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Can Lean Management Principles Help Optimize Agriculture? Application and Evaluation on Selected Farm Cultivating Spring Barley in the Czech Republic

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Signature……

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Miloš Hána

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Summary

The increasing global competition challenges businesses to optimize operations, stay profitable and ahead of the competition. Even though agronomists know their business thoroughly, based on their previous long experience, continually evolving management practices on the one side, and rigidity of established stereotypes on the opposite side, encourages adoption of new methods.

To improve the performance of the company, an external viewpoint is often necessary to discover bottlenecks and evaluate each step accordingly to value adding process.

The objective of the study "Can Lean Management Principles Help Optimize Agriculture? Application and Evaluation on Selected Farm Cultivating Spring Barley in the Czech Republic »; is to observe and research applicability of lean principles, usually used in the production industry, in different segment, in an agriculture. The goal of the research is to evaluate possibility of introducing the Lean management principles into highly volatile sector. A sector, where the price depends prevalently on the weather, the season, the location, agro-technological development, together aligned with the need of robust forecasting ranging up to several years ahead. On the other hand, low product variability, logistics, and repetitive working operations favors to implement Lean methods to the cultivation process.

The output of the thesis is to evaluate all processes during whole cultivation cycle to find bottlenecks, optimize the process flow, with primary goal to shorten the lead times between every step and mitigate inefficient work.

We work with two hypotheses. Can be Lean techniques applied on selected farm with regard to cultivation of spring barley?

Second hypothesis is: Can be 5S method introduced and if yes, what are the results of hypothetical implementation?

A literature study is performed to gain insights to factors influencing the cycle of growing barley, storage management, logistics, and adjacent processes. Information retrieved from the literature study helps to detail the theoretical framework. Main analyzing tools are Value Stream Mapping, GANTT framework, and 5S for floor plan designation.

Proposed method is to identify all ongoing processes, which adds value to the final quality of barley required by malt industry. We examine all the actions and processes from the preparation of field, through cultivation, and final delivery to the customer. These steps comprise of mapping existing farming processes - planning purchasing seeds based on negotiated amount proposed by a malt factory, farm preparation in terms of availability of machinery and human resources, seeds minimizing sowing techniques, proper care of growing crop from standpoint of steps involved within exact time windows, drying, and final preparation in the storage. This describes the current situation and overall efficiency, from which we can deduct non—adding value activities and recommend which lean techniques should the Company implement, to achieve stable and more efficient workflow.

Obtained information will be in form of panel data, questionnaire evaluating the hypothetical implementation of Lean methods (5S), and literature overview.

Three sub-objectives have been set in the processing of this work:

• Literature research of the subject and adjacent topics – History of Barley in Czech Republic, current situation regarding procurement of malt and description of quality measures that provides the value for the customers, Lean history, principles of Kaizen philosophy, Lean management used in the production, presentation of the chosen methods, Value Stream Mapping, GANTT Chart and 5S.

• Characteristic of AGRA Řisuty s.r.o., analysis of internal materials and description of the business cycle regarding barley cultivation. Evaluation of value stream, timeline, and lead times during the cultivation.

• Preparation of a semi-structured interview with Agra Řisuty's storage mister to obtain general information on the use of the 5S method.

Key words: Supply Chain Management, 5S, Lean production, Lean Management, GANTT chart, Spring Barley, Farm Management, Market, Gemba, Kaizen, Information system, Agriculture, Quality, Malting Barley, Czech Industry

Thesis Structure:

The thesis is divided into 3 chapters. An introduction to barley cultivation topic in the Czech Republic and overview of the Lean principles and methods are presented in chapter 1. The chapter aims to describe the history of barley, role of barley cultivation in the Czech Republic, how is quality – added value determined, maintained, and created for the customer. Followed with overview of Lean principles and management techniques, further used in the research framework.

Chapter 2 contains description of the farm, evaluation of lean applicability, research questions and hypotheses followed with the company structure, cultivation cycle, and farm organization. Along with selected research questions, important part of chapter 2 is utilization of Value Stream Mapping for observed processes, GANTT time schedules for timeline observations, and 5S for warehouse organization.

Chapter 3 presents the case study results, express the situation of Lean and summarize performance of proposal. At the end is the conclusion with answers to our hypothesis.

Tools used for the evaluation of the case study are: Value Stream Mapping, semi structured interviews with agronomist and storage master, 5S and GANTT chart. The diploma thesis was processed in MS Word and MS Excel and using LucidCharts for diagrams.

Part 1: Literature Overview

1. Agriculture in the Czech Republic

1.1. Introduction

To introduce the problematic of cultivation of spring barley, basic overview of why the cereal is chosen and what position holds in the Czech Republic agriculture is further presented.

1.2. History of Barley

Barley (Hordeum vulgare) has been known to the people for at least 9000 years and it was situated mainly in Eurasia. It's one of the first cultivated and domesticated grains, expanded to Europe in the Middle Age (5th to 15th Century). Relatively low requirement for a soil, a climate resiliency, and comprehensive processability, made the barley significant and widely spread source of the proteins for humans and animals nowadays.

Domestication of a barley in the Czech Republic can be traced till 9th Century. Barley was through the time moderately crossbreed to achieve and sustain higher yields, resistance to different diseases, and provide effective cultivation on soils with lower overall nutritional value. In the current times, it's a major cereal grain used as inexpensive fodder for a livestock, but we preferably recognize it as an important ingredient of beer, whisky, vinegars confections and food supplements.

1.3. Barley Characteristics

Barley is the second most widely used cereal in the Czech Republic after wheat. The importance of barley cultivation lies in its universal utilization in many various sectors. Barley can be used in various forms, ranging from food supplements, beer production, a feeder, through the production of starch and bioethanol.

In food industry, barley is used in the form of flour, semolina, whole flakes, crisps, etc. Barley flour contains less gluten and is therefore used for healthy and dietary nutrition. Barley is nutritious, in the early stages of growth in antioxidants and contains many valuable amino acids, vitamins, and minerals.

In the field of feed industry, barley is used as part of various compounded feeders and granules for the livestock, domestic animals, and fish.

1.4. Barley in the Czech Republic

Barley has specific position in the Czech Republic agriculture mostly due to world renown beer industry, which accounts for one-third of spring barley demand in the country. The rest two-thirds of produced barley is consumed by a livestock as a fodder or, in minority, used for bioethanol production.

Barley can be observed from biological and utilization scope. Biological factors describe the robustness and development of the kernel, and are basically divided into

spring barley varieties and winter barley varieties. Winter barley is more tenacious during harsh cultivation conditions, on the other hand is not suitable for parametric cultivation, as its's difficult to sustain required chemical values over the time. Division by purpose classify barley for its specific qualitative parameters required by the industries. We recognize malt barley, feed barley, industry grade barley, and food grade barley.

In the Czech Republic in 2018 was harvested total area of about of 222 000 hectares of spring barley, with an average yield 4.93 ton per ha, compared to 2017, the growing area decreased by 8000 hectares. In sum, 1 095 000 ton of spring barley were harvested in 2018.

For comparison world's largest barley producer is the Germany, producing 10,412,000 tons followed by the France (10,102,000 tons), the Ukraine (8,485,000 tons) and the Canada (7,605,000 tons). The Czech Republic ranks 16th in the world barley production rankings with total barley production (considering all the variants) of 1,845,000 tons.

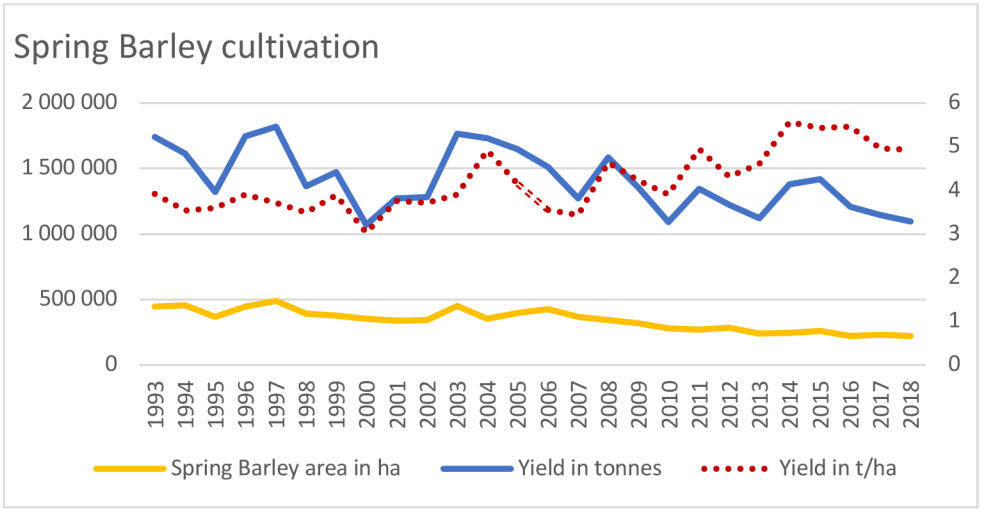


Figure 1 – Own work based on CZSO – Czech Statistical Office 2019

On figure 1 we see total amount of harvested spring barley on left axis of y, on the right side is average yield in tons per hectare unit, followed by axis x describing the timeline.

1.5. Malt Industry

Notable customer of barley is a beer industry (despite the quantity, it's a minor customer). Spring barley is the primary ingredient for manufacturing malt, so called malt barley. The oldest malthouse in the Czech Republic is in Žatec and was built in the 16th century.

Commercial malting plants produce approximately 78% of the total production of the malt and the largest producer is the Soufflet ČR company, with production around 350,000 tons per year. Soufflet ČR malting plants are key supplier in Central Europe and accounts for 94% of total malt exports from the Czech Republic to the EU countries (Poland, Germany, Great Britain, Cuba, Switzerland, Russia, Hungary, and Slovenia. The largest malting place in our country is the malt house in Nymburk, which has capacity of 108 thousand tons. Brewery malting plants produces about one-fourth of

the total volume of malt. The largest malthouse Soufflet ČR contributes for more than 95% of all types of Czech malt. Remaining share falls on Munich malt and individual varieties. In year 2019 was active 33 malting houses of various sizes as stated by ("Ječmenářská ročenka", 2019, p. 194).

1.6. Quality of Barley

Barley is a low-input cultivar, the number of steps for grow (steps including applications of additional nutrients, chemicals in pesticides and herbicides, followed with soil preparations) are relatively low compared to other cultivars, nevertheless this also implicit higher dependency on the right methodology. This is the reason a barley is convenient for our research. Quality parameters are considered when malt houses buy grown and harvested spring barley from the farmers, or when malthouse requires reproduction of new variety to the wider market. Vice versa those measures must be fulfilled by the farmers, to be able sell the barley in adequate quality to the customer.

1.6.1. Varieties of Barley

Adapted agrotechnics together with right variety depends on the success of the cultivation, followed by the ability to offer it on the market to corresponding customer. Type of variety and achieved quality of barley serves as the basis for cooperation between farmer and malthouse. Every year can be introduced new variety for multiplication, based on previous discussions with a brewery, which then "pulls" specific sensorics requirements from malthouses and consequently farmers. The agreement of cultivation seeds for variety multiplication, to further push it on the marker, is created between malthouse and farmer on pull production basis. The search for new variety corresponds with the requirements of breweries that frequently changes varieties to fulfil final customers taste preferences. The Czech Republic belongs to the leaders in the world research and participates in developments of new barley varieties for malting purposes.

1.6.2. Indicators of Barley Quality

The quality of the Barley is influenced by location, agrotechnics, harvesting method, post-harvest treatment and treatment of stored barley. Quality of the batch is consistently monitored with the given conditions of the cultivation, harvest, and post-harvest treatment by agronomist or delegated person. It should be mentioned that aside those factors the biggest impact has quality of a variety. If it's breeder (cultivated variety) the greater chance to evaluate harvest suitable for malt production. Usually used varieties are Jersey, Prestige, Malz, Sebastian, Diplom, Tolar and Bojos. Each variety has distinguishable sensorics parameters thus used by various beer producers for different variants of final product.

1.6.3. Czech Quality Norm for Barley

ČSN norm 46 1100-5 is the standard that consolidates requirements of malthouses and breweries for a quality of malting barley grains. It's the definition of chemical

parameters of barley used to produce malt and subsequently beer. The norm is used to determine the price as well as for monitoring of quality during the storage.

Quality parameters set by ČSN 46 1100-5	Recommended value in %	Minimum required value in %
Humidity	15	max 16
Filtration of grain over a sifter 2,5 x 22mm	90	min 70
Grain damage	2	max 5
Kernel with brownish tips	2	max 6
Kernel with hidden growth	0	max 0,5
Total Waste - Unwanted material	3	max 7
Germination	98	min 92
Nitrogen content	11	max 12,5
Color of kernel	light yellow	yellow
Glume	with decent pattern	smooth with visible pattern

Table 1 – Own work, data from Ječmenářská ročenka 2019

On table 1 are presented all relevant aspects of a barley to be considered suitable for malting purposes. Important criterion in evaluation of spring barley quality is the proportion of grains that pass the sifter with 2,5mm holes. It is a percentage of the amount of grain that, after a five-minute shaking on punctuated desk, does not fall through. This step exclude big grains from small grains and grains above the sifter have balanced size, which has a big advantage during malting process, when the grains receive water and germinate evenly. The smaller ones are undesirable, because in further processing it can create unsprouted grains, which make easier to spread the mold and can destroy the rest of the batch.

Total waste – includes grain fragments, grain slump, harmful impurities, organic and inorganic impurities, green barley grains and unwanted additives. Damaged grains and fractions are undesirable and increase considerably the risk of the infection by fungal and other microorganisms. Grains with a broken kernel receive water faster than healthy grains, and excessive water content results in slowing down or even stopping the germination.

Germination – is crucial indicator of malt barley. Low germination of barley affects the course of the malting process, unsprouted grains are not only a waste, but also suitable substrate for the development and spread of unwanted fungus. Lack of germination of barley is also reflected in poor deciphering of malt and affects all other qualitative characteristics.

Nitrogen content – should be 11%, while ensuring the content would not exceed the 12.5% threshold.

Humidity - Although moisture limits for the purchase of malting barley are up to 16%, grain with this moisture cannot be stored permanently. Treatment using the after harvest conditioning is necessary to reduce humidity to at least 14%, to prevent possible spread of unwanted microflora and grain pests.

1.7. Processing and Storage

Harvested barley is living matter with complex ongoing biochemical processes that must be limited by post-harvest treatment. This means appropriate storage conditions and proper handling, to ensure grain shelf life without degradation. These processes are more intense at higher temperature and humidity. The aim for farmers is to reduce its temperature, humidity, and remove impurities so it can be stored for a long time.

