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Lean-inspired development work in agriculture: Implications for the work environment

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Abstract. Farmers operate in a turbulent environment that includes international competition, weather conditions and animal behaviour, for example, and is difficult for them to control. However, economy and productivity always have a high priority. As a consequence, farms have started to implement lean-inspired work systems. At the same time, health and safety are of urgent concern in the sector. This article explores how famers apply lean-inspired work processes. It identifies work environment changes during and after a lean implementation, as well as possible developments in the work environment following implementation of the lean philosophy. Data were collected from three groups: lean, lean-light and development-inclined reference farms (in total 54 farms), using a questionnaire and interviews. The results indicate that a majority of the lean farms were applying several lean principles and tools, and the lean philosophy. The lean-light farms applied parts of the lean concept, while the reference farms applied some of the more general tools, used in lean and elsewhere, such as visualisation in various forms and to various extents. The results showed positive effects of lean on the psychosocial work environment, better work structure and improved information, communication and co-operation. The physical work environment was improved to some extent by lean, where advantages such as a more structured and practical work environment with less physical movements and locomotion could be noticed. The lean concept provided a more structured and systematic approach to dealing with work and production environmental issues, for managers as well as for employees.

Key words: farm, farm business, Lean Production, physical work environment, psychosocial work environment, safety and health, structure, work organisation.

INTRODUCTION

Swedish farm structure is evolving towards larger units with more animals and/or more acres (Ekman & Gullstrand, 2006; Swedish Board of Agriculture, 2017). In the EU the number of regular employees is falling and the standard output per holding is increasing, indicating a trend towards more productive farms (European Commission, 2015). This development is a part of a rationalisation trend that makes farm strategy and management increasingly important (Rydberg et al., 2011). In other sectors, Lean

Production (lean) has had a substantial impact as a productivity concept. Swedish agricultural stakeholders have therefore implemented a lean programme for farms.

Alongside this restructuring and rationalisation, there is concern about the work environment and safety. Furthermore, having bigger farm units implies more employees and increased management responsibility for the work environment. This paper examines the work environment and safety when lean is introduced in agriculture.

Lean Production

Lean is a quality and productivity concept that originates from Toyota´s production system (Womack et al., 1991). In 1984, researchers concluded that North American and European car manufacturers were incapable of learning from their competitors in Japan, who had increased their share of the automobile market. The International Motor Vehicle Program (IMVP) was established, from which Krafcik (1988) concluded that Toyota's production system seemed to be more 'lean', with fewer buffers, better productivity and better quality.

Since then the concept has spread from the production sector to the service, public and private sectors. Lean is based on four principles: philosophy, processes, people and problem solving (Liker, 2004). The philosophy is based on responsible long-term thinking, which may be at the expense of short-term economic goals. The philosophy and principles aim to continuously improve processes and increase customer value. People, such as employees and temporary staff, are a highly important group because they are the main part of the organisation. Challenges, development and letting people take responsibility create an environment that motivates employees to contribute. Problem solving is related to continuous learning and to understanding the organisation and its processes. Lean has the advantage of giving an overview of several business production factors simultaneously by means of the lean tool Value Stream Mapping (VSM). VSM enables processes and waste, among other things, to be visualised and possibly removed (Colgan et al., 2013). The concept has been proven to contribute to better quality and productivity (Simons & Zokaei, 2005) in various organisations, although the influence on the work environment is open to debate, as described below.

Several literature reviews have examined lean in relation to the work environment, health and well-being (Landsbergis et al., 1999; Brännmark & Håkansson, 2012; Hasle et al., 2012; Toivanen & Landsbergis, 2013). Landsbergis et al. (1999) and Toivanen & Landsbergis (2013) point out the lack of evidence to support the empowerment of manufacturing workers according to lean. They also mention a noticeably increased work pace and work demands, although decision-making authority, skills and decision latitude continue to be low. Hasle et al. (2012) report ambiguous results, with a slight predominance of negative impacts of lean on the work environment, such as a trend of reduced job autonomy, higher demands (such as cognitive demands), and a higher work pace, work load and work intensity. The positive aspects are improved job content, broader job roles, skill utilisation, social relations, empowerment of employees and task involvement. A literature review by Brännmark & Håkansson (2012), with the focus on work-related musculoskeletal disorders (WMSD) and their risk factors, provided inconclusive results, with individual studies giving positive or negative results and others showing mixed results. Overall, according to Brännmark & Håkansson (2012), there are more negative results from studies in non-Swedish contexts, and there are both positive and negative effects for employees. A recent literature review showed how Just-in-time

(JIT) and standardised work intensify work processes, which contributes to negative effects on the physical and psychosocial work environments (Koukoulaki, 2014). Westgaard & Winkel (2011) also list the negative outcomes of lean (higher repetitivity and work intensification) and positive outcomes (increased involvement in the process of change and increased focus on quality), and conclude that workers with more routine jobs have a higher risk of negative outcomes. They also highlight the important match between resources and responsibility.

Hasle et al. (2012) conclude that lean takes many different shapes, from perspectives on how it is implemented to the context with which it interacts and how it is used in a practical sense. These different shapes affect the work environment in different ways.

New research areas are evolving in relation to lean, e.g. environmental performance (Dieste et al., 2019). Another new area aims to deepen the understanding of how the work environment and ergonomics could be integrated naturally in lean tools as a part of holistic sustainability (Brito et al., 2019). Lean´s strong emphasis on a safe work environment has also spurred interest in how safety management and lean-inspired work could be integrated and performed more effectively (Hafey, 2017).

Following the recognition of lean in the manufacturing industry and in services, it has now started to be implemented in the agricultural sector. In the UK, aspects of lean, especially VSM and Value Stream Analysis (VSA), have been implemented in the meat value chain (Keivan Zokaei & Simons, 2006; Taylor, 2006). In Italy, VSM has been implemented on the farm level (Colgan et al., 2013). In both cases, the focus is on productivity and efficiency, and the conclusion is that lean may be an approach to enhancing productivity and efficiency. In Denmark, an agricultural advisory stakeholder has introduced lean in its services (Fladkjær Nielsen, 2013). These services focus mainly on lean tools such as whiteboards, meeting structure and VSM. In the USA, farms have started to use a more holistic lean approach, including lean tools, principles and philosophy (Hartman, 2015).

