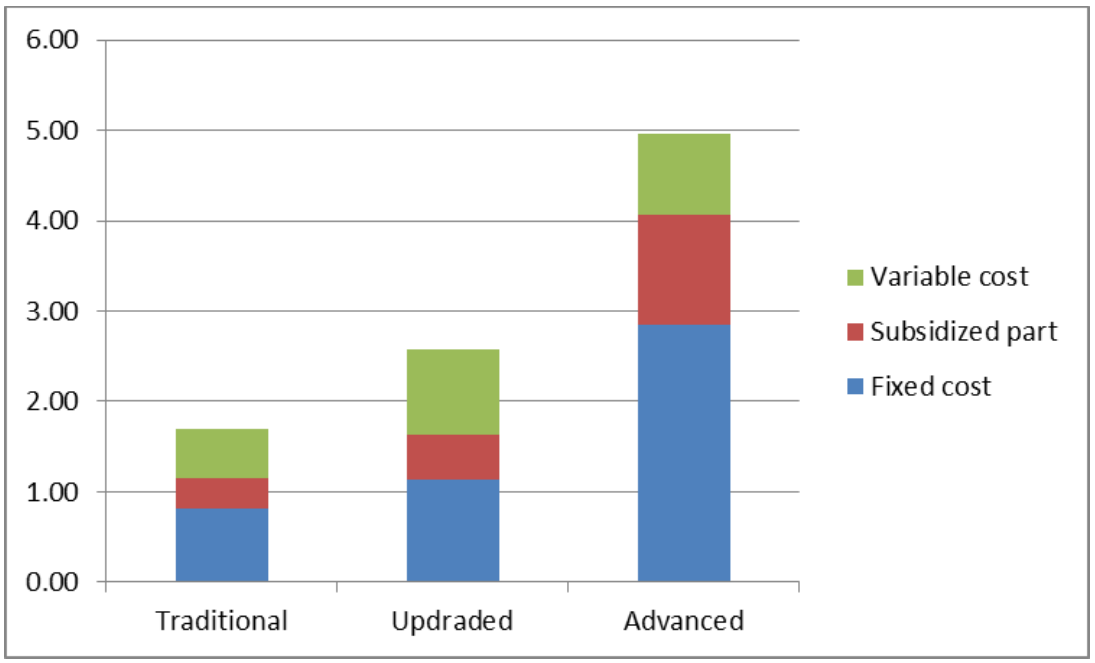

Figure 2.2. Composition of cost price ware potato storage (INR per kg).

Revenues

McCain pays 2 - 3 INR[1] per kg rent for traditional storage, and 5.0 - 6.0 INR per kg for bulk storage (advanced). No figures were available for rent paid in upgraded cold storages. We assume this will be about 3 INR. Assuming these rents, storage activities seem to be profitable but without subsidy margins are small.
Remark: calculations are based on a few storages visits and expert information. Basic data and results need to be checked. Points for discussion and research:

- Subsidies in the past were higher (40%)
- Lower investments in potato storage; some experts indicated 4 crore (8,000 INR per tonne)
- Life of storage is longer (old storages): lower depreciation costs.

2.3.2 Store-owning wholesalers

Some wholesalers deliver raw material to the chips processing industry. For chips processing small size potatoes are sorted out (extra handling); these small sized potatoes are used for flakes processing and upper sized potatoes are sold to chips processors.

2.3.3 Inventory of operations

During the 2014 mission a broad inventory of operations in potato growing and storage has been made in Punjab and Gujarat. These inventories are a result of farm and storage visits. It gives an overview of operations (activities) and the way these operations are carried out.

Table 2.7. Operations in potato growing in Gujarat, ware potatoes.

Activity	Traditional	Upgraded	Advanced
Tractor			
	They use tractors from 20 to 60 hp, mostly about 40 hp. These cost 600.000 IRN / € 8000. Tractors usually don't have hydraulic system connection, but this can be made on.		
Soil preparation:	Chisel plough, 2x Sub soiling, 1x Moldboard plough Harrowing, 1x	Chisel plough, 2x Sub soiling, 1x Harrowing, 1x	Chisel plough,2x Sub soiling, 1x Harrowing, 1x
	The soil is prepared before planting with a subsoiler, several times with a cultivator and with a rotary tiller / rotavator. These simple machines are made locally. Prices: subsoiler 20.000 IRN / € 260, cultivator 50.000 IRN / € 650, rotavator 100.000 IRN / € 1300.		
Seed treatment:	No	Moncereen	Moncereen
Seed cutting:	By hand	By hand	By hand
Planting:	Hand and shovel	Half automated planter	Automated planter
	The planting of potatoes is mostly done with a half-automatic planter, 2 rows at a time. These relative simple machines are produced locally for 50.000 IRN / € 650. This machine requires two labours to put potatoes in the hopper and from the hopper in the plant-discs.		

[1] Other informants indicated lower rents: 1.3-1.8 INR

Fertilization: manure:	Tractor plus manually spreading	Tractor plus manually spreading	Tractor plus manually spreading
Foliar:	-	Through irrigation system	Through irrigation system
NKP:	By hand	Basal dressing by hand, side dressing through irrigation system	Basal dressing machine spread, side dressing through irrigation system
	The fertilizer is applied with the planter (the planter has an extra hopper to contain the fertilizer, the fertilizer is drilled) or applied manually. The fertilizers used are a sort of bulk-product with a variable grain-size. By means of this variability will a machine give an irregular pattern.		
Disease control:	Knapsack (5 times)	By handgun & tractor supported (5 times)	Boom spraying (5 times)
Weed control:	Hand picking	Knapsack(1 time) + hand picking (1 time)	Boom spraying + hand picking (1 time)
Irrigation:	Furrow by hand labour	Gun/pivot	Drip
	In the Punjab region most of the irrigation is done by flooding, with a lot of manual labour. In the Gujarat region drip irrigation is commonly used. For both methods wells are bored to supply the water. For pumping up the water electricity is needed, which is sometimes free for some hours but also isn't always available. The regulation of drip irrigation is sometimes done manually or sometimes automated. For installing and removing the tubes/pipes al lot of labour is needed.		
Haulm killing:	By hand	By hand	Boom spraying
	Haulm killing (if necessary) is done manually with a sickle. They tried to kill it with spraying paraquat, but this was not very successful.		
Lifting:	By hand (?)	With lifter, left on the bed	With lifter, left on a row on the bed due to transport band on lifter
	The harvest is done with a digger which lift the potatoes and lies them on top of the ridges. After drying these potatoes are then manually collected in bags of 50 kg. The diggers are locally made costing 60.000 IRN / € 780.		
Collecting:	collecting by hand	collecting by hand	Collecting by hand
Maturing:			
Transport to storage facility:	50 kg bags loaded onto truck	50 kg bags loaded onto truck	50 kg bags loaded onto truck
	Most of the potato transport is on the back of labour, carrying bags of 50 kg each. From the field to the trailer, from the trailer to the storage, from the storage to the truck. The labour was mostly paid per bag. On a few locations were conveyer belts, mostly only to transport the bags into the cold storage levels.		
Storage loading:	50 kg jute bags loaded to cooling facility by hand	50 kg polyamide bags loaded to cooling facility by hand	Bulk stored in cooling facility by machine
Storage unloading:	50 kg jute bags loaded to cooling facility by hand	50 kg polyamide bags loaded to cooling facility by hand	Bulk stored in cooling facility by machine

	The potatoes are stored in cold stores, where on 6 floor the bags with potatoes are placed (by labour). At several times the bags are checked and moved in the store. The new build stores have this same structure. We've seen one store with bunker storage with hopper, conveyer belts and shovel loader. This storage used twice the amount of electricity/energy		
Drying:	Unbagged by hand and dried on concrete floor	Unbagged by hand and dried on concrete floor	-
Grading/selecting:	By hand	By hand/ machine graded	Machine graded
	The sorting and grading of potatoes is mainly done manually. We've seen grading machines, locally produced. They are used by the larger farms and the processing industry. (capacity 10 tonne = 1000,000 IRN / € 13,000)		
Bagging:	In 50 kg jute bags by hand	In 50 kg jute bags	In 50 kg jute bags
Truck loading	By hand	By hand	By hand (??)
Transport to end user	Truck	Truck	Truck

Table 2.8. Operations in potato growing in Punjab, seed potato.

Activity	Traditional	Upgraded	Advanced
Tractor			
	They use tractors from 20 to 60 hp, mostly about 40 hp. These cost 600,000 IRN / € 8000. Tractors usually don't have hydraulic system connection, but this can be made on.		
Soil preparation:	Chisel plough, 3x Sub soiling, 1x Disc ploughing, 1x Power harrowing, 1x	Chisel plough, 3x Sub soiling, 1x Disc ploughing, 1x Power harrowing, 1x	Chisel plough, 3x Sub soiling, 1x Disc ploughing, 1x Power harrowing, 1x
	The soil is prepared before planting with a subsoiler, several times with a cultivator and with a rotary tiller / rotavator. These simple machines are made locally. Prices: subsoiler 20,000 IRN / € 260, cultivator 50.000 IRN / € 650, rotavator 100,000 IRN / € 1300.		
Seed treatment:	No	Moncereen	Moncereen
Seed cutting:	By hand	By hand	By hand
Planting:	Hand and shovel	Half automated planter	Automated planter
	The planting of potatoes is mostly done with a half-automatic planter, 2 rows at a time. These relative simple machines are produced locally for 50,000 IRN / € 650. This machine requires two labours to put potatoes in the hopper and from the hopper in the plant-discs.		
Fertilization: manure	Tractor plus manually spreading	Tractor plus manually spreading	Tractor plus manually spreading
Foliar		knapsack	Boom spraying
NKP	By hand	Basal: Tractor + hand Side dressing: Machine spread	Basal: Machine spread Side dressing: Machine spread
	The fertilizer is applied with the planter (the planter has an extra hopper to contain the fertilizer, the fertilizer is drilled) or applied manually. The fertilizers used are a sort of bulk-product with a variable grain-size. By means of this variability will a machine give an		

	irregular pattern.		
Disease control	Knapsack	By handgun & tractor supported	Boom spraying
Weed control	Hand picking	Knapsack + hand picking (1 time)	Boom spraying
Irrigation	Furrow by hand labour	Furrow by hand labour	Pivot/gun irrigation
	In the Punjab region most of the irrigation is done by flooding, with a lot of manual labour. For this method wells are bored to supply the water. For pumping up the water electricity is needed, which is sometimes free for some hours but also isn't always available. The regulation of drip irrigation is sometimes done manually or sometimes automated. For installing and removing the tubes/pipes al lot of labour is needed.		
Haulm killing:	By hand	By hand	Boom spraying
	Haulm killing is done manually with a sickle. They tried to kill it with spraying paraquat, but this was not very successful.		
Lifting:	By hand (?)	With lifter, left on the row	With lifter, left on a row
	The harvest is done with a digger which lift the potatoes and lies them on top of the ridges. After drying these potatoes are then manually collected in bags of 50 kg. The diggers are locally made costing 60.000 IRN / € 780.		
Collecting:	Collecting by hand	Collecting by hand	Collecting by hand
Maturing:			
Transport to storage facility:	50 kg bags loaded onto truck	50 kg bags loaded onto truck	50 kg bags loaded onto truck
	Most of the potato transport is on the back of labour, carrying bags of 50 kg each. From the field to the trailer, from the trailer to the storage, from the storage to the truck. The labour was mostly paid per bag. On a few locations were conveyer belts, mostly only to transport the bags into the cold storage levels.		
Storage loading:	50 kg jute bags loaded to cooling facility by hand	50 kg polyamide bags loaded to cooling facility by hand	Bulk stored in cooling facility by machine
Storage unloading:	50 kg jute bags loaded to cooling facility by hand	50 kg polyamide bags loaded to cooling facility by hand	Bulk stored in cooling facility by machine
	The potatoes are stored in cold stores, where on 6 floor the bags with potatoes are placed (by labour). At several times the bags are checked and moved in the store. The new build stores have this same structure. We've seen one store with bunker storage with hopper, conveyer belts and shovel loader. This storage used twice the amount of electricity/energy		
Drying:	Unbagged by hand and dried on concrete floor	Unbagged by hand and dried on concrete floor	-
Grading/selecting:	By hand	By hand/ machine graded	Machine graded
	The sorting and grading of potatoes is mainly done manually. We've seen grading machines, locally produced. They are used by the larger farms and the processing industry. (capacity 10 tonne = 1000,000 IRN / € 13,000)		
Bagging:	In 50 kg jute bags by hand Logo printed on bags by hand	In 50 kg jute bags	In 50 kg jute bags
Truck loading	By hand	By hand	By hand (??)
Transport to end user	Truck	Truck	Truck

Table 2.8 and Table 2.7 show which activities are done by hand nowadays (traditional). It is important to trace/identify these time consuming operations in potato growing and handling and to find practical laboursaving solutions.

2.4 Opportunities on mechanisation

2.4.1 Tractors

The most expensive machine on the farm is the tractor, which costs about €8000,-. The Indian tractors owned are relatively small in hp compared to Dutch tractors (Table 2.8 and Table 2.7). More than 68% of the farmers in Punjab have tractors being the state with the highest tractor intensity of India: 78.92 tractors per 1000 ha are available compared to Gujarat where only 18 tractors per 1000 ha are available (Chouhan & Singh 2014). Tractor driven mechanised equipment has to comply with these small tractors, up to a maximum of approximately 60 hp. Most farmers we met had 40 - 50 hp tractor.
The small farmers can most likely not afford a state of the art tractor from Holland. However, they may be affordable when shared by a group of farmers, which is a known concept.

2.4.2 Machines

Machines to be used in Gujarat and Punjab have to comply with the tractors used and the educational degree of the labour. This means that non tractor driven machines must be easy to use and that tractor driven machines must be operational with a maximum of about 60 hp. State of the art Dutch machines are too complex and most likely too expensive at the moment for most farmers to purchase. Some machinery is shared amongst farmers, especially when farmers are relatives and which is the case in the Punjab area. But new and state of the art machines need skilled labour which is not always available. Most machine operators now are illiterate and hard to train.
Solutions and opportunities for machines are found by digging up some sketches of machines from the 70s. In addition, the designs are best made in conjunction with a local manufacturer. Local manufacturers are eager for improvements and they probably can make such machines to a price that is according to the Indian standards.
Machines identified where labour can be reduced and which connect to the degree of mechanisation locally:

- planting: automated planter
- fertilizer: improvement of fertilizers can lead to using spreaders
- spraying: better and safer spraying equipment (especially safer for operator and improved efficiency of chemicals used)
- irrigation: a spray gun (Punjab area to replace furrow irrigation), which also can be used in other crops; drip irrigation in Gujarat to replace sprinkler irrigation
- haulm killing: this can be mechanised by use of a haulm shredder / haulm topper
- harvest: the potatoes are now picked up by labour, this can be easily changed by using a conveyer belt which loads to a trailer behind/next to the digger or if wanted loaded in bags.

Some examples are shown in Figure 2.3.

Figure 2.3. Some examples of mechanisation options for the potato cultivation in India. Above left and middle: tractor supported spray gun irrigation; above right: a one row harvest bunker; below left: haulm shredder; middle: haulm topper; right: harvest directly loading on truck.

2.4.3 Manual handling of potatoes

Grading and sorting of potatoes is a handling that is done several times at different moments in the chain from harvest to delivery. Differences in manual handling of potatoes are found depending on the kind of potato produced. Potatoes for the fresh marked are sold from the field, where manual handling is limited to hand picking, sorting of damaged potatoes and grading before bagging for transport directly from the field to the market. In both areas, Gujarat and Punjab, this is the same.

In Gujarat, processing potatoes are produced. After lifting, potatoes for processing are left on the field for some hours to dry, graded and sorted by hand or sometimes by small portable graders, manually bagged and either sold directly to the processor or cold stored immediately after bagging. Sorting and grading is done again after cold storage, mainly to remove the diseased and damaged potatoes.

The most intensive manual handling is done with seed potatoes in the Punjab area. In the Punjab area, a first grading and sorting is done by labour in the field when the potatoes are placed in little heaps on a jute bag to dry after they are lifted. Damaged potatoes are not collected to the small heaps. Then the potatoes are put into bags and piled up at the corner of the field in bulk. After several weeks the skin is cured sufficiently and the potatoes are bagged, again removing damaged and or diseased potatoes. The bags are transported to the storage facility or to the farmers house. The potatoes are unbagged and sorted, either by hand or by a sorting machine, diseased/ and or damaged potatoes are removed. After sorting, potatoes are bagged and put into cold storage. When unloading the bags from the cold storage, the potatoes are spread out on a concrete floor to dry. Sorting is done, that is the diseased and damaged potatoes are removed. When potatoes are dry, they are treated for diseases by a spray application, after which they need to dry again. Then the potatoes are bagged for transport to potato traders or final destination.

There are of course, reasons why handling potatoes in Punjab is done manually. The main reason for manually handling potatoes after harvest is that the short production period of the potatoes combined with the climatic conditions, cause them to be harvested immature with a very fragile skin. Potatoes are easily rubbed losing their skin. As for now, attempted machines by Punjabi farmers to mechanise steps after harvest, have not sufficiently addressed the fragile skin of the fresh potatoes. Hands are far more careful than a conveyer belt. The main reason after storage is that the potatoes from the cold store enter the ambient air and thus get wet. The traditional stores

have large compartments and no possibilities to warm up without condensation on the potatoes. The wet potatoes have to dry to prevent diseases, forcing the potatoes to be unbagged and bagged again when dry.
This extensive handling of potatoes opens opportunities for mechanisation. Although prices of all the handling was investigated, see Table 2.4 for some indications, it is not yet crystal clear how much labour for what prices are involved in all the manual handling of the potatoes. It was found that labour was paid for handling one bag, for instance to load and unload the truck or cold storage, or to stich a bag when it was full, or that labour was paid an hour wages for sorting or grading. In general, the payment system is very differentiated into tasks, responsibilities, and/or hors work a day. It is therefore that the subject of manual handling of potatoes needs further exploration to estimate the costs savings due to mechanisation.

2.5 Future

The model has to be developed further on. In 2015 and 2016 more detailed information has to be collected on base of which cases will be investigated and calculated. The scenario's will focus on improved handling. Table 2.8 and Table 2.7 show that most storage and harvest activities are done manually nowadays (traditional). Improvements are possible by replacing manual handling by (semi-)automated operations. With that it is important to take into account standards in Indian agriculture and the potato production.

3. Market study into the developments of 1) the Quick Service Restaurant business and 2) the potato snack (chips) business in India

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3.1 Introduction

3.1.1 Population, income distribution & food habits

Population density and growth

India has a young and rapidly growing population. According to McKinsey Global Institute (MGI) this has a huge demographic impact. The scale of India's urbanization will be immense. As an estimated 340 million people already live in urban areas in 2008, nearly 30% of the population, it is projected that over the next 20 years the urban population will increase to 590 million. This is 40% of India's total population. It is said that this scale and speed of urban transformation has not happened anywhere in the world except in China. The total population is expected to increase from 1,270 Million (1.27 billion) in 2014 to 1,470 Million (1.47 billion) in 2030.

MGI projects that the urbanization will spread out across India, impacting almost every state. However, we can distinguish the five large states (Tamil Nadu, Gujarat, Maharashtra, Karnataka and Punjab) where more of their population will live in cities than in villages.

The cities of India are all classified according to their population density. Tier-I cities have more than 4 million inhabitants, Tier-II cities between 1 – 4 million and Tiers III and IV have less than 1 million inhabitants. There are currently about 9 Tier I cities, 33 Tier II cities and over 5,000 Tier III and Tier IV towns, while there are more than 638,000 villages in the country. This will increase up to 13 Tier-I cities (of which 6 megacities with populations of 10 million or more, among which Mumbai and Delhi), to 55 Tier-II cities and > 6,000 Tiers III and IV cities (Figure 3.1).

Age and income distribution

The Marketing Whitebook 2011-12, (Anonymous 2011c) indicates that the age group between 13 - 24 will be 300 million people, of which 29.5% lives in an urban area (88.5 million people).
The spending power of the young and rich is € 40 (Rs. 3000) to € 540 (Rs. 40,000) per month and the spending areas are clothing & accessories, food, entertainment and durables. The younger and richer India is fuelling rapid growth in the eating-out segment.