Barley is stored in silos or warehouses with appropriate technological equipment (escalator, belt-conveyor, air conditioning). The standard process is to harvest a barley, transport it to the silo, pass through the system of sifters and air dehumidifier, reload on a belt-conveyor, and move to a warehouse for long-term storage. This ensures best assumptions how to ensure qualitative parameters. For better understanding the following figures from (Skalický, 2008) and (Martínek & Filip, 2012) show the funnel and the filtering process.

In the following picture we can see silo with constant air drier from a book of (Skalický, 2008), used for conditioning the moist barley followed by figures from (Skalický, 2008) and (Martínek & Filip, 2012) showing the funnel and the filtering process.

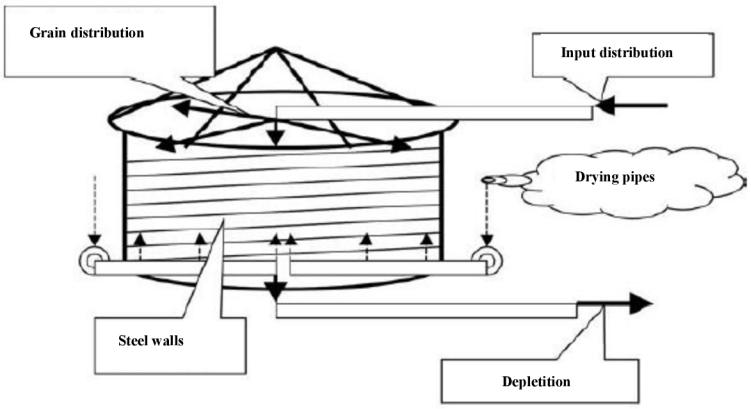
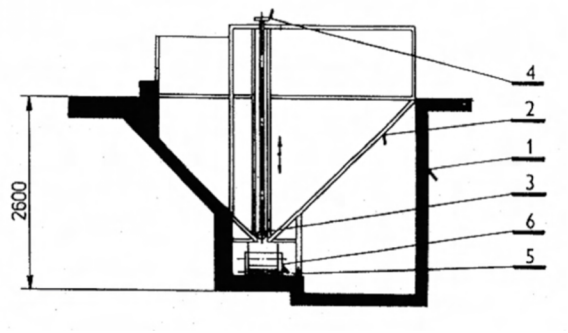


Figure 2 - Skalický 2008



2 – Grain input

5 – Adjust of the decline

6 – Filter hub

Figure 3 - Skalický 2007

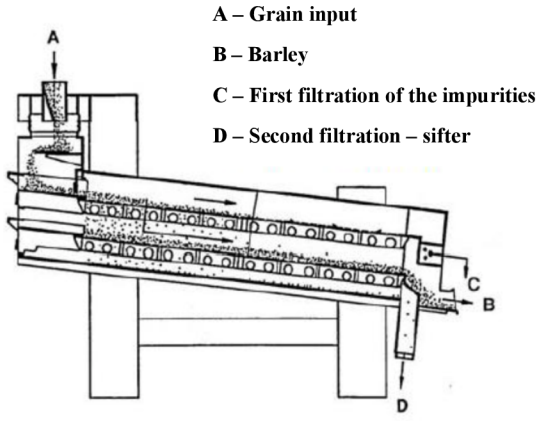


Figure 4 - Martínek 2012

Reducing grain moisture is ideally done by use of hot air, but we need to assure the grain won't be overheated. The physiological activity in the grain is then slowed down, the development of microflora is dampened and margin of the water, from the grain, is dried. Second method is using a cold air. With this method, there is a certainty that the grain will not be damaged and due to low investment costs and ease of use, it is economically advantageous, however it's not as efficient (consume up to 20x more air for the same effect).

Barley, which is primarily intended for food and feed purposes must be carefully processed to prevent unwanted biochemical, chemical, and physical changes in the grain. During the storage, mycotoxins and carcinogens may be introduced, which in turn pose a significant threat to agricultural animals or the environment.

When the temperature further increases during the storage, the so-called "hot spots" in the pile emerges, which with longer storage period and in colder conditions, creates another ideal environment for the multiplication of the pests and vertebrates.

As stated in article by (Bouma, 2016) to ensure the absence of warehouse pests is a very difficult process, so it is important to recognize the presence of pests in a quickest possible manner and introduce certain measures to reduce them. Methods to detect pests in barley are time-consuming and financially challenging. Neglected pre-harvest preparation of warehouses and technologies can lead to decreased quality of barley, and with subsequent sale, to complaints and significant economic losses. Warehouse pests may occur shortly after the harvest and pre-harvest treatment of warehouses does not guarantee that that storage pests do not appear afterwards.

1.8. Malt Industry View

1.8.1. Value of Barley Seed Varieties in Malt Industry

Malting barley is very demanding for the right weather conditions if it's expected to reach and keep the high value. The value of grain is a result of two major influences. Agro-ecological factors at the time of vegetation such as weather, cultivation technology, pre-crop selection. Rainfall and temperature ratios greatly affect the yield and quality of the grain and extreme weather is undesirable for achieving high quality malt barley. Second influence is the quality of barley itself. The certified seed variety is first precondition for full potential of barley production, which ensures yield stability and quality assurance for the stakeholders.

In real world the market seed value is based mostly on six basic elements. The purity of seeds batch (up to 95% of all matter content must be the barley variety), ability of kernel to germinate, nitrogen content and weight of the thousand's seeds. The seed value may also vary depending on whether the seed comes from the conventional or organic farming. Another rated feature of malt barley is proportion of the kernel and content of the moisture. The standard humidity when buying malting barley is 14%. Limit value is 16%, but only if the grains are not permanently stored and ongoing procedures are planned to reduce humidity below 14% for further storage. Higher humidity could cause mold and spread pests. The equipment used in the malting plants also affects the quality. The arrangement of the machinery must guarantee 100% sanitary safety of operation and at the same time gentle processing of barley up to malt.

(Černý, 2007, pp. 33-38) states that based on technological tests, varieties with selective malting quality are approved annually:

> Spring barley is procured based on the requirements of malting companies and breweries. Varieties are strictly selected and only 6-8 varieties are purchased in a given ratio according to the need for production of individual beers. Among the many varieties registered in the Czech Republic and in the European catalogue, only 10 varieties are widely used. The varieties are selected by leading breweries and malthouses, according to suitability to produce individual malts and subsequently beers.

Varieties are divided into suitable for European type of beers (high alcohol content and low residual extract) and varieties suitable to produce Czech-type beer. Commercial malting plants exporting malt must adapt to the variety requirements of the foreign customers. For this reason, foreign varieties known in Europe – Jersey, Sebastian, Prestige, Xanadu– had spread on the fields of the Czech Republic.

1.8.2. Quality Parameters of Malt

Quality can be defined as value of goods or services mutually recognized by supplier, producer, and consumer, as stated by (Hayes et al., 1988) in their work Dynamic Manufacturing. Based on their findings we are unable to simply parametrize exact value of quality, because it is connected to various characteristics and external variables, which in turn creates the final product. We constantly participate in the quality making by monitoring value for all engaged stakeholders and with set standards, we streamline the processes on order to be in line with requirements of the others.

From the previous pages is apparent there are numerous factors influencing final quality of the barley product. To consolidate all relevant parameters under one standard, the ČSN norm was introduced. This standard sets out the elementary quality parameters for growers and traders, provides objective information of samples evaluation and takes into consideration international methods and practices, including the European Brewing Convention method. Evaluated grain quality data are used, among other things, to determine the price and monitor changes in quality during the storage.

To achieve and evaluate the agrotechnical requirements of malt, the Malt Quality Index was established. Malt Quality Index or MQI, is primarily a guide for the common grower of malting barley providing him with the selection of suitable variety.

Malting Quality Index ČSN 46 1100-5	Units	Insufficient value	Threshold	Pilsner Malt/České pivo
Protein / Nitrogen content	%	Min 9,5	Min 10,2	
		Max 11,7	Max 11,0	
Extract in dry malt	%	81,5	83,0	80,0
Relative extract at 45°C	%	35,0	40,0	
		53,0	48,0	
Kolbach index	%	40,0	42,0	39
		53,0	48,0	
Diastatic Power	WK	220,0	300,0	220,0
Final attenuation	%	79,0	82,0	82,0
Friabity (fragility)	%	79,0	86,0	75,0
ß-Glucans content	Mg/1	250,0	100,0	

Table 2 – Own work, data from Ječmenářská Ročenka 2019

Pilsen Malt - České pivo, is commonly used term for certain quality of malt. The norm requires minimal quality parameters shown in table 2. Nitrogen content should not deviate outside the interval 10% to 12%.

1.9. Price of Barley

Price of Barley has wide range depending on factors such as market demand, selected variety, quality, time of transaction, traded amount, and localization. In malt sector, the competitiveness is high, and depends practically on the size of the cultivated field climate, selected variety, and water availability. The intensification can be introduced, nevertheless, to achieve required malt quality, the right conditions are crucial and cannot be introduced to the extensive industry farming easily. This fact puts pressure

on the Czech farmers to abandon barley and switch to other cultivars, such as cultivation of the rapeseed or keep specialize in malt grade barley, but with uncertainty of stable yield due to high dependency on the external factors (climate changes, floods, and other unexpected events). On graph in figure 5 we can highlight the demand is in overall lower than produced amount and the stocks are in surplus every year.

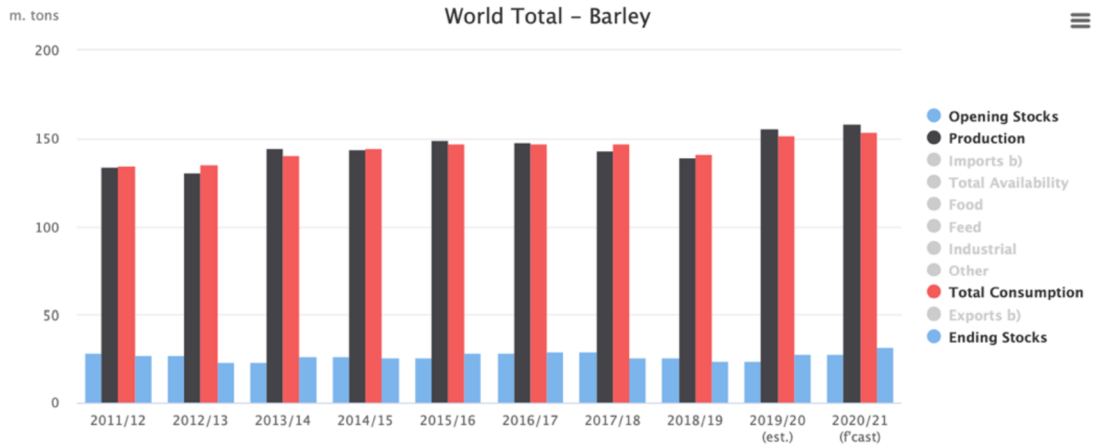


Figure 5 - https://www.igc.int/en/markets/marketinfo-sd.aspx

Using own calculations, we observe, surplus of price of malt barley in comparison with food barley is around 10 % and briefly over 30 % between feed and malt combination. When we consider 100 ha field with minimum (necessary) costs (excluding overheads and investment), the costs to grow spring barley for malt purposes, averages about 15 000 CZK, in study done by Tereza Sixtová in 2015. (Sixtová, 2015). We compare the price data from same year, where the average yield was 5.43 tons per hectare and the price was 4820 CZK per tons. The results are approximately:

Total costs: 1 500 000 CZK, Price offered for malt barley: 2 600 000 CZK Profit without overheads and investment: 1 100 000 CZK

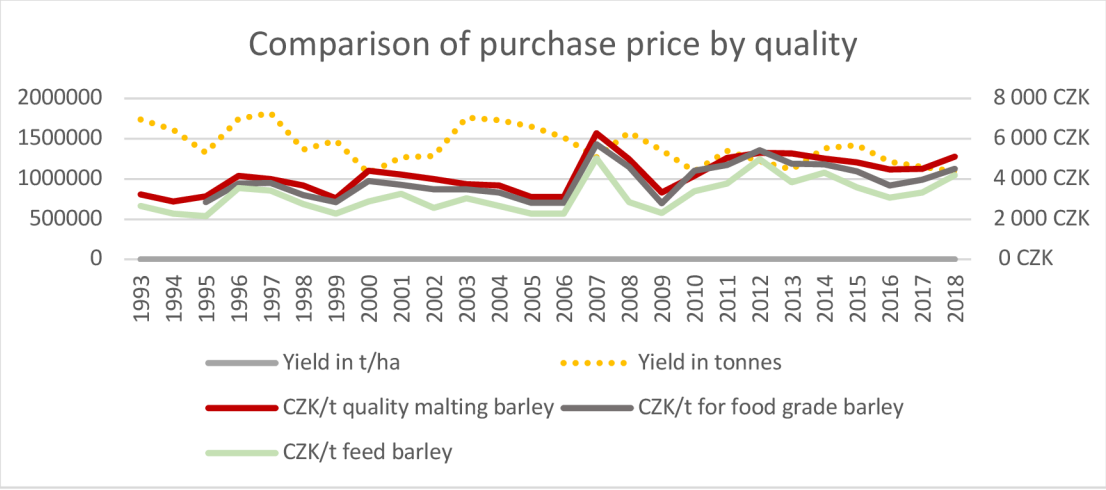


Figure 6 - Own work, data from Czech Statistical Office

2. Lean Principles

2.1. Lean as the Philosophy

Lean thinking emerged from tough times of destroyed post war industrial situation in Japan at the beginning of 1950's. The new start was needed, but to become competitive as early as possible, production management had to evolve from the bottom. In the beginning it was more about approach of thinking and habits than standardized management structure. The standardization and a full nature of Lean thinking crystalized, when Toyota started to build plants from scratch in the West in the 80's, when the Lean system, as we understand now, was introduced.

Lean thinking can be summarized in a short sentence. Precisely specify value of the product, identify the value stream, make value flow smooth as possible, without unnecessary waste, let the customer pull value from the producer and pursue perfection on all levels.

This was in contradiction to then (till late 90's) time practices, when a "push" manner (pushing products) in high frequency to a market and tasking marketing departments to sell as many products as possible, was a standard procedure to achieve high margins on a market. The idea was revolutionary at the time, the Lean outranked competition and massive implementation, notably in the Western economic culture, was done after Toyota proved how efficient this style of holistic management can be.

The concept of Lean is constructed around mutual understanding of collective responsibility to achieve shared goals. The first step for this is define and understand the value itself. To concept of lean was specified by (Womack & Jones, 2003, p. 19).