Lean implementation in Swedish agriculture

In the Swedish manufacturing industry, lean is seen as an opportunity to enhance production processes. A programme implemented in the manufacturing industry, the Production Leap (Brännmark, 2010; Medbo & Carlsson, 2013), influenced stakeholders in the agricultural sector. After trial implementations of smaller parts of the lean concept and the implementation methodology (see Rydberg et al., 2011; Åström & Melin, 2012; Melin et al., 2013; Olsson et al., 2014), a European Social Fund (ESF) project followed as the first project in the lean implementation programme Lean Agriculture (see Fig. 1).

A detailed description of how the implementation was executed and what was included in the lean implementation is given by Barth & Melin (2018), who based their contribution on the same project as this study. The ESF project started in autumn 2012 and ended in spring 2014. The lean farms in the project comprised various farm enterprises such as dairy, egg, broiler, pig, beef, grain and garden nurseries. There were also combinations of these on mixed farms, which is common in agriculture. The farms had an average of five employees. However, the composition of the workforce differed substantially between farms. On some farms the workforce consisted only of family members, while other farms had only externally employed staff. Full-time, part-time and hourly employment differed between farms. The employment of immigrants in the workforce also varied between none and a major extent.

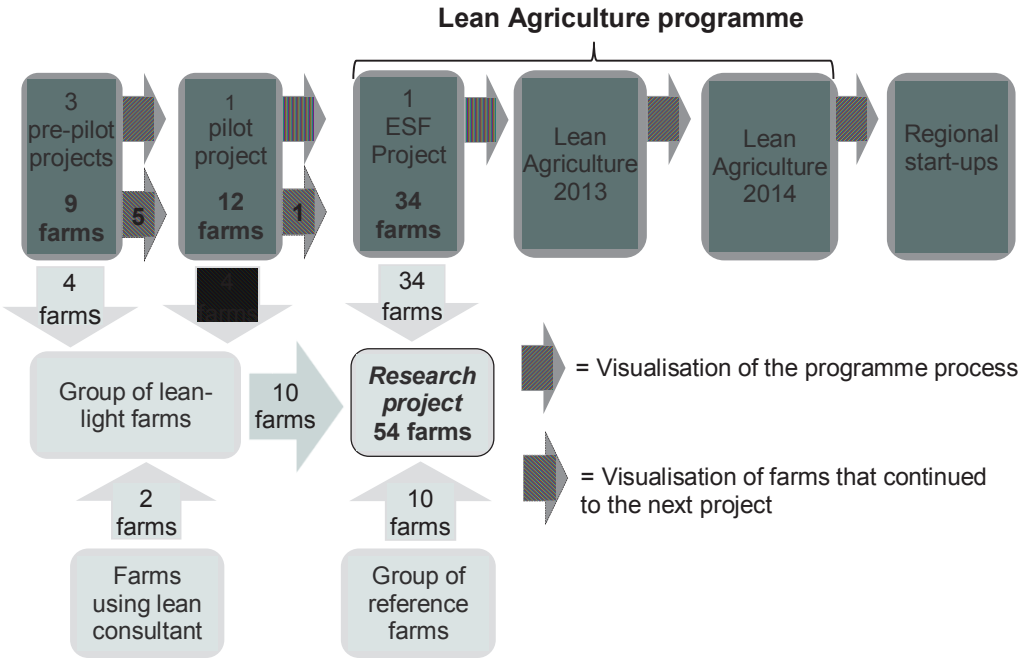

Figure 1. Visualisation of progress and development in Lean Agriculture (marked by dark grey colour) and its relation to this research project (marked by light grey colour).

Physical work environment in Swedish agriculture

Health and safety issues in agriculture are highlighted by Tómasson et al. (2011), who argue that Swedish agriculture (including forestry, hunting and fishing) has one of the highest levels of fatal occupational accidents in the country. Several studies report that the most common injuries are related to machinery, falls and animals (Lindahl et al., 2012). After scrutinising 3007 male and female respondents in the dairy industry, Gustafsson et al. (1994) concluded that the majority of them, irrespective of gender, had musculoskeletal problems. Age, years of working in the industry, working hours per day and personal physical characteristics strongly affected the extent of musculoskeletal symptoms. The lower back, knees, shoulders and neck had the highest frequency of symptoms. However, that study did not identify the specific activities or movements that pose the greatest risk. In a systematic literature review, Osborne et al. (2012) identified different risks of musculoskeletal disorders (MSDs) among workers and owners in agriculture and found that the two major risk factors were worker age and dairy farming. Lunner Kolstrup (2012) reports that despite improved and restructured technology in the sector, musculoskeletal strains, especially in the back, hand/wrist and knees, are common on dairy farms.

Accidents in Swedish agriculture

Between 2007–2016, the number of employees in Swedish agriculture fell by 3% (to 171,400 in 2016) (Swedish Work Environment Authority, 2017). However, the number of work-related and fatal accidents remains high (see Table 1). Corresponding numbers from the EU countries are questionable due to inconsistent data collection

(Merisalu et al., 2019). Large intervention and information campaigns (see Danielsson, 2012) have not had prolonged effects. According to Donham & Thelin (2016), achieving sustained effects from interventions in the agriculture sector is problematic.

It is in general important to integrate health and safety improvements as a management matter (Kuimet et al., 2016). In a survey among Irish farmers, 27% of the respondents related the causes of accidents at the farm to organisational matters (Griffin et al., 2019).

Comprehensive health and safety plans are rarely developed in agricultural management (Murphy, 2016), despite work planning being an important factor in reducing risk-taking behaviour that might lead to injury (Salminen, 1997). After analysing relationships between quality of management and injury risk, Suutarinen (2004) suggested that work procedures that integrate ergonomics can contribute to a better work environment in agriculture. Better management would mean, for example, having enough work capacity for the intended task, which could reduce the risk of injury. According to Hasle & Limborg (2006), a good way to prevent accidents is to mergeaction-based health and safety initiatives with organisational management and its goals. Health promotion also plays a vital part when the organisation wants to enhan ce work motivation and efficiency and reduce labour turnover (Kuimet et al., 2016).