From MGI research it appears that about 75% of the urban citizens in 2008 lived in the bottom income segments, earning an average of € 1.60 ($ 1.80) a day (Figure 3.1, lower part). This large, but poor socio-economic group (the bottom of the pyramid) composes indeed a huge purchase power in the future. These poor of today are the middle class of tomorrow. Besides, there is a rapid increase of the upper middle class (from 2% in 2010 to 5% in 2020) and of the lower middle class (from 11% in 2010 to 29% in 2020), decreasing the bottom of the income pyramid from 86 to 64%.

It is estimated by MGI that by 2030 urban India will generate nearly 70% of India's GDP (from 58% in 2008). This implies a near fourfold increase in India's per capita income between 2008 and 2030 (Figure 3.2).

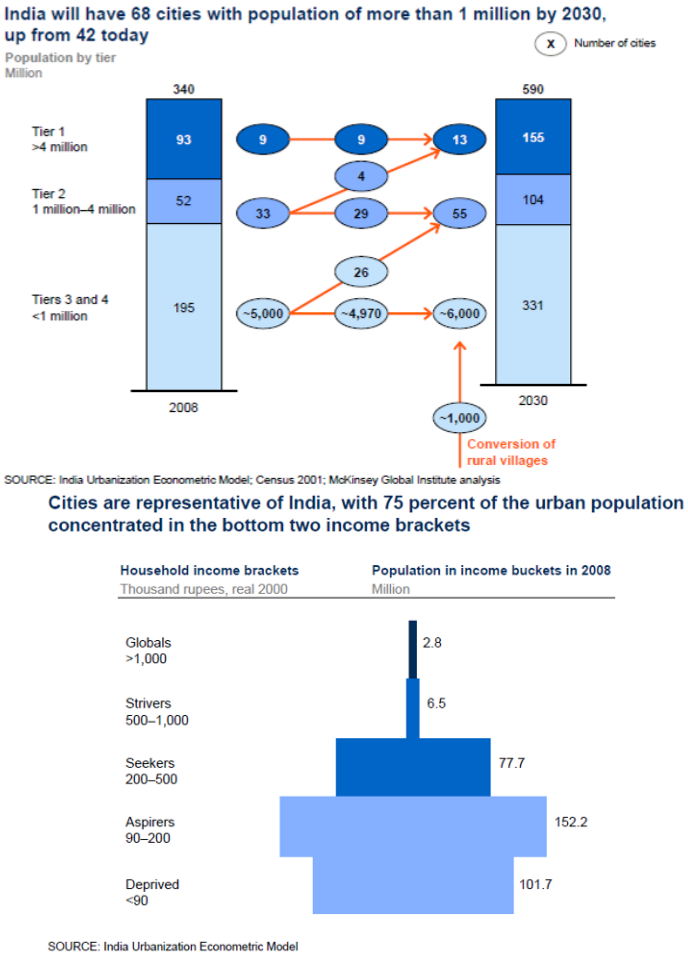


Figure 3.1. The increase in number of Tier I, II , III and IV cities (above) and the percentage of the population with an average monthly income (below).

The number of middle class households will increase to about 547 million individuals by 2026 or 113.8 million households (Anonymous) compared to 267 million individuals in 2016 (53.3 million households) and 931 million individuals in 2011 (160 million households). When extrapolating this increase to 2030, about 650 million individuals or 21.8 million households belong to the middle class. In 2013, approximately 16% of these middle class households lived in Tier I cities and 8% in the Tier II cities (Anonymous 2013). Due to this increase of the middle class households, the number of households living in Tier 1 cities will increase to 9.4 million by 2016 to 21.8 million by 2030. The so estimated increase in Tier II cities is 4.7 million households in 2016 increasing to 11 million households by 2030. This does not include growth of middle class households due to ongoing urbanization, so this is a rather conservative estimate.
Looking to states of India with the highest GPD most of these are situated in the north west of India (top 3: Maharashtra, Gujarat, Uttar Pradesh).

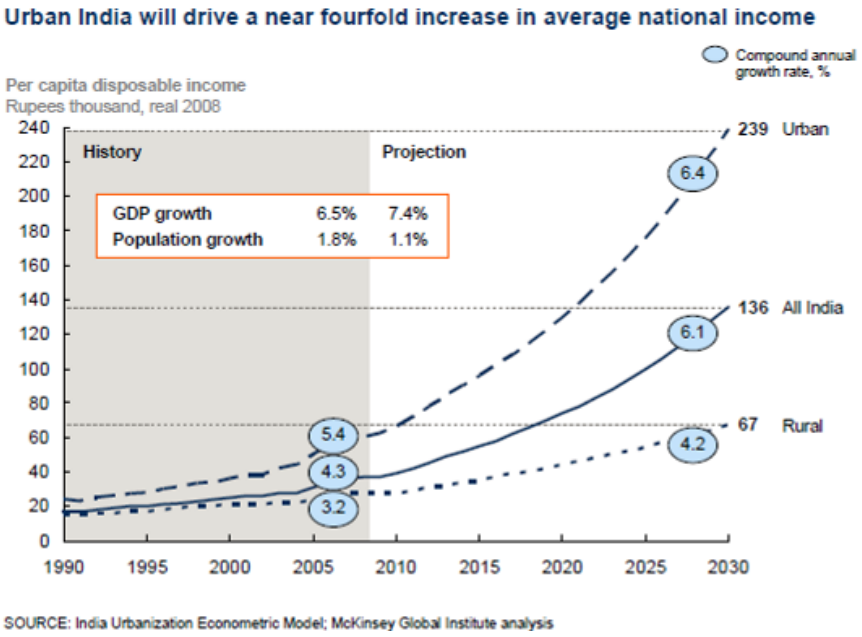


Figure 3.2. Increase of average income.

Food trends and habits

There is a rapid change going on in food consumption habits in India. This is due to demographic shifts. E.g. it is expected that the younger and growing middle class population will increasingly eat outdoors and spent more of their income on out-door meals. According to a Rabobank Industry Note (2013) there is a shift from in-house to out-of-home consumption. A larger group of the population is exposed to western lifestyles leading to experimentation with new dietary habits and higher protein consumption (instead of carbon hydrates). Most of Indian consumers are not yet familiar with processed French fries and places like Quick Service Restaurants are places to experience the novelty of eating out in a western setting.
With more women joining the workforce and thus less time at home to prepare meals but larger disposable incomes, there will be more occasions for families to eat out. It is said that already 25% of the Indian population eat out at least twice a month and this will only increase. This figure also includes the consumption of out-door quick lunches (spending € 2/Rs. 150 to € 6.75/Rs. 500 per meal).

Indian people love potatoes. They usually prepare a potato-based side dish with every meal. Home-made French fries are also known. However, the consumption of fresh potatoes is declining for quite some time now whereas the consumption of processed potato products is increasing. The increase is mainly due to increased chips consumption. Out-door French fries consumption is also on the rise, as mentioned above.

In addition to eating out, ordering meals is on the rise (Sinha 2012). In the large cities, more than 25% of the educated and employed young citizens orders home delivered meals for more than 5 times in a month, 20% once a week and 22% once a month.
Although the Indian population has a strong preference for Indian flavours and cooking styles, consumers are portraying an ever changing lifestyle, one of the key characters of an emerging economy.

Socioeconomic changes across India's population base and changing and evolving lifestyle trends will lead to an increasing demand for processed food products, especially products which meet the convenience and health requirements of the consumer.

Modern middle upper class families prefer service and safe food of high quality. To them food safety is an important issue. So they buy A-brands in closed packaging.

3.1.2 The potato processing industry

The potato processing industry has undergone an enormous growth in the past 10 years (Figure 3.3). In 2003 there were just 4 to 5 companies, and in 2008 there were about 28 industries manufacturing potato chips, flakes and French fries in the organized sector only. The production has gone up to 10 lakh tonnes by both the organized and unorganized sectors (Bhajantri 2011).

The potato chips market is said to be worth € 0.3 billion (Rs. 25 billion) and account over 60% of the total Potato processing capacity of the industry (the industry's potato processing capacity includes all kinds of potato products, including Potato chips, French fries, Potato flakes/powder and other processed products such as dehydrated chips, Alu Bhujia, Samosa, and Tikkis) (Bhajantri 2011).

Potato processing industry in India is mainly composed of three segments: potato snacks (including potato chips, Alu Bhujia, etc.), potato flakes/ powder and Frozen potato products. Potato chips have been the leading segment of potato processing industry in India. Apart from potato chips, potato flakes or potato powder is another segment of potato processing in India that is showing impressive growth in terms of existing/ expected processing capacities.

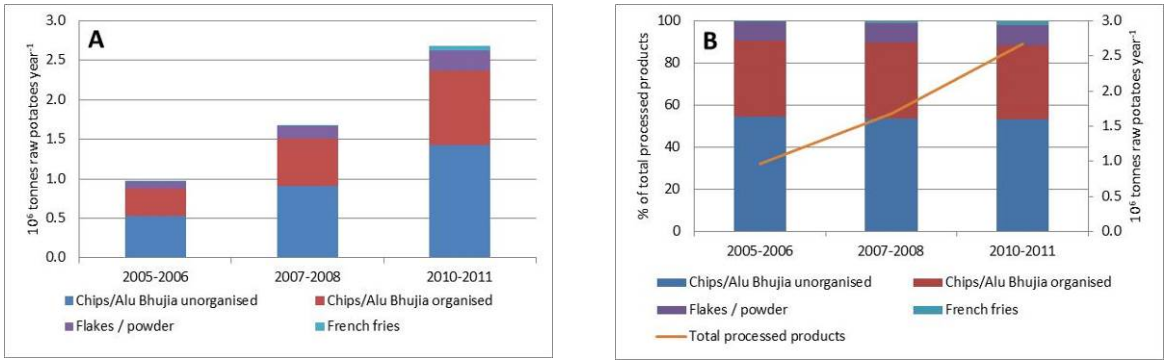


Figure 3.3. Potato processing of India: A: 10^6 tonnes raw potatoes · $year^{-1}$ and B: % of total processed products.

Frozen products

The level of potato processing (frozen potato products) is still very low, hardly 0.5% of the Indian total produce (compared to The Netherlands this percentage is over 80%). Due to shortage of required raw material, the actual amount of manufactured French fries in India is far less than its manufacturing capacity.

McCain currently leads the fast-emerging Indian market of French fries and other frozen potato products (specialties). Nowadays (2014) the company has captured 85-90% of the market and processes 75,000 tonnes of

potatoes, all at the Gujarat plant. Compared to India's total potato production of 42.34 million tonnes potato this is still less than 0.5% of India's total potato production. McCain is working with about 1,200 contract farmers over 4,000 acres, all in Gujarat, to cultivate quality potatoes suitable for processing. McCain plans to expand its capacity to 150,000 tonnes next year (2015).

Chips

About 85%-90% of all processed potatoes are processed into chips. We estimate that at least 3 million tonnes raw potatoes is used for processing chips and other salty snacks nowadays, both by the organised and the unorganised sector. This equals about 7% of India's potato production. Chips processors are more or less scattered all over India, see paragraph 3.3.

3.2 The Quick Service Restaurant business

3.2.1 Market characteristics

The first foreign quick service restaurants (QSR) entered the Indian market nearly 20 years ago (Jashnani 2014). Anno 2014, approximately 52 QSR brands are operating 2500 outlets across India. The number of Indian QSR chains is also rising and over 60 chains are in operation. But, not all of these QSR serve potato products such as French fries or potato wedges (Figure 3.4). Table 3.1 gives an overview of most important QSR's which have French fries or potato wedges listed on their menus. Hardly any Indian QSR has French fries listed on the menu whereas potato wedges may be served.

Figure 3.4. French fries (left) and potato wedges (right).

Table 3.1. Overview of French fries and/or potato wedges selling QSR's in India.

Chain / Brand	Year started in India / location	Number of restaurants	Number of restaurants 2014	Share (Anonymous 2011c)	Source
Foreign				63%[1]	
Domino's Pizza	1996/New Delhi	101 (2001)	749	20%[2]	(www.jubilantfoodworks.com/brand/dominos-pizza/)
McDonalds	1996	21 (2001)	271	11%[2]	(Sen & Mudgil 2013)
Subway	2001/New Delhi		282	12%[2]	
KFC	1995		340	9%[2]	(http://en.wikipedia.org/wiki/KFC)
Pizza Hut	1996	19 (2001)	184	8%[2]	
Wimpy's	1989				
Burger King	2014/New Delhi	1	1	-	Business Standard
Local/Indian				37%[1]	
Bangs Fried Chicken	2009			Potato wedges	http://www.bangsindia.com/#

[1] Percentage of total share based on the number of operational outlets
[2] Percentage of foreign share

McDonald's was followed into India by other international brands such as Dominos, Subway, Pizza Hut and KFC. These brands typically operate through the franchise model, which helps them expand rapidly with minimal capital investments. These foreign players have established themselves strongly and currently dominate the Indian QSR market with an aggregate share of 63 per cent (Table 3.1).

In 2011, the total Indian restaurant market was € 5.8 billion (Rs. 43,000 Crore) (Anonymous 2011c). About 80% of the Indian restaurant market is unorganized, 13% is organized and 7% belongs to the QSR, good for € 0.4 billion (3000 Rs. Crore) annually. The QSR market is growing at an annual rate of 25 - 30% and dominated by foreign brands like McDonalds, KFC and Domino's Pizza, owning 63% of the QSR market (Table 3.1). The driving forces for this rapid growth are a (rapid) increase of the upper middle class. As mentioned in paragraph 3.1.1 it is expected that the younger and richer Indian population will increasingly eat outdoors and spent more income on outdoor meals. QSR provide four needs: service, take-away, home delivery and outdoor eating.

The majority of the QSR's are located in large centres, the Tier I cities. In Tier I cities (such as Bangalore, Chennai, Delhi, Hyderabad, Kolkata and Mumbai) the 6.8 million middle class households (annual income> € 2900 / Rs. 200,000) spend € 52 (3,700 Rs.) per year in QSR's (Anonymous 2013) and is expected to increase to € 85 (6,000 Rs) in 2016. In Tier II cities (such as Agra, Amritsar, Ahmedabad, Coimbatore, Faridabad, etc.), 3,4 million middle class households spend € 21 (1,500 Rs.) per year in QSR's. This is expected to increase to € 54 (Rs. 3,750) per year by 2016. The rapid growth of the QSR's is expected to be mainly in the Tier II as well as the Tier III cities (Figure 3.5).

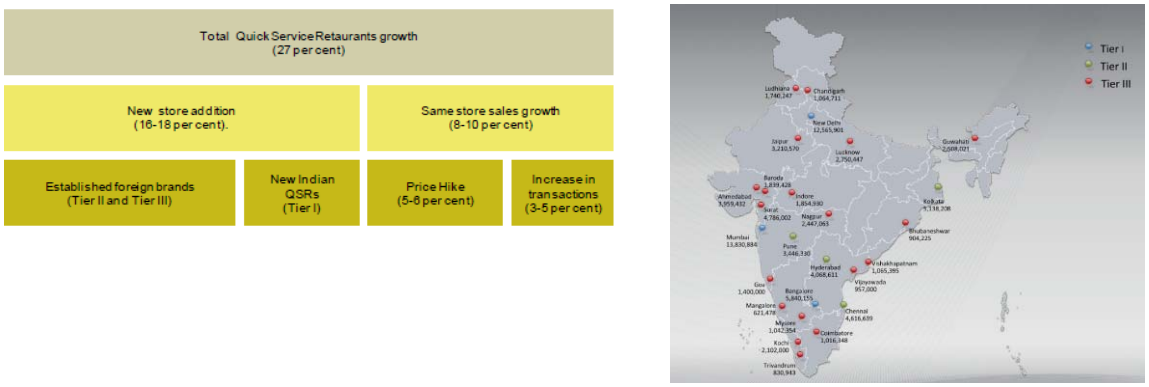


Figure 3.5. The growth of the Indian QSR industry (left, (Anonymous 2013) and the distribution of Tier I, II and III cities in India.

The QSR market is still quite nascent and there is immense scope for growth. Last 5-10 years QSR's have rapidly grown in metropolitan cities. In these Tier I cities the QSR growth rate declined but is still 20%. Meanwhile the QSR growth rate in Tier II and Tier III cities increased to 40-45% yearly. In the future it is expected that the growth will shift to smaller cities. Besides cities, QSR branches started expanding to the food courts at the main highways between the major cities. Especially modern upper class families that travel by car and frequently visit QSR's in cities, are visiting these highway QSR's. They prefer the service and the safe and high quality food that these restaurants serve. Table 3.2 shows Consumer Food Service Outlets in retail and travel environments are increasing.

Table 3.2. Consumer Food Service Outlets (%).

	2012	2013	2014	2015
Standalone4	86.2	85.7	85.5	84.9
Leisure	0.8	0.9	0.9	0.9
Retail	5.9	6.3	6.5	6.8
Lodging	3.2	3.3	3.3	3.3
Travel	3.8	3.9	3.9	4.2
Total	100	100	100	100

QSR Suppliers

QSR's in India sell French fries as part of their total assortment; French fries are just one product as part of a range. Specific QSR chains are more or less specialist in burgers, pizza or chicken. They mostly serve French fries as a side dish of burger meals. A QSR chain like Domino's is specialized in pizza. As Rabobank (2013) indicates QSR's will actively look to (preferred) suppliers across the regions as they expand their network, instead of looking at the entirety of India. For example cheese production facilities are mainly restricted to western India , but there is potential growth opportunity in other regions. Similarly, for processed chicken, most of the capacity is located in south and western India, with limited capacity in north and east. Lack of processing capacity across categories is one of the major growth barriers for QSRs in India. Frozen potato products are mostly processed in Gujarat (supplier McCain) where raw material of perfect quality is available. To supply QSR's and retail outlets frozen potato products are transported all over the India by truck (to give an example: transport cost are € 0.07 /Rs. 5 per kg. The distance is sometimes no less than 1,800 km and the travel frequency is mostly 5 days per week). Limitation of logistics and refrigeration capacity are big challenges. However, logistics (modern roads, hubs, cold stores, cooled trucks) is one of the fast upcoming sectors in India (Source: visit Crysil), which means it will be more easily to distribute frozen products all over India in the future.

Distribution (Sharma 2013)
McDonald's India has pioneered the cold chain management system wherein the freshness, crispness and nutritional value of vegetables and processed products are retained (McDonalds).
McDonald's is present in more than 40 cities of India with 250 eating outlets and adding more every now and then. This huge supply chain is entirely outsourced without any legal contact with them. Transportation from distribution centres DC (4) to MD-restaurants (250) is done by trucks.

3.2.2 Production of frozen potato product

Production and import

McCain is known as the number one frozen potato product producer in India. The McCain company has a market share of 90%. Major of the remaining 10% is imported from USA (Lamb Weston) and Belgium. Besides McCain there are just a few smaller producers French fries in India (see paragraph 3.2.2).
The amount of potatoes processed into frozen products is still small: 75,000 - 80,000 tonne raw potatoes (only McCain in 2014) out of India's total potato production of 42.34 million tonnes (2012) which equals 0.2% of the total production). The outlook of the frozen potato product market is positive (30% growth rate per year).
70,000 tonnes of potatoes is processed into 30,000 - 35,000 tonnes frozen products (French fries and specialities). Experts indicate that most French fries are sold in the northern and western part of India; consumers in the south and the east have relatively lower incomes and thus less spending money, but this is subject to change in the future.

Import
The import frozen potato products into India is shown in Table 3.3.

Table 3.3. Import of frozen potato products to India.

year	value ($)	Net weight (tonnes)	Volume from USA
2009	4788993	5720	82%
2010	8202259	8085	60%
2011	7116702	6816	66%
2012	7292992	5927	64%
2013	5824086	3347	52%

Source: Comtrade

In recent years more than half of the total amount of imported frozen potato were from USA: Lamb Weston imports French fries from the USA. Figures indicate that 10 - 15% of Indian frozen potato products use was imported. While India's produced volume of frozen potato products increases, figures show decreasing imports of frozen potato products; the share of volume from the USA has declined as well.
New players in the Indian frozen food sector (such as food traders and/or packagers) are importing French fries from Belgium, a country where the potato processing sector has expanded last decade. In some supermarkets in (Mumbai and Ahmedabad) we found packed frozen product imported from Belgium (Agristo; aims to import 500 tonnes frozen French fries in India in 2014 which is packed by a new India importer (West Coast Fine Foods). West Coast Fine Food experience comes from handling aquaculture products; they manage the supply chain on their own.

Figure 3.6. Production location of largest frozen potato products processor in India.

Figure 3.6 shows the processing location of McCain. Balaji (2015) as well as Simplot (2017) intend to start production of frozen potato products in the same region (Gujarat).