> Lean thinking therefore must start with a conscious attempt to precisely define value in terms of specific products with specific capabilities offered at specific prices through a dialogue with specific customers. The way to do this is to ignore existing assets and technologies and to rethink firms on a product-line basis with strong, dedicated product teams. This also requires redefining the role for a firm's technical experts (like the inward-looking German engineers we just cited) and rethinking just where in the world to create value. Realistically, no manager can actually implement all of these changes instantly, but it's essential to form a clear view of what's really needed. Otherwise, the definition of value is almost certain to be skewed. In summary, specifying value accurately is the critical first step in lean thinking- Providing the wrong good or service the right way is Muda.

The win-win situation is when everybody feels anticipated and constructively shares goals of the company. On the other hand, the "enemy" of Lean is waste, precisely, to mitigate waste of all kinds, from the human work to the product leftovers. Lean thinking is more than a system, it provides a managerial perspective. It is a way to do more, with less human effort, less equipment, less time, less space, and transforming waste into value. Emphasis goes mainly to the continuous process of learning and team cooperation with seeking the unite goal. Key objective is the recognition of workers to be one of the most important elements in the organization. Lean also considers lowering costs by increasing employee productivity in comparison with the traditional concept, where cost reduction is in the form of investment and automation.

Taiichi Ohno, the founder of the Toyota production system, described lean method as looking at the timeline from the moment the customer gives an order to the point, when the cash is collected.

The Lean procedural approach was defined in 2003 by Womack and Jones in the book Lean Thinking, where the lean approach was defined as a set of five steps/principles:

1. Precisely specify offered value
2. Identify value stream
3. Make value flow without interruptions
4. Let customer pull value from producer
5. Pursue perfection

2.1.1. **Muda, Muri, Mura**

The concept of Lean is in mitigating all the necessary waste and can have various forms. To express the specific kinds of wastes the Japanese developed three terms 'Muri, Mura and Muda', which are known in the English as 'wastes' or in the Japanese "Muda", which refers to anything that does not add value.

Every production and every human activity consist of processes that either add or do not add value to resulting a product or an action. Anything we put into production process costs in turn money. Such as materials, time, means of production, etc.

Basic types of Muda:

- Waiting for material, missing parts
- Material stocks
- Transport of products and materials
- Poor quality
- Manufacturing errors
- Overproduction - increasing stocks of finished products
- Unnecessary movements - non-satisfying ergonomics

Muri means overload, strain, and Mura means deviation, unevenness. (Davim & Machado, 2017). The simple visualization of the Muda is presented on figure 7.

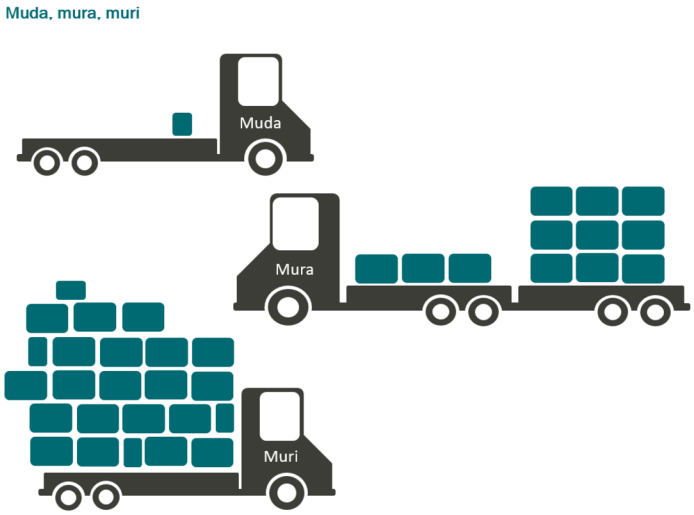


Figure 7 - https://www.horsum.be/nl/tools-procesverbeteringen

2.2. What is Lean Management?

Lean management is systematic application of lean thinking into an organization. It's comprehensive system that covers entire enterprise. It ensures a stable quality product with minimalized costs. It covers all business processes and it's an extension of the concept of Lean production. Lean management can be defined as a way of work/philosophy that aims to increase the added value of all corporate activities for a customer, while reducing amount of waste of resources, such as human labor, time, material or, in our example, warehouse space.

Lean management can be used in both production and administrative departments. It can focus on customer principle, concerning internal and external customer, slim organizational structure, customer-supplier relationships. Through lean management, the company strives to set up teamwork and plans, manages and uses all the company's resources using various tools. These tools are numerous and stretches all over the various Lean implementation cases.

Among basic tools used by lean methodology are:

- Value stream mapping
- Analysis of process flows
- Process performance
- 5 S's

The concentrated management around common objectives is typical for Lean characteristics and is also reflected in workplace layout. To provide an infrastructure for workers to participate, is necessary to implement layout, which would provide the right conditions to eliminate waste.

2.2.1. Lean and Kaizen

Whatever Lean manufacturing tool a company introduces, it will make a lot of effort to implement it. If people are not motivated and educated in the mindset of Kaizen, an implementation of anything is just one-time act, which sooner or later gets back on the track and quickly become obsolete. Kaizen is the only way to avoid this, which forces all employees to think about their work, about possible small improvements that will make it easier, faster, cheaper, and better utilized.

2.3. Lean Tools

2.3.1. Kaizen and Gemba Kaizen

Kaizen means continuous improvement, in which everyone is involved, from the managers to the workers. It is an expression composed of two words: KAI – change and ZEN – good, better, which means change for the better. Kaizen is a system of continuous improvement in personal, social, and also work life ranging from the workers to the managers. Simply described Kaizen is way of life and a philosophy of life.

Kaizen is a built around two pillars:

- Improvement – everything can be improved - quality, deadlines, costs, productivity
- Constant change – nothing in the world is fixed, everything is constantly changing and evolving – markets, products, customers, and their requirements

Kaizen primary concern is about improving ourselves and only after we can improve the relationships and cooperation with co-workers, things, and processes around.

(Imai, 2012, p. 221) states: Kaizen is a job for everybody, but especially for top management. You cannot create a kaizen department because kaizen must be within everyone's spirit. It's a constant improvement process. Kaizen is based on the fact that people in the business must use brain as well as muscles and hands.

In his work he also describes what Gemba means; Gemba is where the activity or process that we want to improve is carried out. In the production company it is a workshop, in the hospital office, in the hotel dining room. Gemba is not the manager's desk. You can't get any better from the table. Many companies still use the traditional way of working – managers sit in offices, study analyses and reports with spreadsheets and graphs, prepare cost-cutting strategies and concepts. From

time to time, they walk around the traffic to see if the floor is clean and that the workers are working intensively enough. (Imai, 2012, p. 14).

Gemba can be visualized as pyramid shown in figure 9.

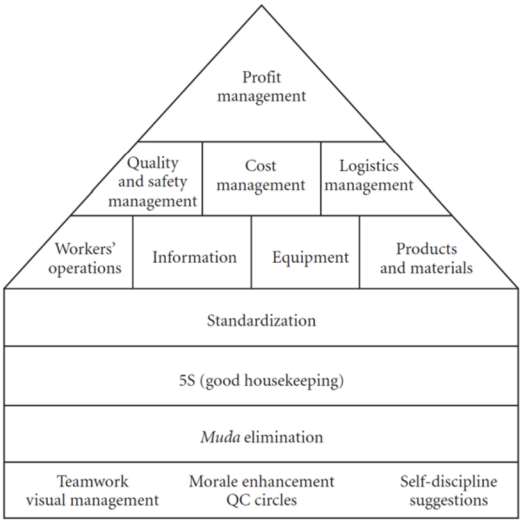


Figure 8 - Gemba House, Imai 2012

2.3.2. **Value Chain-based Management**

Value chain-based management identifies each step in a pipeline of actions. Lean organization determines how the value is identified and explicitly states if adds the customer value. Thus, it is always a ration between the cost and benefit for stakeholder responsible for each step.

2.3.3. **GANTT Chart**

Gantt chart is a project management tool for planning the sequencing the activities over time. It was introduced by American mechanical engineer H.L Gantt and used during the 1st World war and was invented around 1910.

"It's a tool for planning and scheduling projects of all sizes that is particularly useful for simplifying complex projects. Project timelines and tasks are converted into a horizontal bar chart, showing start and end dates, as well as dependencies, scheduling, and deadline. " (*What is a Gantt chart?*, 2020)

GANTT Chart describes:

- Visual display of the whole project
- Timelines and deadlines of all tasks
- Relationships and dependencies between the activities
- Work phases

2.3.4. **Pull Production**

Pull production means explicit limitation of amount of work in a process that can be placed in a system, in contrary with push production stating the amount of work in a process has no limitations. Lean production emphasizes customer pull instead of organizational push, meaning that pull system optimizes activity of production and increases customer involvement in product development and delivery phases. Pull system management focuses on customer's needs and waste reduction along the production process.

2.3.5. **Just in Time**

Just in time is a type of organizational and production management that aggregates distinctive characteristics of Lean Production. In the strict sense on the production example it means, the pieces should arrive on the production line at the exact moment, in corresponding quantity and at same time with no delay in the system. It is important to place inventory orders at the right time. The timing of replenishment should reflect the effects of uncertain lead times and ambiguous customer's demand.

Process design in the distribution is very important as we will discover in our case study. Quality of Just in Time can be expressed by following indicators. Minimum throughput time (performance of system), dependability (influencing factors), flexibility (change easily between processing states) and cost (appropriate capacity to meet the demand, eliminate process waste in terms of excess process capacity, in-process delays, in-process errors, and inappropriate process inputs).

2.3.6. **5S - Organizing Workplace**

5S is the most visual and tangible element and starting point for Lean implementation. Its goal is to mitigate or at least reduce occurred wastes using time-space organization (in its wide definition – office space, farm space, warehouse space, etc.). The name 5S is based on five Japanese words: Seiri, Seiton, Seiso, Seiketsu and Shitsuke or in English; Sort, Set in order, Shine, Standardize and Sustain.

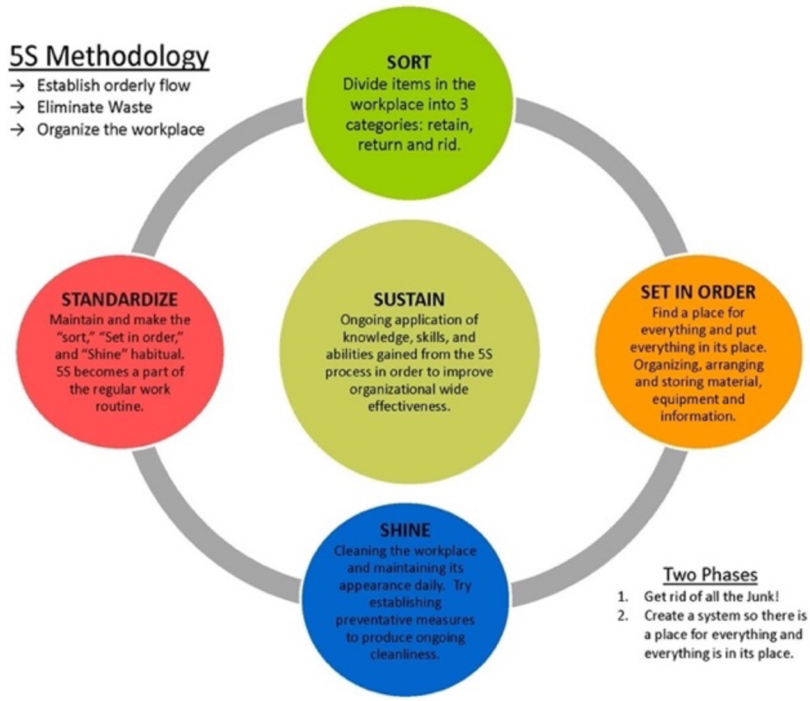


Figure 9 - https://blogs.mtu.edu/improvement/files/2011/08/5S.jpg

- Sort — excludes all the actions, tools, or other components that are not necessary. Prioritization of actions according to the level of needs and benefits
- Set in order — means that everything that is needed has a designated place and marked location. The individual needs of the process are stored in such a way that they are readily available and to ensure the smoothness and efficiency of work performance.
- Shine – says that workspaces must be organized and maintained in order and cleanliness, so that they are just as easily and easily accessible and in order, created by the previous two steps, as well as the next process cycle. Organization and cleaning operations are part of every process cycle, not initiated, only when workplace clutter is intolerable.
- Standardize – assumes that workflows should be aligned and standardized to ensure the repeatability of individual operations. Where several workers perform the same task on several stands or workstations, they should carry out the same activity. Standard procedures also ensure that the condition created by the previous steps is stabilized.
- Sustain – focuses on compliance with the workflows, instructions, and rules set out in the previous four steps. It should be continuously checked so that the process does not slip back on track over time.

(Ortiz, 2015) Created manual for the new adopters of the 5S tool focused on manufacturing sector and made a comprehensive guideline for implementation into the company. The citation focused on floor space is mentioned by (Ortiz, 2015, p. 17).

> Floor space should be used to perform value-added work that creates revenue for the company. It should not be used to store junk or act as a collector of unneeded items. Renting, leasing, or buying a manufacturing building is one of the highest overhead costs. The production floor is in place to serve one purpose: to build products. Although the factory is used for other items, such as holding inventory, shipping, receiving, maintenance, and so on, the production floor should be effectively utilized for value-added work. Value-added work involves the act of building products or the steps needed to change fit, form, or function of the product you intend to sell. Production lines, equipment, and machines all produce same product, and the floor space needed to perform this work should be properly used.

3. Lean Management in Agriculture

3.1. Overview

Lean Management in agriculture is compelling topic due to fundamental differences between the standard production and biological production. Important characteristics for considering the implementation of lean in the agriculture that requires different approach are:

- Biological production specific nature
- Long lead times
- Low product variability and highly repetitive environment
- The individual nature of the farm

Biological processes cannot be standardized in a scale we observe in manufacturing industry. Currently developed precision technology and automatization narrow this gap as much as possible, nevertheless the nature can't be controlled in the ultimate manner. Farmers only try to alter environmental conditions as much as possible to maximize plant's innate ability to grow.

The lead times such as the time from planting to harvesting a crop, are relatively long compared to the most industrial production, and are predisposed by genetic inherence of variety, climate, and soil conditions. Farming is planned at least one or several years ahead and agricultural products are pushed into highly volatile market, where prices depend very much on the weather in different parts of the world and thus offered amount of commodity on the global market constantly fluctuates. In those circumstances lean production struggle to adequately respond to large fluctuations in the demand and the introduction of pull production and Kanban is difficult in agriculture. However, production closer to customer demand (Germany, Poland, Hungary) in our country means, the farms actually sell all of their products and are regularly catching up the demand.

The issue with lead times lies in the low product variability and individual nature of the farm. The farmers are limited with the option of cultivar depending on chemical and nutrition balance of the field and are not able to quick switch the "belt", just because the demand of chosen commodity changes in time.