Table 1. Reported work injuries with sick leave, fatal accidents and gainfully employed in agriculture (2009–2018). Data include agriculture, forestry and fishing (SNI codes = 01, 02, 03)

Year	Reported work injuries	Fatal accidents	Gainfully employed
2009	301[*1]	7[*2]	95,276[*3]
2010	351[*1]	7[*2]	100,252[*4]
2011	354[*1]	13[*2]	100,264[*3]
2012	357[*1]	6[*2]	100,130[*4]
2013	349[*1]	4[*2]	100,907 [*4]
2014	377[*1]	10[*2]	100,564 [*4]
2015	342[*1]	6[*2]	99,312 [*4]
2016	287[*1]	6[*2]	94,772[*4]
2017	318[*1]	12[*2]	96,551[*5]
2018	326[*1]	10[*2]	Not available

[1] Swedish Work Environment Authority (2019a); [*2] Swedish Work Environment Authority (2019b); [*3] Official Statistics of Sweden (2015); [*4] Official Statistics of Sweden (2018); [*5] Olsson (2019).

Note that both SNI codes and the definition of gainfully employed may have changed slightly during the period 2009–2018.

Psychosocial work environment in Swedish agriculture

According to Glasscock et al. (2006), the work environment of farmers differs from those of other occupations. Farmers often work alone, for longer hours, and with very varied work tasks. At the same time, they are expected to deal with (changing) laws and regulations, various administrative tasks, changing weather, (global) economics, and livestock diseases. Other factors affecting farmers are taxes, unexpected expenses and a negative attitude in society towards farming (Lunner Kolstrup et al., 2013). These types of factors are reported to contribute to psychosocial disorders such as anxiety, substance abuse, increased rate of injury and sleep problems (Lunner Kolstrup et al., 2013). Other factors, such as the unexpected behaviour of farm animals and rapidly changing weather conditions, simultaneously contribute to an unpredictable work environment that farmers and employees can control only to a minor extent.

Established stressors in the agriculture work environment, compiled by Kallioniemi et al. (2016), are: 'policy or new legislation', 'public perception or the position of the farmers', 'future of the farm', 'administrative burden', 'the amount of paper work', 'long hours of work or amount of work', 'machinery breakdown', 'uncontrollable natural forces', 'animal diseases', 'media criticism', 'finances', 'health problems', 'isolation' and 'family problems'.

'Agricultural policy of the EU', 'the treatment of farmers in society and the media', 'the future of the agricultural sector', 'administration of the farm', 'amount of work' and 'lack of possibility to predict work situations' are major stressors among Finnish dairy farmers (Kallioniemi et al., 2016). Those authors concluded that stressors related to social relationships and individual matters were not among the most prevalent stressors. Glasscock et al. (2006) found that stressors with economic characteristics, stress symptoms and insufficient safety procedures were connected to accidental injury. Kolstrup et al. (2008) conducted a study of the psychosocial work environment of pig and dairy farmers in Sweden and found, among other things, that feedback, social support and the quality of leadership need improvement on dairy farms.

Several studies have shown that farmers have a greater risk of developing mental illness, such as depression, and that farmers have a higher suicide rate than the general population (Roberts & Lee, 1993; Booth & Lloyd, 2000). Some studies reviewed by Fraser et al. (2005) reported a higher level of anxiety and depression among farmers than in the general population, while other studies found no such pattern. Booth et al. (2000) discuss whether the increased suicide rate among farmers may be due to their access to firearms and having greater difficulties than urban populations in accessing medical care. Associations have been shown between MSDs and risk factors in the psychosocial and personal areas (Osborne et al., 2012), and especially between depression symptoms and lower back injury (Sprince et al., 2007).

The effects of the lean concept on the work environment are open to debate, so it is important to scrutinise lean's effects when it is implemented in an agricultural context, which is already associated with negative work environmental issues, such as the many accidents. Lean implementation in agriculture started as an initiative to increase productivity in the industry, being viewed initially as a concept with the potential to contribute to farm competitiveness.

The primary aim of the present study was to explore how farmers apply lean-inspired work processes. A secondary aim was to identify work environment changes during and after lean implementation.

MATERIALS AND METHODS

Data were collected using mixed methods (Creswell & Clark, 2017). A longitudinal quantitative questionnaire was followed by semi-structured deep interviews based on the answers from the questionnaire. Occasional observations were made during visits to farms. However, those observations were not generalised because of the varying durations of different agricultural processes. Triangulation was used to validate data from the questionnaires and the interviews and, to some extent, from the observations (Morse, 1991). Data were collected from three respondent groups.

Respondent groups

The first of the three respondent groups consisted of farms participating in an ongoing project in the Lean Agriculture programme (see Fig. 1). Those are defined as lean farms. The lean farms included all farms attached to the ESF project and were at the beginning of the 18-month lean implementation process. The second group, the lean-light group, comprised four of the nine farms included in the three pre-pilot projects, and four farms from the pilot project. Those are defined as lean-light farms because their lean implementation consisted of a one-day workshop, a study visit and two days when implementation researchers visited the farms. The main methods and tools taught and used were 5S (sort, set in order, shine, standardise and sustain), VSM, fishbone diagram, spaghetti diagram, PDCA, and visualisation (see Langstrand, 2012). Those interventions were also conducted one year before the lean farms started their lean implementation process. Two farms with a private consultant were added to the lean-light group because their lean implementations were more similar to the lean-light group than to the lean farm group. The third group was a reference group of farms that did not use lean (see Fig. 1). The reference group was chosen from a larger group of farms that was considered to be inclined to improvements and development projects because of previous contact and participation in various research projects, with a more technical approach, at Research Institutes of Sweden (RISE). The reference group was established through an email survey at RISE. In this, research colleagues were asked to recommend development-inclined farms. Research colleagues with suitable contacts contributed contact information. The method of choosing farms and respondents thus involved 'spreading the net' (Hignett & McDermott, 2015). The reference farms were selected to match the lean farms in terms of size, production sector and geographical location.