List of producers of frozen potato products

As indicated in the previous paragraph the market share of McCain's frozen potato products in India is 90%. There have been some additional small producers but they didn't survive (Table 3.4). Currently, some small competitors on the French Fries market are BB foods, Golden Fries and Satnam. Golden fries has a production location in the south of India.

Table 3.4. Total potato processing capacity per state (raw material input) and French fries production (tonnes/year) in 2014.

Company	City	State	Capacity	Production	Source
McCain India	Mehsana	Gujarat	90000	40000	Pers. Communications
Golden Fries	Coimbatore	Tamil Nadu	22000	11000	(www.gmdu.net/corp-670479.pdf)
Tarai Foods Ltd	Rudrapur	Uttaranchal	7200	3100	(Singh 2013)
Satnam Agri Products Ltd	Jahlander	Punjab	13200	6600	(www.punjabagro.gov.in/SAPL_Profile.pdf)
Himalayan Food Processors Pvt. Ltd.	Vadnagar	Gujarat	60000	25000	(www.foodprocessing-technology.com/news/newshimalaya-industries-opens-food-processing-plant-in-india 2014)
Hyfun Frozen Foods	Ahmedabad	Gujarat	32000	14400	(www.potatopro.com/news/2012/successful-start-equipment-manufacturer-florigo-international-bv)
Total			224400	102168	

Nowadays McCain is processing 75,000 - 80,000 tonnes of potatoes (this equals 50% of McCain's production capacity); therefore 2,500 ha potatoes are contracted directly from farmers. The product line for French fries is operational for 3-4 days a week while the processing line for speciality products is operational for 7 days a week. It is said that McCain uses 16 cold stores to store raw material (high quality potatoes) to secure the supply whole year round.
Other brands get their labelling done from either McCain or regional players such as Golden fries or BB Foods (Bankey Bihari Ji Food Products Pvt. Ltd; Agra, New Delhi). It is said that BB foods also does job work for McCain. BB Foods recently tied up with Reliance Retail to come out with its own brand as frozen fries is becoming a commodity.

The Satnam Agri unit has been closed but should be leased to a 3rd party. Indian snack processor Iscon Balaji Foods will start processing frozen potato products in a plant near Ahmedabad. Iscon Balaji Foods, a joint venture between Balaji Wafers, Iscon Group and SP Chips Potato Pvt Ltd is a manufacturer of potato flakes in Gujarat, India. Balaji Wafers is one of the larger potato chips producing companies in India (see paragraph 3.3). The company announced that it will start production of frozen French fries and "Indianized" frozen potato specialties in May 2015.

After a stranded joint venture with Himalayan Food Processors Pvt. Ltd Simplot is preparing to enter the Indian market in 2016/2017.

During desk research also other businesses handling French fries were found, for example Indus Mega Food Park Pvt. Ltd. and Tarai Foods Ltd. Most of them offer a wide range of frozen vegetables including French fries. It is not always clear if they produce French fries themselves or buy or import frozen potato products.

Estimates of needed French fries and raw material to satisfy expected consumption

The total annual French fries production in India was estimated to be 30,000 tonnes in 2013 (Pronk *et al.* 2014) and the imported amount of French fries around 8,000 tonnes in 2013 (Table 3.5). About 60% of the French fries are sold through QSR (Anonymous 2005). Assuming this 60% approaches the sales share in 2012-13, the average consumption by middle class households is ≈ 0.80 kg French fries per person per year or 3.8 kg per household (Table 3.5).

CRISIL (2013) also provides numbers on increased consumption in QSR's. Under the assumption that spends continue to increase and that the share of French fries of the consumption in QSR's does not change, the estimated demand for French fries ranges from 57,558 tonnes in 2016 to 0.55 mil. tonnes in 2030. In terms of raw input materials, the QSR business needs about 1.2 mil. tonnes potatoes to meet consumers demand by 2030.

Table 3.5: Calculated demand (tonnes fresh potato per year) for French fries production in 2015-16 to 2029-30.

	Tier I		Tier II		Total spend	Consumption		Demand
Year	Spend[1]	# households (x 10^6)	Spend[1]	# households (x 10^6)	M Rs./y	kg/h	kg/p	Tonnes fresh potato/y
2012-13	3700	6.8	1500	3.4	30260	2.3	0.48	23494
2015-16	6000	9.4	3700	4.7	74134	4.1	0.85	57558
2019-20	9700	13.0	5200	6.5	159519	6.4	1.3	123851
2024-25	15700	17.4	8900	8.7	350114	10.4	2.2	271830
2029-30	25400	21.8	14100	10.9	706820	16.8	3.5	548777

[1] Spend in Rs. in QSR per household per year

The processing capacity of potatoes in 2014 is estimated to be approximately 224,400 tonnes (Table 3.4), which can produce about 102,000 tonnes French Fries. However, some processing companies are not processing up to their full capacity. Satnam Agri Products Ltd for example is not producing at its full capacity due to marketing and financial difficulties (Anonymous 2011b) whereas Himalaya Industries and Hyfun Frozen Foods may not have started processing yet.

Potato specialties

Indian population has a strong preference for Indian flavours and many consumers prefer vegetarian food. In order to anticipate the Indian food habits and to attract consumers, Indian potato processors have developed specific products for the Indian QSR-market and in-home snack market. For example the veggie-burger is introduced as an alternative for beef burger, veggie-nuggets for chicken nuggets and so on.
Potato specialties entail all frozen products that contain potato. Some of these products contain 30 - 75% of potato. Experts indicate that about 20-25% of processed potatoes (raw material) is used to produce potato specialties and the other 75-80% as frozen French fries. As we understood these special veggie-products are produced by McCain as well as by some other companies.

Table 3.6. Some examples of potato specialties (supermarkets New Delhi).

Product	% potato	INR	Net weight (gram)	INR/kg
Aloo tiki	73	132	760	174
Veggie nuggets	45	90	325	277
Potato cheese shotz	33	165	400	413
Veggie burger	48	90	360	250
Potato alphabites (imported from Belgium)	86	110	300	367
French fries	100	90-100	450	200-222
French fries	165-170		1250	132-136

3.2.3 Consumption patterns and preferences

Out of home

The out-of-home consumption will increase further more. Young people living in the urban areas are considered the prime target audience for QSR's.

Vegetarian food

Around 40% Indians are vegetarians, and even non-vegetarians turn vegetarian for about 60 days in a year. Most (also Western) QSR chains in India are tapping this space by launching new products like veggie-burgers and veggie-nuggets. McDonalds introduced a vegetarian burger which contains potato (48%) and other vegetables. To anticipate on Indian consumer preferences a wide range of typical Indian speciality products have been developed especially for the Indian market, like the Veggie nuggets, Alloo Tikki, the Veggie burger, etc. (see previous paragraph). All these products contain at least 30% potato as ingredient. This means QSR's (have to) anticipate more and more on the traditional food habits of the Indians. There are even some QSR-restaurants that exclusively serve vegetarian products (for instance some McDonalds restaurants).

Spicy food

Since Indian people prefer spicy food, there are even sachets of dried spices available at the QSR's to make the French fries extreme spicy. Spices are also used in vegetarian potato products (burgers, nuggets).

In-home snacking

The processed (deep) frozen French fries in the retail shops are bought by the upper class income groups and the middle class. Increasing incomes will increase the number of consumers.
Only 5% of the Indian households and 20% of the Indian food operators are currently buying frozen French fries. Potato processors like McCain expect a huge potential as in-home snacking will grow by more than 20% among high-income households.

The consumption of French fries is more concentrated in the north and west of India. In the south and the east of India people have relatively lower incomes and thus less spending money, but this is subject to change in the future.

Wimpy Delhi (QSR)
Wimpy International Ltd. is a fast food restaurant chain comparable to McDonalds but much smaller. We visited shop no. 31 at Aurobindo Place Market, Hauze Khas, New Delhi. Wimpy has 3 outlets in Delhi NCR.
Wimpy sells French fries in small (70 g, 50 Rs.) and regular (100 g, 75 Rs.) portions. Purchased Fries are produced by McCain India and bought frozen in 60 ounce bags (84 Rs. per bag incl. VAT). This Wimpy restaurant sells 250 kg per year.

3.2.4 Future prospects

Besides visiting QSR's Indian middle upper class consumers buy frozen potato products in supermarkets for home preparation as well. Supermarkets are the second important selling channel for a wide range of frozen potato products. All retail stores sell frozen products of McCain and besides this they offer one or two other brands. Smileys and letters are popular to tempt families with young children. At home Indian's prepare fried products in oil heated on gas or electric. We did not find the electric French fries pan in supermarkets (mission 2014). But Indians are used to bake several dishes in oil and use this way of preparation for French fries or other frozen potato products as well.
Experts indicate that QSR restaurants sell 60% of frozen potato products and retail (mainly supermarkets) 40%. They expect that the sales of frozen potato products via the retail chain (including smaller grocery shops) will increase faster than via QSR's in the future.
As indicated most QSR's are located in Tier I, II and III cities. At this moment the product availability of frozen (potato) products is nil to very poor in smaller cities and villages. An important development in the future is the increasing availability of frozen potato products in traditional grocery stores in these smaller towns and villages. These stores already invest in (small) freezers for selling frozen products like ice-cream, frozen vegetables and also potato products. In the future this trend will continue which will lead to an increase in volumes as well.

3.3 The potato snack (chips) business

3.3.1 Market characteristics

The salted snack market

Salty snacks are distinguished in namkeens (traditional Indian snacks) and potato chips (wafers). Namkeen is mainly (98%) a mixture of native vegetable- (like pea), rice- and noodle based products. There are one or two namkeens that are pure potato (flakes) based. Namkeen mixtures have different spicy flavours, which depends on regional taste preferences. The total snack market (sweet and savoury snacks) consists of 25% chips, 50% namkeen and 25% other snacks (source: spokesman of the consultancy organisations that the research team visited in Mumbai). At least 80% of the Indian snack market is salty. Salty snacks includes packaged and loose snacks.

Potato is used for the production of chips. As indicated in paragraph 1.2 the potato chips sector is the biggest potato processing sector in India: about 7% of India's potato production is used for chips. Besides this a part of potato flakes/powder is used as ingredient for salty snacks: for instance production of extruded snacks and some namkeens.

The total market for salty snacks in India is worth € 1.8 billion (Rs. 13,000 crore) and traditional snacks account for € 0.7 billion (Rs. 5,200 crore). The puffed snack market is valued at € 0.3 billion (Rs. 1,950 crore). The potato chips/wafer market is worth € 0.5 billion (Rs. 3,900 crore) where Uncle Chips and PepsiCo's Lays are market leaders (Business Today, 2014. Maharaja of Munch).

The snacks market is classified into two broad segments: the Western (all potato chips, puff snacks, etc.) and traditional snack segment (mixtures, namkeens, banana chips, daal, chivda, masala peanuts, bhakarwadi, khakhra, bhujia), wherein western snacks enjoy more popularity in comparison to the traditional snacks. Moreover, the western snack segment is dominated by a large number of multinational companies (MNCs) and organized snack manufacturers. Some sources also talk about a third category, the so called bridge snacks (a mixture of the two main categories, where the product format is e.g. 'Magic Masala'). It is like a western snack with Indian taste.

Organized – unorganized

To understand the Indian chips market it is essential to distinguish the organised sector and the unorganized sector. There are vast unorganized sectors in almost every product category in India, as is the case for potato chips and potato based snacks.

Characteristics of the organized salty snack sector are: quality certification, competitive pricing, intensive (aggressive) marketing, widely spread distribution networks, and strong traditional products. Other characteristics are: much automation, care taking of standards and regulations (like food safety regulations), branding (A-brands), and high quality and safe packaging.
The strengths of the unorganized sector are: accessibility to a large section of population, readily available at 'Mom & Pop' stores and relatively cheap (Aradhey 2008). Other characteristics of the unorganised chips (and namkeen) sector are: lot of small businesses, production at home, hardly no automation and branding, no attention for food safety regulation, poor working conditions[2], simply packed or loose product, and local market orientation.

In the chips and snack market the organized sector consists of producers of brands, such as PepsiCo, Haldiram and ITC. They are buying their raw material from contracted farmers whereas the unorganized sector consists of particularly local snack producers, buying their raw material at the wholesale markets or from sub wholesalers. According to different sources very high proportions of potato are processed by the unorganized sector in India (Pronk *et al.* 2014).

Looking to the salty snack market 40% of the business is organized and 60% is unorganized but the organized part is increasing. Looking to the organized sector 60% is chips and 40% is namkeens. Other experts indicate that the market share of the unorganized and organized sector within the chips market is 50% – 50%.

The unorganized snacks market remains undocumented, but industry players conversion from loose to branded is happening rapidly. An unorganized market/sector is one where offerings are not branded. In general, the unbranded offerings are priced much lower than the branded ones and each manufacturer in the unorganized sector markets the offering within a specific geographical region (very often within 25 km of the place of produce). The infrastructure and distribution costs can therefore be low and expenses for marketing are small.

Branded - unbranded

The branded salty snacks market has come a long way from the 1990s, when the market was marked by the presence of brands like Haldiram's and Uncle Chips (eventually acquired by PepsiCo) and there were few other regional brands. The market registered a major leap in the mid-90s when PepsiCo introduced Lay's and Cheetos, and later, Kurkure. Since then, many national and regional players have forayed into the space with diverse offerings. After 2005, consumer products companies ITC and Parle also entered the snack market, and, in 2009, Cavinkare also made inroads into the market through the acquisition of Garden Namkeens. These value players market share is said to be still growing, for example, Parle Products has indicated to be aiming to touch 8 to 9 per cent market share in potato wafers from the current (2014) 6 per cent share. Also several organized retailers have introduced their private labels in this space. In the last decade the relatively new player Prataab Snacks (formerly known as Prakash Snacks) says being able to reach higher margins than the big established companies. These higher margins can be attributed to falling equipment prices and clever distribution strategies (Singh & Anand). For more information on the current key players and the list of producers see paragraph 3.3.2.

Competitive sector

The salty snack market is strongly competitive. Small producers (who minimise spending's on marketing) realise a low cost price and try to increase their market share at the expense of A-brands.
As the snacks market was previously dominated by western snacks such as branded potato chips this is changing since consumers buy more and more branded namkeen instead of loose products from bakeries due to the hygiene factor.

[2] There are two types of setup in the unorganized sector, the so called Own-account enterprise (OAE) and the Own-account Manufacturing Establishment (OAME). (The difference is whether or not a hired worker is employed on regular basis. In an OAME at least one hired worker is employed on a fairly regular basis). (Mohammad R., A. Shatroopa & S. Neeraj, 2013. Food processing industry in India: S&T capability, skills and employment opportunities. Journal of Food Processing and Technology 4, 260.)

Companies also have increased availability and affordability. A spokesman from Balaji Wafers has for example indicated that a few years ago about 80% of the revenues came from western snacks, while this is currently 50%. The success for branded namkeen is not due to the fact that consumers of western snacks shift to traditional snacks but rather to the fact that consumers are upgrading from the unbranded segment to the branded segment. (Anonymous).

Since the South of India does not have a potato cultivation culture, traditional Namkeen did not contain any potato and potato chips were unknown until recently (a decade or so ago). This is why mainly the branded companies have conquered the market in the South, but they will encounter stiff competition by the unorganized sector in the coming years. The small size ± € 0.07/ € 0.14 (5 and 10 rupees) packages of ±18/35 g make 90% of the market (in volume). These small packages are affordable for the huge lower income group (e.g. children, day labourers) and you will find them everywhere in the street shops. New and existing small competitors in the snack market offer more volume per package to compete with A-brands.

Supermarkets that serve middle and upper class incomes groups offer bigger volumes packages.

The import of potato chips in India is small due to high import duties, a complex distribution network and availability of relatively cheaper domestic products.

3.3.2 Producers and production

Processing

Chips processing accounts over 90% of the total potato processing capacity of the potato processing industry (starch, frozen products and chips). Only big players contract a part of their potato need directly from farmers but most are bought at wholesale markets or from traders and storage holders. At least 3 million tonnes raw potatoes is used yearly for processing chips and other salty snacks like Alu Bhujia.

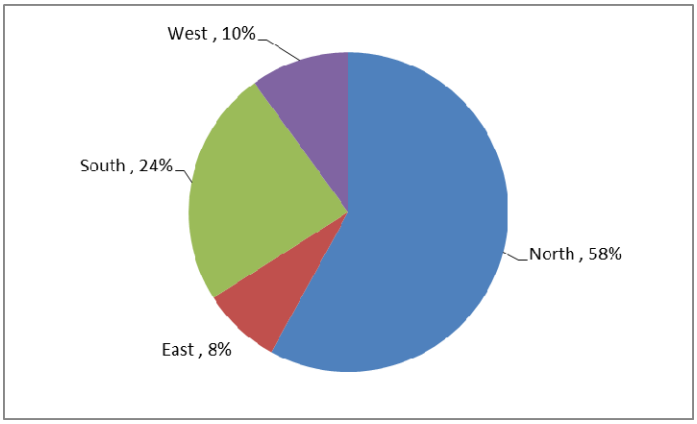


Figure 3.7. Region-wise share in snack (ethnic and potato chips) processing (Mishra & Mishra 2009).

Chips processing is taking place all over India. Figure 3.7 shows that almost 70% of the snack processing in India is situated in the north west of India. Some concentration of smaller chips processing companies is found near Mumbai.

The snacks segment is dominated by big players like PepsiCo Frito-Lay, ITC Food's (snack brand Bingo) and Haldiram's and regional players like Rajkot-based Balaji Wafers, to name a few. Most of these big processors operate more plants (Figure 3.7).

Figure 3.8. Production location of largest chips processors in India. Note: it is not clear on which Parle location(s) chips are produced.

Figure 3.8 shows the production locations of the largest chips processors in India (the branded segment). Most facilities are located in the North and West, the regions where most potatoes are cultivated. Both Gujarat and Maharashtra are big markets for the salty snack segment, with Balaji holding over 70% market share in Gujarat and having an equally strong presence in Maharashtra along with Haldiram and Parle. Many of the Indian players first started selling their products at 'the bottom of the pyramid' consumer group, creating markets where there were none, before moving to the urban areas. Bigger snack producers focussed on the urban market till it was saturated,

before looking towards the rural areas. Balaji started with one product from Rajkot, then took it to Gujarat and afterwards to Rajasthan and Maharashtra. Western India is the top snack consuming region, followed by the North. With rising disposable income, consumer spending on food continues to increase.
PepsiCo (brand Lays) and ITC have a wide distribution network which enables them to sell different products including chips all over India. In India PepsiCo operates over 40 distribution centres that serve more than 2,500 active stockists, reaching approximately 1 million retail outlets.
Gujarat has at least 400 small chips players (including players in the unorganized sector). They use 100 – 2,000 bags of potato per day and buy them at the market from wholesalers. In case a chips processor uses at least 5,000 bags per day a deleverage from cold store is more usual. Smaller chips processors are more or less scattered all over India.
Mumbai is also said to be a large market for potato chips and Alu Bhujia (Figure 3.9) and there are many medium and small potato processors in and around the city. The raw material requirement for potato chips manufacturers in Mumbai is estimated during 2010/2011 at 0.0775 million MT.

Market share

PepsiCo is market leader for chips (>40%) and Indian based company Halidram for traditional snacks. Other major players include Parle, ITC, Balaji Wafers and Prataab. A great number of smaller regional players have also entered the market over the past few years and are giving tough competition to the big players. The market share of PepsiCo and ITC is still declining in favour of Indian originated processors.

The € 0.07 and € 0.14 (5 and 10 Rs.) packages entails 90% of the market (in terms of volume). Salty snacks including potato chips are mostly sold on the traditional markets: small stalls and shops near the road. Small packages (20-40 gram) priced at € 0.07 and € 0.14 (5 and 10 Rs.) makes salty snacks reasonably priced for most lower class consumers. Domestic players offer fixed price packages of € 0.07 and € 0.14 (5 and 10 Rs.) with more volume compared to 'Lays' and ITC's 'Bingo'. Looking to market share development more grams per packet is an effective strategy. In 2011 PepsiCo-Frito Lay introduced a new chips brand 'Lehar' in 2011 that is 40% cheaper than 'Lays'. Along with smaller packs, priced at € 0.04, € 0.07 and € 0.14 (Rs. 3, 5 and 10) big snack makers also offer products at higher price points of € 0.28, € 0.42, € 0.85 and € 1.41 (Rs. 20, 30, 60 and 99) for in-home consumption and family occasions.
Small payers have been low in advertising (no expensive marketing campaigns or TV-commercials with Bollywood actors) and they penetrate the smallest of towns through a direct sales force and sub-stockist.