The lean implementation in agriculture is in the development phase and extremely varies in terms of the right selection of applied lean procedures. The lean organization is prevalent in the bigger corporate farms, which are mostly process driven. Important part and the root of most failures of lean implementation is the company itself. The change of managerial behavior is necessary and require strong commitment from the management and motivation of employees must be considerably valued. The educational aspect is the prime factor.

Nowadays we see trends of two ultimate directions of the farming. One towards specialized, small to medium sized, family owned, farms distributing their products to local markets utilizing the ecological agriculture norm. In the opposite, the big farms engaged in the multinational companies and their economy can be supported among other stakeholders within food-supply chain network. Both requires same Kaizen philosophy, but with individually adapted lean tools.

For illustration in the United States, profit-through-growth farming is more common. Huge, industrial-scale agriculture – which serves the interests of investors and agribusinesses, not local communities – dominates the nation's rural landscape. According to a USDA report, farm size has doubled since 1990 "and the trend is likely to continue." (*Farms are gigantic now*, 2013)

3.2. Inventory Management

Inventory is one of the most expensive and important assets of many companies so in the result, firm usually reduces costs by decreasing amount of inventory on hand. On the other side, customers become dissatisfied with frequent inventory depletions, if the inventory is reduced under required threshold.

Inventory control confine of the storage, the acquisition, handling, and utilization of the inventories to ensure availability of stocks whenever needed. Inventory management can provide adequate provision of a resources and a material, and thereby deriving maximum economic use – minimizing of a wastages and losses across a supply chain. Inventory control refers to a system, which ensures supply of required quantity and quality of stocks at the right time and preventing unnecessary investment in stocks in supply chain tiers. Precise description of problematic was presented by Davim and Machado:

> Inventory can be reduced by improving the demand forecasting, converging supply chains, increasing flexibility of processes, reducing administration costs, investigating alternative delivery channels that reduce transport costs, reducing process time between customer request and dispatch of items, and by reducing throughput time in the downstream supply chain. The flow of input resources from farms to consumers' needs to be described in detail and the constraint in each sub-process needs to be identified to develop appropriate solutions for logistics related problems. (Davim & Machado, 2017, p. 50)

We can paraphrase this into the agriculture, where well-planned transport system enables and support farmers in harvests and help market crops more efficiently, reduce unnecessarily movement and shorten time delays in-between.

3.3. Case study of previous Lean Adoption in the Agriculture

Whereas current manufacturing industry adopted lean methods in almost every aspect to stay competitive on the market, lean maturity in agriculture sector is debatable.

Important research was conducted in the academic sphere when Swedish government funded lean program to support Swedish farmers in lean adoption. The program was called Lean Lantbruk, and the goal was to support farmers in utilization of lean (implement resource efficient and less wasteful production) providing them with educational frame and required resources. After 18 months of program duration, 34 farms were fully engaged in various lean adoption phases and 100 farms were participating in at least one lean application. Unfortunately, the official programme result was not publicly published, nevertheless the underlying data were extracted from the interviews, observations, diaries, and questionnaires for the consequent research done by Melin and Barth in 2018. The goal of this new research was to present a public framework of lean implementation from the operational and the strategical perspective, based on challenges farmers had to previously overcome.

The original program found out there are 24 barriers to successfully adopt lean techniques. Majority of those barriers arise from the "family feeling" farming, followed by problems with long-term implementations, where the farmers evaluate changes as individually executed action rather than changing the tradition, "DNA" of the farm, and inability to introduce self-improvement of every employee to be a part of the change movement. This resulted in impossibility to achieve a fourth phase, which states the lean methods are applied generally all over the farm (horizontally and vertically) thus assuming them as Lean matured. Despite this, individual improvements were applied, and the program was partly achieved. First remarkable obstacle was role and definition of the "Lean Coach".

The change agents in our lean programme were the external 'Lean Coaches' who acted as facilitators for the lean process on the farms. We confirm the crucial role of the change agents in the lean initiative and the fact that there was some misunderstanding about the role of the Lean Coaches may have hampered the lean process among the farms in the Knowing lean phase. The farmers expected the Lean Coaches to offer prescriptive advice and answers to questions. However, as conceived by the Lean Agriculture programme, the Lean Coaches are facilitators, not advisors. This misunderstanding may explain the somewhat tense relationships between some farmers and their Lean Coaches. Some farmers even requested substitute Lean Coaches. In addition, the farmers had little or no knowledge about Lean before entering the programme. The Lean Coaches could supply this Lean

knowledge as well as training in the use of Lean. This dysfunctional relationship, therefore, posed a serious challenge in the Knowing lean phase. The situation deteriorated to the point at some farms that the farmers conducted planned Lean activities only when the Lean Coaches made their monthly visits. (Melin & Barth, 2018, p. 850, 851)

Second notable obstruction, as previously referred, was “Lack of consensus among the farm owners created another challenge in this phase. For example, one of the four owners at a particular farm strongly opposed the programme. He repeatedly raised arguments challenging the value of Lean. “ (Melin & Barth, 2018, p. 851)

Part 2: Case Study of AGRA ŘISUTY s.r.o.

4. Case Study of AGRA ŘISUTY s.r.o.

4.1. Company Introduction

AGRA Řisuty is middle sized private company operating in the central region of Czech Republic and spans over six districts thus individual centers in: Ledce, Drnek, Malíkovice, Jedomělice, Slabce, Hřebečníky.

The company AGRA Řisuty s.r.o. was founded on August 10, 1994 by Jan Vicence and František Krček after the disintegration of then JZD Development of Řisuta Kladno. At that time, the company had about 120 employees and 1400 hectares of agricultural land. In 2002 they took over the bankrupt company and expanded its operations to the Slabec region, where acquired about 1200 hectares of agricultural land and several real estate buildings. In 2005, the ZD Byseň ceased its activities from which AGRA Řisuty s.r.o. acquired another 1000 hectares of agricultural land in the central Czech Republic region.

Currently AGRA Řisuty manages about 2650 ha of agricultural land, of which 1000 ha operates on its own and employs 32 employees, 7 in administration, 13 in plant production and 12 in livestock production. The rest is rented from individual farmers. Most of the growing area is used to produce quality food and feed grain, oilseeds, legumes. Part of this production is directly processed for feeding livestock. Thanks to the long-term good agrotechnical care of the managed land, they achieve significantly above-average yields for all cultivated crops.

AGRA Řisuty emphasize plant production based on careful soil manipulation using the latest scientific knowledge and using rich historical experience. Since the late 1990s, AGRA Řisuty have been using soil protection technologies in soil processing and pre-seed preparation to prevent wind and water erosion, reduce soil tightening and handle soil moisture more sparingly. Due to the management in one of the driest regions of the Czech Republic, proper work with soil moisture and efforts to minimize water losses during plant cultivation are essential. To maintain soil fertility, it is also very important to achieve a balanced balance of nutrients. They regularly invest in stock fertilization with phosphorus fertilizers and lime, in addition to conventional agrotechnics. Another aspect affecting the condition of the soil is the content of organic matter, which, in addition to fertility, directly determines its water requirements. Thanks to strong livestock production and related manure production, they can apply quality manure to 400-600 hectares of arable land every year and thus maintain organic matter in the soil at a high level.

Since foundation, AGRA Řisuty s.r.o. has been one of the leaders and innovators in its field and strives to implement modern technologies in the management, which further help to increase the efficiency, economy, and environmental convenience. For this reason, they cooperate on several projects with experts from the Czech University of Life Sciences in Prague, Czech Technical University, SPZO and other scientific and professional workplaces.

4.1.1. **Company Structure**

The company employs 32 people in total. 7 in administration, 13 in plant production and 12 in livestock production. The organizational structure does not have rigid hierarchy as all the work fluently transcends between the branches. We can define it as "family ties" driven company, where everybody participates on same goal, to keep company profitable and aware of necessary wastes. The operators of machinery - drivers has dedicated machine and are arranged together by tasks, during all the actions on the field. We can assume them as task micro-teams, where they know each other and based on their previous experience they work altogether.

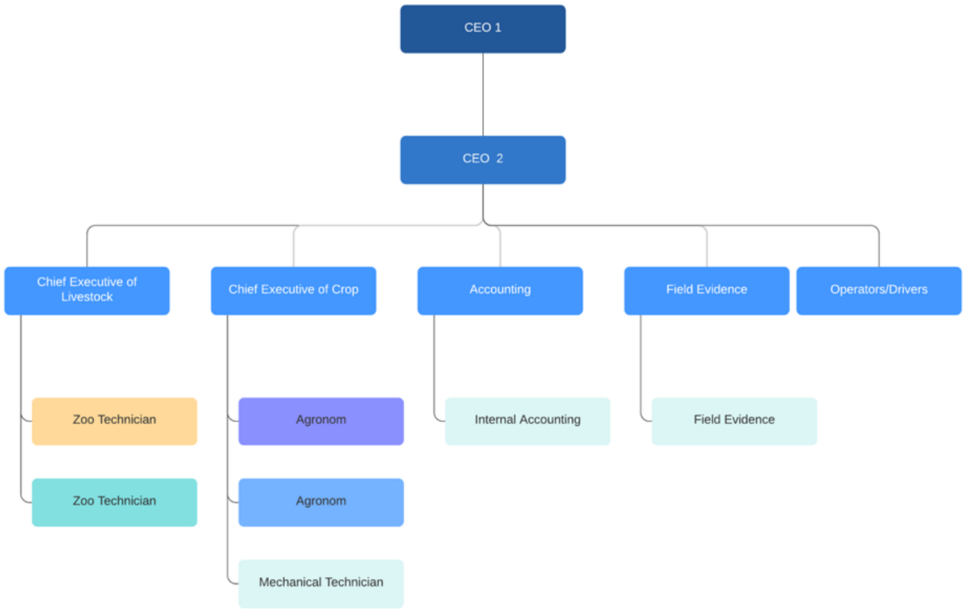


Figure 10 - own work

4.2. Goal of the Research

4.2.1. Hypothesis

Agra Řisuty is modern farm and adopter of new precision agriculture technologies. All machinery is GPS controlled and use prepared yield maps for selective application of herbicides and pesticides. The farm map their fields in cooperation with other companies and together creates yield matrix that serves as base map for navigation on the field. High engagement in adoption of new technological solutions and active company culture favors to observe and map the operations of the company.

The Lean can be good companion as it prone to form a rigid intern structure, capable of constant improvement and unites the company value for all stakeholders. The Lean methods can be used in farm with any size, but to be able to quantify it, standardized data collecting method must be present. To observe of company efficiency requires to have multiple data to support and quantify differences in any relevant changes. As in introduction, the Lean is widely used in big manufacturing companies, which gather enormous quantity of information that can then be evaluated, and the performance can be adjusted.

For purpose of the research, we have chosen this farm due to its relative preparedness for the conducted study. There are not many studies focused on Lean implementation itself. The notable one was described in the previous chapter, where we concluded the biggest problem was with the insufficient adoption of Lean management approach and human barriers.

The scope of work is to make a first step and proposition of lean in the Czech Republic agriculture. The full maturity lean can take up to decade and the first step is to propose and discuss the topic and support it by introduction of tools and management guidelines. Because of this, the hypothesis is set with respect to “green field” of actual state. We will first start with Value Stream Mapping, where we quantify and determine individual steps and then continue with consultation and proposition of 5S adoption in the post-harvest and storage area. The goal is to prove the concept can be done and prepare the company for eventual next steps.

4.3. Examining Farm Timeline Using GANTT Chart

We start with specifying the timeline using GANTT chart, where we observe farm life cycle dedicated to the cultivation of spring barley. On this diagram we see all relevant actions. The priorities are stated towards spring barley cultivation.

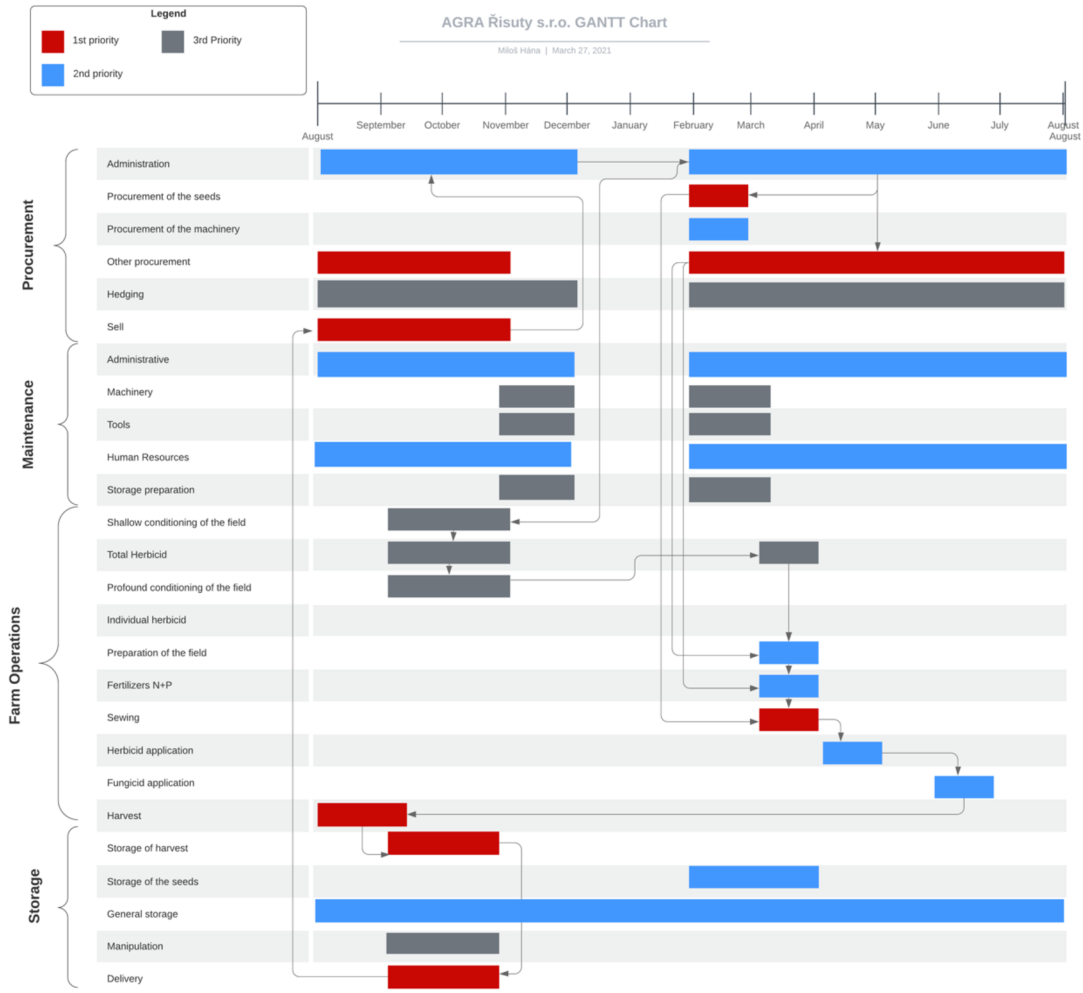


Figure 11 – own work

The whole timeline follows natural grow and seasonal agriculture cycle, thus from November till January most of the activities are postponed and employees takes vacations with their families. After the break, employees return to the offices and continue in the work. New year starts with necessary administration, communicating with all engaged stakeholders and monitoring the commodity values on French commodity exchange market MATIF. Notable to highlight in the beginning phase is delivery of seeds and observation of state of machinery, tools, and if something is missing or needs to be repaired, it is promptly ordered before the cycle begins. The row "Other procurement" also contains procurement of the herbicides, pesticides and materials ranging from the office supplies to fuel supplies.