The maturity of and interest in continuous improvement and organisational development could be assumed to differ among the three respondent groups. The reference group had primary experience of development from a more technical approach. The lean-light farms were more interested in the development of their operations.

The questionnaire

A questionnaire was developed and validated to capture the present statuses of the physical and psychosocial work environments and the improvement and development work on the farms (Wilson & Sharples, 2015). The validated questionnaire comprised four sections: physical workload, discomfort in locomotive organs and eyes, psychosocial work environment and improvement work. It was sent out to farms in the fifth month of their lean implementation. In the questionnaire, lean was equated to improvement and development work and was covered by nine questions, which are presented in Table 2.

The questions were taken from a questionnaire developed in the Leadership and Organisation for Health and Production (LOHP) project (Fagerlind Ståhl, 2015). The questionnaire was validated by five individuals working on a farm, with three or more individuals related to the farm operation. The lean coaches distributed the questionnaires in person to farm owners and employees during their regular visits. They reminded them at the next two meetings. On the reference farms, the questionnaire was sent directly to the individual farm owner, who distributed the questionnaire to employees. The reference group was reminded by telephone twice, with one month between reminders.

Table 2. Specific statements related to improvement and development work posed to respondents in different sections (E5, E6 and E9a-i) of the questionnaire

Position in questionnaire /statement no.[1]	Statement	Referred to below as:
Improvement work E5	Is there a vision for improvement work in your business?	E5
Improvement work E6	Is there an overall goal for improvement work in your business?	E6
Improvement work E9a	I participate in a group that works with suggestions for improvement	A
Improvement work E9b	I take part in the work to develop guiding principles on values for our department	B
Improvement work E9c	I am involved in value stream mapping and analysis	C
Improvement work E9d	I take part in improvement projects	D
Improvement work E9e	I am involved in efforts to shorten waiting times	E
Improvement work E9f	We practise a standardised work approach	F
Improvement work E9g	We work systematically on keeping things in order	G
Improvement work E9h	We use a follow-up board (e.g. whiteboard) at our daily meetings	H
Improvement work E9i	We use a follow-up board/improvement board in our improvement work	I

Semi-structured in-depth interviews

Semi-structured interviews (Yin, 2009; Kvale & Brinkmann, 2014) were conducted to extend and expand the questionnaire data. The interviews were carried out according to a developed interview guide divided into four sections. The first section invited the respondent to talk freely about the farm and farm operations. In this section, interviewees were encouraged to talk about their work on lean/development and improvement work. The second part dealt with goals, business metrics and their assessment, productivity and efficiency. The subsequent sections gave the respondent the opportunity to describe the effects on the physical and psychosocial work environments.

There was diversity among the respondents in terms of their agricultural sector, employer/ employee, geographical location, and the lean coach serving the farm. There were 28 respondents from 14 farms (see Table 3). There were two interviews on each farm, so the owner was self-appointed and was asked to invite an employee representative of the median age among employees. The interviews lasted between 40

Table 3. Number of interviews performed with different respondent groups

No. of interviews	Lean	Lean-light	Reference
Employers	5	1	1
Employees	5	1	1

[1]Statements E9a-E9i used a five-point Likert scale: 'Don't know' (0) 'Not at all' (1), 'To a fairly minor extent' (2), 'Partly' (3), 'To a fairly major extent' (4), and 'To a major extent' (5). A sixth choice, 'Don't know', was excluded from the analysis and is accounted for separately.

and 75 minutes. The interviews were recorded, transcribed verbatim and thematically analysed, both by hand and using NVivo software (Hignett & McDermott, 2015).

Pulse meetings

Pulse meetings between the ESF project leaders and lean coaches were observed. A pulse meeting is a short and frequently convened (daily/weekly/monthly) meeting that aims to help guide work. Those observations aimed to use triangulation to validate data from the interviews at the lean farms. The pulse meetings gave the project leader an opportunity to check how the lean coaches' work was going at the farms. Before the meetings, the coaches were meant to mark their own farms with a green, yellow or red colour according to how well the lean-inspired work was going at the farms.

RESULTS AND DISCUSSION

Results

The qualitative data are presented in representative quotations throughout the discussion, while the results from the quantitative data are presented in Table 4. The questions from the questionnaire were first analysed by an independent sample Kruskal-Wallis test (Field, 2013). Medians, variances and significance levels are shown in Table 4. Kruskal-Wallis pairwise comparisons were made continuously for questions that indicated significance with the Kruskal-Wallis test. The significance levels and effect sizes are also shown in Table 4.

Table 4. Results of questionnaire for the three different respondent groups subjected to Kruskal-Wallis test and pairwise comparison. Medians, variances and significance levels are shown. Lean farms (L.): $n = 56$, lean-light farms (L.-l.): $n = 19$ and reference farms (R.): $n = 12$), $P > 0.005$

		Kruskal-Wallis test			Kruskal-Wallis test pairwise comparison		
Question	Group	$\tilde{x}$	s^2	Sign.	Group	Sign.	r
A: I participate in a group that works with suggestions for improvement	L.	4	1.90		R. - L.-l.	0.001	
	L.-l.	4	3.09	0.001	R. - L.	0.001	
	R.	1	1.36		L.-l. - L.	1.00	
B: I take part in the work to develop guiding principles on values for our department	L.	3	2.31		R. - L.-l.	0.049	
	L.-l.	3	2.65	0.006	R. - L.	0.005	
	R.	1	1.52		L.-l. - L.	1.00	
C: I am involved in value stream mapping and analysis	L.	3	2.12		R. - L.-l.	0.052	
	L.-l.	2	2.81	0.002	R. - L.	0.001	
	R.	1	1.55		L.-l. - L.	1.00	
D: I take part in improvement projects	L.	4	1.71		R. - L.	0.002	
	L.-l.	4	1.62	0.001	R. - L.-l.	0.001	
	R.	1	2.45		L. - L.-l.	0.924	
E: I am involved in efforts to shorten waiting times	L.	3	2.27		R. - L.-l.	0.333	
	L.-l.	3	3.32	0.033	R. f. -L.	0.028	
	R.	1	2.81		L.-l. - L.	1.00	
F: We practise a standardised work approach	L.	3	1.27		R. - L.-l.	0.109	
	L.-l.	3	1.92	0.005	R. - L.	0.003	
	R.	1	1.54		L.-l. - L.	1.00	