Figure 3.9. Aloo Bhujia is an example of one of the salty snacks made from potatoes.

Producers of potato chips

Compared to frozen potato processors (market leader McCain) there are many potato chips processors. Currently there are a few large chips producing plants in India (Table 3.7). These belong to a few big chips production companies, with a production capacity of 20 tonnes/day or more.

Table 3.7. Big producers of potato chips in India (capacity >20 tonnes chips per day).

		2013		
Processor	Brands	Capacity (raw material t/year)	Production (finished material t/year)	Market share (basis: capacity)
Balaji	Balaji wafers	85,680	25,200	18%
PepsiCo	Lays	198,000	55,000	42%
	Uncle Chips			
	Lehar			
Haldiram	Haldiram	28,800	7,200	6%
ITC	Bingo	38,880	10,800	8%
Parle Products Pvt Ltd	Parle	68,400	18,000	15%
Prataab Snacks	Yellow Diamond	50,400	14,400	11%

Source: personal contacts

In a competitive market like the chips market many suppliers are active. The largest processors operate one or more lines of 20 tonnes per day, in some cases spread over different plants. Besides these there are about 50 middle (line <10 tonnes per day; Table 3.7) and 200-300 small (line 0-5 tonnes per day) sized chips processors (Figure 3.10). The relatively small companies operate manually or semi-automatic and do packaging manually. Besides chips most Indian originated processors process other salty snacks (extruded, namkeens) as well.

Some of the big companies are able to work very cost effective, the so called value players and they compete successfully with multinational companies like PepsiCo and ITC.

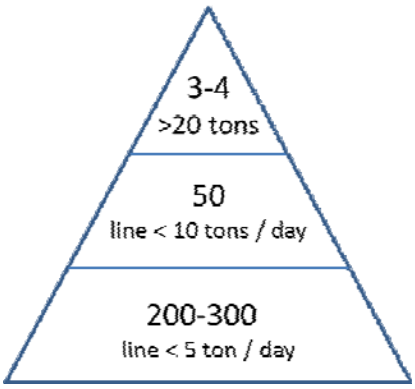


Figure 3.10. Number of processors operating chips processing lines in India (estimated).

Furthermore there are many small producers who produce chips at home (unorganized sector). They buy potatoes at local wholesale markets and sell unpacked chips locally.

Some companies work according to the so called 3rd-party model. They lease their production capacity to other companies. This is the case with, for example, the company that the research team has visited near Mumbai. This company has a production capacity of 600 tonnes chips (2,400 - 3,000 tonnes raw potatoes) and 1,800 tonnes namkeens per year. They produce 75% for their own brand and 25% is leased out (private labelling). This company produces 10 - 12 chips varieties and 50 - 60 namkeen varieties (average price namkeens € 1.28 – 1.43/kg or 90-100 Rs./ kg).

Reliable figures of capacity and processed product per processor are rarely published. Fryo Foods and Pragati Snacks have a production capacity of about 14,000 tonnes per year (2013) each and produce about 3,600 tonnes finished material (personal announcement). This also indicates their production efficiency for chips is about 25%.

Table 3.8. Medium size Indian potato chips and potato based snack producers and their brand name (processing capacity around 10 tonnes per day).

Player	Brands potato chips	Production location
Bikaji Foods International Ltd (formerly known as Shivdeep foods)	Bikaji Bhujia, Bikaji Namkeens, Bikaji Fungama (extruded snacks)	Bikaner (Rajasthan), regional office Mumbai (market in Northern India)
Fryo Foods Pvt. Ltd	Fryo (different flavours)	Meerut (Uttar Pradesh)
Bikanervala Foods Pvt Ltd (Bikano)	Bikano (traditional namkeens, such as Aloo Bhujia)	Haryana (?), Greater Noida (expected)
CavinKare	Garden Namkeens (namkeens, such as Alu Bhujia) and Garden Cruncho (3 flavours)	Bhiwandi (Maharashtra)
Atop Food Products Pvt Ltd	Atop Potato Chips, Atop Namkeen	Morbi (Gujarat) (strong presence in Western part of India)
Apricot Foods Pvt. Ltd	Everest's eVita Natural Potato Chips, Everest's eVita Namkeens	Rajkot (Gujarat)
Patco Foods Pvt Ltd	Patco Potato Chips, Patco Namkeens	Surat (Gujarat)
GeePee Foods Pvt Ltd	POGO Potato Chips (different flavours)	Kolkata (West Bengal)
Kutch Agro's	Kenty's	Pune
Euro India Fresh Foods Pvt. Ltd.	Euro	Surat (Gujarat)
Gopal Corporation Pvt. Ltd.	Tat-o	Delhi (New Delhi)
Pragati Snacks Pvt. Ltd.	Jo's	Delhi (New Delhi)
Hello Indo Food Product Pvt. Ltd.	He'llo	Indore (Madhya Pradesh)
Chheda Specialities Foods Pvt. Ltd.	Chheda's	Kandivali, Mumbai (Maharashtra)
Agrawal Namkeen	Agrawal	Udaipur (Rajasthan)
Maxvita Foods India Pvt. Ltd.	Maxvita	Mysore (Karnataka)
Kishlay Food Pvt Ltd	Mamoo'z, Krunch, Non-stop, Zing, Tricone, Krispy (potato chips and namkeens)	Guwahati (Assam)

Note: The list is not exhaustive – Including the 6 biggest producers it is only about 8% of the total amount of producers, and about 50% of the larger companies with a chips production capacity of significance, more than 10 tonnes/day or about 10 tonnes/day).

Figure 3.11. Visit of the production line of Fryo Foods.

Estimates of needed raw material and chips to satisfy expected consumption

According to diverse sources the chips market in India is still growing. Chips consumption increases with 12.5% per year; so we expect that the raw material need for potato based salty snacks will be about 4 million metric tonnes in 2014. Others sources indicate a growth of approximately 12% or a growth between 12 – 15%. Even a growth of 20% yearly is spoken of. Another source indicates that the demand of potato as raw material for processing into chips is expected to rise by 4.5% on Annual Compound Growth Rate basis. The average growth rate is to be expected 12.5% and we estimate that 300,000 tonnes raw potatoes (2013) are processed into chips nowadays (within the organized and unorganized sector). Processing results depend on efficiency rates, which varies between 20% and 25% (1 kg potato = 0.2 - 0.25 kg chips).

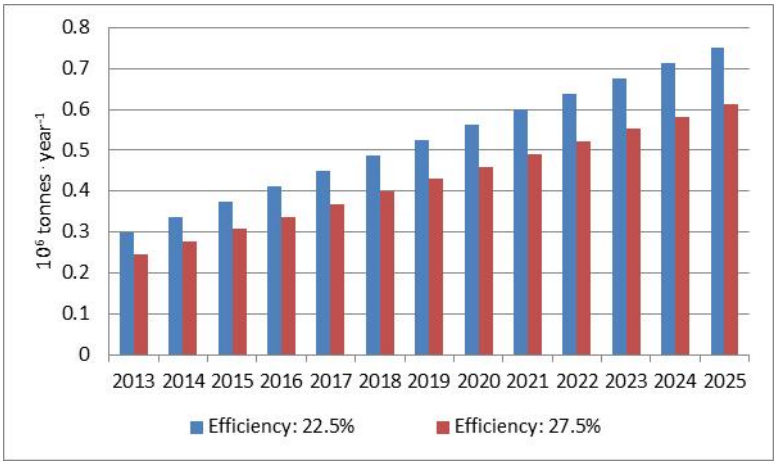


Figure 3.12. Estimation of raw potato need for chips processing by varying efficiency (tonnes · year^{-1}).

Ongoing professionalization in the chips industry, potato growing and potato storage (increase in the organized sector, decrease in the unorganized sector) will improve potato quality and efficiency in future but in all cases of efficiency improvement the demand for raw material will increase.

Very high proportions of potato are processed by the unorganized sector in India. Based on Dey (2005) the potato processing requirement of this unorganized sector was estimated to be 1.4241 million tonnes during 2010 - 11. Thus the total potato requirement of the processing industry (organized as well as un-organized) was estimated to be 2,3735 million tonnes during 20 1 0-11 (Figure 3.3).

The production process in practice

One of the companies that the research team has paid a visit to in Mumbai, a relatively small player, has recently (2013) shifted from manual operations to automatic. This after more than 20 years of manual operations. They have purchased their production line and machines from Belgium. They have semi-automatic packaging. They are assisted with knowledge and knowhow of an Indian consultancy company (Siddhivinayak Agri Processing Pvt. Ltd.).

The company is producing 50% chips and 50% namkeen. The manager sales indicated that the market for both is growing at the same rate. He predicted that the snack market will grow with 10 - 12% yearly for the coming 10 years. They would however rather invest in chips production than in the namkeen production line, since chips is more profitable (margins on chips are better). The most costly item within the production process is the baking oil (palm oil, cheapest oil), which has a fluctuating price. They indicate that chips and namkeen sells itself; little marketing effort is needed. They do not sell directly to consumers but to distributors from various states. Those distributors sell to local retailers who sell the chips to consumers. Distribution is said to be the key to higher consumer offtake. Raw material is collected from some big farmers in the neighbourhood and the wholesale market.

Figure 3.13. The mall producer shows his products.

3.3.3 Consumption patterns and preferences

The following consumption patterns and consumer preferences are worthwhile mentioning:

- The average annual per capita consumption of commercial savoury snacks is 500 g, with urban consumers consuming 10 times more than rural consumers.
- The young generation has taken branded potato chips as a way of life. The demand for snacks is increasing with the youth consumption segment being more of a grab-and-go types.
- By buying chips consumers take into account: price, brand, packaging and flavour.
- There has been an increase in acceptance for packed salty snacks as compared to plain salty snacks in rural and semi-urban India. It shows that the Indian consumer's consumption habits and requirements have changed. As a result of the changing demands of the consumers, the snack market is evolving. Consumers want new varieties and flavours.
- 90% of the chips market consists of small € 0.07 and € 0.14 (5 and 10 Rs.) packages which are mainly sold in small street shops and stalls. Snack food packaging ranges from 18/20 g sachets to 400 g economy packs. Small packs work very well in India as it makes this snack being affordable for the lower income groups

(Aradhey 2008). Bigger package sizes for home snacking are available in supermarkets and bought by middle and upper class families in urban and semi-urban areas (Tier I and Tier II or III cities).

- Indian customers prefer Indian tastes. The consumption patterns and tastes in India change significantly across geographies and income class. Brands keep on innovating on flavours and include offerings with specific regional flavours (spices). Multinationals like PepsiCo Frito-Lay produced their 'Magic masala' (Figure 3.14 left) specifically for the Indian market (see also 3.1: bridge snacks).
- Consumer demand is diversifying towards healthier (e.g. low-fat, Figure 3.14 middle/right) products, but given low penetration levels and low per capita consumption in India, this is a slow process and healthier products take a longer time to become part of the consumers food habits. Branded chips are seemingly less oily, and it tastes irresistible.
- Consumers are a bit spoiled with lots of varieties of snacking options (namkeens, extruded snacks, Kurkure[3]) and with different flavours. This forces all players to keep on innovating with new snack products, flavours and making the market very competitive. Snacks is an impulse purchase product and in general consumers are not loyal to a particular brand. Flavour and price seem to be most important.
- Industry insiders also believe that customers no longer make namkeens at home, and they prefer buying it off the shelves as there's proliferation of choice, packaging and innovation that is helping this category boom and it will continue to grow.

Figure 3.14. Left: Launched broadly in India, Magic Masala. One in every five packs of Lay's sold in India is Magic Masala. Middle/right: This company has indicated 'cholesterol free / trans-fat free' on its package.

3.3.4 Future prospects

The chips market is part of a competitive snack market. In a strongly competitive market new suppliers offer more chips for the same price (€ 0.07 and € 0. 14 /5 and 10 Rs. packages). This means that the growth of the chips volume (and potato need) is expected to grow faster than the turnover. The unorganized sector dominates the market but this is changing.

The need and demand for raw material (potatoes) of perfect quality will increase. Processors of Indian origin increase their market share; after being successful on regional markets these Indian processors will open up markets in new neighbouring regions. Middle sized processors (about >10 MT; organized sector) focus on regional markets and use 3rd-party models.

[3] Major innovations, like Kurkure made from dal (lentil) for example, to regional innovations, like South or East flavours for regional markets, or more recently, the launch of Kurkure Puffcorn or Kurkure Monster Paws.

4. Potato storage experiments in Gujarat 2014

Lubbert van den Brink & Romke Wustman, Wageningen University & Research centre, the Netherlands

4.1 Introduction

Indian potato processing companies require raw material during 12 months per year. The raw material has two supply chains:

- Field February – March
- Cold stores April – January

The raw material quality differs per type of cold store:

Table 4.1. Overview of the type of cold store and raw material of the trial.

Type of cold store	Quality raw material
Traditional store	Deteriorates from July / August onwards
Improved traditional store[1]	Deteriorates from October onwards
Advanced store	Possible extension thru to December -January

[1] Improved implies introduction of a forced ventilation system, registration and control of relative humidity (RH) and CO_2 levels

Total volume of potatoes for processing into French fries and chips is calculated at 720,000 tonnes per year (data 2013). The raw material quality of about 300,000 tonnes (40%) during August-January is insufficient due to poor storage management. Storage management is inadequate and leading to:

- Insufficient product temperature control
- Accelerated physiological aging
- Poor quality raw material

Moreover product handling during transport, store loading and store unloading has severe impacts on the quality of the potatoes and consequently on the product quality at the retail end and at the processing factory gate.

4.2 Experiment prolonging processing suitability

A workshop held at Ahmedabad (Gujarat, India) on 29 November 2013 recommended to run an experiment focusing on maintaining sufficient quality raw material supply for a longer period of time: extending up to January. The workshop had participants from:

- Potato processors:
  - Iscon Balaji
  - McCain India
  - Pepsico India

- Store construction companies:
  - Mooij Agro (the Netherlands), SV Agri, Indian partners
  - Omnivent (the Netherlands)

- Store construction companies:
  - Wageningen University & Research centre (the Netherlands)

The participants proposed to conduct an experiment aiming at prolonged storage of potatoes for processing. It was decided to conduct the experiment in Gujarat state as some major potato processors get most of their raw material supply from this state. The experiment is focusing on:

- Temperature pattern within stores
- Weight changes within stores
- Processing quality changes within stores
- Energy consumption during storage period. It is essential to measure the electrical energy consumption per store chamber. Such can either be done 1) on the basis of running hours of refrigeration or 2) through specific devices available with the store constructors (Mooij Agro and Omnivent). Recording running hours of refrigeration per chamber. Starting from day 1 of loading of each store.
- Registration of RH levels
- Registration of CO_2 levels

Lubbert van den Brink and Ravindra Ravindra Bahugandhi visited Gujarat in the period 8 – 14 August 2014. During this visit it was possible to make appointments with McCain about providing frying quality data, temperature data and RH recordings of different stores:

- Storage season March – November 2013
  - 1 bulk store
  - 1 box store

- Storage season March – November 2014
  - 1 Bag store in which one traditional chamber and one traditional chamber upgraded by Mooij Agro
  - 2 bulk stores
  - 2 box stores

Different varieties and lots are stored in each of the stores. This makes it difficult to determine exactly the effects of the different storage systems. Nevertheless the data can provide a first impression of the performances of the stores. Data analysing has been started but is not finished yet (December 2014).

Figure 4.1. Traditional store with netted bags.

4.3 Follow-up in 2015

A second experiment will be started in 2015. The approach will be as follows:
Start:

- The experiment starts in March 2015 and will last until at least December 2015 and preferably to January 2016. The actual starting date may differ as each store has its own momentum of loading and completion of loading. The experiment starts from the day loading starts at any store as all of them will have different types, varieties and will last until January 2016.
- The earliest harvested crops will be colder and the later crop warmer at time of loading. The pull-down will be included because this is the part of the storing phase where most energy is used and most weight loss is realized.

Samples in the stores:
All samples should be put together from one lot of potatoes per each variety.

- Samples for changes in weight and quality (to be specified by processors) will be positioned close to the temperature sensors.
- Samples will be assessed once per month for changes in weight and processing quality. A more frequent assessment is interesting, and should be agreed upon by the India based R&D and processing industries.
- It is proposed to use the weight samples for processing quality assessments.
- The Weight Watcher will do a great job for this purpose. As the sample will not have to be transported from the storage room to the laboratory.

Varieties:

- Chips (crisps): LR, FC3
- French fry: Innovator
- Table: Kufri Badshahfoo[4]) (to show the effect of storage conditions also for table potatoes)

[4] Table stock has the largest share in potato stores in Gujarat. The likely spin- off (sale of forced ventilation systems) is larger when table stock is included in the experiment.

Stores:
Four types of stores could be included in the experiment:

1. Traditional bag store; operator managed. Piles of wide meshed artificial fibre bags (with no upgrades such as: central temperature registration, relative humidity registration, CO_2 measurement system)
2. Upgraded bag store (upgraded by Mooij Agro or Omnivent); piles of artificial fibre bags. Provided with heat exchanger, automatic measurement, ventilation system.
3. Box store according to Dutch design. Potatoes in boxes, with forced ventilation system and automatic measurement system.
4. Recently commissioned bulk store; for example a bulk store either designed by Mooij Agro or Omnivent.

Data recording:

- Temperature. Product and air temperature patterns in stacks in all stores will be recorded and will be online accessible through an internet connection.
- Relative humidity. The relative humidity is important and should be measured on a number of positions within the relevant chamber(s).
- CO_2. The CO_2 content is very important because due to keeping the CO_2 level low; a flow of heat will be entering the rooms. This may have impact on the temperature in the store. One CO_2 recorder per room will do.

Role of partners:
Staff (representatives) from the three processing companies (Iscon Balaji, McCain and Pepsico) and both store construction companies (Mooij Agro and Omnivent) will run the experiment in India.

Staff from the store constructors will work with staff from the processors.
Main task of the processors will be:

- arranging raw material for all samples to be placed in one of the stores with chipping (crisping) potatoes.
- weighing samples prior to storage
- assessing quality of samples prior to storage
- putting the samples in store
- unload samples during the storage period and at (final) unloading.
- assessing the chipping (crisping) or frying quality employing the company quality requirements (including pressure bruise at the end of the storage period). Assessments are on a monthly basis: first day of each month from March 2014 thru to January 2015

Main tasks of the store constructors will be:

- installing sensors
- installing energy use measurement devices
- providing internet links with each store for monitoring data India and the Netherlands

Role of Wageningen UR:

- Wageningen UR will collect all experimental data and will collaborate with the processing companies and store constructors.
- Wageningen UR will coordinate all activities.

5. Chain solutions and introduction of innovations, new products and approaches

Anton Haverkort, Wageningen University and Research centre, the Netherlands
Jan Hak (NAFTC / Hak & Partners)
Yaakov (Yankale)
Cohen (Clootwijk Estate),
Tom van der Kooij (HZPC)

Program:

May 11 Amsterdam – Tel Aviv

May 12 Meetings with:

1. IlanBio about use of micro tubers produced in bioreactor Liam Gal-On (liam@ilanbio.com) CEO, Elliot Spits Director Business Development, Dana Ayzenshtat (VP R&D), Ohad Zuckerman (member advisory Board).
2. Scan Task Israel Fraier (Israel@scantrask.com) CEO, Erez Ben-Noon.
3. Visit fields and packing house of Geley Moshe company.

May 13 Activities

1. Field visit with IlanBio to planting micro-tubers at the Golan Heights.
2. Meeting Arjen Kool (Head Economy NL embassy).
3. Meeting SkanTask Israel Fraier (Israel@scantrask.com) CEO, Erez Ben-Noon, Yuri Magrisso (CTO) and Andrew Schetinin (Software R&D manager).

May 14 Tel Aviv - Amsterdam

IlanBio:

- David Levy to replace Avi Nachmias as agronomic advisor
- Propagation by this company through undisclosed procedures (black box) but disclosed is that it takes place in about 25 L containers under fluorescent light (TL-tubes). In-Vitro plants enter this container, are grown intermittently submerged in liquid media. When plants are large enough sugar is added, plants are placed in the dark and then they translocate biomass from foliage to tubers.
- Company claims more rapid, higher numbers at lower costs technique than found on market. However this seems to confuse their micro with other company minis.
- Resulting micro-tubers are classified into small, (<1 g), medium (>1.5 g, <3 g) and large (>3 g)
- Next generation production:
  - planted immediately leaving incubator continuing their (secondary) growth (unhardened) or:
  - after hardening when detached from the mother plant and stored for 4 months in a cold store.
- Lenticels callus formation may be an issue.
- Proper comparison would seem to be in-vitro plantlets (from sterile conditions) yielding minis in the next generation to micro-tubers (from sterile conditions) yielding minis.
- A comparison is proposed of mini-tubers on plants in pots produced from in-vitro plantlets and from plants produced from micro-tubers (see scheme below).