The storage master begins with preparation of the storage and warehouses, checks the amount of resources and reports the state to the administration office. They confirm it with the orders and based on this, the procurement resolution is arranged. Concurrently preparation of the space for upcoming deliver of seeds is in parallel process.

Among duties of the headquarters is to maintain number of seasonal workers, observe meteorologic data and prepare frame dates of upcoming field processes. The dates are not strict and every year floats, but based on previous experience, everyone follow general time schedules.

When machinery, tools, harrows, warehouse with resources, storage for seeds are prepared, machinery drivers wait for the signal to start with on-farm activities. This is determined by meteorological conditions and approval of farm supervisor in charge.

When both, internal and external conditions are right, the tractor fasts the harrow and travels to the field in the middle of the March. First, it will spread the field with herbicides, fungicides to remove all unwelcomed weeds and microorganisms grown during the winter. During this phase the condition of the field is observed and administrative is informed about ongoing biological processes. If the field is infested with specific type of weeds and fungi, the procurement buys adequate materials to mitigate it in the next step, after the fertilization.

Secondly after the spread, the soil needs to be aerated properly using the plough. Then the fertilizers are added, the amount depends on weather conditions (the fertilizer can be washed away if heavy rains occur), on previous cultivar and type of the soil.

When the processes are done, the sewing comes into place using tractor with seed spreader. It uses precisely defined rows with exact width and it's coordinated (as also all other on/off-farm movement) by GPS satellite navigation. Remark, the used row width is unified across all field movements, so the machinery has smallest possible footprint, which compacts and damages the soil (thus lowers the total yield).

During April the specific herbicides and pesticides are introduced and spread over the areas, where non-essential biological processes had erupted. This step depends on the condition of the field from previous monitoring and prognosed future weather.

Somewhere during June, fungicides are usually applied to the spots, where is considered higher risk of unwanted spread.

Finally, during August, the crop is matured and ready for harvest by combines. They are in formation with hopper trucks, which leaves as soon, as they are full and head to the storage for further evaluation. The trucks are waiting and the number of them depend on size of the field and their capacity. When they are full, they head to the storage for post-harvest preparation, including evaluation and eventually directly pass to the storage or to the sifter.

The last phase is crucial in terms of adequate time scheduling. The company concurrently cultivates other commodities as rapeseed and prevalently wheat, but as those commodities has various ontogenesis and differs in the time of final harvest, bottleneck should not occur. In case it occurs, the batch can be stored in the "buffer" storage, waiting for following manipulation within the storage area by a digger, and trucks can continue transporting crop from the field to the storage area.

Next steps involve storage during September and October. The duration is based on the agrochemical values of the barley, namely nitrogen content, and humidity. Usually, best agrotechnical values barley has after one month of storage, when the values are saturated, and the kernel is "chilled". On the other hand, two months can lead to unwanted depreciation of quality, nevertheless the batch is regularly monitored for mitigating loss of quality by using hand sensors.

4.4. Examining of All Actions and Processes using VSM

Next step is evaluation of the Value Stream. Due the profound and robust information technology system AGRA Řisuty utilizes, we can search and observe all

necessary steps in the detail. For purpose of our research, we choose 25-hectare field Carda to observe all the on-going processes to produce and expedite the barley.

The journey starts at the headquarters. From the past, major costumer of malting barley is company Soufflet ČR, owned by French Groupe Soufflet. Majority of year production of malt barley is sold to this company. Varieties (prevalently Bojos a Solist) are selected to meet the conditions not only for Soufflet, but also producers of malt in Poland, or they are sold directly to the Pilsen brewery. In terms of quantity, batch around 700 tons of spring barley is dispatched and further transported every year. The ratio of cultivated malt quality and food grade quality barley is about 30%. Total production is 2300 tons of both winter and spring barley per year. Procurement of the seeds takes places in August, November, with delivery during February (one month before the sowing). AGRA Řisuty also produces seeds on its own, which are used in house for consequent years. The variety is bought on yearly basis, before start of the grow cycle. In case the quality of final crop is not sufficient, barley can be used as feeder for AGRA Rišuty's livestock.

Main headquarters in Ledec is a place where all tasks are organized and divided. This is a central hub for all internal/external company operations, ranging from administration, maintenance, procurement, development to organization of delivery and sale. The map of the central area is shown in figure 12. Blue rectangle borders main building and yellow area describes parking spots for all machinery.

Figure 12 - Main Headquarters in Ledec – www.mapy.cz

Based on internal customs and family "DNA" of farm, every skilled employee knows about the incoming processes and is adequately prepared. There is not a rigid procedure of regular task dividing in the morning, thus based on the interviews to some extent is, but we can't describe it as a regularity.

When the driver receive order, the employee chooses correspondent heavy machinery in the garage and proceed to selection of appropriate harrow. First place to visit is the field, where he conditions the soil with plough. After he finishes the operation, he returns to machinery garage and proceed with the new task. Machinery garage is a contact point as all field related operations needs some variant of tools. Usually, this action is done during August and September. For simplification of our research, we omit batching multiple fields together.

The 2nd task is prevention of unwanted weed population, this step requires to pick up the truck with sprayer with auxiliary tank, which then sprays herbicide chemicals all over the field.

3rd task is profound ploughing, the soil is turned upside down to better ingest all future nutrients and makes it more aerated.

4th task is repeated herbicides application. Till this task, all the done steps depended on qualitative state of the nutrition and historical condition of the field (previous cultivar, type of soil, weather, water conditions).

5th state is the pre sowing preparation and general observation. The field is prepared for the seed application, followed by 6th state, when the nutrients (nitrogen, phosphorus) are scattered over the field. The amount of used chemicals is maintained by previously created soil maps.

Next, 7th step is sow of the seeds. This step involves pickup in the storage of barley seeds in the warehouse and then transfer to the field. When the process is complete, tractor comes back to the garage.

During cultivation is important observe first half of the growth cycle. As the soil is full of nutrients, weeds followed with pests, and vertebrates can occur.

8th and 9th farm cycle are about individual application of affected spots using herbicides and pesticides. The farm is trying to work with the lowest possible amount of added chemicals, they use precision segmented sprinklers and spray only necessary spots with proved erratum.

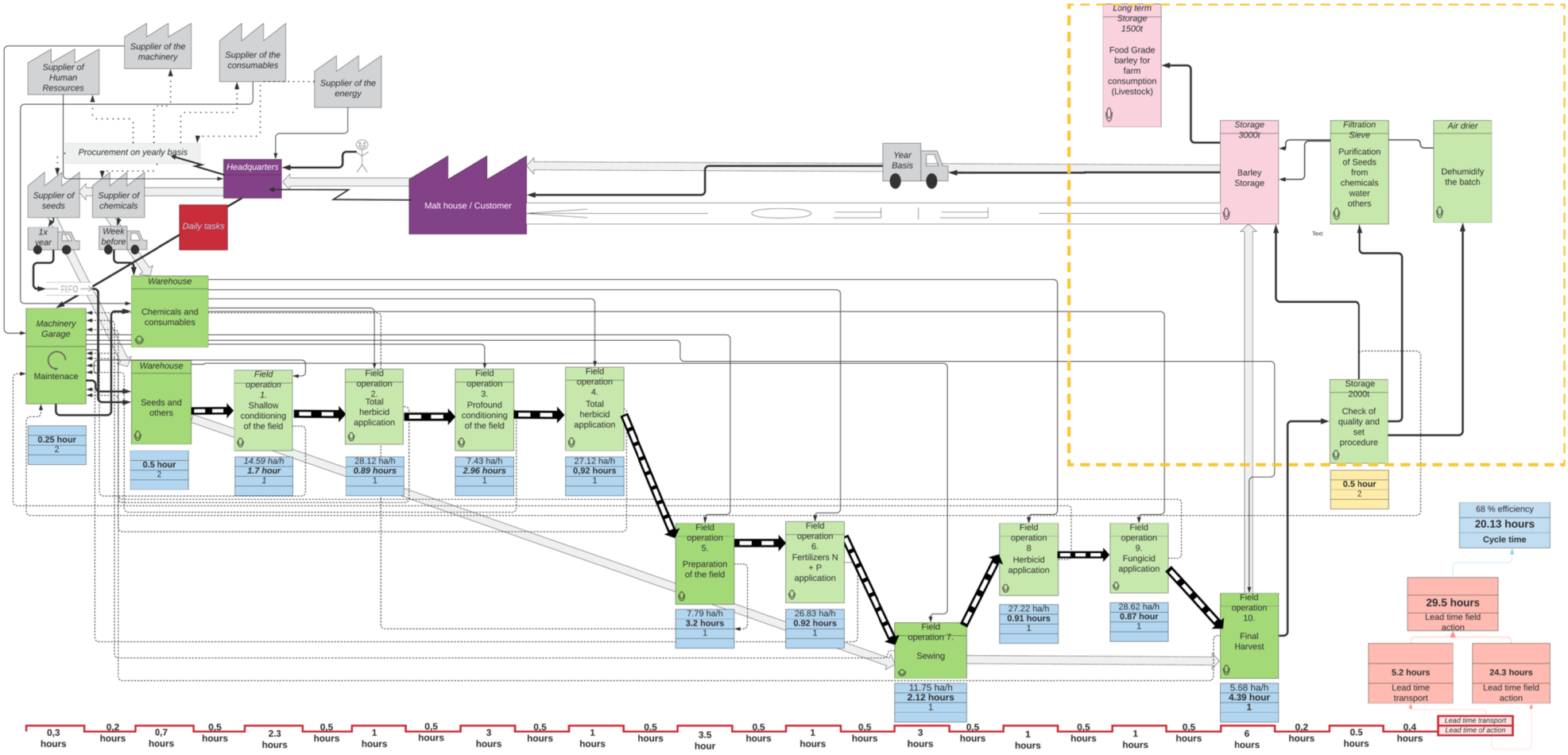
Finally, when the cereal has reached physiological maturity, the harvest occurs. This time tractors with auxiliary harrows are replaced by combine machines followed by hopper trucks. The combine harvests the crop and transfer it to the hopper truck. When the hopper is filled (next one is already prepared in the row), the truck leaves the field and continue its way to the storage place to post-harvest conditioning line. Usually two hoppers are used, but this depends on field size, distance from the storage and its operatively driven based on agronom decision.

At the preparation storage, experienced storage master decides the next procedure based on results of sampling method. This is done with hand tool and using electronic sensor machine that evaluates humidity, nitrogen content, and purity.

Based on this resolution, the barley would stay in the buffer storage for further processing or if already fulfil the requirements, it's then stored in dedicated storage.

Last step is the delivery, that is processed by Malt house Soufflet ČR, which is informed about the crop harvest and consequently send their transport truck to the storage to pick up. Manipulation – load is provided using top loading platform in post-harvest line location. The transfer between the system and long-term storage by dedicated storage tractor. When the delivery is done, the confirmation paper of transfer is signed, and the barley leaves the farm.

The yellow border shows the storage area, which full be discussed further in the text.


Supplier of the machinery
Supplier of the consumables
Supplier of Human Resources
Supplier of the energy
Procurement on yearly basis
Headquarters
Supplier of seeds
Supplier of chemicals
1x year
Week before
Daily tasks
Malt house / Customer
Year Basis
Long term Storage 1500t
Food Grade barley for farm consumption (Livestock)
Storage 3000t
Barley Storage
Filtration Sieve
Purification of Seeds from chemicals water others
Air drier
Dehumidify the batch
Text
FIFO
Warehouse
Chemicals and consumables
Machinery Garage
Maintenace
Warehouse
Seeds and others
0.25 hour
2
0.5 hour
2
Field operation 1. Shallow conditioning of the field
14.59 ha/h
1.7 hour
1
Field operation 2. Total herbicid application
28.12 ha/h
0.89 hours
1
Field operation 3. Profound conditioning of the field
7.43 ha/h
2.96 hours
1
Field operation 4. Total herbicid application
27.12 ha/h
0,92 hours
1
Storage 2000t
Check of quality and set procedure
0.5 hour
2
Field operation 5. Preparation of the field
7.79 ha/h
3.2 hours
1
Field operation 6. Fertilizers N + P application
26.83 ha/h
0.92 hours
1
Field operation 7. Sewing
11.75 ha/h
2.12 hours
1
Field operation 8 Herbicid application
27.22 ha/h
0.91 hours
1
Field operation 9. Fungicid application
28.62 ha/h
0.87 hour
1
Field operation 10. Final Harvest
5.68 ha/h
4.39 hour
1
68 % efficiency
20.13 hours
Cycle time
29.5 hours
Lead time field action
5.2 hours
Lead time transport
24.3 hours
Lead time field action
Lead time transport
Lead time of action
0,3 hours
0,2 hours
0,7 hours
0,5 hours
2.3 hours
0,5 hours
1 hours
0,5 hours
3 hours
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1 hours
0,5 hours
3 hours
0,5 hours
1 hours
0,5 hours
1 hours
0,5 hours
6 hours
0,2 hours
0,5 hours
0,4 hours
Legend
Throughput: The speed to complete a task(hectar per hour)
Cycle time: The actual time spent completing a task (value added time)
Lead time: Overall time spent completing task (Non-value added time)
Personnel: How many people are engaged in the process
Fraction: The percentage of total spent hours of cultivation
Throughput
Cycle Time
Number of people

4.5. Farm Process Mapping

We described whole cycle using GANTT approach to observe timeline and VSM in simple manner of steps involved in the process. Next step will be evaluating the steps, where we can see the biggest risk of mitigable delays. From observations we can deduct the liaison points of influence, the field plan and storage areas.

To sum up, farming process consists of following major phases: planning and estimating cost of the production, purchasing seeds, farm preparation, seeds sowing, ploughing, irrigation, proper care of crops through frequent use of fertilizers and pesticides, harvesting, storage of crops, and selling the harvest.