Table 4 (continued)

G: We work systematically on keeping things in order	L.	4	0.73		R. - L.-l.	.	.
	L.-l.	4	0.72	0.061	R. - L.	.	.
	R.	4	2.64		L.-l. - L.	.	.
H: We use a follow-up board (e.g. whiteboard) at our daily meetings	L.	4	1.42		R. - L.	0.022	
	L.-l.	4	2.59	0.015	R. - L.-l.	0.024	
	R.	2	1.54		L. - L.-l.	1.00	
I: We use a follow-up board/improvement board in our improvement work	L.	4	0.901		R. - L.	0.012	
	L.-l.	3	1.93	0.001	R. - L.	0.001	
	R.	2	2.02		L.-l. - L.	0.765	

This study provides an indication of how lean is applied and implemented and the effects it can bring within a new sector (agriculture). The study contributes to the beginning of a conceptualisation of lean in agriculture. The data presented provide insights into how farm employers and employees are approaching lean, for example as a set of tools, as a philosophy, or both. It also shows how lean is applied, in terms of the extent to which a sample of Swedish farmers is working systematically according to lean. The study explores applications to improve the understanding of how lean influences the work environment. The results provide suggestions for how the implementation of a lean approach might reduce the frequency and severity of physical and psychosocial work environmental concerns.

The philosophy

The philosophy is reported to be an important part of the lean concept in successful lean implementation (Bhasin & Burcher, 2006). Liker (2004) defined the philosophy as how the long-term thinking (mission) outweighs the short-term gains, as well as the focus on customers' demands.

The results in Tables 4, 5 and 6 show that parts of the lean philosophy have been conveyed and implemented. Barth & Melin (2018) show how the lean farms defined challenges and developed visions, goals and values for their organisation at the beginning of the lean implementation. Those visions, goals and values are connected to the lean philosophy and how lean organisations should approach the long run. However, Barth & Melin (2018) stated how all 34 farms had applied the lean philosophy with a focus on reducing waste and improving customer value but without a long-term perspective. What is remarkable are the results from lean-light farms, which have established visions and goals to the same extent as the lean farms but with much less or no training. The lean philosophy is an important part of the work environment because it avoids the short-term (economic) gains and rationalisations that seldom encourage a healthy and safe work environment (Westgaard & Winkel, 2011). Lean theory emphasises not only the importance of

Table 5. Results of question E5. The question asks whether farm respondents consider there is a vision for improvement work (lean)

Is there a vision for improvement work in your business?				
	No	Yes	Don´t know	Total
L.	1.4% (1)	92.9% (65)	5.7 % (4)	100% (70)
L.-l.	3.8% (1)	96.2% (25)	0.0% (0)	100% (26)
R.	0.0% (0)	100% (14)	0.0% (0)	100% (14)
Total	1.8% (2)	94.5% (104)	3.6% (4)	100% (110)

defining values and goals for the business, but also the incorporation of the guiding principles (Liker, 2004; Barker, 2011). Question B highlights the extent to which the three different groups recognise themselves in the work on developing their guiding principles. The lean farms and the lean-light farms had a lukewarm response to their participation, and participation at the reference farms was non-existent. Barth & Melin (2018) showed how all 34 farms had an extended, defined in their paper as 'to a large degree', focus on lean principles such as values for customers. The lean farms identified steps in production processes that added value and activities that enhanced process flow. However, they also developed leaders devoted to the lean philosophy. They developed an applied and individual version of the 'Lean house' (Åström, personal communication, 2018) that defined the farm's guiding principles. It is questionable how it is possible to develop and apply visions, goals and principles while scoring 'partly' in question B *I take part in the work to develop guiding principles on values for our department*. In this case they would probably also have scored lower in the other lean activities. One possible explanation is that only a few of the employees participated in the development of the guiding principles, and the rest of the group was better informed/educated about them.

Table 6. Results of question E6. The question asks whether farm respondents consider there is an overall goal for improvement work (lean)

Is there an overall goal for improvement work in your business?				
	No	Yes	Don´t know	Total
L.	4.3% (3)	88.6% (62)	7.1% (5)	100% (70)
L.-l.	0.0% (0)	88.5% (23)	11.5% (3)	100% (26)
R.	0.0% (0)	100% (14)	0.0% (0)	100% (14)
Total	2.7% (3)	90% (99)	7.3% (8)	100% (110)

Continuous improvement

A review of the literature concluded that several technical tools, a long-term view of lean, work on continuous improvement (CI), and culture changes including empowerment and the value chain are necessary for successful lean work (Bhasin & Burcher, 2006). CI is promoted as a lean principle closely connected to the lean philosophy. The farmers reported that they often support CI work with tools such as visualisation, whiteboards and standardisation, while their way of achieving CI often involves teamwork and employee interaction. The reference farms indicate that the use of those kinds of aids is poor, and it is common for the owner or manager him/herself to be seen by the employees as the person responsible for solving and improving processes.

'I wouldn't say we had any… So in the dialogue with, with the so to speak personnel, what they perceive as problematic I will try to find a solution for.' (R.)

In relation to question H, both lean and lean-light farms use tools such as visualisation, whiteboards and standardisation that aid their day-to-day processes as well as their development work.

'We already had a weekly plan, a whiteboard, that was very good support for young lads, who… Yes we work quite a lot with newly trained lads who are not very structured.' (L.-l.)

CI is an easy tool to use, and is also a general and logical tool that could be used at different system levels. This mind-set is systematically practised to a greater extent on the lean and lean-light farms, although it is also a general activity on the reference farms. CI is planned in regular periods that include follow-ups more often on the lean farms

than on the other two farm types. The median reveals on question A, *I participate in a group that works with suggestions for improvement*, how the lean and lean-light farms are more likely to relate to their participation in suggestions for improvements than are the reference farms. Improvements, especially CI, are one of the fundamental pillars in lean. It therefore becomes more logical that those two groups, with externally organised lean implementation, score higher. As the interviews reveal, CI is something they work on more regularly and systematically. The regular and systematic approach ensures suggestions for improvements are handled by a chain of integrated activities. The integrated activities provide a cognitive aid to judging how the work is going.