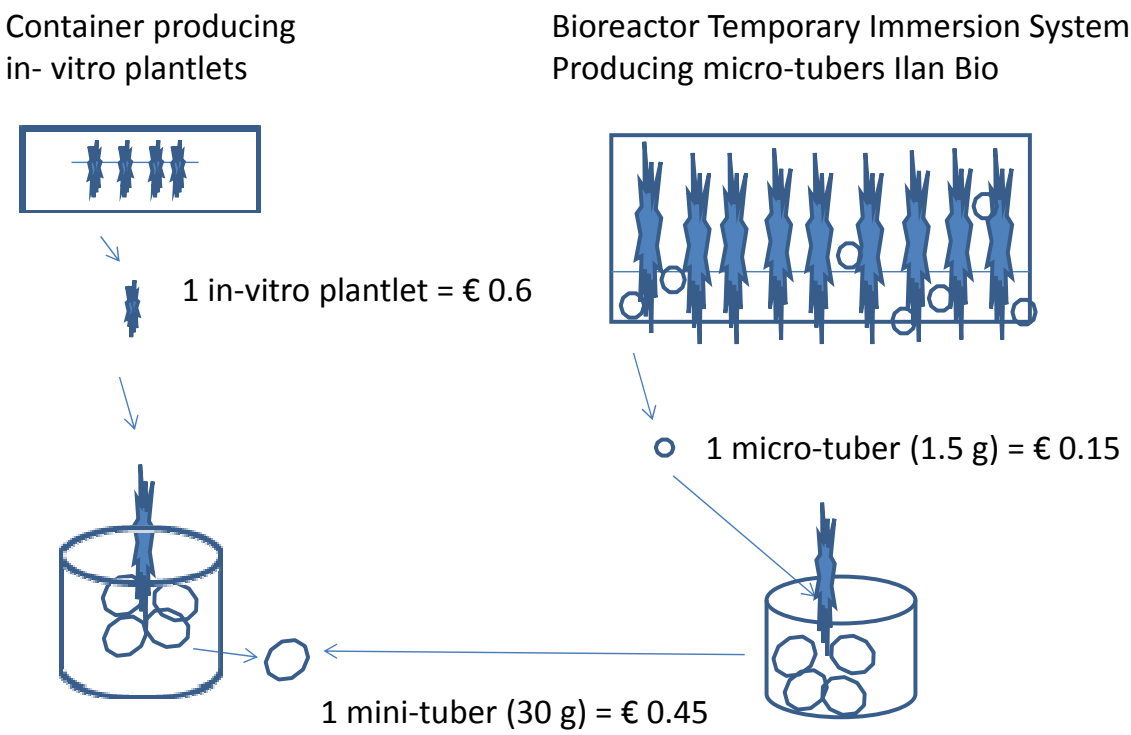


Figure 5.1. Comparison between the production of mini-tubers on plantlets in pot from in-vitro plantlets and from plants from micro-tubers.

Decisions taken:

- To be able to assess the added value of micro-tubers from IlanBio a test will be carried out by HZPC at its laboratory and greenhouse in the Netherlands. Therefore IlanBio will send 100 in vitro plantlets and 100 micro-tubers (average size about 1.5 g) of between 4 and 6 months old (out of dormancy) to HZPC well before the first greenhouse planting season, i.e., mid February 2015.
- HZPC, in cooperation with WUR (A. Haverkort) will carry out a replicated trial (4 reps 25 plants each from in-vitro and micro-tubers) producing mini-tubers. Result will be fed back to IlanBio.
- Based on results HZPC and NAFTC (H&P) may decide to develop a business plan to exploit the potential of the micro tuber approach.

Scan Task:

- Company's product is a registration system of all operations in crop production; the entries done by the grower or his advisor.
- The system may be used to satisfy the need of procurement, bench mark efficiencies and early warning of incidences.
- For the Israeli conditions the company has produced a (rudimentary, alternating active ingredients for example not included) decision support system (DSS) for late blight control. One for irrigation scheduling on its way.
- Company has ambition to develop a registration systems and DSS. Note the DSS systems developed by Scan Task are not transportable to other growing areas as parameters have not been tested there and there is no evidence that use has been made of generic DSS's.
- Self-learning (artificial intelligence) is not part of the produce.
- So users outside Israel will have to insert data (input and output) of all DSS and operations themselves.
- The performance = Genotype x Environment x Management x Society structure needs to be implemented for two purposes:

1. Data mining of multi annual operation of all growers of a population supplying part of the market. (e.g. a factory, a packing station, supermarket chain,..)
2. Real time following a crop and based on all input to date (operations and DSS regarding fertilization, irrigation, crop protection (blight, insects, nematodes,…) suggest optimization of inputs.

- Suggestion: to gain experience start with one or two potato companies (packing Geley Moshe) and or processing (Tapugan) to gain experience. Haverkort offered to give assistance at the back ground. It is suggested to structure the database according to the potato ontology:
- Performance = Genotype x Environment x Management x Society
  - Performance = yield and quality (e.g. recovery kg finished product per tonne)
  - Environment = weather and soil
  - Management =operations, inputs
  - Society = e.g. restrictions posed by good agricultural practices

Embassy:

- Two initiatives regarding potato emerge (follow-up: Forum Cooperation Agri, Food & Technology NL-IL and PPS):
  - Tripartite Initiative: Netherlands – Israel – Ethiopia aimed at food security and water use Funds from Mashaf (Israel) and OS (NL Stas/minister Ploumen.
  - Larger OS (only, not including Israel) agenda regarding food security for Ghana, Kenya, Ethiopia and Rwanda
- Initiatives aim at seed potato program development, supply value chain support and optimizing water use efficiency.
- Partners are NAFTC (with emphasis on HZPC), IlanBio and WUR (list not exhaustive).
- It was decided that Haverkort will contact Israeli embassy when in Addis in June 2014 to discuss project development.

Other initiatives with WUR involvement:

- City to city Amsterdam - Tel Aviv/Jerusalem/Haifa (eventual Addis) initiative: potato as a case, urban farming, potato trade, processing,
- Tripartite cooperation/projects NL-IL and NL-PA to be investigated.

6. Improved transparency in seed potato certification and transparency in potato varietal testing for DUS and VCU

Romke Wustman & Anton Haverkort, Wageningen University & Research centre, the Netherlands

NAFTC requested the Wageningen UR team to focus on:
1. 'Improve transparency in Distinctness, Uniformity and Stability (DUS) testing and Value for Cultivation and Use (VCU) testing;
2. co-operate in setting up seed certification scheme in Punjab' in 2014 - 2015.
The relevant background is provided below.

Aim:

- Increase transparency in DUS (registration) and VCU (commercialisation) of Dutch potato cultivars in India.
- Introduction of a licence based seed potato certification scheme in Punjab.

NAFTC DPVC member: HZPC

Rationale:
Currently HZPC is active both in Ethiopia and India. In Ethiopia the Company Solagrow headed by Jan van de Haar; who acts as HZPC agent and registers and multiplies its varieties. Registered to date are Mondial, Caesar (Ff), Red Scarlet, Sagitta (Ff), Courage (chips) and Derby (Ff). These varieties now have to find a place in the markets.

In India HZPC has signed a contract with the Mahindra company that ultimately will distribute HZPC varieties and pay royalties to HZPC. In 2011, 10 varieties were supplied to the Central Potato Research Institute (CPRI) for registration. CPRI carries out the necessary work to establish the new varieties' Distinctness, Uniformity and Stability (DUS) needed to register and enlist the variety in India. Subsequently the All Indian Coordinated Research Project (AICRP) needs to carry out commercial value testing at 16 locations throughout India for at least two years. First variety release is anticipated for 2016.

Current seed flow is: CPRI delivers plantlets to growers and RM companies. These companies sell seed under own brand name (e.g. Bhatti seeds). There is a seed scheme Breeders' seed, Foundation seed Certified seed with norms for certified seed but the State Seed Board does not certify. Seed companies like POSCON cannot export to neighbouring countries for lack of GAP, certificate and bilateral agreements with Pakistan and Bangladesh. Lack of certification also reduces opportunities to collect levies (royalties).

Approach:
Insist with CPRI and AICRP that Indian Industry should be member or at least observer to assure a level playing field for non-Indian potato varieties.

- Produce scenarios of how a certification system could be established; what are costs and benefits, role of growers, state government seed board CPRI. Especially the latter needs to be appeased by giving them a role such as carrying out tests, diagnostics.
- To this end contacts with Mahindra and POSCON will be (re)made also regarding royalty payment facilitated by the certification system.
- Initiate platform of all stakeholders: POSCON (seed producers), CPRI (DUS, VCU testing), PAU (R&D), ICAR (Departments on DUS and VCU) and Punjab State seed certification agency.
- Report to the DPC of NAFTC.

WUR approached POSCON by email on 15 May 2014 (and re-approached on 2 June 2014) proposing a workshop in second week December 2014. POSCON responded on 24 June 2014 stating it was a matter the Punjab State government and suggested the Punjab Agricultural University (PAU) at Ludhiana to take the lead and organize the workshop. PAU was approached by email on 28 July 2014. PAU never responded to this email inquiry. The earlier planned workshop (for December 2014) was not organized.

Planning 2015:

- Re-start the discussion with involvement of HZPC.
- Deliverable: Missions to Punjab. Report on organizational structure and progress.

These tasks will be carried out by WUR Staff: Anton Haverkort (WUR-PRI) and Lubbert van den Brink (WUR-PPO).

7. Centre of Potato Expertise in Punjab

Anton Haverkort & Romke Wustman, Wageningen University and Research centre, the Netherlands

From February 16 - 19, 2014 a major Agricultural Summit took place at Chandigarh Punjab to which Romke Wustman and Anton Haverkort were invited to deliver addresses on seed potato developments in the Netherlands.

PROGRESSIVE PUNJAB
OPPORTUNITIES UNLIMITED

AGRICULTURE SUMMIT 2014
FATEH BURJ, BABA BANDA SINGH BAHADUR WAR MEMORIAL CHAPPAR CHIRI, MOHALI, NEAR CHANDIGARH
16th – 19th February, 2014

From

Arvinder Singh Bains, IAS,
Nodal Officer for Technical Session
Development of Seed Potato Production in Punjab.

To

Prof. Anton Haverkort,
Crop Ecologist, Plant Research International,
Wageningen University & Research (WUR).

Sub: Invitation as a Panellist for Technical Session on Development of Seed Potato Production in Punjab.

Dear Haverkort,

The State Government of Punjab, India is organizing Agriculture Summit – 2014 at Fateh Burj, Baba Banda Singh Bahadur War Memorial, Chappar Chiri, Mohali, near Chandigarh from 16th to 19th February, 2014. The details of the Summit can be seen at www.punjabagritech.com.

It gives me immense pleasure to inform you that you have been nominated as one of the Panellist for the Technical Session on **Development of Seed Potato Production in Punjab**. This Technical Session shall be held on 17th February, 2014 from 03:00 pm to 05:00 pm in the Summit Venue.

The detailed topics of discussion and overall frame work of the Technical Session is attached with this letter for your information.

It is requested that you may prepare a presentation on the topics mentioned against your name. The details of the topics are indicative in nature and not exhaustive. You may add or delete points as you may think it appropriate but the same may not deviate from the overall theme of the topic.

I would further request to confirm your participation in the Technical Session and may also send me your Travel Plans so that necessary arrangements for local transportation and accommodation could be made at our end.

It would be indeed very helpful for us if your presentation could be sent to us in advance so that we are able to document it well before time.

It will be our pleasure to have you with us and we look forward to your participation.

Yours sincerely,

(Arvinder Singh Bains)

Punjab State Warehousing Corporation, SCO 74-75, Bank Square, Sector 17-B, Chandigarh – 160017
+91-9357926700 Tel: 91-172-2702220, 2703014, Fax: 91-172-2705853, 2723176, e-mail, arvinderbains@gmail.com

Figure 7.1. Document of Intent for "Centre of potato Expertise in Punjab".

7.1 Introduction

During the Progressive Punjab Summit at Chandigarh from 16th through 19th February 2014 the Punjab Agricultural University (PAU) in India and Wageningen University and Research centre (WUR) in the Netherlands expressed an intention to set up a University to University (U2U) cooperation to facilitate a Business to Business (B2B) model. The business partner of PAU is the Confederation of Potato Seed Farmers (POSCON) and that of WUR is the Netherlands Agro, Food & Technology Centre (NAFTC-India). This endeavour shall be supported by Government of Punjab, India.

Specific potato statistics for Punjab are total potato area of 84,114 ha of which 52,000 hectares is seed (1% certified) with an average yield 25 t/ha representing a total production 2.1 million tonnes (1.8 m t stored) of which home consumption represents 0.4 million tonnes and 1.3 million t marketed and 1% processed. Figures for the Netherlands are 160,000 ha planted yielding 45 t/ha producing 7.2 million tonnes: 1 m t of seed (100% certified), 75% processed. Of all seed and ware 75% is exported. The country exports seed to about 70 countries all over the world. The added value given to potato in the Netherlands is 0.75 billion Euros and the gains are equitably shared by farmers, consumers and end users. This achievement was strongly assisted by Research and Development and made the Netherlands potato cluster one of the strongest in the world.

The aim of the formal cooperation among the five partners is to establish a Centre of Expertise of the potato value chain in Punjab whereby Punjab wants to gain experience to model its policies, following the Dutch example. The model of cooperation between the various partners is that of the "Golden Triangle" between the Governments-Knowledge Institutions-Private Companies and Farmers. This is represented schematically in Figure 7.2.

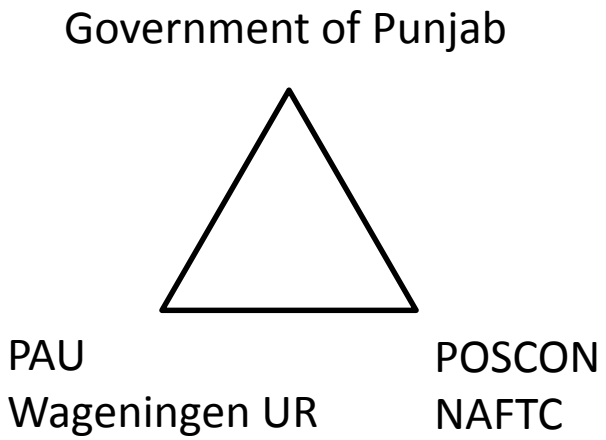


Figure 7.2. Scheme of the Golden Triangle following the Dutch example.

7.2 Role and activities of the Centre of Potato Expertise

The Centre of Potato Expertise (CPE) will be established under the auspices of PAU. The purpose of the CPE is to upgrade & improve the potato chain in Punjab, through cooperation along the whole supply chain. In order to specify the areas of cooperation in the specific parts of the chain several activities are identified for this proposal:

- Propagation material. To broaden the genetic base of potato in Punjab and to improve the seed health status, new varieties will be introduced and tested. When additional value is assessed, introduction and exploitation of IPR will be explored. Disease diagnostics, rapid multiplication techniques and rational certification strategies are an integral part of this exercise.
- Field production. In order to increase the competitiveness of the Punjab seed potato sector, major improvements are foreseen in mechanization from planting through harvest, fertilization through soil tests, water supply and disease control. This is aimed at Good Agricultural Practices making use of Decision Support Systems (DSS) for growers.
- Post-harvest handling and storage. Options replacing bags as transport and storage unit such as big bags, boxes and bulk will be explored using various store loading and unloading equipment combined with optimized storage regimes that use state of the art store sensing (Temperature, Relative Humidity, CO_2) and ventilation techniques. Investigation on storage facilities will be a part of the programme.
- Processing. The amount of potato processed in India is expected to increase exponentially during the next decade. The raw material specifications need to be met as close as possible in order to arrive at high rate of processing recovery (kg finished product per t raw potato material). The CPE foresees a pilot processing line

for crisps, fries and flakes to investigate the optimal specifications and to lay down a procedure to arrive at the same. Nationwide marketing studies for long term investments are integral part of this activity.

- Knowledge transfer. Training by and among the knowledge institutions PAU and WUR will take place in all relevant disciplines (propagation….processing) and at all relevant levels (growers….academic).Training of trainers is aimed at to increase the impact of the effort.

7.3 Executive arrangements

PAU is the recipient of funds from the government of Punjab and responsible for setting up the CPE and its facilities and subsequent management of projects:

- PAU will invest in the necessary technology and set up the relevant facilities in close consultation with Department of Horticulture Punjab, POSCON and NAFTC members
- POSCON will fine tune its demand for technology with NAFTC regarding technical specification, need and kind of investment
- PAU assigns exclusively the relevant Indian and Dutch technology and hardware providers shortlisted by POSCON and NAFTC to implement the project technology and hardware
- PAU and WUR jointly develop a Research, Development and Knowledge Transfer agenda in close collaboration with the Department of Horticulture, Government of Punjab and to be monitored by the Department of Horticulture Punjab. Additional need based consultation may also be done with POSCON and NAFTC to assure its continued relevance to the Punjab potato industry.
- All the stakeholders are involved in the management of the project. Management structure: to be decided after the proposal is cleared in principle.

7.4 Financial arrangements

The PAU & WUR including the government of Punjab and other stakeholders intend to require the necessary funds for successful implementation of the project.

Chandigarh, Ludhiana February 21, 2014

Dr. Ernst van den Ende, Director
Plant Science Group
Wageningen University & Research centre, the Netherlands

Dr. Baldev Singh Dhillon, Vice Chancellor
Punjab Agricultural University, India

Suresh Kumar,IAS
Financial Commissioner Development,
Govt. of Punjab

Supported by:

Mr Sukhjit Singh Bhatti, President,
Confederation of Potato Seed Farmers

Mr Marijn Leijten, Director,
NAFTC, New Delhi.

8. *Rhizoctonia solani* in potatoes and its control

Lubbert van den Brink & Romke Wustman, Wageningen University & Research centre, the Netherlands

8.1 Preface

During visits of Wageningen UR researchers to potato production fields in Punjab (India) in 2013 and 2014, it appeared that many plants had severe incidences of *Rhizoctonia solani* (Pronk *et al.* 2014). *Rhizoctonia* has become a serious problem in the Punjabi seed potato production system. This report summarizes information on *Rhizoctonia* and its control.

8.2 Description of the disease

Rhizoctonia solani (Thanatephorus cucumeris) is a fungus which is causing damage to many crops. The fungus is divided into subgroups called anastomosis groups (AGs), in which isolates are categorized according to the ability of their hyphae to anastomose (fuse) with one another. The most well-known anastomose groups are AG-2, AG-3 and AG-4. AG-3 is relatively specific to potato, and sclerotia on tubers belong almost exclusively to AG-3. Other AGs may be pathogenic to potato at some temperatures, but they generally cause little damage.

Rhizoctonia diseases are initiated by seed-borne or soil-borne inoculums. The fungus survives in the form of sclerotia and mycelium on infected tubers, in plant residue or in infested soils. Both mycelium and sclerotia may become destroyed by soil inhabiting micro-organisms, insects (springtails) and nematode species. In absence of a host plant, the density of the pathogen decreases significantly. Because of its capacity of rapid growth, however, the population can quickly recover if a suitable host is available. Most damage is caused at temperatures below 10°C and above 24°C. Under these temperature conditions it takes the sprouts longer to emerge, and consequently the fungus has the opportunity to infect the underground shoots. Susceptibility of the plant tissue decreases quickly when shoots emerge and chlorophyll is formed. Cool temperatures, high soil moisture, fertility and a neutral to acid soil (pH 7 or less) are thought to favour development of *Rhizoctonia* diseases of potato.

When infected seed tubers are planted, the fungus grows from the seed surface to the developing sprout, and infection of root primordial, stolon primordia and leaf primordia can occur. Infection is also possible from soil-borne inoculum. Roots and stolons may be attacked anytime during the growing season. However, most infections probably occur in the early part of the plant growth cycle. The plant's resistance to stolon infection increases after emergence, eventually limiting expansion of lesions. At the end of the growing season, especially after vine death, sclerotia are formed on the daughter tubers. The mechanisms that trigger sclerotial formation are not well understood, but they may involve products related to plant senescence. However, daughter tubers produced from infected mother plants do not always become infested with sclerotia. Sclerotial formation can continue during storage, especially if too much soil is present.