4.5.1. Procurement

Purchasing, planning and management is important phase of pre-cultivation operations. Proposal is necessary to determine the optimal quantity of the seeds and ensures smooth cultivation process with regard to minimize overall costs. It is done on yearly basis in November, when the agronom calculates required amount based on the previous harvest and own production, and orders 70% from external producers and the rest 30% of seeds are grown in-house.

Here is notable to highlight the in-house grow of certified seeds. AGRA Řisuty produces own seeds, which are then sold to other growers, or used in the following year's sowing. The crucial difference of procurement of the seeds is in the mutual agreement between the grower and the malt house. The malthouse introduce new variety from laboratory (own fields) and needs to multiply this batch to enter the market (so they have enough seeds for other customers regarding specifics of the breweries). The malthouse negotiate with the farm and based on malthouse needs, farm will sow their seeds to further resell. This is done on push production basis and practically grow exact amount upon the agreement. Reason for this is to in this case the farm obtains the certificate of variety and can be then reselled in large scale as certified seeds by the creator (malthouse).

The optimal supply and purchases of consumables are decided by the administration. Inventory management is procured operatively. Inventory is stored on a month-by-month basis according to current needs, supply storage capacity and conditions are regularly monitored, for example the input fuel storage for all the machinery. The storage has capacity of 20000 liters. This amount is depleted in three days during the heavy harvest's days. On other hand, there is no demand during the sabbatical time over the Christmas. The amount of fuel is constantly monitored and ordered one week before projected dates of heavy machinery movement.

Another important factor, of course, is the price, which can vary from month to month and is agreed upon the order. Stocks are hedged over a period of several weeks, usually up to months in forward. Highest prices of commodity are in January, as the offer is low, price is high as opposed to the prices right after the harvest (when the offers on market are high).

4.5.2. **Movement on the Field**

AGRA Řisuty uses GPS controlled navigation system that follows the route calculated from the field dimensions. This route also includes the yield matrix for sprinkler and seeder application. Yield matrix is a map with indicated soil potential and serves as the input for tractors electronic units, which accordingly to the yield map opens the valves / sprinklers only on places, where the chemicals or seeds are required. This has tremendous effect on economy of cultivation. On the other hand, higher investments had to be done.

For better overview maps with pathways over the spring barley field are presented. The example we use is the field Carda. It covers the area slightly under 25ha, which has simple boundaries and its nearby to our storages.

Figure 13 - WayQuest software

Figure 13 show us the system of pathways to navigate the field with minimum possible turnarounds, delays, and fill all the spots, therefore, to efficiently harvest whole field with minimum unnecessary movement – in lean term, non-value-added time - waste.

Figure 14 shows the route for trucks from the field to the storage and post-harvest procedure, the field is 2.5 km away thus 7 minutes takes only the transfer between locations:

Figure 14 - www.mapy.cz

Figure 15 shows the route from the post-harvest conditioning to the headquarters/garage, it takes 15 min and is 4.4 km distant:

Figure 15 - www.mapy.cz

The utilization of this technology is very much in the conformity with idea of Muda elimination, due to constant 24/7 monitoring all data (location, consumption of fuel, seeds, chemicals, distance) can be evaluated and the planning of the resources can be based on up to several years back. Those results are then precisely utilized in selecting the correct amount of used chemicals, seeds, fuel and consumables and coordination of movement in-between the fields during repeated actions. They offer good overview of the soil nutrition basis and the changes over the time, shows total fuel consumption, and based on the those data agronomists can evaluate and plan with better confidence and probability.

4.5.3. **Harvest of Spring Barley**

Harvest is the crucial moment in barley life. To sustain best properties of barley, the harvest must be done as quick as possible. To found out if the kernel is sufficient matured, we follow rules:

- Kernel is not flexible but firm
- Rest of plant is dead
- Humidity of kernel is under 16%

The kernels are also vulnerable to mechanical damage, so the combine harvester must adjust speed accordingly to keep damage to the minimum. The average speed is around 4-5 km/h.

Due to high sensitivity to humidity conditions, cereal harvesting is possible only on days without rain. Delayed harvesting increases the risk of yield and quality degradation, in terms of sprouting, seed rot, shattering, etc. Consequently, crop harvesting must be achieved as soon as possible for appropriate grain storage condition.

4.5.4. **Coordination of Transportation from the Field**

Coordination of a machinery in general is the most operative and complex process of all actions of the cultivation process. Harvest logistics depends on many factors. From the one side is crucial to finish the harvest in the quickest possible manner, on the opposite, there is certain limitations of weather, machinery, and human capabilities. The biggest issue is planning of the steps based on previous weather predictions and prioritization of specific tasks in the environment of limited machinery and human resources. Also due to fact the harvests are done over extensive area, its needed to consider road conditions and find shortest pathways among all the fields (the machinery is not dedicated to one kind of commodity and switches them). Secondly, due to nature constraints, the crop maturity depends on climate of the area and the transfer capacity is limited by amount of available machinery and human resources within the districts (the combine can't be easily transferred across the state).

Coordination of AGRA Řisuty's transportation is therefore based on operative basis and available capacities. It basically follows the rule to have one tractor with various harrow tools (such as plough or tank for spraying) and combine paired usually with two trucks for the harvest ex post transportation. Importantly, the experience also affects the workflow. Drivers works in narrow coordination, divided into small task teams, know where both turnarounds, and how to proceed in limited space. The responsibility of every employee is to achieve the shortest and the most efficient way to harvest all grown barley and transport it to the storage (supported by GPS set pathways). This shouldn't be interpreted as the imperative order from the above, but rationale of the employees avoid spending unnecessary time. Usual work time in harvest period is between 8:00 am till 22:00 pm (from sunrise to sunset), when the weather conditions are appropriate.

4.5.5. **Barley Sorting after the Harvest and Cleaning**

When the barley is transferred from the field, test sample from each delivery is taken at the pre-storage ramp using sampling rod. Storage master obtains a representative sample from the cross-section of the batch. Then mobile electronic laboratory is used to evaluate parameters of barley quality, among others humidity in kernel and nitrogen content. Based on the evaluation there are three options how to continue.

- When the nitrogen content is around 11% and the humidity tops at 14.1%:
    - This perfectly suits to malthouse's quality needs and farm requirements for long-term storage. Those nutritional values don't need further conditioning than filtering over the sifter, to lose fragments and select correctly sized kernels. Then the barley can be stored or directly expedited.
- When the nitrogen content is under 10% and the humidity over 14.1%:
    - Nitrogen content is not sufficient and due to high humidity cannot be stored in the long-term storage, because of risk of fast spoil and contamination of the rest. Humidity can be lowered using air drier, but the nitrogen content shows lower potential for further processing of quality malt barley. This round is air dried and used for other purposes (feeder).

- When the nitrogen content is above 12% and the humidity tops at 14.1%:
    - Nitrogen content is very high which can lead to problem in further standardized malt processing and different rate of batch germination. Humidity is in norm thus no further conditioning is needed, and the batch can be passed as feed barley.

If the barley contains impurities or needs to be dehumidified after the harvest, it's first unloaded at dedicated buffer storage place (which is big funnel under the ground level, from where is transported by elevator to the top floor of the conditioning system, then it passes down through the sifter or through the air drier cycle. Here is cleaned of all non-essential materials and internal humidity is lowered. After each batch the cleaning is carried out to remove intake barley impurities, unwanted additives, small dust particles plus the grains lose excessive water and humidity. The system is regularly checked by the external company and service history is regularly recorded. Barley can be divided into three classes according to the size of the grains. This is done for specific malthouses demands.

The system is described in the following figure. The storage master can select which procedure is needed and can observe and control whole process from the office. On the left we see elevator, then the cleaning phase with sifter, air drier and destination place (currently used only for wheat).

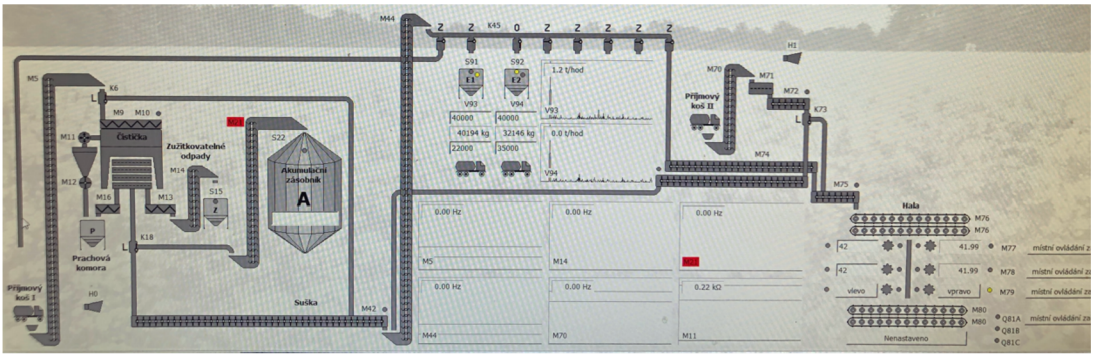


Figure 16 - Circulation Conditioning System

Storage master can adjust final quality of barley within the system. The quality is specified as the seed's purity by amount of barley grains in whole batch.

- Premium – 95% of all matter is barley (and minimally 2.5 mm wide, majority of barley for malt purposes)
- Normal – minimum 80% of barley in all of the matter
- Other – processed then as barley feed

After this procedure, the barley is transferred by Manitou tractor with shovel and expedited for long-term storage or expedited by truck from Soufflet ČR. In case the quality doesn't meet requirements, part of is transferred into farm storage for feeding of the farm livestock.

The barley is also harvested for seed purposes. This is by technological mean same as previously mentioned, but with different requirements. For seed barley is crucial to maintain high rate of germination. The nitrogen content and size of kernels are not strictly controlled, but the humidity and germination rate are.

In this step is remarkable the throughput of the system, namely the sifter and the air drier. The principle of the sifter is based on shaking up grains through individual sieves. At the bottom is accumulated dirt, on higher level grains with smaller size and on the top are kept vital and correctly sized grains. Sifting has takt time 63m^3 per hour when we want to achieve 95% purity. The air drier has half performance of the sifter, around 30m^3 per hour and based on interview with the storage master, usually two rounds must be done to fully dry the batch thus the throughput can decrease to 15m^3 per hour. In comparison, the takt time for the harvest is 50m^3 per hour. We can conclude this phase is the candidate for bottleneck of all related operations and we will follow on this problematic.

For the whole picture, the system is also used with other commodities as wheat or green peas, which causes another time delay for cleaning the tracks after previously processed commodity. Cleaning is done by processing the feed barley before the quality one, where the sifter cleans itself using lower quality barley, so the probability of contamination of the following quality batch is lowered. For our findings we won't consider this fact in the system.

4.5.6. **Barley Storage**

To store barley, we need storage with stable moisture conditions. For short-term storage is used the temporary storage. The batch is deposited in stockpiles on the grounds around the funnel, easy reachable for further processing (cleaning, drying through the escalator or tractor manipulation to the long-term storage). The temporary storage serves only for short-term storage, where the grain can significantly degrade over time, because it's only covered by roof. Usually when the harvest is done and customer wants to withdraw batch immediately, the barley won't be moved to the long-term storage. Based on interview with the storage master, the longevity of quality could last in temporary storage in average one week and then rapidly depreciates, influenced by outside temperature, weather, and sun rays as the storage is not fully enclosed.

Figure 17 - Storage map - www.mapy.cz

Long term storage capacity (blue rectangle on the map) is 3000-tons. The internal manipulation is executed by the Manitou tractor. The storage doesn't have floor vents and is necessary to observe the microclimate and humidity by visual control using the sampling rod regularly. It is also important to take certain measures against insects and unwanted vertebrates (those was the cause of floor vent removal in the past). The sorting is done according to the variety and respective quality from the left to the right. On the left side is barley with ideal parameters 14.1 % humidity and 12.1 % of nitrogen content. Passing to the right, the quality decreases, and on the far-right is situated lower quality feed barley.

Unsorted harvested barley is temporary stored in 2000-ton temporary storage (highlighted in the green) accompanied by the funnel and the post-harvest treatment line.

The current long-term storage is served by building from 1960's with low height and skewed roof. This condition unfortunately blocks any attempt to introducing the belt-conveyor with top-down direction straight from the sifter.

The quality of the storage is mainly influenced by humidity and temperature of the grain, the quality of cleaning and sorting, the degree of damage to the cereals and presence of the pests, the sum of these conditions affects duration time of the barley storage.

As we at the beginning stated in the GANTT timeline, the most important is the beginning of storage period, when the grain stabilization and conditioning take place. This improves germination and "chill" the grain. Best time for the expedition is one to two months. Average period for long-term barley storage is one year.

4.5.7. **Barley Delivery and Sell**

Soufflet ČR send the hopper truck to pick up the batch on yearly basis during September and October. Transport of barley is always provided at the expense of the carrier, who count the cost of transporting barley in the purchase price. This is part of the contract price and does not increase it.

4.6. Evaluation of Critical Processes

4.6.1. **What are the Critical Processes?**

Due to AGRA Řisuty's implementation of precision agriculture techniques, effectivity of the cultivation cycle is high and controlled. Amount of used material resources is constantly monitored, evaluated, and using segmented sprinklers/sowers, in combination with precision row establishment, only necessary amount of the resources is used. From this point, it's in conformity with Lean philosophy – the necessary waste during cultivation cycle is mitigated to the minimum. This type of eliminating Muda results in the lower amount of all transported chemicals, optimized trajectory pathways, consequently lowers the number of sown seeds, farm movement, and all mentioned ultimately result in the efficiency waterfall, which streams to lower storage volumes, lower consumptions of other consumables, lower procurement, lower human labor requirements, lower work amount, and in overall leads to higher ratio of value added processes.

The most critical process that creates bottleneck in the system is the post-harvest phase, followed by the manipulation and coordination of movement within storage boundaries. In this phase we currently see relatively lower organization in the direct comparison of very systematic approach during cultivation cycle.

The transportation phase from the field can be scaled by introducing more available trucks to transfer the barley from the field to the storage. The operativity assure that the bottleneck won't occur in this phase.

After we have successfully mapped the value stream it's clear the next step is to optimize storage's organization and manipulation. This last part of whole cultivation cycle is significant in terms of controllability and as it's a bottleneck of all operation, is also crucial in finalizing created value. In the next chapter we focus on 5S storage implementation based on proposition by Ortiz.