Question D, *I take part in improvement projects*, is closely connected to question A (*I participate in a group that works with suggestions for improvement*). D indicates that suggestions for improvements are taken to the next step in the organisation and really are dealt with. It seems clearer that the respondent participates in CI tasks than that the respondent participates in a group that works on CI. The meaning and definition of 'group' and/or 'works' could be questionable in A. There are significant differences between the reference farms versus both lean and lean-light farms, but not between lean versus lean-light farms.

Visualisation

The progress of CI is often managed through visualisation using whiteboards, among other things. Question I, *We use a follow-up board/improvement board in our improvement work*, provides evidence of how farmers in the lean farm group make more use of visualisation such as different kinds of boards in their work on CI. The lean farms were trained in the meaning and importance of visualisation, while individual farms developed and designed the boards in response to their own needs.

The data analysis underpins the results for the lean farms' use of visualisation related to CI, with the lean-light farms working partly with it. The reference farms use this tool to only a small extent. This question also indicates a significant difference between lean and lean-light farms versus reference farms, but not between lean versus lean-light farms. The reference farms scored fairly low. There are several possible explanations. Workers might not relate to the term 'group' because the farms could be defined mostly as micro businesses. Alternatively, the workers do not talk explicitly about suggestions for improvement or they do not work on them systematically. An interview with a reference farm revealed that they work on improvements but less systematically.

Value stream mapping

VSM was taught and implemented on 34 of the lean farms by carrying out a VSM of one process on the farm with employees. The farms were meant to choose a process on their farm and perform a VSM with employees (Barth & Melin, 2018). None of the lean farms mentioned VSM during the interviews, which could be a sign of no further engagement in VSM and its results. The tool could contribute to the organisation's operations from several angles. For instance, it could be used both to increase productivity and improve the work environment (Jarebrant et al., 2016). The farm employees would then be able to jointly analyse important processes, discuss them and create an understanding of the parts of the process in practice. This tool was tested on the lean-light farms, but only to show participants the need for improvement. It was not

used on the reference farms. Question C provides an expected result, in the sense that lean farms scored higher ($\tilde{x} = 3$, $s^2 = 2.12$) than lean-light farms ($\tilde{x} = 2$, $s^2 = 2.81$) and the reference farms ($\tilde{x} = 1$, $s^2 = 1.55$). This could be explained by the extent to which the lean and lean-light farms were trained in the tools and by the non-use of VSM in the reference farms group. The result indicates that VSM was not one of the mostly used tools within the lean concept. There is significant difference only between the lean and reference farms in this case. The difference between this result and that of Barth & Melin (2018) could once again be related to the time of measurement. As Andreadis et al. (2017) discussed, on the basis of results from manufacturing industries and support from the literature, VSM is likely to be implemented when an organisation implements lean. Early in the process, however, the 5S tool is preferred over VSM. A lack of understanding of VSM was one of the major reasons why companies have not implemented it. A secondary reason was the tendency for there to be a shortage of trained workers and support. 'Lack of management commitment', 'lack of documented or properly defined processes' and 'lack of employee training' were the biggest hindrances during implementation (Andreadis et al., 2017). A concluding remark was a suggestion that organisations apply 5S to start the lean journey, to make the workspace easier to picture and measure and in preparation for the subsequent VSM. What is remarkable in the results is the use of VSM on the lean-light farms. This group had not been trained in the VSM method by the project's management. This knowledge could be obtained in this case from agricultural interest parties such as advisers or consultancies and/or by themselves through books, etc. The difference between the reference and lean farms is significant and could indicate how farms without lean integrated into their processes do not work according to the VSM method. VSM visualises waste, for example time of waiting, which is covered by question E *I am involved in efforts to shorten waiting times*. The results from the lean, lean-light and reference farms seem to correlate with C logically but with a wider spectrum of variance. It is perhaps remarkable that the median of lean-light farms' deployment of shortening waiting times ($\tilde{x} = 3$) was higher than their median representing their use of VSM ($\tilde{x} = 2$). This could be due to VSM methodology being a holistic and systematic visualisation of a whole process, while efforts to reduce waiting times could easily be made ad-hoc by an individual worker in a delimited activity. The narrower variance of C could also provide an input for VSM as a methodology that includes a certain frame of theory, while the wider variance in E should signal 'shortening waiting times' as a less specific tool. What does the tool include and exclude?

5S

The 5S and inventory reduction tools are more commonly used on all farms. In an agricultural context, 5S includes an effort to work on those issues using a holistic approach and at the same time continuously improve. Since farmers have applied 5S, their inventories and storage have reduced (in both space needed and number of items). Respondents from the lean farms more commonly reported organising storage, removing material they have not needed for years and placing the materials they use more often on the most convenient shelves.

Question G, *We work systematically on keeping things in order*, applies to 5S. It covers all the steps in 5S and is related to the expected outcome. According to Barth & Melin (2018), the 5S tool is used to a certain extent by the lean farms. A total of 26 of

the 34 farms have implemented 5S. This result shows $\tilde{x} = 4$ in all three groups. The lean and lean-light farms have similar and narrow s^2 of 0.72 and 0.73 respectively, which could be an indication of how the farms refer to the same lean tool when interpreting the question as a result of their knowledge of and training in the tool. However, the reference group also makes wide use of keeping things in order, while its s^2 is much wider ($s^2 = 2.64$), which could be interpreted as a greater spread in the respondents' interpretation of the question's content. The biggest difference between how the three groups are 'keeping things in order' is the consciousness of the value an integrated 5S could add. The lean farms have integrated 5S into their systematic structure in their efforts to develop better production. 'Keeping things in order' is, for example, integrated not only into the development and use of standardisation but also into the work on CI. The reference farms approach 'keeping things in order' merely as 'keeping things in order' and nothing else.

'…and I have always been one for neatness and tidiness and… I want it around me because I hate it when it's like untidy and slipshod and so on' (R.)