Rhizoctonia can cause considerable damage to the crop. After emergence infected sprouts may die and as a consequence crop stand will be poor. Infection of young stolons may cause their tips to die and as a consequence the numbers of tubers may decrease. Multiple branching of stolons may occur, which lead to tuber formation near the stem, resulting in nests of small, deformed tubers at or just above soil surface. These tubers cannot be sold. Also tubers in the soil can show a lot of deformations and cracks. Presence of sclerotia on the tubers is downgrading tuber quality, especially in seed potato production. *Rhizoctonia* potato disease can cause marketable yield losses up to 30% (Tsror 2010).

8.3 Symptoms

Symptoms of *Rhizoctonia solani* are described by Delleman et al. (2005). Symptom descriptions in this chapter are mainly based on this publication.

8.3.1 Black scurf on tubers

Black scurf is the best known symptom of *Rhizoctonia* in potatoes. On the skin of the tubers dark, crust-like structures are present. They can be observed easily after washing. Washing should be done carefully, otherwise black scurf is removed. They can be easily removed with the fingernail. The distribution of black scurf on the tuber and the size of the sclerotia may vary. Usually, the individual sclerotia are 1 mm to 5 mm thick and 1 mm to 10 m long, but sometimes an entire tuber or part of it is covered by a black crust. Black scurf is developing on the tubers especially after haulm killing and it can continue during storage. Some varieties show varying degrees of resistance to formation of sclerotia on tubers (Johnson & Leach 2003).

Figure 8.1. Black scurf on harvested tubers in a field in Punjab, 26 January 2014 (left) and Black scurf in the Netherlands (right).

8.3.2 Damaged young sprouts, poor crop stand

Subterranean penetration of developing sprouts is causing considerable damage to the crop. On the young sprouts reddish-brown to grey, distinctly sunken lesions could be observed. With the aid of a magnifying glass, many dark brown, long hyphae can be seen on the lesions. Lesions can girdle the young sprout completely, causing the part above the lesion to die. Secondary sprouts are often formed below the affected area. If these secondary sprouts also become infected, tertiary sprouts may be formed from non-affected lower buds. This process may be repeated several times. As a consequence, sprouts will fail to emerge or will wilt after emergence. This is causing uneven and irregular emergence and, in severe cases, may lead to a poor crop stand. These symptoms can easily be confused with those of calcium deficiency. However calcium deficiency causes lesions directly below the top, which are not sunken. Poor stands may also be mistaken for seed tuber decay caused by *Fusarium* or soft rot bacteria unless plants are dug up and examined. *Rhizoctonia* does not cause seed decay, damaging only sprouts and stolons. Poor stands and stunted plants can also be caused by blackleg, a bacterial disease that originates from seed tubers and progresses up stems, causing a wet, sometimes slimy rot. In contrast, *Rhizoctonia* lesions are always dry and usually sunken.

Figure 8.2. Damaged young sprouts in a field in Punjab (India; November 2013, left) and damaged young sprouts in the Netherlands (right).

8.3.3 White fungus sheets and lesions on stems and stolons

At the base of the stems and on the stolons reddish-brown to brown lesions could be seen. As these lesions mature, they become cankers that are rough and brown and can have craters, cracks or both. At the base of the stem and on the parts of the plant that are in contact with soil a white fungus sheet can be formed. These sheets consist of greyish-white, felt-like mycelium. The sheet symptom of *Rhizoctonia* may be confused with an attack by *Rosellinia necatrix*. The *Rhizoctonia* sheets, however, are mostly on and just above soil surface, while those of *Rosellinia* are found just below soil surface.

Figure 8.3. Rhizoctonia *lesion on an underground stem part; Punjab (India), November 2013 (left) and* Rhizoctonia *lesions on sprouts in the Netherlands (right).*

Figure 8.4. White sheet on a stem; Punjab (India), November 2013 (left) and white sheets on stems in the Netherlands (right).

8.3.4 Tuber formation near the stem and nests of small, deformed tubers

Infection of young stolon's causes their tips to die. One of the consequences of this may be a drop in the number of tubers. Another possible consequence is multiple branching of the stolon's, which may lead to tuber formation near the stem, resulting in nests of small, deformed tubers at or just above soil surface. These symptoms are often confused with those caused by pink rot and phytoplasmas. In case of *Rhizoctonia*, however, these symptoms are accompanied by underground stem infection.

Figure 8.5. Nests of small, deformed tubers (the Netherlands).

8.3.5 Stunting and rosetting of plant tops

Infection of the stem causes stunting and rosetting of plant tops (curled leaves), which sometimes turn red or yellow. Sometimes the affected plants are more erect than the unaffected plants. Curling of the leaves could be confused with symptoms of potato leaf roll virus (PLRV). However, PLRV symptoms appear at the lower plant parts while *Rhizoctonia* caused curling is in the upper plant part.

Figure 8.6. Stunting and rosetting of plant tops; curled leaves (Punjab, December 2013) and erect plants and curling of top leaves (Punjab, December 2013).

8.3.6 Aerial tubers

The interference of carbohydrate movement may also cause the formation of aerial tubers in the leaf axils of stems. These are green to reddish-purple round to bottle-shaped transformations of lateral shoots in the axils, with a few small leaves at the top. Aerial tubers are not only caused by *Rhizoctonia*, but it could be also a result of damage to the stem caused by pests, machinery, wind, late blight, pink rot and phytoplasmas.

Figure 8.7. Aerial tubers (the Netherlands).

8.3.7 Scab-like lesion on tubers, deformed and eyeless tubers, dry core symptom

On tubers large, scab-like lesions may develop. The fungus growing on the tuber surface retards the growth of the underlying tissues, which may result in deformed tubers. The typical scab-like structures on mature tubers are caused by the structure of the rectangular mycelium of *Rhizoctonia solani* (Figure 8.8). Also growth cracks could be developed.

Figure 8.8. Typical rectangular mycelium growth of Rhizoctonia solani*.*

Figure 8.9. Scab-like symptoms, growth cracks and deformed tubers; (Punjab, February 1014, left) and slight symptom of Rhizoctonia solani *(the Netherlands, right).*

Figure 8.10. Dry core symptoms observed on the surface of the tuber (left) and dry core symptom observed after cutting the tuber (right, the Netherlands).

Rhizoctonia is sometimes causing small lesions with a relatively deep, dry core on the tubers. The lesion is characterised by the presence of a hole in the centre of the affected skin. The latter symptom may be confused with a wire worm infection. Infection of the initiating sprouts on the young tuber will result in eyeless or blind tubers, which do not sprout.

Figure 8.11. Eyeless or blind tuber (the Netherlands).

8.4 Host plants and crop rotation effects

Rhizoctonia is surviving in the soil in the form of sclerotia and mycelium. Mycelium is able to survive in dead plant cells. Planting potatoes too frequently in a crop rotation increases the risk of infection. In literature it is stated that three-year rotations or longer are often required to reduce damage caused by *Rhizoctonia*. The frequency of potato in a crop rotation has a larger effect on *Rhizoctonia* than crop rotation (Tsror 2010).

In literature it is shown that AG-3 strains are specialized to potato, whereas strains of other less-specialized AGs of *Rhizoctonia solani* infect potato as an alternative host. AG-3 has been isolated from different other crops: barley, flax, sugar beet (Tsror 2010). In pathogenicity trials, many other crops were susceptible to AG-3 isolates: buckwheat, carrot, cauliflower, alfalfa, oats, reddish, clover, tobacco, tomato, wheat, bean, lettuce, maize, onion, sweet clover and sunflower. In general, *Solanum* species are belonging to the host range for AG-3.

AG-3 has been isolated from various weeds: *Chenopodium album, Diplotaxis eurocoides, Solanum nigrum* and *Sorghum halepense*; and also from various wild plants: *Capsella bursa-pastoris, Cirisum arvense*, *Elytrichia repens, Fumaria officinalis and Matricaria recutita*. In Canada 56 weed species were found to harbour *Rhizoctonia* (Sturz *et al.* 1995).

In several parts of Punjab potato is planted after rice. Thind and Aggarwal (2008) found that isolates from potato and rice in Punjab were belonging to different anastomose groups: Potato isolates were belonging to AG-3 and AG-5 and rice isolates were belonging to AG-1 1A. Isolates from rice showed a varied degree of virulence on potato with some isolates unable to cause disease while others produced black scurf symptoms of different severity. However, the sclerotia formed by rice isolates on potato tubers were observed to be less firm and could be removed easily when washed in water indicating their weak pathogenic nature on potato. Sclerotia formed on tubers by potato isolates were more firm and were not removed easily while washing in water (cv. Kufri Jyoti).
From research in the Netherlands it is known that next to AG-3 also AG-5 and AG-2-2 are occurring in potato. Both, AG-5 and AG-2-2, are giving less sclerotia on the tubers than AG-3. Maize is a host for AG-2-2.

There is no specific information available about the effect of inundation, which is occurring during paddy, on *Rhizoctonia*. In literature, it is stated that *Rhizoctonia solani* is sensitive to CO_2 accumulation in soil, which occurs during periods of water retention (Wale 2004). For obtaining a significant effect of inundation on *Rhizoctonia solani* at least a three weeks inundation period is needed (personal communication Lamers). It is known that AG-3 is suppressed more by inundation than AG-2-2.

In 3-year cropping systems in Canada it appeared that canola, barley or sweet corn grown prior to potato led to lower levels of *Rhizoctonia* in potato than soybean, green bean and clover. *Rhizoctonia* disease was aggravated by

rotation with certain legumes, sugar beet and broccoli (Baker & Martinson 1970). In 2 – year cropping systems in Canada it appeared that potatoes grown after red clover were showing less black scurf than potatoes grown after barley or Italian ryegrass. Bains *et al.* (2002) found that sugar beet, *Brassica campestris*, barley, peas, wheat and maize could not be infected by potato isolates of *Rhizoctonia solani*, suggesting that these crops are acceptable choices as rotation crops.

8.5 Control strategy in seed potato production

Currently, it is hardly possible to control *Rhizoctonia* completely. In the control strategy cultural measures and crop protection strategies should be combined: an integrated control is to be used. Monitoring of the disease level of seed potatoes and in the soil are important elements of the control strategy.

8.5.1 Strategy

Top quality seed potatoes must be disease free including free from *Rhizoctonia solani*. Basic seed is the core of each seed potato production system implying the seed grower must keep best seed and sell of poorest seed or sell of poorest seed as ware (fresh) potato. Additional seed disinfection and the selection of *Rhizoctonia* free production fields are elements of the same strategy. In the following paragraphs different measures are described for controlling *Rhizoctonia solani*.

Planting sclerotia free seed potatoes

One of the keys to minimize *Rhizoctonia* is to plant seed potatoes free from sclerotia (or most as free as possible). Tuber inoculum is more important than soil inoculum as the primary cause of *Rhizoctonia* damage. Monitoring black scurf incidence on seed tubers can be the first stage in preventing the disease. Based on knowledge of black scurf incidence of the seed lots it must be decided which seed lot should be planted or which seed lot should be sold as ware potatoes.
There are differences in viability of black scurf sclerotia. There are techniques available for testing the viability of black scurf.

Rhizoctonia free fields, crop rotation

Each potato field has a disease history, the farmer should be aware of such a history and use such knowledge strategically.
Fields free from *Rhizoctonia* inoculum are preferred. Advanced molecular techniques for detection of *Rhizoctonia* inoculum in the soil are available. With the aid of these techniques it will be possible to develop a decision support system to assist growers in the selection of fields to be cropped with potato. However, up till now there are no decision support systems which are used in practice (in the Netherlands).

In general, *Rhizoctonia solani* is occurring more on light sandy soils than on clay soils or soils with a high organic matter content. A high frequency of potato in crop rotation will promote *Rhizoctonia solani*. It is not known very well which crops should be preferred to be grown before potatoes. In general, *Solanum* species should be avoided if AG-3 is the most important anastomose group. If AG-2-2 is present, maize should be avoided.
Increasing the rate of crop residue decomposition and the amount of organic matter in the soil decreases the growth rate of *Rhizoctonia*.

Treating seed potatoes with fungicides

In seed potato production, it is almost always needed to treat seed tubers with a fungicide before planting. This is also needed if no sclerotia are visible on the tubers. Tubers with no sclerotia can still be infested with mycelium, which cannot be observed with the naked eye. In potato production for ware, French fries or chips, it depends on the level of infection if treating is needed or not. For each situation, thresholds should be developed. Several fungicides are available for treating seed potatoes against *Rhizoctonia*. The most well-known fungicides are: pencycuron

(Moncereen), flutolanil, fludioxonil. Table 8.1 provides an overview of fungicides used in the Netherlands for seed treatment, including the rate of application.

Table 8.1. Fungicides used in the Netherlands for seed treatment to control Rhizoctonia solani*.*

Fungicide (active ingredient)	Type of application	Rate of application (g active ingredient/1000 kg seed potatoes)	Time of application
Pencycuron	Liquid	250 g	Before pre-sprouting or just before or during planting
Pencycuron	Powder	250 g	Just before or during planting
Pencycuron/prothioconazool)	Liquid	150 g pencycuron+ 4,8 g prothioconazool	Before pre-sprouting
fludioxonil	Liquid	25 g	Before pre-sprouting, before sprout are visible
Flutolanil	Liquid	92 g	Before pre-sprouting
Tolclofos-methyl	Powder	150 g	Just before or during planting
Flutolanil	Powder	90 g	Just before or during planting

Moncerene (pencycuron) is the most commonly used fungicide. This fungicide can be applied a few weeks before planting or at planting. The product is stable under normal storing conditions. After application extremes of temperature and direct sunlight should be avoided.

The availability of fungicides differs from country to country. Other potential fungicides are: boric acid, methoxy-ethyl mercuric chloride, captan and iprodione. Experiments in Canada showed that fludioxonil was providing a better protection than captan, iprodione and mancozeb. Experiments in Punjab showed that methoxyethyl mercuric chloride was controlling *Rhizoctonia* better than boric acid and boric acid had a better result if applied before storage than after storage (Somani 1988). There are very serious disadvantages of mercuric chloride, especially for human beings and the environment. In most countries it is not allowed to apply mercury based product. If mercury is used – where still legal – it should be applied with utmost prudence for humans and environment. Not under any condition and circumstance is skin contact of workers with the liquid allowed. The waste fluid must be disposed of in legal manner and not be flushed to surface nor ground water.
Tsror (2010) stated that *Rhizoctonia* isolates are highly sentitive to flutolanil, iprodione and pencycuron, except AG-5 isolates, which were only moderately sensitive to pencycuron (Campion *et al.* 2003).

Figure 8.12. Spinning disk atomizer (Mafex) attached on a rolling table.

There are different application techniques of liquid fungicides on seed potatoes: spraying with a knapsack, dipping or dusting with a spinning disk atomizer attached on a rolling table. The application with a spinning disk atomizer has the advantages of an even coverage of the tuber and tubers are not becoming wet. Knapsack spraying of the tubers can lead to uneven coverage of the tuber surface. This can be improved by rolling the tubers several times i.e. on a rolling table. Dipping has the disadvantage that the dipping liquid can increase the spread of (dry and wet) rot diseases from tuber to tuber.

In-furrow and whole field treatments with fungicides

Especially on soils infested with *Rhizoctonia*, in-furrow or whole field application of fungicides may improve the control of the disease. Table 8.2 provides an overview of fungicides used in the Netherlands for in-furrow treatment and for whole field treatment, including the rate of application.

Table 8.2. Fungicides used in the Netherlands for in-furrow and whole field application to control Rhizoctonia solani.

Fungicide	Type of application	Rate of application in the row (g/ha)	Rate of application whole field (g/ha)
Azoxystrobin	Liquid	3 L Amistar	6 L Amistar
Fluoxastrobine/pencycuron	Liquid	390 fluoxastrobine 1200 g pencycuron	
Pencycuron	Liquid	1875 – 3125 g pencycuron*	3750 – 6250 g pencycuron*

*Depending on organic matter content of the soil: 1875 g in the row and 3750 g whole field if om% < 5%; 2500 g in the row and 5000 g whole field if om% between 5 and 10%; 3125 g in the row and 6250 g whole field if om%>10%

Optimal emergence and growing conditions

Emergence of potatoes should be as quick as possible. Optimal soil conditions are required for a quick emergence (moisture and temperature). If planting is done in cold, wet soil rate of sprout growth will be low and young sprouts could easily be attacked by *Rhizoctonia*. Shallow planting will promote rapid emergence and less chance for infection of sprouts and stems will occur. A level of resistance to *Rhizoctonia* infection is imparted to an emerging plant with light interception.

Development of black scurf on the tubers is slow during the growing season. Black scurf is increasing under stress conditions, like shortage of water, oxygen around the roots and nutrients and during crop senescence.

Biological control

It is possible to suppress *Rhizoctonia solani* with various fungi, bacteria and nematodes (Tsror 2010). The most well-known antagonists are *Trichoderma harzianum* and *Verticillium biguttatum*.

Verticillium biguttatum has the potential to control *Rhizoctonia* diseases in potato, as it suppresses the production of sclerotia. Soil temperature should be 15°C or more. *Rhizoctonia*-specific fungicides (pencycuron, flutalonil) co-applied with *Verticillium biguttatum* showed additive effects on black scurf control, while broad-spectrum fungicides (azoxystrobin, chlorothalonil, thiabendazole) were fungitoxic to *Verticillium biguttatum* (Van den Boogert & Luttikholt 2004).

Trichoderma harzianum is able to reduce the severity of stem lesion symptoms and black scurf on progeny tubers and it is giving fewer malformed and green-coloured tubers (Tsror 2010). Based on experiments with the combined use of fungicides and antagonists, Wilson et al. (2008) were suggesting that combining the application of *Trichoderma harzianum* with seed dressing with flutolanil may provide the best protection against damage caused by *Rhizoctonia solani* in potato.

In the Netherlands, it is allowed to apply *Pseumonas* species (Proradix Agro) to control *Rhizoctonia*. It is applied in combination with fungicides.

It is possible to suppress *Rhizoctonia solani* with amendments of compost. However, its efficacy depends on the maturity of the compost. Mature compost is leading to a reduction of the damage caused by *Rhizoctonia*, while immature compost is causing an increase of the disease (Tuitert *et al.* 1998).
Scholte and Lootsma (1998) showed that organic amendments of green manure crops (white mustard, forage rape and oats) and farmyard manure (alone or in combination with white mustard) reduced disease severity.

Methods of haulm destruction

The method of haulm destruction has a major effect on the final incidence of black scurf at harvesting time. Bouman et al. (1983) found that fewer sclerotia on tubers were found after haulm pulling than after chemical haulm destruction. Haulm pulling cuts the stolons from the other plant parts and disturbs the soil. It stops the sap flow from the roots to tubers and reduces exudation of liquids from the tubers. Haulm pulling provides also a better aeration which probably prevents the accumulation of stimulatory volatile exudates at tuber surface (Dijst 1989). Cutting off the shoots at soil level or 10 cm above soil level is stimulating black scurf formation as much as chemical killing (Dijst 1989).There are different machines available for haulm pulling. The stems are cut at a length of 15 – 20 cm above ground surface and stems are pulled with belts or rollers. For getting a good result it is required that stems are in centre of the ridges and that the tubers are sufficiently in the soil (more than 4 cm soul cover). The position of the tubers in the ridges is depending on the variety and on the year. Haulm pulling should not be carried out under wet conditions and not every variety is suited for haulm pulling. If haulm pulling has not been carried out successfully, additional chemical killing of the haulm is still needed.

Period between haulm destruction and harvest

Because of the risks of skin losses harvest cannot be carried out directly after haulm killing. For example in many seed potato production systems haulms are killed very early and skins are not set at that moment. For skin setting a 2-3 weeks period between are haulm destruction and harvest is required, while on the other hand black scurf on the tubers will increase when this period is longer. Sometimes it is necessary to find a compromise between a certain level of skin loss and a low level of black scurf.