4.7. Movement and Coordination Across the Storage

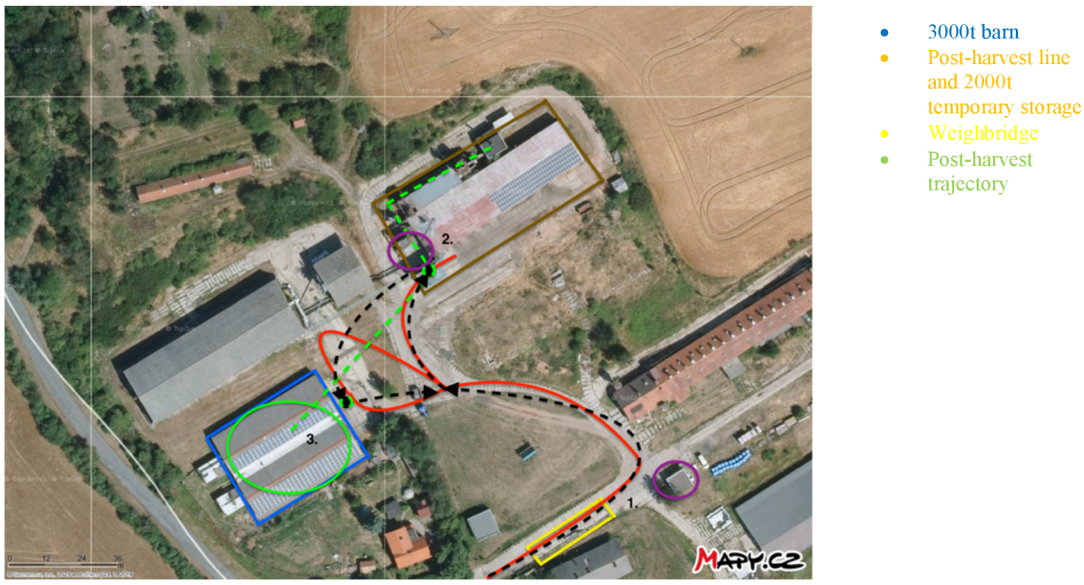
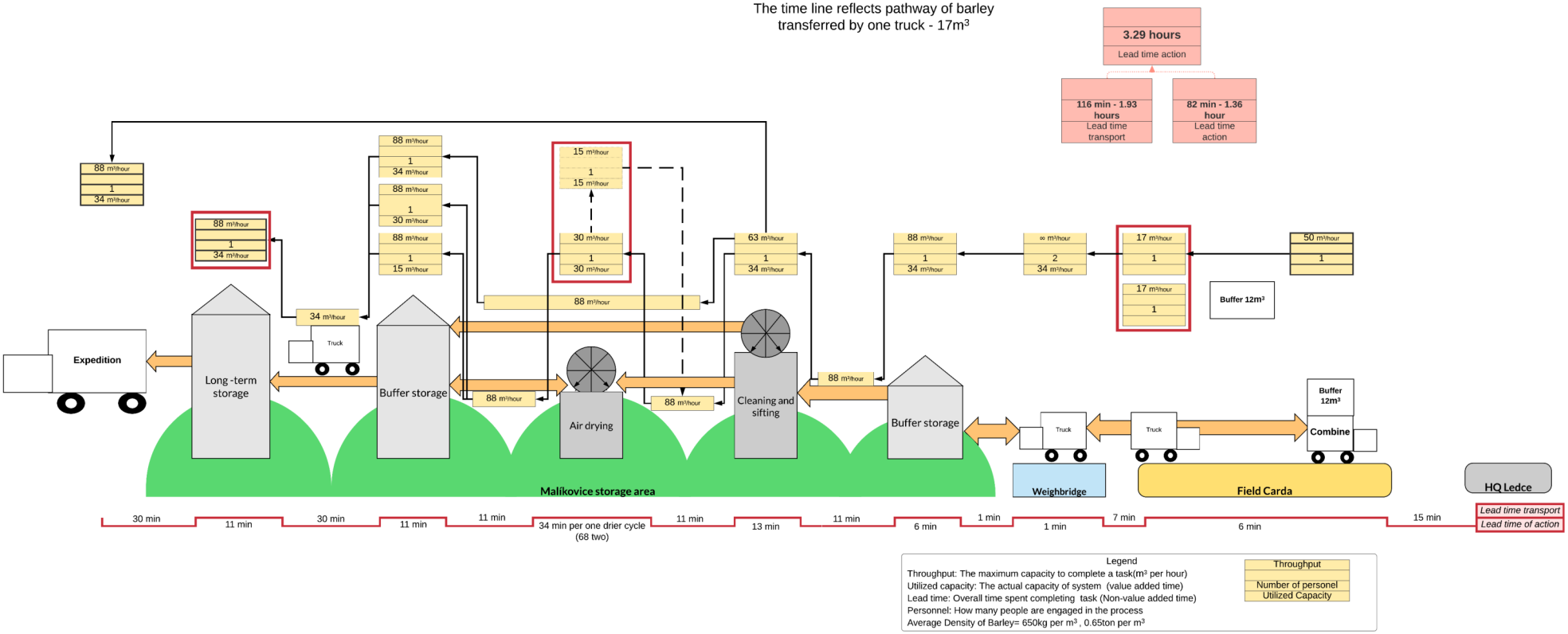


Figure 18 - own work, mapy.cz

On the satellite map is shown the storage area. At the bottom of picture is the entrance and right after is situated weighbridge for the trucks (number 1). Currently, the nearby area is observed by watchhouse with receptionist that controls the weighting procedure in and out (always for external companies, for internal its voluntary or only when they exit). The vehicle continues up the hill north and arrives at the post-harvest line. There sits the storage master, who eventually check the quality of barley and decide what steps are necessary and where the truck should stop. Also, he controls all expedition related actions and operates the post-harvest line. The truck unloads the batch in there for conditioning or to the short-term storage. Small Manitou tractor serves as manipulator between the post-harvest preparation phase – short-term storage, long-term storage, and expedition. The expedition is done in front of the blue building, where the manipulator with shovel loads incoming truck. Then the truck leaves the station, goes through the weighbridges to check if the quantity is right, and exits the area.

Following figure show us the whole transport process from view of one truck operation. The capacity of the truck is 17m^3 and we accordingly calculated how long takes to process it from the harvest to the final expedition.

The time line reflects pathway of barley transferred by one truck - 17m³



Legend

Throughput: The maximum capacity to complete a task(m³ per hour)
Utilized capacity: The actual capacity of system (value added time)
Lead time: Overall time spent completing task (Non-value added time)
Personnel: How many people are engaged in the process
Average Density of Barley= 650kg per m³ , 0.65ton per m³

Throughput
Number of personel
Utilized Capacity

4.8. Proposed Storage Organization (5S Optimization Proposal)

Based on discussion of proposed solution with farm agronom, the farm is already engaged in project of building new silo for efficiency purposes, as the current situation is not ideal. The capacity is in discussion, but we consider the proposal of ten silos, each with projected capacity of thousand tons.

Introduction of the silos has multiple advantages. Precise division of commodities, direct connection to the post-harvest line, no manual movement, better conditions for mitigating vertebrates, and suppressing the molds, which all together brings ability to store barley longer and better, so it can be sold when the prices are seasonally higher and maximize profit. This can also prolong the quality of barley more than one year to two years and sold when the price is more convenient for the farm. Hand by hand the overall logistics become more streamlined, and everything can be operated by one person.

On following figure is proposal of new area organization.

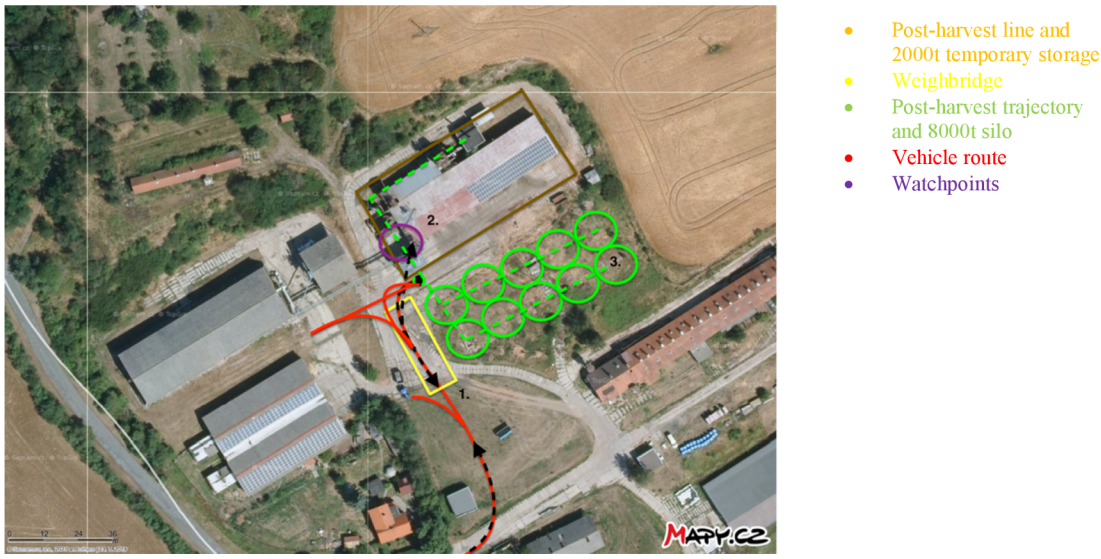
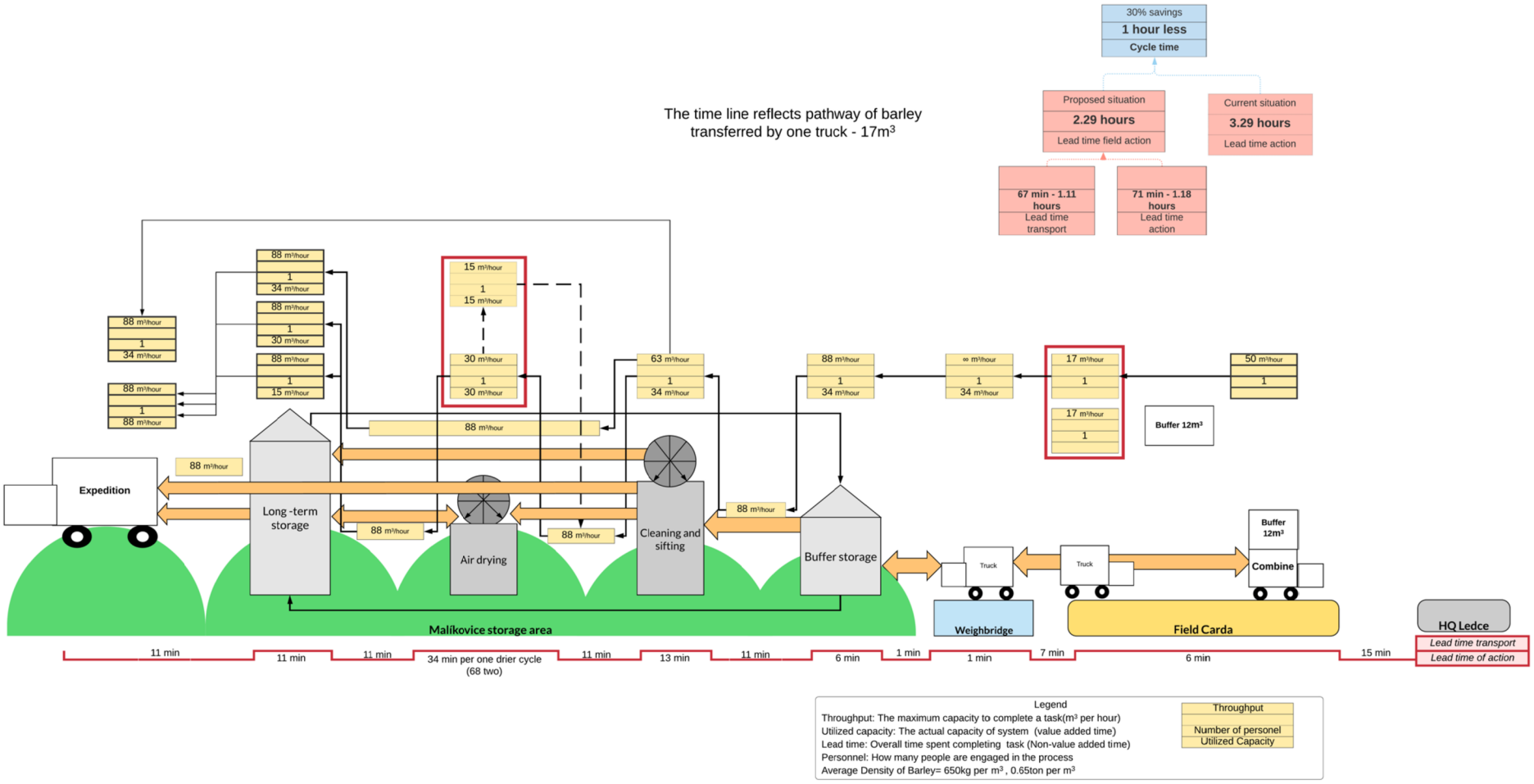


Figure 19 - own work, mapy.cz

The truck enters the storage area. Instead of proceeding to center of the area, driver immediately turns left uphill. The weighbridge is in the direction of the incoming way. This already mitigate need of second watchpoint and all actions are done on one place with one stable personnel. The truck go through the weighbridge, the storage master check the weight of crop, proceed with the quality check in case its incoming delivery from the field, and let the truck unload the barley on trough situated in the beginning of the post-harvest line. The truck then reverse itself and can continue over the weighbridge (if loaded) or go sideways and save time waiting for next truck. Then he leaves the area in the shortest way possible. Also, the loading is done here and only requirement for the trucks is to go backwards under the funnel, to load the barley, and then continue through weighbridge and leaves. This is ideal proposition as the barley is all the time in the silos, and no other movement is engaged in the process.