Standardisation

A standardised work approach, which Barth & Melin (2018) define as standardised operating procedures, is trained for on all lean farms and implemented by 27 of them. Examples of standardised work tasks include 'procedures for calf rearing, milking, stalls cleaning, and animal health checks' (Barth & Melin, 2018). On the lean-light farms, examples of standardised work tasks include checklists of the tasks and tools needed when the tractor driver leaves the farm for a working day in the fields. Beyond that, standardisations may be legal requirements. Examples are the standardisation of the handling and use of chemical pesticides, and of how to manage manure to avoid leakage or to manage processes related to spraying to minimise negative environmental impacts. However, standardisation seldom takes a holistic view of the work environment. On the lean and lean-light farms in this study, there was broader use of detailed process standardisation, such as of the milking process and standard inductions for new employees. However, those farms also showed an understanding of conscious improvement of the standards.

'As you know there is a standard here for how to feed a straw press and there is a visualisation and documentation that it is done. Then you can write a comment that it is done… It is not the finished item, but a first attempt now that... It is like night and day compared with what we had before.' (L.-l.)

E9f reveals how the lean ($\tilde{x} = 3$, $s^2 = 1.27$) and lean-light farms ($\tilde{x} = 3$, $s^2 = 1.92$) have a partially standardised work approach while the reference farms ($\tilde{x} = 1$, $s^2 = 1.54$) have no standardised work. According to Bath & Melin (2018), standardised work was fully implemented at the end of the lean farms' 18-month implementation period.

General discussion

Time of measurement

It must be emphasised that Barth & Melin (2018) depict the planned content of the lean implementation at the same time as the data for this article were collected. This means that this paper's results should be 'lower' or 'less' than those of Barth & Melin (2018), whose data were collected before, during and after the 18 months and whose Appendix (Barth & Melin, 2018) is interpreted in this article as a concluding result

following the 18-month implementation. Also open to discussion is the extent to which the lean training affected the answers from the lean farms. Questionnaire and interview data were collected during the lean farms' training during the lean implementation. The positive mind-set and the wish to achieve the goals, with the lean concept being a means to reach them, could affect the data positively. A common trait in the analysis is the differences between the three groups. There was a significant difference between the lean and reference farms and between the lean-light and reference farms. However, there was no significant difference between the lean and lean-light farms. There was a noteworthy difference between the implementations, in terms of both duration and content, so it might be logical to assume there should be a significant difference between the two groups.

Lean – a concept of inclusion

This study's results give a clear view of high employee participation in the lean implementation, in both the lean and lean-light groups.

The reference farms group has a notably lower score for their participation in organisational activities. Question A-I are all framed in terms of the individual's engagement in a specific activity or as the individual's engagement as a member of a group.

The high degree of employee inclusion in the lean and lean-light farm groups could be related to the importance of teamwork in the concept and to how lean activities are often performed or established through group meetings and joint decisions. Teamwork has become an important ingredient in the daily production process on lean farms where regular pulse meetings provide opportunities to raise the need for help with certain work tasks. This way of structuring production and working activities might also become more important with the changing structure of farms, towards larger units with more animals and/or greater area (Ekman & Gullstrand, 2006). The farms need to organise their work in other ways because the number of employees is increasing, which can have other impacts on the work environment. The new structure with regular meetings at which employees are involved in work planning provides a clear picture of the tasks to be managed during the day or the week. When the tasks are presented using a clear visual approach like this, employees can plan tasks together. Both the planning process and the need to be part of the team in the practical execution of particular tasks create teamwork. Employee involvement and the feeling of individual inclusion are not as obvious as in the two other groups.

Lean provides a systematic development approach

The lean concept gave the lean farms an underlying philosophy and principles as well as hands-on tools. The philosophy, principles and tools are closely interrelated in the lean concept, and are used in different combinations, on different organisational levels and in a chain of activities. This is something not found in the reference farms. The lean-light group scored fairly high in terms of the lean training they received and the time elapsing between the lean training and implementation and the time of measurement. As an example from the observations, visualisation could be used as an aid in the pulse meeting, where important information needs to be shared, as well as for suggestions and the state of the CI activities. The concept created a standardised arena for cause-and-effect tools such as '5 Why' in which troubleshooting was organised. This

integrated and systematic approach was found in the lean farm group. However, while the other groups also carried out troubleshooting, there was no great effort to find the core reasons for problems or any help to deal with the core reason. This could be due to the training component of the lean project, in which the farmers were taught how important it is to find the core reason for a problem so that it never recurs. VSM was applied in the lean farms that integrate waste elimination. Waste elimination is one of the main methods used on the lean farms (Åström, personal communication, 2019), and has been integrated systematically into daily operations. The owner/foreman and employees often employ a waste 'lens' with the eight wastes in mind. In the two other groups of farms, waste elimination is not integrated into processes, and established structures for handling new ideas for improvements are not present to the same extent.

Lean and the agricultural psychosocial work environment

The context discussed reveals an application where soft lean characteristics are taken into greater consideration. Questions A (*I participate in a group that works with suggestions for improvement*), B (*I take part in the work to develop guiding principles for our department*), D (*I take part in improvement projects*), H (*We use a follow-up board (e.g. whiteboard) at our daily meetings*) and I (*We use a follow-up board/improvement board in our improvement work*) related to organisational and human-centred activities. In contrast, questions C (*I am involved in value stream mapping and analysis*), E (*I am involved in efforts to shorten waiting times*), F (*We practise a standardised work approach*) and G (*We work systematically on keeping things in order*) related to a more instrumental way of approaching lean. However, instrumental approaches often involve and include soft approaches. For example, VSM and work on shortening waiting times include teamwork. Standardisation is often developed in a context of more than one person. In a small company, involving a greater part of the company makes co-operation unavoidable.