Green-crop-harvesting

In the Netherlands, the green-crop-harvesting (GCH) method has been developed some twenty years ago. GCH is a combination of mechanical haulm killing and digging. First the haulms are removed by cutting at soil level or by pulling. This is followed immediately by carefully digging with a lifter, while tubers are placed back on the soil and are recovered with soil. Usually tubers of two rows are put together in one row. After skin setting and wound healing during a certain period of time tubers are harvested. GCH can only be successful if skin damage at the first lifting is low. This requirement is met by diggers which are especially designed for the purpose of GCH. Another prerequisite is that no haulm pieces are coming into the new ridge, because these pieces will promote the incidence of black scurf. It is also possible to apply fungicides or antagonists during the first lifting to control the development of black scurf. In the Netherlands in some experiments, GCH combined with the application of *Verticillium biguttatum* resulted in a close to 100% disinfection of *Rhizoctonia solani* on the tuber (Mulder *et al.* 1992). In the Netherlands, it appeared that GCH could be a useful method on sandy soils and light clay soils. Nowadays however, GCH is not used on a large scale in the Netherlands, because it is too expensive.

Figure 8.13. Lifter which is lifting two ridges and which is putting the tubers in one row (left) and the machine which is covering the lifted tubers with soil.

8.6 Recommendations for controlling *Rhizoctonia solani* in Punjabi seed potato production

In Punjab, *Rhizoctonia solani* has become a serious problem of the seed potato production system. Almost all farmers in Punjab are treating seed potatoes before planting, but nevertheless the incidence of *Rhizoctonia* seems to increase from year to year. There are also signals that potato growers in other states of India are complaining more and more about the quality of seed potatoes produced in Punjab. It is not clear if these quality problems are only due to *Rhizoctonia solani*. It is also possible that some problems are caused by other diseases, like dry rot and wet rot. Therefore it is needed to find out to which extend *Rhizoctonia* is a problem in seed potatoes sold to the other states.

In Punjab, seed potatoes are treated before planting with one of the following fungicides:

- Pencycuron (Moncerene), usually spayed with a knapsack while rolling the tubers, 25 – 80 g pencycuron per 1000 kg seed potatoes;
- Boric acid (Boric Acid powder), applied by dipping in a solution of 2.5 – 3.0%;
- Mercury (Emisa-6), applied by dipping in a solution of 0.25%.

Moncerene is the most frequently used fungicide.

The following recommendations could be given for improving the control of *Rhizoctonia solani* in Punjab:

- Planting seed potatoes free from sclerotia (or most as free as possible). Black-scurf incidence of the different seed lots should be monitored. Based on knowledge of black-scurf incidence of the seed lots it must be decided which seed lot should be planted or which seed lot should be sold as ware potatoes. Planting heavily infected seed lots has the risks that fields are becoming more and more infested by *Rhizoctonia* and this should be avoided.
- Selecting *Rhizoctonia* free fields. Farmers have experiences with different fields and very often they know which fields are giving disease problems.
- Optimizing treatments of seed potatoes with fungicides:
    - All seed potatoes should be treated. Even if there is no black scurf visible on the tubers it is possible that mycelium or hidden sclerotia are present on the tubers.
    - It is not advised to use mercury because of its dangerous effects for people and the environment. Skin contact of workers with the liquid is not allowed.
    - The application of Moncerene should be optimized.
        - It should be investigated if the higher dose rate that is common in the Netherlands (250 g pencycuron per 1000 kg) is giving better results than the dose rates that are common in Punjab (25 – 80 g pencycuron per 1000 kg). There are no indications that a higher dose rate will be phytotoxic.
        - It is not advised to apply Moncerene by means of a drip treatment. A drip treatment can increase the spread of (dry and wet) rot.
        - The application method should be improved. The risk of applying Moncerene with a knapsack sprayer is that some tubers or parts of tuber will not be covered with fungicide. Making use of a rolling table will be an improvement. The introduction of a spinning disk atomizer attached on a rolling table is the most preferred improvement.

- An investigation on the type of AG (whether AG-3 or AG-5 or AG-2-2) should be carried out at R&D-level (i.e. PAU, Ludhiana). If AG-5 is involved it is possible that pencycuron is not (or less) effective in controlling *Rhizoctonia*. If AG-2-2 is involved, fields on which maize has been grown should be avoided.
- An investigation on different fungicides for controlling *Rhizoctonia* should be carried out at R&D-level (i.e. PAU, Ludhiana). For example it could be investigated if fludioxonil or flutolanil or tolclofos-methyl are giving better results than pencycuron.
- An investigation should be done at R&D-level (i.e. PAU) on the carry-over *of Rhizoctonia* in the most common crop rotation systems in Punjab. For instance studying the effects of maize, paddy, sunflower, green manure, cucurbits and legume crops.
- In severely infected fields in-furrow or whole-field fungicide treatments could be tried. Pencycuron, azoxystrobin and fluoxastrobine/pencycuron could be tested.
- An investigation on the possibilities of suppression of *Rhizoctonia* with antagonists should be done at R&D-level (i.e. PAU). The efficacy of the different antagonists under Punjabi conditions should be investigated. Also the possibilities to produce antagonists in a commercial way should be investigated.
- An investigation should be done at R&D-level (i.e. PAU) on possibilities to shorten the period between haulm killing and harvest.
- An investigation should be done at R&D-level (i.e. PAU) on haulm pulling. Haulm pulling is giving a reduction of the incidence of black scurf.

- An investigation should be done at R&D-level (i.e. PAU) on green-crop-harvesting (GCH). With GCH it is possible to reduce the incidence of black scurf, especially if GCH is carried out in combination with the application of antagonists or fungicides.

9. Visits to Ethiopia

Anton Haverkort, Corné Kempenaar & Romke Wustman, Wageningen University and Research centre, the Netherlands

In 2014 three missions took place to Ethiopia to assist the potato Platform of the Addis Ababa Chamber of Commerce in realizing its goals. In November The Platform, Solagrow and WUR were approached to assist in an FDOV tender to establish a potato processing factory in Addis funded by Veris Investments.

9.1 Trip 1

On January 29, 2014 the first meeting took place (A.J., Haverkort, C. Kempenaar and R. Wustman) at the Harmony Hotel in Addis Ababa organized by the Agriculture Business Support Facility (ABSF). ABSF is a 3 year initiative funded by the NL embassy and is located at the Addis Ababa Chamber of Commerce and Sectorial associations (AACCSA). ABSF has several platforms (e.g. dairy, fish) and this was the first meeting of the now initiated Potato Platform. The WUR team within the framework of the NAFTC guided India-Ethiopia Topsector PPS attended and contributed to the first Potato Stakeholders. The meeting was attended by about 40 persons coming from various backgrounds: Cottage processors of potato, Government, R&D and Traders. The actions are planned and funded by ABSF with backstopping by WUR-researchers within the framework of the Topsector India-Ethiopia PPS.

- A demonstration of the comparative advantages of potato versus other food stuffs in Ethiopia. This is to create awareness among stakeholders of the importance of the crop,
- A study of the transaction costs of the current potato fresh produce value chain from grower to consumer with intermediates such as brokers, transporters and traders,
- A statistical study on production data such as area, yield per season Meher, Belge, winter crop and main production regions; this is to be conducted for a representative number of years to conclude trends,
- A statistical study on consumption as fresh and processed products in Addis Ababa and other population centres in the country; current and expected consumption and based on population trends of fresh potato home consumption (cooked and fried), restaurants, hotels and cottage industry,
- A costs and benefit analysis of storing potatoes for varying periods with varying degrees of levels of storage technology (soil, simple, refrigerated),
- Research and development and implementation of the on-farm activities with highest impact on yield and quality for ware and processing potato with emphasis on *Phytophthora infestans*,
- Capacity building on production, processing and marketing for large holders and investors with Business to Business (B2B) elements.

9.2 Trip 2

On June 12, 2014 the second meeting of the Potato Platform took place and again was attended by 40 persons. Trip program of A.J. Haverkort and Programme of the attached. It was decided to organise the break-out sessions around three themes to reduce the seven items mentioned in the first meeting.

1. Creating awareness regarding potato importance with policymakers
2. Piloting the value chain from consumer to breeder
3. Any other important issues not covered by the first two

Decisions taken at the parallel sessions:

Subject 1: Advocacy of the importance of the potato
Potato in Ethiopia is considered an “orphan” crop, a crop that is not considered as a priority crop by policymakers. This contrary to e.g. Kenya where potato is the second important food crop after maize or Rwanda after cassava.

Therefore an activity is needed to create awareness with policymakers. It is needed to show the importance of the crop production (statistics), how well the cop makes use of resources, contribution of potato to food security and people's health. The findings need to be published and dispersed. Initiative of this activity is with Gebremedhin Woldegiorgis (EIAR) and Anton Haverkort (WUR) and the following sub-activities were described:

a. Potato statistics (yield, area, consumption) in 3 seasons in production areas showing the importance of the crop:

- Surveys carried out by Central Bureau of Statistics (socio-economic department) Consultants. Source Ministry of Agriculture? Research Institute, farmers, Horticultural Agency
- Make sure all three seasons are accounted for
- Department of Socio-economics of EIAR should lead it (assisted by Science and Technology University Dept. Food Science)

b. Resource use efficiency of potato versus other food crops to show how well crop makes use of resources:

- Kg of potato per ha, per mm rain, per mm irrigation, per Joule energy, per kg Nitrogen applied
- Compare potato with other food crops
- Wageningen University EIAR, Ethiopian Ministry of Water Resource

c. Contribution of potato to health and food security
The following institutions will be contacted to yield information regarding this subject:

- Institute of Health and Nutrition (Ministry of Health)
- Ethiopian Public Health Institute
- EIAR Wageningen University
- Ministry of Agriculture

d Written results from these studies:
i Scientific article proving the importance of potato
ii Popular folder: based on this article a colourful popular brochure for policymakers

Contribution of potato (*Solanum tuberosum*) as a main stream staple to food security in Ethiopia

Potato Research Volume xx, issue yy
Authors……..

Abstract

- Tables of acreages and yield of potato and wheat and maize rends over time
- Tables of resource use efficiency (land, water, minerals, labour) to produce calories, vitamins and protein of potato versus teff, wheat and maize
- Tables of availability of energy (calories), vitamins, micronutrients (Fe, Zn) in Ethiopia and how potato fits in
- Conclusions and suggestions for investment in potato in Ethiopia

e. Positive actions: communications, campaigning
The publications based on investigations and data gathering will be used to start a campaign to attract attention to the:

- Make a review of strategy of potato versus other crops in Ethiopia (Research, extension, teaching at various levels, marketing, value chain…)
- Policy briefing to ministries (Agriculture, Trade, Health)

- Organize an event attracting free air time
- Take part in exhibitions
- Buy air time
- Distribute scientific article and BROCHURE colourful
- Articles in Newspapers
- Demonstrate potato food stuffs for Institutions (hospitals, universities, …).

Subject 1: Value chain pilot with a targeted number of actors per link
Many studies have described various aspects of the potato value chain in Ethiopia. Jan van de Haar of Solagrow introduced the subject of not reporting descriptions but starting a practical pilot, motto: "Leave the paper and go to the field".

Lessons learned:

1) daily supervision is needed (as neighbours), nucleus farm needed in each region,
2) seeds for other crops in rotation are needed (linseed, barley, cabbage)
3) need of mechanization (renting out tractors) and seed grading
4) farmer is not only link in potato chain but value web
5) set up producer groups of potato, linseed, barley, vegetables (600 groups aimed at with micro finance!)
6) marketing.

Challenges are:

1) variety selection and registration (early maturing Dutch seed for irrigated crops), Ethiopian varieties such as Gudene, Jalene, for rainy season
2) land at two altitudes is needed (low for winter crop irrigated, high for rainy season crop)
3) basic seed import or mini-tuber?: choice was made for tissue culture in Ethiopia contrary to Kenya to reduce risks of introduction of diseases. Risks of import of not existing diseases: so choice for in-vitro tissue and mini-tuber production
4) lack of awareness of government (starting with tissue till export to Middle East takes 8 years) and crop rotation aspects.

Second stage challenges:
1) linking the Value Chain (VC) actors a)website Solagrow with its own seed but also of its competitors b) quality diversification: identify French fries quality identification and supply
2) awareness necessity crop rotation and soil fertility
3) government support by showing advantages of potato (resource use and health)
4) organize continued supply according to demand (user group 'pool').

This activity will be initiated by Gertjan Becx and supported by a Solagrow agronomist.
The group session yielded the following:

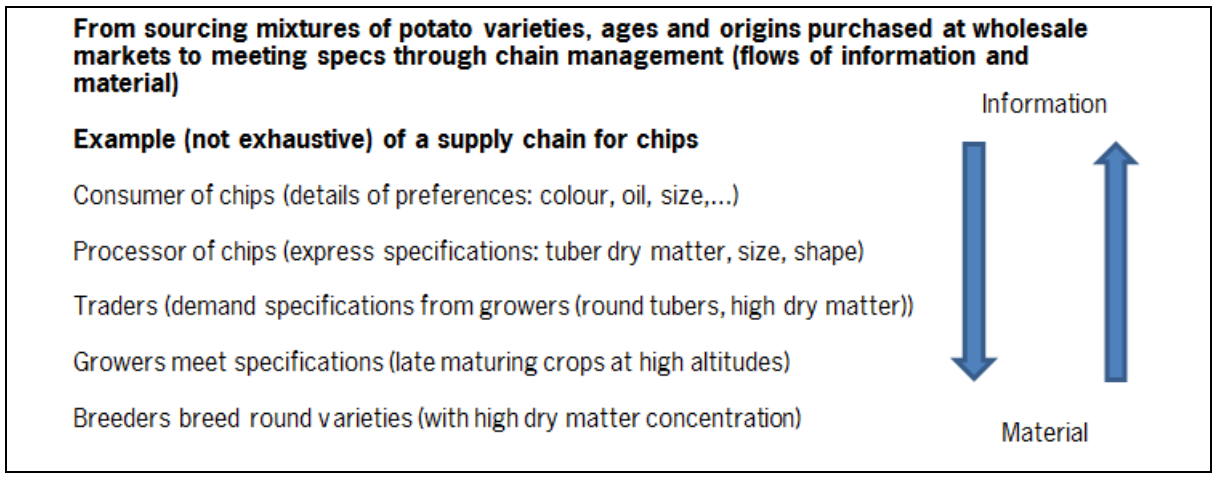
a. General remarks:

- Labelling is needed of varieties in shops and supermarkets.
- The motto "Leave the paper and go to the field" was appreciated.
- Ethiopia now is one big mixture of ages, varieties, origin so labelling is needed that shows variety, origin and harvest time of the product.
- Ethiopia is blessed with many new varieties. However also collect local older varieties and get them back to the market subject to the outcome of the study).
- Wholesaler brokers and other intermediaries should play positive role and will still be needed. If not a good job is done such links may disappear.

- Convince farmer to grow a low yielding variety by offering higher prices, e g for crisping round high dry matter are needed with lower yields but higher raw material value.
- Credit: seed price of premium variety is higher so here credit is needed. Not only credit for fertilisers.
- High yielding varieties are they more susceptible? Like cows that yield much milk? Not likely but thorough testing is needed before varieties are introduced.

b. Activities foreseen:

- Analyse each link, start from demand, study discuss and improve each connection between links: consumer - processor, restaurant, shop – supplier,….ware grower ….seed growers …basic seed….breeding (variety selection).
- Resulting in full description of each link, requirements and specs of each link, costs.
- Identification of 1-3 actors per link.
- Questionnaire per link.
- First from consumer to processor/retail-trader-ware producer seed producer basic seed producer – plant breeder This yields a flow of information.
- Then follows a series of action points between each link to assure a desired physical flow.



- Potato material (e.g. labelling).
- If participants want to become involved: contact Gertjan Becx.

Subject 3: Additional subjects

The break out session was chaired by Gertjan Becx who will also give follow-up. The following subjects were raised:

- Advertise and advocate potato not only to policymakers but also to the public
- Include potato in for instance school feeding programmes and institutions such as hospitals and universities
- To the same end produce a potato Cookbook for Ethiopia (including potato bread)
- Knowledge gap in processing exists that need to be tackled such as crisp/chips how long to cook at which temperature of the oil, reducing sugar concentrations and browning issues (THIS MIGHT BE COVERED BY THE SUPPLY CHAIN PILOT)
- Origin of potato (variety, site, harvest time) should be clearly indicated (also subject 2)
- Consider making potato flakes (mashed potato powder) to reduce transport costs

Trajectory June - December 2014

The three subjects will each prepare a work plan and budget and submit it to Gertjan Becx within two weeks who will make funds available. In the first week of December the third meeting will take place and progress reported.

9.3 Trip 3

The third meeting in December also identified Business opportunities for Ethiopian businesses together with Dutch ones:

a. Deliverers of crop inputs (substances and services)

MACRO: Increasing population, more interest to consume (processed) food and potatoes etc. options to develop the chain:. Earlier in this report the relatively lower pressure on resources land and water in Ethiopia than in some other East African countries so far reduces the need for Ethiopia to improve the use efficiency of the main resources land and water. With increasing population, urbanization and food from animal products also in Ethiopia improved use of land and water – with the rapid increase of irrigation schemes in the country – become important and will potato with its high land and water use efficiency play an increasingly important role. This – coupled to the versatile use of the crop (boiled, fried, mash) and the increasing role of its products in diets is the largest business opportunity for potato. Businesses supporting the higher area of the crop larger individual farms and fields with upscaling following urbanization and higher yields are the first ones to benefit: 1)producers and distributors of equipment and machinery, 2) agro-chemicals such as synthetic fertilizers and crop protection agents 3) along with service providers advising growers on the optimal use of such inputs. Examples of such companies (xxxx) exist in Ethiopia so this likely is a matter of more companies entering the market and others expanding.

b. Producers of seed potatoes.

So far the bulk of the seed potatoes planted in Ethiopia consist of the sprouted left over small, tubers of the previous crop. Diseased plants yield smaller tubers than healthy plants so the use of small tubers enhances degeneration of seed. For inputs to assure a higher rate of return, three of them need to be applied simultaneously: 1) healthy (certified) seed of appropriate varieties, this is more expensive by far than farm saved seed so needs to yield more and therefore has to be provided with more fertilizers and be protected better from pests and diseases to assure the rate of return. 2) fertilizers are needed to boost growth of plants emerging from this improved seed and 3) crops need more pesticides – especially fungicides - to protect the crop from late blight caused by *Phytophthora infestans*. So businesses breeding and or selecting improved varieties (i.e. varieties that are better adapted to local growing conditions and more resistant to local pests and diseases) with higher yields and less in need of pesticides and producing healthy seed of these varieties through in-vitro and mini-tuber production and rapid multiplication, basic and certified seed multiplication will offer scope of profitably through their important basic role in the potato value chain . Part of business plans will be the remuneration of the efforts to breed new varieties such as through breeding rights also the organization of out-growers under contract multiplying seed for such companies and reselling after harvest. There likely is need for credit for many growers to purchase seed to cover the period between seed purchase - planting - harvest – and sale of produce. Possibilities of exporting propagation material to surrounding countries, including those in the Middle east certainly need to be explored. The company Solagrow I an example of a start-up of such a company within Ethiopia.

c. Potato processors

With an increasing role of potato as food stuff, increasing urban population with higher income and less time to buy ex-field food on the market and to prepare meals at home the global trend of the need for processed (potato) food will also be made felt in Ethiopia soon. The following products will enter the market to greater and great degree:

- Graded, sorted, washed, packed and branded fresh potatoes
- Crisps (packed in various sizes and seasoned to like)
- Chips (French fries) frozen (storable for months) or chilled (storable for days)
- Potato flour (producing mashed potato when water or milk is added)

The value c needs chains, needs key businesses procuring the raw material at affordable prices year round mobilizing many small holders and needs the processing equipment (grading, washing, peeling, cutting, blanching,

frying, freezing, packing) and a sales and distribution apparatus. At small scale cottage type of such enterprises currently exists.
Meanwhile in November The Platform, Solagrow and WUR were approached assist in an FDOV tender to establish a potato processing factory in Addis funded by Veris Investments. Here follows a summary of the Potato Processing factory aimed to be established in Addis with FDOV subsidy (Submitted December 1, 2014).