30% savings
1 hour less
Cycle time
Proposed situation
2.29 hours
Lead time field action
Current situation
3.29 hours
Lead time action
67 min - 1.11 hours
Lead time transport
71 min - 1.18 hours
Lead time action
The time line reflects pathway of barley transferred by one truck - 17m3
88 m³/hour
1
34 m³/hour
88 m³/hour
1
30 m³/hour
88 m³/hour
1
15 m³/hour
88 m³/hour
1
88 m³/hour
15 m³/hour
1
15 m³/hour
30 m³/hour
1
30 m³/hour
63 m³/hour
1
34 m³/hour
88 m³/hour
1
34 m³/hour
∞ m³/hour
1
34 m³/hour
17 m³/hour
1
17 m³/hour
1
50 m³/hour
1
Buffer 12m³
88 m³/hour
Expedition
Long -term storage
88 m³/hour
88 m³/hour
Air drying
88 m³/hour
Cleaning and sifting
88 m³/hour
Buffer storage
Truck
Truck
Buffer 12m³
Combine
Weighbridge
Field Carda
HQ Ledce
Lead time transport
Lead time of action
Malíkovice storage area
11 min
11 min
11 min
34 min per one drier cycle (68 two)
11 min
13 min
11 min
6 min
1 min
1 min
7 min
6 min
15 min
Legend
Throughput: The maximum capacity to complete a task(m³ per hour)
Utilized capacity: The actual capacity of system (value added time)
Lead time: Overall time spent completing task (Non-value added time)
Personnel: How many people are engaged in the process
Average Density of Barley= 650kg per m³ , 0.65ton per m³
Throughput
Number of personel
Utilized Capacity

Part 3: Result and Summary

5. Results

5.1. Results of Observation

The Value Stream Mapping of the farm presented high degree of coordination among all the activities. The reason of this coordination is partly caused by the narrow gap between management and field workers, due to the nature of farming, where every responsible person is a part of the grow process community and co-operate tightly with other engaged workers. As the team is experienced, it profits from this mutual relationship and we can consider it as the first proposition for kaizen culture. From the results, we see the crucial part lays in the operative coordination during crop harvest, requiring engagement from the on-field workers and agronom. From lean perspective everybody is informed, coordinated, and acts in the symbiosis. Also, due to precision techniques the lean is already present on the field level. Minimizing turnarounds, defined width of tracks on fields, to suppress losses on field yield, selective use of chemicals, GPS navigated machinery, and precise sowing techniques makes the process as effective as it can be. On management level, as the office is centralized, every administration step can be evaluated and discussed, while preventing information noises. Also, the family organization and recognition of mutual goals participates in creating of value for other stakeholders, which summarizes in one representative body for the customer.

The part requiring lean conditioning is the logistics, which poses highest difficulties. The inputs and outputs can vary, based on external and internal factors, further complicating operativity of logistics. On one side, we are determined by weather and crop maturity, on other side, offering of human resources, available machinery, distance from the field, capacity of the post-harvest line, and capacity of storage.

The extent of this thesis is focus on better floor/storage space allocation in order to optimize time spent on weighting, loading, storing, unloading, and transporting.

5.2. Results of Proposed Floor Space Coordination

Goal of conducted 5S storage proposal is to lower the lead times of trucks going to and from the post-harvest line, sort the barley storage on one place, mitigate unnecessary movement, and optimize employment.

On our first VSM diagram is described the current flow state on which we see three critical points. First is the bottleneck between combine harvest on field and final storage. Based on previous experiences, two companion trucks are necessary, as they are able cover the transport operation at the bare minimum. The combine has own buffer for $12m^3$ that serves when the trucks are on their way, but when the field is distant, more trucks must be arranged. This is solved operationally by agronom, who shall decide if this amount is viable or not and is scalable.

Then the trucks arrive at the storage Malíkovice, pass through the weighbridge, and continue to the grain sensor check. This pathway is introduced in proposal of new storage movement. The time savings in storage are one hour in total, 30% of previous state. Also, important achievement is the optimization of pathways during “Rush

hours", when the movement of multiple vehicles won't be obstructed by unnecessary cross movement.

Then the truck unloads barley into the ground funnel, which is then transferred by belt conveyor to the post-harvest treatment line. Here we see bottleneck in air drier system, which needs to work carefully not overheat the grains, but must dry the grain enough for long-term storage. This system has on the other hand benefit that it can work autonomously and 24/7.

Another change introduced by the proposal is silo storage at the backend side of the post-harvest line. Currently the post-harvest line is not directly connected to the storage, thus truck must be used to transfer the barley to storage. This is not efficient by design as the dust and impurities together with other quality decreasing aspects negatively affects final quality. Now the one central point is introduced for all related operations, where the unload, load, conditioning, takes place.

This controlled environment provides standard to quality of barley and adds the value of grain for further processing entity as it grants homogeneous batch from one kind of storage. The proposition lowers the amount of used fuel, mitigate necessary waste that arisen from ineffective manual loading with manitou tractor shovel, and assures the best possible quality of barley from the acceptation to the final expedition.

To summarize our research proposal, we consolidate the findings with previously presented 5S framework. Our goal was to exclude all the necessary actions, designate storage processes, propose organization that could be maintained, and created background for further Lean implementation.

- Sort — We have sorted all relevant processes, found out bottlenecks in the cycle, prioritize every action and created a total overview. Based on findings, we have had researched the current storage situation is not efficient and have proposed new state.
- Set in order — Our proposal introduces minimization of travel distance, unite storages in to one place, and optimizes human labor that can monitor the operations from one place. All processes related to storage, disembark, load, and manipulation is now concentrated in one designated place, to ensure the smoothness and efficiency of the work performance.
- Shine – The storage place now better corresponds to its function and offers centralized point for the following actions. Due to fact the maintenance and cleaning procedures are held only around the storage area, there is less wasted labor time, less of used consumables, and more effective utilization so the kernels of barley are situated only at place, where they should be, and the clutter is eliminated.
- Standardize – Due to standardized size of post-harvest reception funnel and grain bins, the load and unload procedure can be universal for all trucks.
- Sustain – The proposal created organized floor plan that can be used for further lean implementation.

6. Summary

The scope of the thesis is to observe and evaluate if can be lean techniques applied on selected farm regarding the cultivation of the malt barley, and if can be 5S method applied and how.

Trough the research over the time interesting findings emerged. The farm is wider adopter of precision technologies, such as GPS driven movement on fields, regularly mapping of fields characteristics, using aerial devices to do so, and has overlap of automatization in animal production. This high level of automatization has big advantage for solving problems with the efficiency. As the nature of agriculture is very variable, no other thing than adequate database of previous lead/cycle times, agrochemical values of field, meteorological forecasts, price of commodities, timing of actions can help to pave a road to the full lean adoption. To this time, all the decision making was on the agronom, who know local conditions and has vast experiences in the topic. This won't mitigate the need of his role, but the option to have such data means that they can be used for the longer forecasting and making the decision making easier also to other departments.

Farm management is described as middle sized, family style, data driven agriculture company. For our purposes of lean adoption hypothesis, the discussion was opened with management of the company. The topic was discussed, but even despite high rate of controllability, the lean as we know from the production corporate companies, cannot be implemented in its ultimate extensa. On the other hand, whole company can be declared as on way to the lean philosophy. There isn't rigid hierarchical structure, and all employees and employers are constantly involved in solving problems, dividing tasks, consulting next steps, and working altogether in teams. Agriculture has its roots and traditions, and all the people are taking work with responsibility and actively engages in the processes. Also, their motivation is to get work done as soon as possible, without delays as the measures of the performance is indicated by successful processing of the crop. From these findings, we observe the lean philosophy is somehow applied in the elementary sense.

The next step of this research was to create Value Stream. This described the differences between every action, and we are able to see overall efficiency. The result was around 68% so it can be considered as good with the space to further optimize. We must consider there are also many factors influencing the process, no crop is the same as previous one, and we need to focus on the processes that can be controlled.

Another finding is related to the ability to work in pull production manner, which we must refute. After observation of economies of scale, regarding specifics of agriculture, and food industry demand, this style of production cannot be used in basic food commodity sector. We have found examples, where the push production is viable, mainly in driven multiplication of malt barley seeds based on order from malthouses and cultivation of narrow spectrum of herbs, but this cannot be done in scale of usually traded commodities. The push production is still prevalent as the food demand constantly rises all over the world.

Related to pull production system is needless to mention the just in time capability. The demand for commodities changes seasonally. During the Summer, the offer is high, but when the customer wants to buy commodity during the winter, the prices are higher and offerings are limited. The just in time cannot be adopted in manner we recognize

in the production, but due to future development of the storage areas enabling long-term storage without affecting the final quality, the farm will be able to fulfil orders also during the winter and practically over the whole year. The idea of just in time can be transposed to ability to sell wide range of commodities to the customer during the whole year without waiting for next crop.

Due to this the second hypothesis was application of 5S method. The 5S method, as was described previously, is the first step of adopting the Lean. Again, to some extent the 5S method is already implemented. The information system gathers and standardizes all the data from machinery, the pathways on the fields, consumption, time, and is able to observe all relevant indicators of resources status. The decision making is easier than before because we have all the details of every field, vehicle, process and can be drilled further to the history up to several years. All on one place, available for every employee.

The farm done tremendous job in implementation of this technology. The opposite side of the ability to have data is that problematic parts become visible.

Major issue is the old infrastructure of the farm. Based on the interview with storage master, who do this job whole his life and works on this farm during 1970's. The infrastructure at that time was very robust in terms of future preparedness. At those time, the long-term storage has itself floor with air vents, that aerated the piles, but the technology was not very precise, thus the vertebrates emerge, and this solution had to be dismissed. Current requirements are not very different, but as the technology constantly develops, the updates should be implemented to stay competitive.

Regarding the second hypothesis we have tried to streamline the process of storage movement and coordination. The proposition lowers the amount of used fuel, help achieve hygienic norms, save time, human labor, mitigate necessary waste that arisen from ineffective manual loading with manitou tractor shovel, and assures the best possible quality of barley from the accept to the final expedition.

To summarize finding of the thesis, there is a space for further improvement, but as stated by Toyoda, the true nature of lean lies in constant improvement from those, who are at the bottom of the workflow. We assume the AGRA Řisuty is going this way using new information technologies, which creates the important framework, where measurements can be observed, and will of the employees to also save their time in sake of their families and leading to overall satisfaction and efficiency of all engaged stakeholders. Based on our findings can we approve both hypothesis?

Can be Lean techniques applied on selected farm regarding cultivation of the malt barley? Yes, Lean management principles can be applied globally, they provide processes and methodologies to streamline and unify all activities using not only modern technologies, but also there are certain limitations in term of unpredictability and human resistivity to changing historical patterns. Nevertheless, the robust information system is vital to adopt lean that can be monitored and evaluated in long-term.

Second hypothesis is: Can be 5S method introduced and if so, what are the results of hypothetical implementation? Yes, 5S method is the first and very good step to the optimalization of the farm which does not yet implemented any lean practice, it helps to categorize, prioritize, optimize, and maintain ongoing processes and our case study clearly presented how change of storage organization can lead to more efficient outcome.

Part 4: Appendix

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8. Appendix

8.1. Tables of Contents, Images, Schemas

La concurrence mondiale croissante met les entreprises au défi d'optimiser leurs opérations, de rester rentables et de devancer la concurrence. Même si les agronomes connaissent parfaitement leur métier, sur la base de leur longue expérience, l'évolution constante des pratiques de gestion d'une part, et la rigidité des stéréotypes établis d'autre part, incitent à adopter de nouvelles méthodes.

Pour améliorer les performances de l'entreprise, un regard extérieur est souvent nécessaire pour découvrir les goulots d'étranglement et évaluer chaque étape en fonction du processus de création de valeur.

L'objectif de l'étude "Les principes de la gestion allégée peuvent-ils aider à optimiser l'agriculture ? Application et évaluation sur une sélection de fermes cultivant de l'orge de printemps en République tchèque " ; est d'observer et de rechercher l'applicabilité des principes de gestion allégée, généralement utilisés dans l'industrie de la production, dans différents segments, dans une agriculture. L'objectif de la recherche est d'évaluer la possibilité d'introduire les principes de gestion allégée dans un secteur hautement volatile. Un secteur où le prix dépend principalement de la météo, de la saison, de l'emplacement, du développement agro-technologique, ainsi que du besoin de prévisions robustes pouvant aller jusqu'à plusieurs années. D'autre part, la faible variabilité des produits, la logistique et les opérations répétitives favorisent l'application des méthodes Lean au processus de culture.

L'objectif de la thèse est d'évaluer tous les processus pendant le cycle de culture afin de trouver les goulots d'étranglement, d'optimiser le déroulement du processus, avec pour objectif principal de réduire les délais entre chaque étape et d'atténuer le travail inefficace.

Nous travaillons avec deux hypothèses. Les techniques Lean peuvent-elles être appliquées dans l'exploitation sélectionnée en ce qui concerne la culture de l'orge de printemps ?

La deuxième hypothèse est la suivante : La méthode 5S peut-elle être introduite et si oui, quels sont les résultats d'une mise en œuvre hypothétique ?

Une étude documentaire est réalisée afin de mieux comprendre les facteurs influençant le cycle de culture de l'orge, la gestion du stockage, la logistique et les processus adjacents. Les informations extraites de l'étude documentaire permettent de détailler le cadre théorique. Les principaux outils d'analyse sont la cartographie de la chaîne de valeur, le cadre de GANTT et les 5S pour la désignation du plan d'étage.

La méthode proposée consiste à identifier tous les processus en cours, qui ajoutent de la valeur à la qualité finale de l'orge requise par l'industrie du malt. Nous examinons toutes les actions et tous les processus depuis la préparation du champ, en passant par la culture, jusqu'à la livraison finale au client. Ces étapes comprennent la cartographie des processus agricoles existants - planification de l'achat des semences sur la base de la quantité négociée proposée par une malterie, préparation de la ferme en termes de disponibilité des machines et des ressources humaines, techniques d'ensemencement minimisant les semences, soins appropriés de la culture du point de vue des étapes impliquées dans des fenêtres de temps exactes, séchage et préparation finale dans le stockage. Cela décrit la situation actuelle et l'efficacité globale, à partir desquelles nous pouvons déduire les activités sans valeur ajoutée et recommander les techniques allégées que l'entreprise devrait mettre en œuvre pour obtenir un flux de travail stable et plus efficace.

Les informations obtenues seront sous la forme de données de panel, d'un questionnaire évaluant la mise en œuvre hypothétique des méthodes Lean (5S), et d'un aperçu de la littérature.

Trois sous-objectifs ont été fixés dans le traitement de ce travail :

- Recherche documentaire sur le sujet et les sujets adjacents - Histoire de l'orge en République tchèque, situation actuelle concernant l'approvisionnement en malt et description des mesures de qualité qui apportent de la valeur aux clients, histoire de la méthode Lean, principes de la philosophie Kaizen, gestion Lean utilisée dans la production, présentation des méthodes choisies, cartographie de la chaîne de valeur, diagramme de GANTT et 5S.

- Caractéristique d'AGRA Řisuty s.r.o., analyse des matériaux internes et description du cycle d'affaires concernant la culture de l'orge. Évaluation du flux de valeur, de la chronologie et des délais pendant la culture.

- Préparation d'un entretien semi-structuré avec le brumisateur d'Agra Řisuty pour obtenir des informations générales sur l'utilisation de la méthode 5S.

Mots clés : Gestion de la chaîne d'approvisionnement, 5S, production allégée, gestion allégée, diagramme de GANTT, orge de printemps, gestion de la ferme, marché, Gemba, Kaizen, système d'information, agriculture, qualité, orge de brasserie, industrie tchèque.