The psychosocial work environment on farms appears to have been affected most positively by lean. The respondents reported major positive changes in their psychosocial work environment when lean or lean-inspired pulse meetings were introduced into daily or weekly operations. The meetings mean that employees know what their colleagues are doing, so tasks can be redistributed to employees with less work or arranged to enable some employees to get help with tasks that they are unable to complete by themselves. This was experienced by respondents as a more open environment in which employees have better insights into farm operations. Pulse meetings give employees the opportunity to take responsibility and plan daily operations together. They also facilitate aspects of daily operations such as CI. Working according to lean or in a lean-inspired way was reported to contribute not only to teamwork, but also to a feeling of empowerment and belonging.

The lean farms in particular have established regular structured and systematic pulse meetings that are separate from coffee breaks. These pulse meetings have become the hub of the lean-inspired work systems, because whether they are daily or weekly, they provide an opportunity to improve operations and establish communication. This communication can be defined as a dialogue among employees, but also between employer and employees, which was uncommon before the implementation of the lean-inspired work systems. The meetings also contribute to participation and interaction with colleagues.

Scandinavian lean

The results of this study also point to a more humanised approach for lean-inspired work. However, the results cannot determine the reason for the humanised approach. It should be noted that unions have not had an active part in the ESF project or in the Lean Agriculture programme. The Scandinavian countries seem to have a tradition and a heritage of a sociotechnical culture, which might affect the way lean is applied and the effects of lean in the work environment (Berggren, 1993; Sederblad, 2013). Lean can be discussed from two points of view: one in which the lean characteristics are related to organisational and human activities, and another in which the characteristics are related to economic and rational activities. There seem to be more lean tools used and principles that relate to organisational and human activities, which might argue for a more human-centred approach with lean that aligns with the sociotechnical heritage. This has been defined as the Scandinavian Lean.

Insufficient consciousness of the physical work environment

The effects on the physical work environment, as revealed in the interviews, were minor. The effects were connected with fewer locomotive movements due to things like alarm systems such as sounds or signals.

For example, automatic feed barrows have a signal system that reduces physical movement in that the farmer does not have to go and see whether the feed barrow is moving. Having the right tools where they are needed and in standardised places (according to 5S) also reduces the amount of physical movement.

It has been theorised that 5S could contribute to workplace safety (Srinivasan et al., 2016), but there is little empirical evidence for this (Ab Rahman et al., 2010; Srinivasan et al., 2016). The data obtained in the present study showed no indications that 5S has actually improved workplace safety on the farms surveyed. Due to issues in the farm work environment, where MSDs are a major problem, the lean-inspired work system does not provide any greater contributions in the short term. The farmers surveyed have to some extent implemented systems such as signals. They have also analysed work environment movements using tools such as spaghetti diagrams to minimise waste by eliminating redundant movements. Over a longer period, the lean-inspired work system could encourage farms to implement a more conceptual and holistic approach that includes CI, and to plan and execute improvements to the physical environment, for example rebuilding work stations such as milking parlours and workshops.

It is also important to understand the aim of the ESF project and the prerequisite that it provides for lean farms. The project had a clear aim of increasing productivity in Swedish farms and improving their competitiveness. Without any clear and expressed focus on the work environment, the whole work environment or specific areas within at are at risk of being affected negatively. Because the implementation of lean has been directed to a great extent towards organisational aspects, the psychosocial work environment has been affected automatically. The physical work environment has not been included, so no reflections have been made upon it. The physical work environment is seldom actively managed on farms, and the very few reflections on the area have not been related to the work with lean but on the farm's ordinary perceptions and work in the area of the physical work environment.

The work environment has a low priority in agriculture. The safety and work environment on farms depends on farmers' perceptions of the subject (Elkind, 2008).

Farmers with confidence in their own ability to manage and prevent accidents, near-accidents and health issues tend to act differently from farmers that think the area is outside their control (Elkind, 2008). Lean-inspired development work can contribute several tools and methods to the work environment that make farmers and employees more conscious of the risks and how to prevent them. For example, pulse meetings could provide a forum in which issues are discussed jointly and transferred to the list of CI. Another example is standards, which could describe how an employee handles a specific dangerous work task.

One of the greatest implications for Swedish farmers is the systematic and structured approach lean provides to the work organisation. The systematic work system connects smaller work tasks to a greater picture that both visualises and makes employees more involved and engaged in the work processes. This type of programme also provides positive effects in implementations with recurrent support from lean coaches. However, the implementation of lean should emphasise a clearer view of the work environment to obtain a better outcome.

CONCLUSIONS

Lean farms received systematic and thorough training in the lean concept that was supported by lean coaches, generally every third week. The farms continuing work with lean did not fully cover the whole training content. The main tools and methods applied were planning, continuous improvement and visualisation. Tools and methods were continuously developed and integrated with each other and into the organisation. However, despite the lean-light farms having had less comprehensive lean training and no coaches, the lean concept was integrated surprisingly extensively. The main tools and methods used were planning, continuous improvement and visualisation (as on the lean farms), but these were less integrated compared with the lean farms. However, the reference farms showed a wider variation in the incorporated tools and principles, and these were not integrated. The reference farms had not applied the lean concept, so there were no signs of an integrated and holistic lean philosophy.

The implementation of lean-inspired work systems was found to improve the psychosocial work environment on the lean and lean-light farms. For example, co-operation and structure as well as information and interaction improved. In some cases, the results also revealed changes to the physical work environment due to the implementation of lean-inspired visualisation systems. Farmers and employees changed their patterns of movement. These changes in mobility patterns were not directed at reducing established risks in the work environment because the changes were a result of the project's aim of improving productivity**.** However, the physical work environment was improved to some extent by lean, with observed advantages such as a more structured and practical work environment with less physical movement and locomotion. The lean concept provided a more structured and systematic approach to dealing with work and production environmental issues, for managers as well as for employees.

Improving the work environment is, generally, not a main objective in the agricultural sector, and is not seen as the top priority for an industry in which farmers and employees are experiencing pressure from external factors and managing an internally strained economy. Integrating lean practices, as a productivity enhancement strategy, could imply some unintended work environment changes.

Further research into and deeper knowledge of how lean-inspired work systems affect the physical work environment in agriculture are needed because the data obtained in the present study showed no indications of actually improved workplace safety. The significant differences between lean and lean-light farm data provide a good opportunity to further explore the methodology of implementing lean-inspired systems in farms, i.e. in micro businesses.

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