Potato processing in Ethiopia: the missing link in the value chain
Veris Investments B.V.
Solagrow PLC; Wageningen UR (Plant Research International); Agri Business Support Facility, part of the Addis Ababa Chamber of Commerce and Sectorial Associations
Ethiopia
FS-2: Improved market efficiency and sustainability of food chains for national and regional markets
1. Potato availability in Ethiopia is low and volatile, despite the favourable climatic conditions for potato production. Yields are estimated to be at 20% of their potential. Because of a lack of storage, the spike in supply during and directly after harvest currently cannot be absorbed nor be dampened by the market. Together with a lack of proper distribution and processing, this causes considerable potato losses before they can be consumed. 2. The 1.3 mln smallholder potato farmers in Ethiopia suffer from low and volatile income. These smallholders invest little in the potato production with low productivity as a result. At local village markets, currently the only outlet for most smallholder farmers, middlemen form the only link between the farmers and the wider market. These middlemen often exploit the farmers' need for cash soon after harvest and the lack of storage by offering low prices, using the information advantage they have over the farmers on the long and in transparent supply chain.
The project objective is to establish the Ethiopian Potato Processing Company (EPPCO) that will directly link smallholder potato farmers to the market for quality fresh potatoes and processed potato products in Ethiopia. The first activities of EPPCO will be the development of a potato supply chain, the construction of a potato sorting and processing factory and the development of a market for processed potatoes. By doing that, EPPCO will provide a stable off-take for potatoes characterized by access to storage, fair and consistent prices throughout the season, contracts with off-take guarantees at any time in the season and price differentiation for high quality products. EPPCO's activities will directly result in an improvement of smallholder farmers' income which in turn will start the flywheel of more investment, better quality and more productivity in the Ethiopian potato sector. This will improve food security in the whole of Ethiopia by driving market efficiency and value chain sustainability, ultimately leading to increased local availability of affordable potatoes.
The project's first focus will be on the development of a supply chain, a processing facility and a market for fresh potatoes. The potatoes will be bought from the farmers and then cleaned, sorted and packed before being distributed to the market. This is a high volume, but low margin business that would not be commercially sustainable stand-alone. Therefore, in order to make the project financially viable, 15-20% of the total potato input will be used to make crisps. The company will sell its products in the Ethiopian market, which is currently a large existing but unmet market (high quality fresh potatoes) and/or served by imports (high quality crisps). Upon achieving success in the project, it is the intention of the project partners to further expand EPPCO's activities to other potato products (flakes, fries) and other vegetables. The project's intervention strategy can be summarized as follows: • In the short term, EPPCO will provide the farmers stable, transparent prices while rewarding them for quality produce. This will incentivize the farmers to invest in productivity and quality. • In the medium term, the farmers' incentive to invest together with access to input and services, will lead to increased productivity of quality potatoes as well as farmer income. • In the longer term, as the company and the industry grow, more farmers will be involved that will all improve productivity, strive for better quality and have more income. This in turn will lead to lower potato prices (more than offset by higher productivity). • Ultimately, the increased market efficiency and enhanced value chain sustainability of the value chain set in motion by this project will have an impact on a significant proportion of Ethiopia's 1.3 mln potato farmers and will improve food security for the country's 90 mln inhabitants.

During the 3rd Mission in December 2014 another workshop was organized by the Addis Chamber of commerce where a TOR to study recovery from potato of different origin was written by A.J. Haverkort. This is the major part of the work-plan beside a folder and an article on potato's contribution to food security in Ethiopia:

Benchmarking study recovery of potato products from potato raw material in Ethiopia

Introduction

Ethiopia produces well over 2 million tonnes of potato, the bulk of which is eaten boiled at home by the producer and her or his family and by consumers in cities buying from the markets or shops. From potato several products can be made in Ethiopia by processors that produce one or more of the following products:

- Branded graded, sorted, washed and packed potato for supermarkets
- Frozen or chilled France fries (also called chips) sold in supermarkets
- Crisps packed in plastic or aluminium foil wrapping seasoned with salt (and spices)
- Potato flour in small carton boxes (when reconstituted with water become mashed potato)

Currently potato processing in Ethiopia is almost non-existing, beside some very limited cottage industry crisps industry and packing for some supermarket. Road side sales of French fries and other fried potato is not an example of processing industry but rather of the food industry. Recently there is more interest in adding value to potato by processing them into products. The rate of recovery (the number of kg of finished product (PERFORMANCE) can be produced from 100 kg 'raw material'? Raw potato being the potato tubers as they appear when harvested from the soil. This performance is determined by the GENOTYPE (variety used), by the ENVIRONMENT and by the growers' MANAGEMENT practices:

Performance = Genotype X Environment X Management

Product	*Variety*	*Season*		*Inputs*
kg Fresh/100 kg	New Ethiopian	Meher M		Seed
kg Fries/100 kg	Old Ethiopian	Belg B		Fertilizers
kg Crisps/100 kg	Imported	Winter W		Pesticides
kg Flour/ 100 kg		Area		Irrigation
		Shashemene	M W	
		Jeldu	M	
		Gumer&Geta	B M	
		Awi	M W	

The objectives of this R&D project are to make a survey of the actual performance of the possible products made from potato in Ethiopia for ulterior use. The performance is expressed as percentage recovery:

Recovery = kg Finished Product per 100 kg Raw Material

The Performance Indicator is key information to any business wanting to process potato in Ethiopia as it indicates the major factor influencing the expected rate of return from purchased potato

Approach

The recovery rate (Performance) of four products will be assessed:

- 1) Fresh, 2) Fries, 3) Crisps and 4) Flour.

The assessment (Performance) consists of the following aspects:

- Determination of the specifications. For each product: what are the specifications the raw material needs to meet in Ethiopian conditions. Examples are tuber size (max and min), flesh colour, length/width ratio, percentage defects (definition of defects), dry matter concentration, fry colour,
- Assessment of each of the specifications and the resulting percentage of the crop that meets the specs
- Calculation of recovery as not each spec equally quantitatively determines the recovery rate. E.g. percentage dry matter influences percentage recovery 2.5 times more than percentage rejects.

The following varieties will be tested:

- The 'old traditional' Ethiopian varieties (local one)
- Three newly introduced varieties by EIAR (through CIP) such as Gudene, Jalene, Belete
- Five imported varieties and distributed by companies importing seed potatoes (e.g Solagrow) This in the winter season only as they are mainly grown then

The following environments (region x season stored) will be used to take raw material from:

- Four regions Shashemene (M, W), Jeldu (M), Gumer&Geta (B, M), Awi (M, W) (= 7 environments x 4 varieties = 28 treatments),
- Stored for 3 months (Meher crop only) in 4 regions (= 4 environments x 4 varieties = 16 treatments)
- Winter crop 5 varieties (= 5 treatments).

Experimental design

- NUMBER OF TREATMENTS: 49
  - 28 treatments (variety x environment)
  - 16 treatment (variety x storage)
  - 5 treatments (Solagrow varieties)
- Take 6 samples from 5 different growers for each treatment (maximally 195 samples to be taken)

Assessments per sample (approximately 5-15 kg per sample should suffice):

- Weigh 100 kg (or smaller sample)
- Grading between 45 and 90 mm (rest = local market)
- Sorting defects, blemishes, misshapen
- Shape length : width ratio (< 1.2 = crisps, > 1.5 chips/fries)
- Dry matter percentage (oven dried or under water weight)
- Peel percentage peel loss
- Sugars fructose/glucose, fry colour (USDA chart)
- Cutting chips or crisps loss in slivers
- Blanching/Frying post frying weight
- Oil post frying oil content
- Flour grind tuber and oven dry

Reporting:

March	May	July	August	October	November	January	February	April
2015	2015	2015		2015	2015	2016	2016	2016
Winter crop Collection Analysis	Report winter crop	Belg crop Collection Analysis	Report Belg Crop	Meher Collect Analyse	Report Meher Crop	Meher after Storage Collect+Anal	Report Meher post storage	Final report

Costs (PM, to be elaborated)

Sample collection
To collect the samples 11 fieldtrips need to be made to the 7 site x season combinations +4 post storage trips after storage of the Meher season crop. Here The first observations will be done here on the farm: Grading and sorting of about 100 kg. Only 10 kg will be purchased and brought to the lab to carry out the analyses.
Costs 80,000 Birr

Sample analysis
Processing the samples is estimated at about 1.3 person (laboratory assistant) per 1 kg sample
Weighing, Grading, Sorting, Shape , Dry matter, Peel, Sugars, and/or fry colour (USDA chart), Cutting, Blanching/Frying, Oil content, Flour Content. Cost 260 days of technician+ laboratory space and equipment (drying oven)
Costs 600,000 Birr

Supervision Ethiopian side
60 Days Supervision of protocols and reporting
Costs 120,000 Birr

Total costs Ethiopian side: 800,000 Birr (k€ 32)

Project coordination Wageningen UR: 20 scientist days. + 2 trips
Cost k€ xxxx (PM)

10. Communication

10.1 Training in Uttar Pradesh and Gujarat

Mission to Uttar Pradesh and Gujarat, October 25 - November 1, 2014
Anton Haverkort, Wageningen University and Research centre, the Netherlands

10.1.1 Introduction, results and suggestions

In September 2014 a memorandum of Understanding was signed by NAFTC and the government of Uttar Pradesh (UP) in the presence of the Ambassador of the Netherlands Embassy. It foresees in the establishment of a Centre of Expertise and a programme of Transfer of Knowledge. Within the framework of the of the agreement the government of UP through the Directorate of Horticulture and the C.S. Azad University of Agriculture and Technology (Kanpur) with NAFTC (Ravindra Bahukandhi) organized a 2 day training session at Kannauj. The opening session was attended and addressed by The Minister and Director of Horticulture, the Chancellor of the C.S. Azad University, its vice chancellor (prof Munna Singh), Mr Marijn Leijten (Director NAFTC), prof Anton Haverkort (Wageningen UR) and the Chief Minister of the state of Uttar Pradesh (population 200 million). Television and press gave a broad coverage of the event as the selection of the newspapers shows (Figure 10.1).

The opening session was attended by about 700 persons, the training session by about 280 persons, mainly growers, store owners, technicians and researchers. Translation was done by Ravindra in Kannauj in Hindi) assisted by prof Munna Singh and by McCain technicians in Gujarat. The event in Gujarat was a somewhat lesser event, attended by McCain growers only.

As follow up the government of UP wants to have a series of similar training sessions. It was suggested by WUR:

- That NAFTC and the department of Horticulture agree on scope and frequency,
- That WUR scientist train a small group of technicians and scientist who subsequently (with ppt-assistance) train growers,
- This will decrease workload of WUR scientist,
- Increase involvement of local scientists and technicians that have better local knowledge,
- Represents an excellent example of train the trainers.

10.1.2 Programme and some photo's

Saturday October 25
Flight Amsterdam – New Delhi
Spent 1 night at JayPee Hotel New Delhi

Sunday October 26
Flight New Delhi – Lucknow with Ravindra Bahugandhi, over land Lucknow – Kannauj
Spent two nights at Government UP Circuit Guesthouse
Official Guest and hosted by government of UP (drivers. hosts, protection by three soldiers, guesthouse and meals free).

Monday October 27
Morning: - Official opening two day training session (650 attendees)
- Chancellor CSA (Chankar Shekar Azad) Agricultural University (Kanpur)
- Minister of Agriculture of Uttar Pradesh
- Director of Horticulture UP
- Director NAFTC (Marijn Leijten)

- Wageningen UR (Anton Haverkort)
- Speech by H'ble Chief Minister Uttar Pradesh
- Introduction to training Perspectives of Potato Production in India (Anton Haverkort)

Figure 10.1. There was ample press coverage of the major event, also Hindustan produced an article where Netherlands potato input by NAFTC was meted broadly.

Afternoon: - about 280 attendees
- Introduction by HZPC/Mahindra
- Presentation "Basic principles of potato production "Anton Haverkort
- Potato research developments at CSA (Chankar Shekar Azad) (CSA Vice Chanceller prof Munna Singh

Tuesday October 28

Morning: - about 60 attendees
- Field visits 4 potato fields, discussing planting, materials, patterns, depth, fertilization,....
- Exchanges with dr Rakash, representative of Omnivent

Afternoon: - About 220 attendees in a tent on farm, lunch included
- Questions and answers
- Presentations Department of Horticulture

Evening: - By road to Lucknow
- Spent the night at V VIP guesthouse government of UP

Wednesday October 29
Morning: - Visit Lucknow monuments, hosted by Dept. of Horticulture
Afternoon: - Flight Lucknow – New Delhi
Evening: - Flight New Delhi – Ahmedabad
Spent two nights at hotel

Thursday October 30
Morning: - Trip to Mehsana by road, Venue for McCain growers: Jaffrony Holiday resort, about 80 participants
- Lecturing on Potato storage and on Sustainability
- Present from McCain: Abinash Gupta (director agriculture), Taroon Gangwal (head Research and Development) and Goppal Sharma (head seed operation)
Afternoon: - Lecturing on pre-planting preparations
- Lecturing on Fertilizer management
- Lecture on Black Scurf (*Rhizoctonia* symptoms and control) Presentation by Mahindra _ HZPC representative

Friday October 31
Morning: - Field visits
Afternoon: - Field visits
Evening: - Flight Ahmedabad –New Delhi

Saturday November 1
Morning: - Flight New Delhi – Amsterdam

Figure 10.2. Rhizoctonia solani *probably is the major factor for yield reduction in India (left). Planting patterns and stem density was given special attention during the field days (right).*

10.2 Missions, symposia, contacts

1. Project mission to Addis Ababa, Ethiopia. 26-31 January 2014. A.J. Haverkort, R. Wustman & C. Kempenaar. Contribution to Potato Platform Stakeholder meeting.
2. Project trip to Punjab Progressive Summit at Chandigarh. 16-20 February 2014. A.J. Haverkort & R. Wustman. Meetings with Chief minister Punjab, Deputy chief minister Punjab, Vice chancellor Punjab Agricultural University, Director Horticultural department Punjab State government.
3. Project PPP meeting. 24 March 2014. Wageningen.
4. Project mission to India, Delhi, Punjab and Gujarat. 6 – 11 April 2014. R. Wustman & C. Kempenaar. Contribution to workshops and CoPE development.
5. Project trip to Israel,

6. Project trip to Uttar Pradesh government at Lucknow for signing MoU between NAFTC and UP government. H. van Duijn, Ravindra Bahukandhi & R. Wustman. 18-19 September 2014.
7. Project trip to Punjab for Potato training at Jalandhar on 19-22 September 2014. R. Wustman accompanied by Ravindra Bahukandhi.
8. Project trip to Uttar Pradesh and Gujarat for Potato training at Lucknow and Ahmedabad 13-19 October 2014. A.J. Haverkort accompanied by Marijn Leijten & Ravindra Bahukandhi.
9. Project trip to Mumbai, Punjab, Gujarat and New Delhi for market research and data collection on potato growing and storage, 25 October- 9 November 2014. B. Janssens, A.A. Pronk, J-M. Michielsen & M. Schoutsen.
10. Project PPP meeting. 20 November 2014. Zoetermeer.
11. Project trip to Punjab and Gujarat for gathering information for the yield gap analysis. L. van den Brink & A.A. Pronk. 19-27 January 2014.
12. Project trip to Gujarat for making appointments about starting research on quality of potatoes in different stores. L. van den Brink, Ravindra Bahukandhi. 8-14 August 2014.

10.3 Presentations

Haverkort, A.J., Kempenaar, C., Wustman, R. & Zhang, X., 2014. Potato prospects for Ethiopia: adding value. Presentation held at Potato Platform Stakeholders meeting. 29 January 2014. Ca. 50 attendees.

Haverkort A.J., 2014. Presentation on marketing seed potatoes held at Punjab Progressive Summit 17 February 2014 at Chandigarh. Ca. 200 attendees.

Haverkort A.J., 2014. Basic principles of potato production Uttar Pradesh State Potato Meeting at Kannauj. Part 1 attended by 550 pp, part 2 by 300 pp.

Haverkort A.J., 2014. I. Basic principles of potato production, II Fertilization of the Potato Crop, III Crop protection . 2 Day Training of McCain growers at Mehsana Gujarat. Attended by 30 pp.

Haverkort A.J., 2014. Presentations held during potato training courses organized by NAFTC and UP government / McCain in Lucknow and in Ahmedabad. Topics dealt with: *Rhizoctonia* and its control, seed potato quality, nutrient management in potatoes, storage and handling of potatoes, potential potato yields.

Haverkort, A.J., 2014. Value addition to the potato crop in Ethiopia. Growing presentation held the Potato Platform meetings of the Addis Ababa Chamber of Commerce in March, June and December 2014. In total about 14 attendees.

Kempenaar, C., Haverkort, A.J, Pronk, A.A., Wustman, R. & van den Brink, L., 2014. Value addition to the potato production and processing chain in India. Presentation held at POSCON meeting in Jalandhar, 8 April 2014. Ca 150 attendees.

Kempenaar, C., Haverkort, A.J, Pronk, A.A., Wustman, R. & van den Brink, L., 2014. Value addition to the potato production and processing chain in India. Presentation held at Potato processors meeting in Ghandingar, 10 April 2014. Ca 10 attendees.

Kempenaar, C., Haverkort, A.J. & Wustman, R., 2014. PPS Potato R&D planning 2014-2015. Presentation held at PPP meeting in Wageningen, 24 March 2014. 12 attendees.

Wustman, R., 2014. Presentation on Seed potato certification held at Punjab Progressive Summit 17 February 2014. Chandigarh. Ca. 200 attendees.

Wustman, R., & van den Brink, L., 2014. *Rhizoctonia* and its control in potato. Presentation held at POSCON meeting in Jalandhar, 8 April 2014. Ca 150 attendees.

Wustman, R., & van den Brink, L., 2014. Benchmarking of cold storages in Punjab. Presentation held at POSCON meeting in Jalandhar, 8 April 2014. Ca 150 attendees.

Wustman, R., & van den Brink, L., 2014. Benchmarking of cold storages in Gujarat. Presentation held at Potato processors meeting in Ghandingar, 10 April 2014. Ca 10 attendees.

Wustman, R., 2014. Presentations held during potato training course organised by NAFTC and POSCON at Jalandhar. September 2014. Topics dealt with: *Rhizoctonia* and its control, seed potato quality, nutrient management in potatoes, storage and handling of potatoes, potential potato yields.

10.4 Publications

Brink, L. van den & Wustman R., 2014. *Rhizoctonia* and its control. Report Applied Plant Research (PPO), Wageningen UR.

Kempenaar, C., 2014. Werkplan topsectorproject Waardevermeerdering aardappelketens in India/Ethiopië, 2014. Project TKI-AF- 12226. Submitted to TKI office. Contact M. Leijten, NAFTC, on behalf of PPP 8 companies and WUR-PPO/PRI.

Kempenaar, C., 2014. Projectverslag topsectorproject Waardevermeerdering aardappelketens in India/Ethiopië, 2013. Project TKI-AF- 12226. Submitted to TKI office, published on KennisOnLine. By C. Kempenaar, on behalf of PPP (January 2014).

Pronk, A.A., Wustman, R., Haverkort, A.J., van den Brink, L., Janssens, S.R.M. & Schoutsen, M.A., 2014. Annual report Topsector Potato India and Ethiopia 2013. Report 546. Wageningen UR.

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Anonymous, 2011c. Quick service restaurants in India, Mumbai, 41 pp.

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Appendix I.
Trip program Ethiopia A. Haverkort 2014

Date, time	Activity
June 9 afternoon	Wageningen Schiphol hotel Ibis
June 10	Schiphol-Frankfurt-Jeddah-Addis
June 11 morning	Meeting Gertjan Becxs (ABSF) and Jan van de Haar Solagrow at hotel
June 11 afternoon	Meeting Ethiopian Institute of Agricultural Research (EIAR) with dr Asnake Fikre director crop research directorate
	Meeting with Steffen Schulz director national programs of the International Potato Center
June 12	ABSF Potato Platform Meeting at Harmony Hotel
June 13 morning	Visit to Maheder Chips cottage industry and Rahel essential oils producer
June 13 afternoon	Reporting
June 13 evening	Addis- Jeddah-
June 14 morning	Jeddah – Frankfurt – Amsterdam

Appendix II.

Program of the 2nd Potato Subsector Platform Meeting June 2014

Activities	Time	Performer
Registration	8:30-9:00	All participants
		Ato Manalgne Ferede
Participants Introduction to each other	9:00-910	ABSF's Subsectors Platform Coordinator
Welcome and opening remark	9:10-9:20	Mr. Gertjan Becx/ MOA
Ethiopian Potato Private sectors opportunities and challenges	9:20-10:10:00	Mr. Jan J. van de Haar General Manager of Solagraw plc
Health Break/Group Photo	10:00-10:30	All participant
Recap of the first potato platform meeting gaps	10:30-11:00	Prof. Anton Haverkort, dr Gebremedhin WoldeGiorgis
Group discussion and & presentation	11:00-11:40	All participate
Break time to summarize the presentation and networking of participants	11:40-12:30	Each group presenters
Plenary session on summarized ideas of presentation	12:30-1:00	All participants
Closing remarks	1:00-1:10	Ato Manalgne Ferede
Lunch	1:10-2:00	All participants